DEPARTMENT OF CLIMATE CHANGE AND ENERGY EFFICIENCY

The Energy Savings Initiative and Energy Markets

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achieve outstanding client success

SINCLAIR KNIGHT MERZ

Contents

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Abbreviations

AEMO	Australian Energy Market Operator (formerly NEMMCO)
CC	Carbon Capture
CCGT	Combined cycle gas turbine
CPI	Consumer Price Index
CPRS	Carbon Pollution Reduction Scheme
DKIS	Darwin-Katherine Interconnected System
DSM	Demand-side management
EEO	Energy Efficiency Opportunities Program
ESI	Energy savings initiative
ESOO 2010	Electricity Statement of Opportunities 2010, a document published by AEMO to provide information on the electricity demand and supply situation in the NEM
IMO	Western Australian Independent Market Operator
LGC	Large-scale Generation Certificate
LRET	Large-scale Renewable Energy Target
LUACs	Large User Abatement Certificates
MEPS	Minimum Energy Performance Standards
MRET	Mandatory Renewable Energy Target
NEEM	National Energy Efficiency Model
NEM	National Electricity Market
NGAC	NSW Gas Abatement Certificate
NWIS	North-West Interconnected System
OCGT	Open Cycle Gas Turbine
ORER	Office of the Renewable Energy Regulator
POE	Probability of Exceedance

PV	Photovoltaic generation
QGEC	Queensland Gas Electricity Certificate
QNI	Queensland NSW interconnect
RECs	Renewable Energy Certificates (now replaced by LGCs and STCs)
RET	Renewable Energy Target
SHW	Solar hot water heaters
SME	Small to medium sized enterprises
SRES	Small-scale Renewable Energy Scheme
STCs	Small-scale Generation Certificate
STEM	Short Term Energy Market
SWIS	South-West Interconnected System
VEET	Victorian Energy Efficiency Target
VoLL	Value of Lost Load. It has been redefined as the “market cap price” and has risen to $12,500/MWh as of 1 July 2010.
WACC	Weighted average cost of capital, defined in real terms and pre-tax in this report. It is defined as $\frac{equity\ \times real\ return\ on\ equity + debt \times real\ interest\ rate}{total\ capital\ invested}$ and is used as a discount rate to annualise the capital costs over the expected technical operating life of the project.
WEM	Western Energy Market

Executive Summary

Improving energy efficiency is seen as an important and low cost response to rising energy prices. Significant potential for energy efficiency has been identified across a range of end use energy sectors. However, uptake of energy efficient opportunities has been limited, due to a range of market barriers.

The Australian Government, in part based on recommendations by the Prime Minister's Task Group on Energy Efficiency, is considering implementing a national energy savings initiative (ESI) based on a tradable certificate scheme. The scheme is designed to overcome the market failures limiting improvements in energy efficiency.

This report examines the benefits and costs of the proposed scheme.

The modelled scheme covers electricity and gas use in Australia. The modelled scheme aims to achieve a 4% reduction in energy use across all end use sectors of the economy, although consideration is also being given to limiting the scheme to households and small to medium sized enterprises. Targets ramp up from 1% in 2014 to 4% in 2020, remaining at 4% until 2030 when the scheme expires. The 4% target is broadly equivalent to the level of ambition of the three existing state based trading schemes, but at a national level.

Approach

The benefits and costs were estimated in a two-stage process. Firstly, the potential uptake of energy efficient options was predicted using a model that determines a range of payback periods from adoption. The model examines uptake for a range of options in the residential, commercial and industrial sectors. Options that meet the payback criteria are deemed to be adopted. By providing financial incentives, the ESI reduces payback periods and leads to increased uptake. Secondly, the reductions in gas and electricity demand as a result of increased uptake are input into simulation models of the energy market to determine the benefits and costs to those markets.

Estimating the benefits and costs of the scheme is difficult due to a number of issues. A modelling approach has been developed that takes into account these issues. The issues and approach adopted include:

- Accounting for legitimate constraints to the uptake of energy efficient options, such as high transaction costs and perceived lower amenity values. This is accounted for in the modelling by using payback periods that are shorter than the economic life of the energy efficient options.

- Accounting for ongoing benefits after the scheme. Benefits of energy efficiency will extend well beyond the end of the scheme. But there is a risk that once the scheme ends, behaviour reverts as end-users do not learn from the program and market failures re-emerge. This has been accounted for in the modelling with variations in assumptions on the level of permanence of the savings.
- Additionality, which occurs when the scheme rewards uptake that would have occurred in absence of the scheme, leading to no net reduction in energy use. This was modelled by excluding options subject to other government policies and by determining the level of uptake of other options in the absence of the scheme.
- Lower than predicted energy savings due to end users using some of the savings in energy costs to purchase more energy services (rebound), or due to a systematic bias in technical estimates of the efficiency gain. A range of values for these effects were assumed in the modelling, based on findings of published studies.

The compliance costs associated with the scheme comprised the additional cost of purchasing and installing energy efficient equipment, and the costs borne by Government and liable parties in administering and complying with the scheme. The economic benefits of the scheme accrued from productivity improvements in energy markets. The productivity improvements were expressed as lower fuel costs and deferred investments in generation, gas processing, and electricity and gas transmission.

In total, 5 scenarios were modelled including a reference case scenario with no ESI, and 4 policy scenarios with variations in key assumptions, as follows:

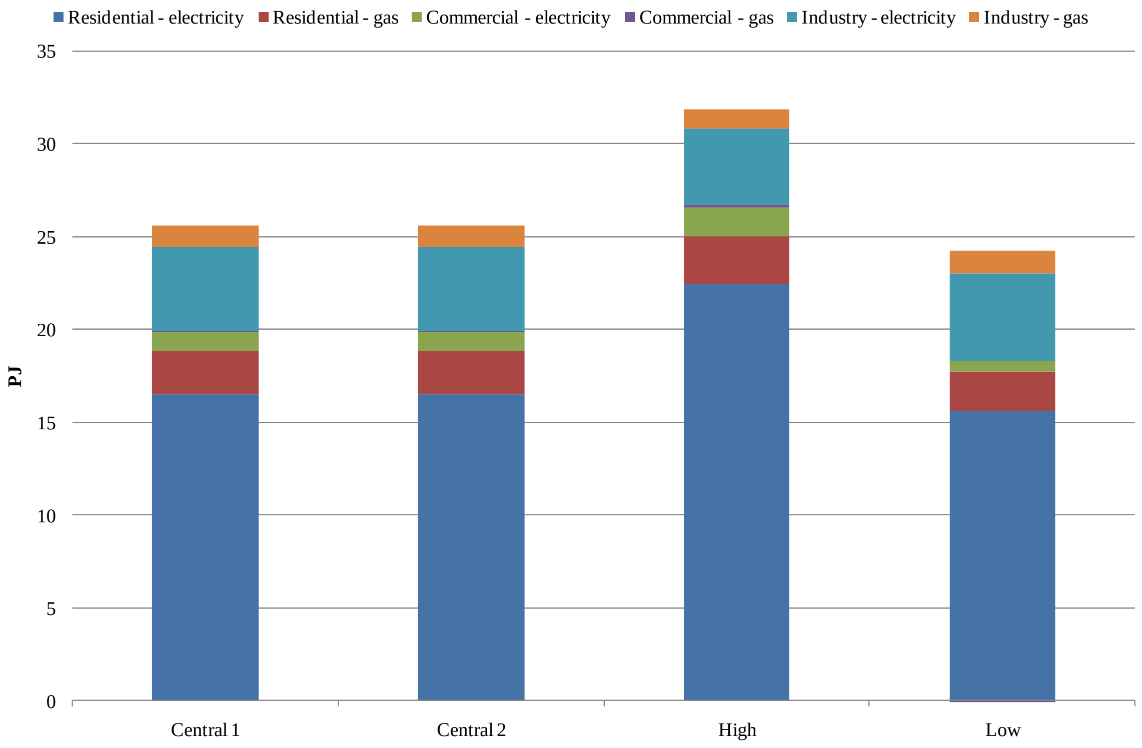
- The ‘low’ and ‘central 1’ scenarios, which assume that an ESI mechanism does not influence purchasing behaviour by increasing consumers’ understanding of the benefits inherent in energy efficiency investments. The low scenario differs by having a higher rebound effect, lower penetration caps and no ongoing benefits through behavioural change beyond the end of the scheme.
- The ‘central 2’ and ‘high’ scenarios assume that an ESI does have an impact on purchasing behaviour. The ‘central 2’ scenario assumes that, after adopting an energy efficiency option under an ESI, 50% of households and businesses will repeat that purchase based on their experience. The ‘high’ scenario assumes that 80% of households and businesses do this. In addition, it assumes that end energy users extend the payback periods they are willing to accept by one year, in response to the incentives provided.

Analysis of another policy scenario confining the ESI to households and small to medium sized businesses was also conducted. However, the modelling indicated that in a situation with high electricity prices as a result of carbon pricing and other factors, no net reduction in energy use was likely given the target set.

Energy savings

Modelling of the uptake indicated that energy savings are likely, although not to the full extent of the target reduction. The savings in energy use are lower than the target savings due to the assumptions that the costs saved lead to end-users to demand more energy services and that the actual savings are less than technical estimates of the savings. Around 25 PJ to 30 PJ of reductions in energy use is possible by 2020 under the ESI, representing a reduction in gas and electricity demand of around 2%.

- **Figure ES-1 Reductions in energy use, 2020**



Two insights come from the analysis. First, the bulk of the savings occur through reductions in electricity use. Over 80% of the savings are savings in electricity use from uptake of more efficient electrical appliances and equipment. In addition, there is a switch from electric to gas appliances (an assumed option under the scheme), which reduced electricity use but offset some of the gas savings encouraged by the scheme. Second, the bulk of the savings occur in the residential and industrial sectors. The residential sector accounts for about 75% of the savings, mainly through improved efficiency of space conditioning and water heating in existing homes. The industrial sector accounted for around 20% of the savings, mainly in the mining, metal processing and wood products sectors, (which is in line with findings of uptake by sector under the EEO program). The commercial sector accounted for less than 5% of the savings due to the higher adoption costs assumed for this sector. This is likely due to the conservative assumptions adopted, particularly the 4-year payback period assumed acceptable to commercial and industrial sectors, which means there is more take-up in the reference case than, for example, suggested by published data[1].

The energy savings reduced electricity use by 6 TWh to 8 TWh in 2020, and 10 TWh to 12 TWh in 2030. Peak demand is expected to be reduced by 650 to 950 MW by 2030, equivalent to 2 to 5 efficient scale open cycle gas turbines.

Gas demand is reduced by up to 7 PJ per annum.

Benefits exceed costs

Despite the conservative assumptions used in estimating the benefits and the relatively low target leading to modest net energy savings, the analysis indicated that the benefits of the scheme are likely to exceed the costs. The net benefit is estimated to be around $3 billion to $5 billion using a 7% discount rate. The net benefit reduces as the discount rate increases due to the fact that the costs of the scheme are borne upfront whereas the benefits accrue over a longer time period into the future. However, even when11% discount rates are used, there is still a net benefit of around $1.5 billion to $2.5 billion.

- **Table ES-1 Benefits and costs of the ESI, $M**

	Central 1	Central 2	High	Low
7% Discount rate				
Costs	2,423	2,423	2,040	2,495
Benefit	5,837	5,798	6,839	5,567
Net benefit	3,414	3,375	4,798	3,072
4% Discount rate				
Costs	3,525	3,525	2,949	3,630
Benefit	9,619	9,443	11,326	9,027
Net benefit	6,094	5,918	8,377	5,397
11% Discount rate				
Costs	1,532	1,532	1,302	1,578
Benefit	3,295	3,312	3,871	3,197
Net benefit	1,762	1,779	2,569	1,619

Note: Values are the present value of benefits and costs over the period from 2014 to 2050, using the discount rates listed.

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[1] Under the Energy Efficiency Opportunities program, only 70% of the options with less than 2 year payback have been taken up by end-users in the commercial sector.

Around 40% of the benefits come from reductions in fuel costs, as generation using natural gas or coal is reduced. Deferring investment in generation accounts for around 40% of the benefits. Deferring investment in electricity and gas infrastructure comprises the other source of benefits.

In estimating benefits, no account was taken of the reduction in emissions of greenhouse gases, as no net gain would occur with a cap on emissions under an emission trading scheme. The greater wellbeing that consumer experience from spending the savings due to energy efficiency on other goods and services were also not included.

Realising these benefits is contingent on the trading scheme being well designed, creating a liquid and transparent market. The benefits are also contingent on the successful exclusion of options that would have been adopted anyway, in the absence of any financial incentives induced by the scheme.

Other impacts

In addition to economic costs, there are a number of distributional impacts. These impacts are not part of the benefit cost calculation as their effects are already captured by costs and benefits included in the net benefit calculation.

Lower generation costs are ultimately expressed as lower electricity prices, even after adding the compliance cost of the measure onto retail prices. Retail prices are about the same or slightly lower in the period to 2020, and slightly higher in the period from 2021 to 2030, assuming the cost of the scheme is spread over all end users. After the scheme expires in 2030, retail prices are lower as a result of the ongoing net savings in energy use. Households adopting energy efficient appliances and fixtures under the scheme benefit the most, with expenditure on electricity expected to fall by around $3/week to $4/week.

The lower wholesale prices, however, reduce trading profits of incumbent generators by around $100 million to $300 million per annum or under 3% of profits expected to be earned in the absence of a national ESI. The lower profits are concentrated in the period to 2020.

1. Introduction

Significant untapped energy efficiency opportunities exist across a range of end use energy sectors.[2] The IEA found that unexploited energy efficiency potential offers the single largest opportunity for emissions reductions and that accelerating progress in energy efficiency is indispensable to meet long term emission targets. The IEA estimates new buildings could be up to 70% more efficient than many existing buildings, through improved window insulation, installing furnaces and air-conditioners that use less energy and more efficient lighting. The IEA also points to major improvements in the efficiency of domestic appliances such as refrigerators, water heaters and washing machines, and new technologies that reduce standby consumption. In the industrial sector, the IEA considers a huge potential exists to reduce energy demand through the improved efficiency of motors, pumps, boilers and heating systems, increasing energy recovery in materials-production processes, increasing recycling and higher efficiency of materials use.[3]

Despite the significant potential, the uptake of energy efficiency opportunities has been limited. Take up has been poor as a result of a range of market barriers.

This report describes the results of a study undertaken by SKM MMA to quantify the impacts of a national, market-based energy savings initiative (denoted ESI) to overcome these market barriers.

The ESI is a tradable certificate scheme. Such schemes require liable parties (typically energy retailers), to implement a prescribed amount of energy savings. Where a retailer can demonstrate that it has saved one MWh (or one GJ) of energy, it can generate a certificate and surrender it to a government regulator to meet its obligations. From an energy consumer’s perspective, the certificates provide an effective rebate to offset any additional expense incurred when purchasing more energy efficient alternatives.

The report is structured as follows:

- Section 2 presents an overview of the modelling approach applied in the study and describes the scenarios modelled.
- Section 3 outlines how the modelling approach treats a number of important energy efficiency considerations, including the issue of additionality, the rebound effect and uncertainties in the energy savings benefits.

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[2] See, for example, the Stern Review on the Economics of Climate Change, 2007, p 398; IEA Energy Efficiency Policy Recommendations to the G8, 2007, Heiligendamm.

[3] International Energy Agency, 2006, Energy Technology Perspectives, Paris: OECD/IEA.

- Sections 4 to 6 summarise the results of the modelling.
- Section 7 discusses the key conclusions.

A set of appendices are attached. Appendix A presents a short literature review of the market failures that prevent greater energy efficiency by households and businesses. Appendix B outlines in further depth how the take-up of energy efficiency options is modelled and documents the specific options that were available for take-up in the residential, commercial and industrial sectors. Appendix C provides an in-depth overview of how Australia’s energy markets are treated in the modelling, whilst Appendix D outlines the assumptions used in energy market modelling.

2. Methodology

2.1. Overview

Policies to encourage energy efficiency are usually designed to overcome market failures that limit take-up. The market failures that prevent the take-up of energy efficient technologies and behaviours are discussed in Appendix A.

The modelling undertaken for this study aims to estimate the benefits and costs of overcoming the market failures. The methodology estimates the benefits and costs by determining the impact that improved energy efficiency will have on:

- energy consumption
- greenhouse gas emissions
- generation mix
- wholesale energy prices
- renewable certificate prices
- reductions in peak load
- savings related to the delay in addition of generation, gas processing and transmission capacity

The costs of the ESI relate to the additional capital and ongoing costs of more efficient appliances and practices. These costs are captured in the model by multiplying the certificate price by the energy savings.

Two sets of benefits are measured:

- *Individual or firm benefits*: This comprises the benefits to adopters of energy efficient appliances and practices.
- *Energy market benefits*: This comprises the avoided costs of electricity supply as load is reduced through the take-up of energy efficient practices. The avoided costs include capital, fuel and other operating costs, which are avoided as a result of an ESI.

These benefits and costs are ultimately passed on to consumers as changes in the prices they pay for energy. The impacts of these changes in retail energy prices on consumers are not included in the benefit cost analysis, because these impacts are the same as the energy market impacts expressed in a different way. Including them in the benefit cost analysis would therefore result in double counting. Notwithstanding, it is straightforward to derive the impacts on energy users' bills from the results of the modelling and these are presented in Section 5.

2.2. Modelling framework

There are two phases to the methodology applied in this study:

- Phase 1: Development of energy efficiency cost curves for Australia
- Phase 2: Estimation of the costs, benefits and impacts of achieving an energy efficiency target in Australia.

2.2.1. Phase 1 – Development of energy efficiency cost curves for Australia

For phase 1, SKM MMA has used its energy efficiency take-up model (called NEEM – National Energy Efficiency Model), to determine the level of energy efficiency as a function of market signal or a regulatory response. The model works on a state basis and runs for each of the residential, commercial and industrial sectors. Various activities are covered within each sector. The residential and commercial sector activities are specific to a given end use, such as space conditioning (heating or cooling) or water heating. The output from phase 1 modelling comprises a set of cost curves (in $/MWh or $/GJ) for a range of energy efficiency actions. These cost curves translate in the modelling to an optimal take-up plan for given annual targets. The economy-wide energy efficiency targets applied in all scenarios are summarised in Table 2-1.

- **Table 2-1 National energy efficiency targets proposed under ESI**

	2014	2015	2016	2017-2030
Target %	1%	2%	3%	4%

Source: DCCEE. Note: the target in one year relate to the proportion of the previous year's total energy demand required to be saved under the ESI.

The economy-wide target for a given year represents the percentage target for that year multiplied by the previous year's actual electricity and gas consumption. The target represents the total number of white certificates required to be surrendered by all energy retailers with scheme obligations in that year. As energy consumption grows over time, the target will continue to increase, even as the percentage target remains constant.

NEEM estimates the total sales of appliances and the share of more efficient appliances including the:

- uptake of energy efficient options in the residential, commercial and industrial sectors by year and by state
- additional capital costs incurred from uptake
- additional operating costs from uptake
- savings in energy use from uptake

- Payback periods and net present values for each option for estimated uptake levels.

The model treats each appliance for each sector separately. For each appliance, the model calculates the level of uptake of the more efficient version, based on its cost relative to the less efficient model and estimated energy savings.

Thirty-two separate appliances/energy efficient practices are modelled for the residential sector. For each appliance, the current minimum energy performance standard is assumed as the base energy efficiency. For the commercial sector, a range of energy use activities (refrigeration, air-conditioning/space heating and other lighting), are modelled for retail, offices, hospitals and other buildings. For the industrial sector, primary and secondary industry sub-sectors are modelled. The energy savings potential is modelled as a statistical function of uptake, based on the costs of energy efficiency improvements and potential savings. The cost functions are based on previous empirical studies, modified by data provided under the EEO program.

The model is modular in structure, allowing for expansion to other appliances and other sectors, if the data is available.

The NEEM is outlined in detail in Appendix B. The treatment of different options for energy savings across the residential, commercial and industrial sectors are also described in this appendix.

For this study, the ESI is modelled to 2029-30, to inform a scheme design decision regarding the optimal duration of an ESI. This does not signal any intention regarding the duration of the scheme.

2.2.2. Phase 2 – Estimation of the costs, benefits and impacts

Under phase 2, SKM MMA has used its Strategist market simulation model of the NEM, WEM, DKIS, Mt Isa and NWIS grids, as well as MMAGas, a model of Australia’s gas market, to estimate the impacts of the optimal take-up plans on the electricity and gas markets. Reference case energy market modelling was based on demand projections excluding any new energy efficiency measures, and was based on a set of demand projections supplied by the Federal Treasury.

The basic approach has been to create a reference case in which the demand forecast excludes savings from the existing schemes in Victoria, NSW and South Australia. The savings and other energy market data from this reference case are then compared with savings and energy market data under a national scheme that would replace and extend the existing state based schemes. This allows the comparisons of outputs such as energy prices, the impact on households, generator profitability, fuel savings, delayed investment in generation and transmission (both electric and gas) infrastructure, and emissions, enabling the assessment of net benefit of the program.

Details of the electricity and gas market models and the assumptions used are contained in Appendix C.

2.3. Scenarios modelled

The general approach was to model five different scenarios against the reference case. Modelling for each of the scenarios was undertaken for the period from 2010 to 2050. Four of the scenarios differ with respect to permanence of the uptake measures, the level of rebound effect under each measure, and maximum levels of penetration of each energy efficient measure. The other scenario was focussed on the residential sector and small to medium enterprises. Full details of each scenario are provided in Table 2-2.

A brief explanation of the key assumptions and the scenarios modelled is provided below.

- Reference case: This scenario assumes that existing state energy efficiency schemes in New South Wales, Victoria and South Australia are discontinued, (a motivation for introducing a national ESI is to replace existing incompatible state schemes). The scenario also assumes all other current policy settings, such as a carbon price starting 1 July 2012, the Renewable Energy Target (RET) and Minimum Energy Performance Standards (MEPS), are in place.
- Four broad-based ESI scenarios were modelled, featuring a national ESI that covers both electricity and gas use in the residential, commercial and industrial sectors. Different key assumptions were applied across these four scenarios to provide low, central and high estimates of the impacts of a national ESI.
    - The ‘low’ and ‘central 1’ scenarios are relatively pessimistic and estimate the response of energy consumers to the financial incentive provided via the creation of energy saving certificates only. These two scenarios implicitly assume that an ESI mechanism does not influence consumers’ purchasing behaviour by increasing their understanding of the benefits inherent in energy efficiency investments.
    - The ‘central 2’ and ‘high’ scenarios assume that an ESI does have an impact on purchasing behaviour. The ‘central 2’ scenario assumes that, after adopting an energy efficiency option under an ESI, 50% of households and businesses will repeat that purchase based on their experience. The ‘high’ scenario assumes that 80% of households and businesses do this. In addition, it assumes that advice received from energy efficiency experts under an ESI, causes end energy users adopting an energy efficiency option to extend the payback periods they are willing to accept by one year.
- Households and SMEs scenario: This scenario features a more narrowly targeted national ESI, covering the gas and electricity use of households and small to medium-sized enterprises only.

The model allows for certain parameters to be adjusted to yield more or less conservative outcomes (refer to the left column of Table 2-2). These parameters are discussed in more depth in Section 3, but are summarised briefly as follows:

- *Payback period:* the period for which an energy efficient project must operate in order for the incremental increase in capital costs to be recovered through reduced operating costs. The "acceptable payback period" is the longest payback period that a firm or household is willing to accept in order to invest in an energy efficient option. This is the key parameter modelling behavioural issues in this study.
- *Permanence of energy efficiency measures:* the fraction of the energy savings associated with an energy efficient product that is assumed to continue beyond the lifetime of the product. Permanence may follow from behavioural or information barriers having been overcome by a user's experience with an energy efficient product, with the result that the consumer does not require the subsidy provided by white certificates in order to select a new energy efficient product. Alternatively, permanence may follow from minimum regulatory standards having increased throughout the lifetime of the first purchase, with the effect that the consumer does not have the option of making a less efficient replacement purchase at its end-of-life.
- *Actual / technical energy savings:* the percentage difference between the energy savings capability of an energy efficient product in real life, relative to its capability as tested under controlled laboratory conditions. Products can have a lower efficiency than claimed by a manufacturer because of their operation under non-standard operating temperatures or because consumers are not operating a product as efficiently as possible.
- *Rebound effect:* the percentage difference between the energy savings of an energy efficient product if it were used exactly as the product it replaces, relative to the energy savings of the energy efficient product as actually used. Consumers often use a new product more than they used the product that it has replaced (for instance, a consumer might drive a new car further or more often), thereby diminishing the benefits of having selected a more efficient model.
- *Take-up as a percentage of maximum penetration*: the percentage difference between the maximum available market for an energy efficient product or service and the actual market. The model assumes that take-up of a new energy efficient product is initially slow, then accelerates as the community become more familiar with the product and demand increases, and finally plateaus as the potential market becomes saturated. This parameter is a conservative assumption expressing that a fraction of the available market cannot, for various reasons, be reached.

All energy efficiency scenarios modelled are based on current trends in the installation of energy efficient equipment and appliances, efficiency of equipment in existing establishments, trends in the efficiency of equipment installed, and current regulations (Federal and State) affecting energy efficiency (e.g. MEPS). All scenarios are based on median forecasts of demand growth for electricity and natural gas consumption. All scenarios assume a carbon price will be introduced in July 2012. The carbon price, provided by the Commonwealth Treasury and drawn from the MYEFO 2009-10, assumes a starting price of $25 (in 2010-2011 dollars), increasing at an average annual rate of 4.6 per cent.

- **Table 2-2 Summary of scenarios modelled[4]**

	Reference	*Low*	*Central 1*	*Central 2*	*High*	*HH and SMEs*
ESI target	0	Equivalent effort to current state schemes in all states	Equivalent effort to current state schemes in all states	Equivalent effort to current state schemes in all states	Equivalent effort to current state schemes in all states	Based on results for broad-based ESI central 1 scenario
Coverage of ESI	n/a	All sectors	All sectors	All sectors	All sectors	Small users
Ring-fencing	n/a	none	None	none	none	HH and SME only
Acceptable payback period	Residential: 2 years Commercial: 4 years Industry: 4 years with exceptions	Residential: 2 years Commercial: 4 years Industry: 4 years with exceptions	Residential: 2 years Commercial: 4 years Industry: 4 years with exceptions	Residential: 2 years Commercial: 4 years Industry: 4 years with exceptions	Residential: 3 years Commercial: 5 years Industry: 5 years with exceptions	Residential: 2 years Commercial: 4 years Industry: 4 years with exceptions
Permanence of EE measures	n/a	-100%	-50%	-100%	-20%	-50%
Energy savings						
Actual/technical[5]	n/a	-15%	-15%	-15%	-15%	-15%
Rebound effect[6]	n/a	-30%	-20%	-20%	-10%	-20%
Combined effect	n/a	-40%	-32%	-32%	-24%	-32%
Take-up of EE, % of max penetration	n/a	75%	85%	85%	95%	75%
Discount rate	4%, 7%, 11%	4%, 7%, 11%	4%, 7%, 11%	4%, 7%, 11%	4%, 7%, 11%	4%, 7%, 11%
Abatement target	-5%	-5%	-5%	-5%	-5%	-5%
Carbon price	MYEFO 2009-10 in real A$2010-11	MYEFO 2009-10 in real A$2010-11	MYEFO 2009-10 in real A$2010-11	MYEFO 2009-10 in real A$2010-11	MYEFO 2009-10 in real A$2010-11	MYEFO 2009-10 in real A$2010-11

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[4] Source: DCCEE.

[5] Downward adjustment required to account for upward bias in technical estimates which may occur as a result of testing in an environment which does not adequately reflect real world use

[6] Empirical data to be used where available. Where these are unavailable, table values are used as default.

3. Issues Affecting Uptake of Energy Efficient Initiatives

The modelling of the benefits and costs of energy efficiency programs are complicated by a number of issues. These issues and how the modelling has dealt with each are discussed in this section.

3.1. Objective of the scheme

Reductions in energy use per unit of output can be achieved either by targeting energy use per unit of output directly (through an energy production / use cap per unit of output), or by imposing an overall limit on energy use, thus requiring an improvement in energy efficiency to the extent that output continues to grow.

Energy efficiency targets can be imposed at different levels from economy wide, to sector or even sub-sector specific and may apply across all energy sources or be limited to specific energy sources. Energy efficiency targets could also be applied to individual products or product classes (for example, washing machines, refrigerators, etc), but policy interventions at this level are commonly implemented through mandatory energy performance standards, rather than performance targets.

Most proposals for energy efficiency targets incorporate a trading scheme, thereby allowing the market to allocate uptake to the most efficient options. Others specify the targets to apply to specific installations or entities, without the possibility of trading excess energy requirements against excess energy savings amongst entities. Non-traded (or partially traded) schemes may allow policy makers to incentivise particular groups to provide energy efficiency improvements, and can thereby be targeted to overcome non-price barriers to the uptake of energy efficiency opportunities. However, by denying the possibility of mutually beneficial trades, non-traded schemes have to be well designed to avoid raising the social cost of achieving a given target.

Imposing a cap on energy use, or energy use per unit output, at an economy wide or sectoral level would only be effective if energy use itself was a cause of negative externalities. Depending on the energy source, energy use could give rise to more or less, and to different, externalities. For example, energy generation using fossil fuels leads to greenhouse and other pollutant emissions, whereas energy generation using wind power does not. Even within energy generated with the use of fossil fuels, the associated air emissions can be different (for example, gas heating versus electric heating using electricity generated from brown coal). Targeting energy use in an undifferentiated way could therefore lead to a less efficient outcome in preventing externalities.

Some energy efficiency target proposals differentiate between energy sources, providing more energy efficiency certificates for energy savings from high emissions sources than for energy savings from low emissions sources. To target air emissions effectively, the energy efficiency target scheme would have to differentiate between energy sources to perfectly mimic what an emissions trading scheme would do, namely to reduce emissions directly. Thus, externalities such as air pollution and greenhouse gases are best targeted directly, rather than by using energy use/energy efficiency as a surrogate. That said, in the absence of full pricing of such externalities, any energy efficiency measure implemented will give rise to additional benefits by reducing such externalities.

An additional problem with seeking to achieve these co-benefits of energy efficiency improvements through an economy wide or sectoral energy efficiency target, is that it could interfere with the price signal provided by an emissions trading scheme. This is because an energy efficiency target biases the choice of abatement measures towards energy efficiency and away from other abatement initiatives such as renewable energy. To the extent that other measures are not themselves creating a bias away from energy efficiency measures (such as through low emissions technology deployment incentives), a mandatory energy efficiency target could reduce the efficiency of the emission trading scheme.

The demand for energy is a derived demand, in the sense that consumers buy energy not for its own sake but rather to achieve desirable outcomes. For example, consumers buy energy to control the temperature of their homes, cook and have light and not for the sake of energy per se.

The main case for energy efficiency policy is to remove persistent *non-price* barriers to the development and deployment of energy efficiency such as information failures and behavioural barriers. Energy efficiency targets can contribute to overcoming non-price barriers to the extent that they are targeted to specific parts of the supply chain for goods and services where non-price related externalities apply. For example, a certificates scheme that applies to developers may help overcome principal agent problems in the building sector, because developers would have a direct stake in the energy efficiency performance of the buildings they build. Similarly, allowing companies to claim certificates for providing energy efficiency enhancing retrofitting solutions and for the replacement of inefficient equipment, could provide low cost abatement that would not be harnessed to a sufficient extent by emissions trading.

A broadly based energy efficiency target that includes trading will incur costs to establish and administer. For instance, it requires the allocation of property rights, the detailed and robust measurement of appropriate energy use categories, and the development of systems to avoid double counting, ensure additionality and establish clear boundaries between carbon credits and certificates.

3.2. Payback period

Payback period refers to the number of years it takes for an investment to recover the initial investment cost. For an energy efficient appliance, it refers to the number of years it takes for the value of the energy savings to equal the additional cost of the appliance.

An acceptable payback period refers to the desired time to recoup an investment cost. If the payback period is equal to or less than the acceptable payback period, then the investment would be worthwhile. This is one of several investment criteria, although it is considered the simplest and is usually used for non-core investments.

Short payback periods (less than the economic life of the option), may be required to account for transaction costs, non-pecuniary costs or uncertainties in the value of energy savings. Payback periods can take into account the costs of searching for and gathering information about energy efficiency options (often referred to, in an energy efficiency context, as transaction costs). A short payback period may also act as a proxy for non-pecuniary costs that are not easily estimated. For example, short payback periods may be required for compact fluorescent light bulbs to effectively compensate for the lower quality of light felt by many end users. Finally, as future energy prices are uncertain, the value of energy savings is uncertain. Investors would have increased confidence in the investment if the payback period is short.

The payback periods for this modelling exercise were selected on the following criteria. First, simulations using the NEEM model indicated the payback periods that would be required to match the long run own price elasticities estimated from econometric studies. The econometric studies have estimated own price elasticities of demand in the range of -0.2 to -0.3 on average. Thus, a 10% increase in price would cause demand to fall by 2% to 3%. Assuming that 70% of the fall in demand was due to changes in the type of appliance used (instead of reducing the level of energy service), payback periods in the NEEM model were adjusted until the required demand response was achieved for this price increase. Second, anecdotal data points to payback periods used. For example, the Energy Efficiency Opportunities program uses 2 year and 4 year payback periods as benchmarks.

In the reference case, it is assumed that end energy users are willing to invest in energy efficiency options with a payback period of up to 2 years (residential sector) and 4 years (commercial and industrial sectors). The payback periods are less than the economic life of most energy efficient options.

In all but the high ESI scenario, the acceptable payback periods are assumed to be the same as in the reference case, which is consistent with the approach applied in previous modelling exercises for existing state energy efficiency schemes. This approach is considered conservative, however, because it implies that the face-to-face interactions with energy efficiency experts (ESCOs) facilitated by an ESI, and the individually tailored advice they provide, does not increase end energy users' understanding of the benefits inherent in energy efficiency investments.

3.3. Permanence

Permanence describes the percentage of end users adopting an energy efficiency option under the ESI who are assumed to repeat their investments at the end of the appliance's useful life in the absence of the financial incentive offered by the scheme. In effect, this is an assumption regarding the extent to which end energy consumers learn from their experiences with more energy efficient options.

The ESI is designed to overcome market failures by providing an upfront reward for the adoption of energy efficient options or providing incentives to third parties. Under an ESI, end users could learn of the benefits of energy efficient options or would be more certain of the future benefits of energy efficient options. However, some market failures such as the split incentives may still have an influence in the absence of any reward mechanism.

The extent to which end users revert to previous behaviours is uncertain. In the modelling a conservative approach was taken in that all scenarios assumed some reversion to previous behaviours. The different scenarios modelled assume permanence rates of 0 to 80 per cent, with both 0 and 50% permanence applied to the central broad-based ESI scenario.

3.4. Additionality

Additionality refers to the level of take-up that is expected to occur under an ESI, in addition to that which would have occurred without an ESI and the expected introduction of a carbon price. The modelling has taken additionality into account in two ways.

First, some energy efficiency initiatives were assumed to be excluded from the scheme because they were not considered additional to the policies and programs included in the reference cases. These initiatives included:

- use of compact fluorescent light bulbs (CFLs), unless they perform at or above the level achieved by current MEPS
- installation of solar hot water systems
- installation of 4.5 and lower star rated gas water heaters
- installation of any water heater systems in new homes
- installation of insulation in new homes
- low flow shower heads

Second, the modelling estimated a background take-up of energy efficiency in the economy and included associated energy and monetary savings in the reference scenarios. This background take-up of energy efficiency was subsequently deducted from all ESI scenarios.

This modelling approach was designed to ensure that the benefits of the ESI (both with respect to energy and cost savings), only follow from energy efficiency actions that are above and beyond the background take-up. These assumptions ensure that benefits are more likely to be underestimated than overestimated.

The ‘free-rider’ effect refers to the unavoidable cost of awarding ESI certificates for energy efficiency options that are most likely to have been adopted, even in the absence of an ESI. This modelling exercise took the free rider-effect into account by including in the estimated costs of the scheme, the cost of awarding certificates for all options adopted under the ESI scenarios, as well as those adopted in the reference scenarios. This approach ensures that the costs associated with the ESI are more likely to be overestimated than underestimated.

3.5. Product performance or operation

The modelling applied conservative assumptions to account for two factors leading to lower energy savings:

- where consumers use new (efficient) equipment more than the old (inefficient) equipment that has been replaced
- where products do not perform in the real world as they do under controlled conditions.

3.5.1. The rebound effect

The rebound effect occurs because subsidising energy efficiency essentially makes energy services cheaper, which can encourage consumers to use more. In terms of water heating or space conditioning, this can occur when consumers purchase a larger system to achieve greater levels of comfort, or it can occur by using appliances more often and setting thermostats higher than might otherwise be set. A literature review conducted by the US Department of Energy found that the size of the rebound effect varies widely depending on the particular energy use[7]. For example, a rebound effect of 10%, means that 10% of calculated energy savings are lost because of increased use.

In this study, the rebound effect was taken into account by discounting the expected energy savings from energy efficiency options by an additional ‘rebound factor’. Rebound factors specific to particular end uses were applied where available, as based on published empirical data (see

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[7] H. Geller and S. Attali, 2009

Table 3-1). Where such specific data is not available, default values of 10%, 20% or 30% (depending on the scenario, see Table 2-2) were used.

- **Table 3-1 Estimated rebound effects**

Sector	End use	Size of rebound effect	Rebound used in modelling
Residential	Space heating	10-30%	20%
Residential	Space cooling	0-50%	25%
Residential	Water heating	<10-40%	20%
Residential	Lighting	5-12%	5%
Residential	Appliances	0%	0%
Business	Lighting	0-2%	2%
Business	Process uses	0-20%	10%

Source: IEA 1998; Greening, Green and Difiglio 2001. Cited in Geller and Attali 2009.

3.5.2. Bias in technical estimates of energy savings

Many studies have pointed to the fact that in the past energy savings have been overestimated. This is due to a systematic bias in calculating the technical savings potential, which is generally calculated under ideal test conditions, rather than under actual real world conditions. The technical savings potential rarely accounts for inefficiencies that occur when appliances are operated under non-laboratory conditions (for instance, in warmer or more humid environments), nor for inefficiencies that occur due to consumers being unfamiliar with operating the equipment.

Published studies have found that actual savings from utility-sponsored programs typically achieve 50% to 80% of predicted savings.[8] This range includes inefficiencies resulting from both technical biases and rebound effects. Since rebound effects are typically in the range of 10% to 30%, the energy savings were reduced by a further 15% in this study to account for technical bias.

3.6. Multiple benefits

Other benefits of improved energy efficiency have not been accounted for in this study. These include:

- non-energy market benefits such as reduction in other pollutants, for example NO_x
- enhanced resilience to supply failures in gas and electricity markets

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[8] R. G. Newell,2005.

The net benefits estimated by this study are biased downwards by the exclusion of these other benefits.

3.7. Certificate pricing

An iterative process was used to determine the appropriate certificate price under each scenario, so that the number of deemed certificates issued in each year matched scheme targets. The price of the certificate was progressively increased until the cumulative target was met. It was assumed that a single value would be appropriate and that this value would be indexed to allow for the opportunity cost of banking certificates to be redeemed in future years. The number of deemed years for each initiative was assumed to be the lesser of 15 and the lifetime of the initiative. It was assumed that each certificate would be equivalent to 1 GJ, and the number of certificates awarded for the adoption of an energy efficiency option would be based on its average energy savings.

3.8. Administrative and compliance costs

An administration and compliance cost equivalent to $1/certificate was assumed, in line with the compliance and administration cost of the Renewable Energy Target Scheme[9]. It is expected that a single national scheme would be more efficient for government and industry than multiple state schemes and would therefore be less costly.

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[9] See http://www.orer.gov.au/new.html#regfee and cost data in ORER's annual reports.

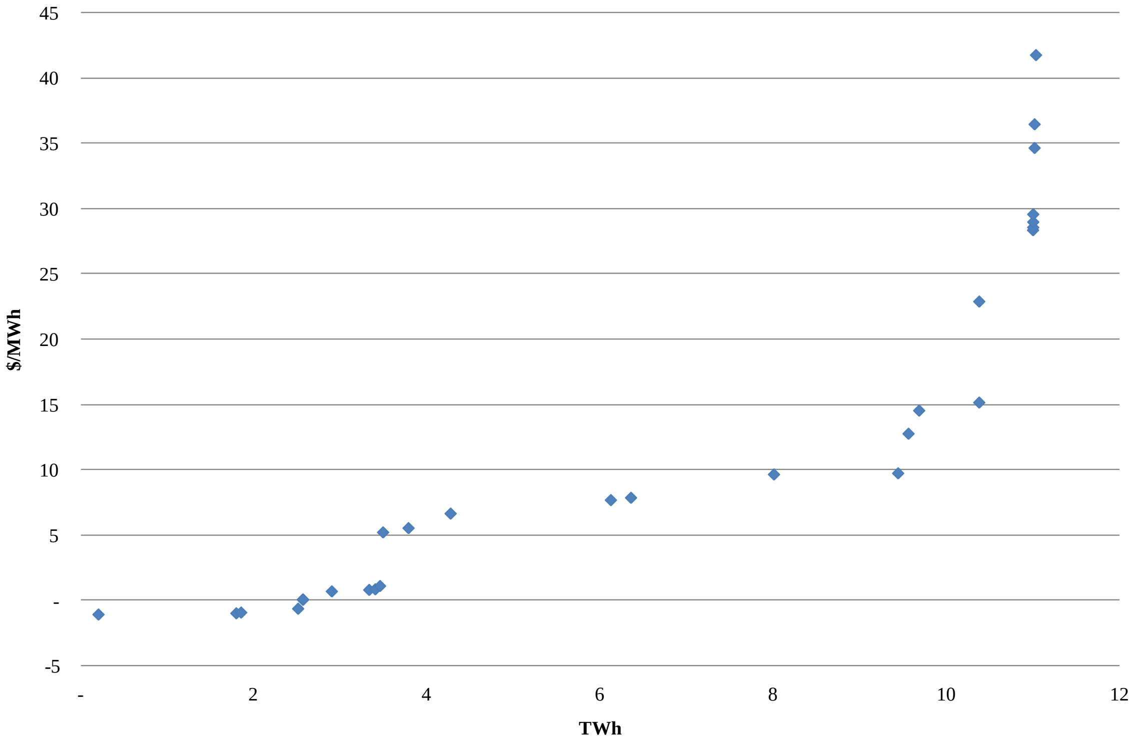
4. Energy Savings under the ESI

4.1. Energy efficiency potential

Energy efficiency improvements can take place autonomously through time simply as more efficient technologies become available. Accelerated energy efficiency improvements can also be expected as a result of rapidly rising energy prices.

For the current study, an energy efficiency cost curve was estimated. The estimated cost curve for 2010 is shown in Figure 4-1. The curve indicates that approximately 10 TWh of energy can be saved for less than $10/MWh. After this point the cost of saving energy rises substantially, so a rebate scheme with certificate values above this level may be of limited net benefit.

- **Figure 4-1 Australian electricity sector energy efficiency cost curve, 2010**



Source: SKM MMA analysis

4.2. Energy savings

Table 4-1 shows the estimated energy savings for the scenarios modelled. Due to the high uptake of energy efficient options under a carbon price, the net gain in efficiency ranges from 21% to 28% of the target. Thus for a target reduction of 4% of energy use, the scheme is estimated to achieve a 1% net reduction in energy demand. Around one-third to half of the remainder is due to the rebound effect resulting from the lower cost of energy services, which still represents a benefit of the scheme.

Energy savings under the reference case versus the proposed target under the ESI are compared in Figure 4-2. The chart indicates that free rider savings would be in the order of one-third of the target. It is also likely that these savings will include savings that may occur as a result of state schemes.

Table 4-1 Estimated energy savings in 2020

	Central 1	Central 2	High	Low
Target, PJ	115	115	115	115
Net savings, PJ				
Gas	4	4	4	3
Electricity	22	22	28	21
Total	26	26	32	24
% of target				
Gas	3%	3%	3%	3%
Electricity	19%	19%	25%	18%
Total	22%	22%	28%	21%
Source of savings, PJ				
Space conditioning	5	5	6	4
Lighting	5	5	6	5
Water heating	9	9	12	8
Refrigeration	1	1	2	1
Appliances	0	0	0	0
Machinery and processes	6	6	5	6
Source of savings, %				
Space conditioning	18%	18%	19%	18%
Lighting	18%	18%	20%	19%
Water heating	36%	36%	38%	34%
Refrigeration	6%	6%	6%	5%
Appliances	0%	0%	0%	0%
Machinery and processes	22%	22%	16%	25%
Sectoral savings, PJ				
Residential	19	19	25	18
Commercial	1	1	2	1
Industry	6	6	5	6
Sectoral savings, %				
Residential	74%	74%	79%	73%
Commercial	4%	4%	5%	2%
Industry	22%	22%	16%	25%

Source: SKM MMA analysis

Of each of the scenarios modelled, it was only when the initiative was confined to household and small to medium enterprises scenario that a certificate price was not required, because the potential energy savings from the residential sector in the reference case are high enough to exceed the required target (see Figure 4-3). That is no additional savings occurred as a result of the scheme when it was confined to the residential sector and small to medium enterprises.[10]

Around 85% of the savings in energy use are from a reduction in electricity use, reflecting opportunities for take-up of energy efficient technologies and that electricity use comprises a larger proportion of total energy use.

Energy efficiency uptake was confined mainly to the residential and industrial sectors (see Figure 4-4 to Figure 4-6). Of the reduction in electricity use, around 75% occurs in the residential sector. The relatively high proportion of electricity savings achieved in the residential sector can be attributed to assumptions about the types and availability of energy efficiency opportunities in each sector, as well as the longer payback periods assumed acceptable to end energy consumers in the commercial and industrial sectors.

In the residential sector, the savings in energy use were predicted to mainly come from residential space conditioning (from roof and wall insulation in existing homes and more efficient air-conditioners), more efficient lighting (early replacement of incandescent globes in existing homes and from adopting lighting globes above current MEPS), more efficient water heating (through insulating existing systems and early replacement of less efficient electric and gas water heaters in existing homes) and uptake of more efficient white goods and electronic equipment. In the industrial sector, the savings mainly came from the metals, mining and wood and paper product sectors. The commercial sector is predicted to benefit least from the scheme, with energy use reduced by less than 1%. Most of the energy savings in this sector are predicted to occur in retail facilities, as a result of more efficient space conditioning and refrigeration.

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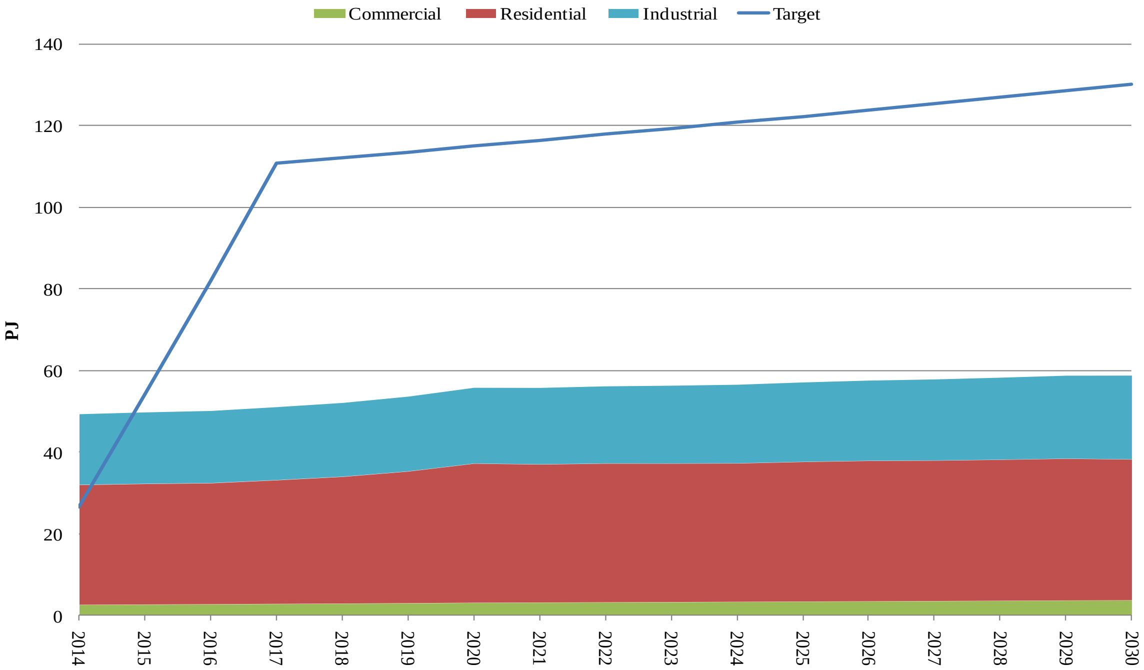
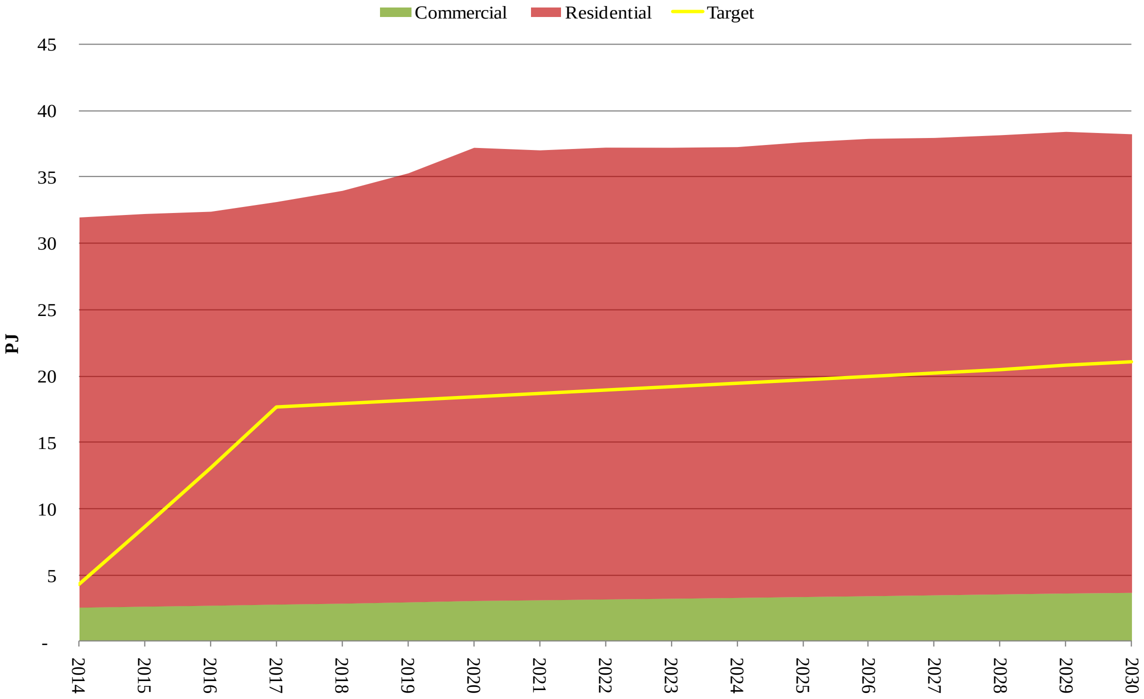
[10] Becuase there is no net savings under this scenario, no additonal results for this scenario are discussed in this report.

- **Figure 4-2 Reference case savings versus energy efficiency target**



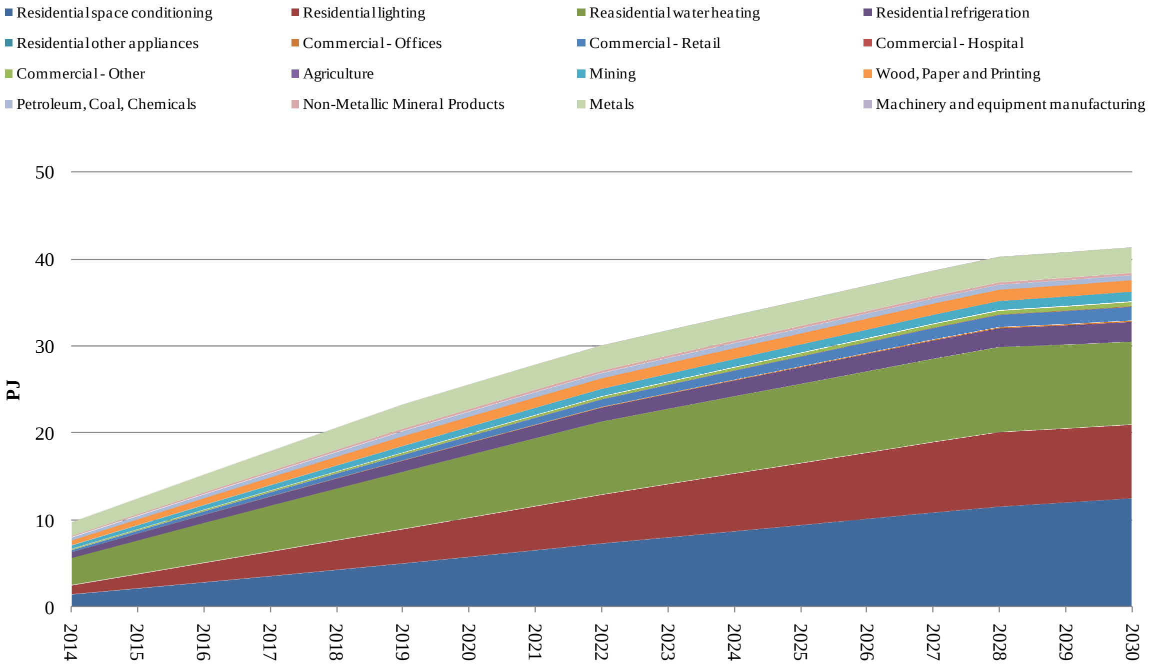
Source: SKM MMA analysis.

- **Figure 4-3 Energy target versus reference savings for households and SMEs**



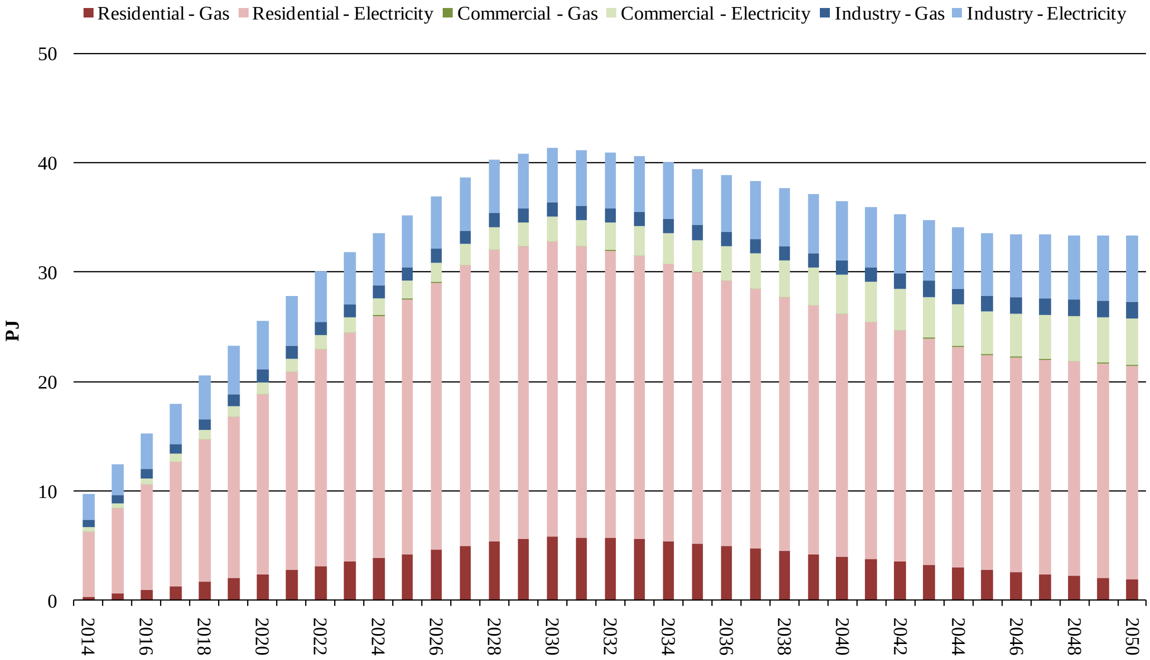
Source: SKM MMA analysis.

▪ Figure 4-4 Net energy savings by measure, central 1 scenario



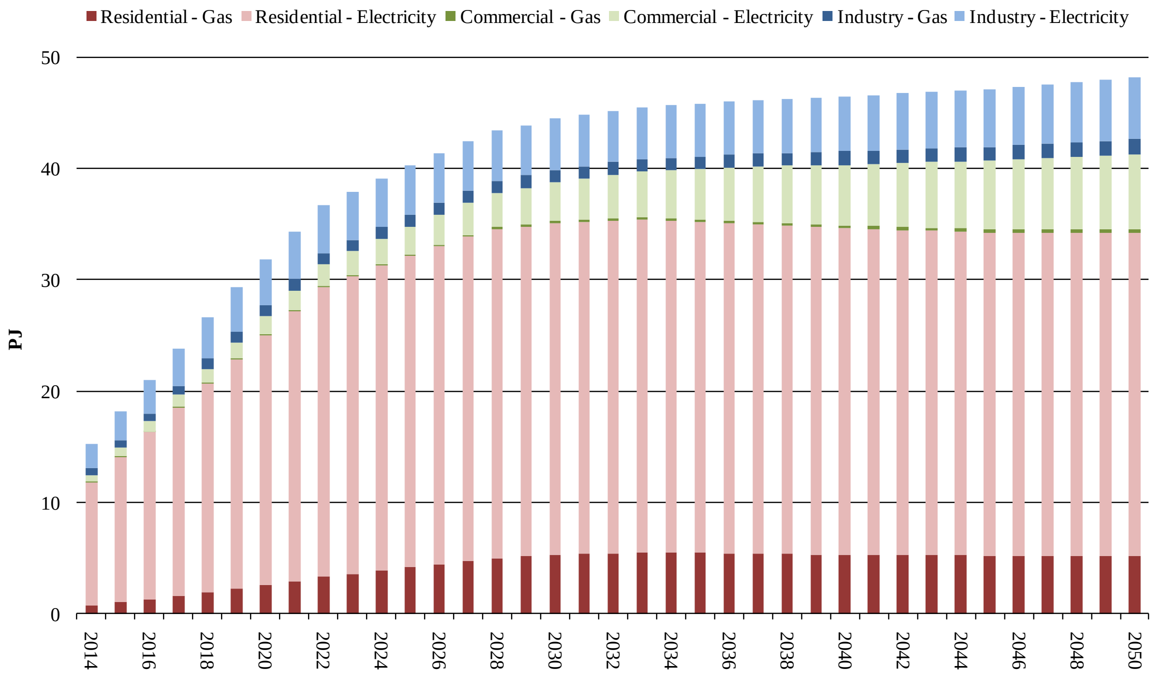
Source: SKM MMA analysis.

▪ Figure 4-5 Net energy savings by end use, central 1 scenario



Source: SKM MMA analysis.

Figure 4-6 Net energy savings by end use, high scenario



Source: SKM MMA analysis.

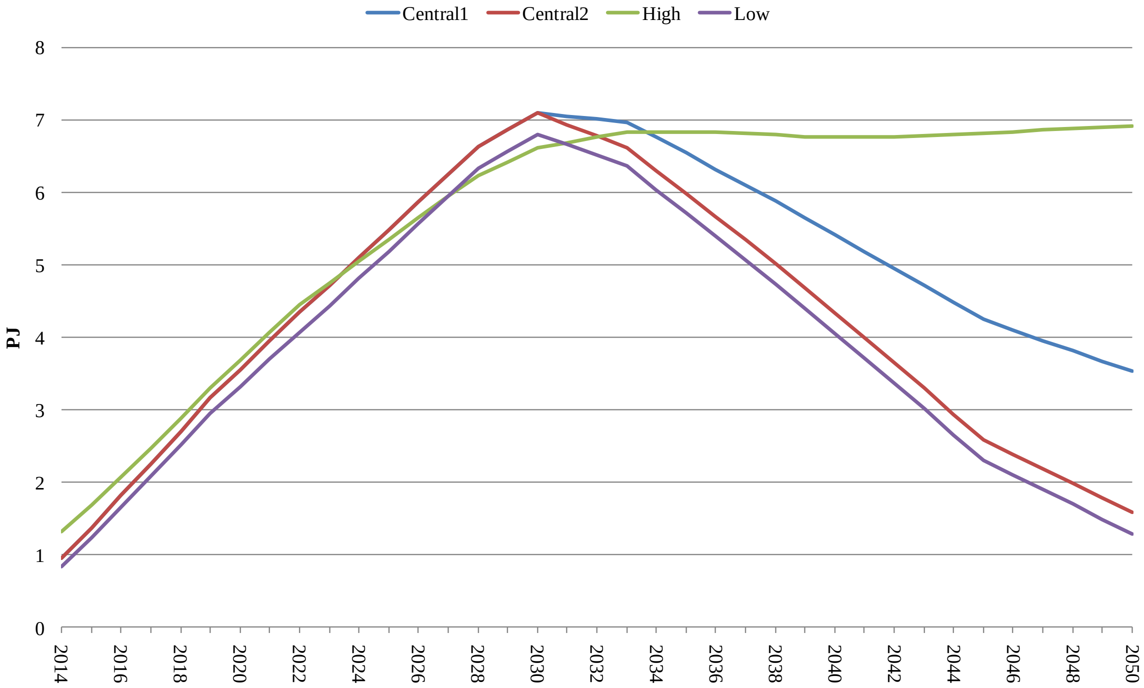
4.3. Energy demand impacts

The impacts on energy markets depend fundamentally on the impacts on energy demand. Net savings in energy use at the customer level lead to a reduction in demand for electricity and gas at the wholesale level, affecting wholesale energy prices, investment in new capacity and costs of generation.

4.3.1. Change to gas demand

The gas market energy savings modelled under each of the other schemes relative to the reference case are shown in Figure 4-7. As might be expected, energy savings steadily increase until around 2030 and decline after this time as the lifetime of the energy efficient appliances and other initiatives ends. After 2030, savings are highest for the high case and lowest for the low case. The savings could have been greater except for fuel switching from electric to gas appliances under the scheme, leading to lower savings in gas use.

Figure 4-7 Gas saved under each scenario



Source: SKM MMA analysis.

4.3.2. Change to electricity demand

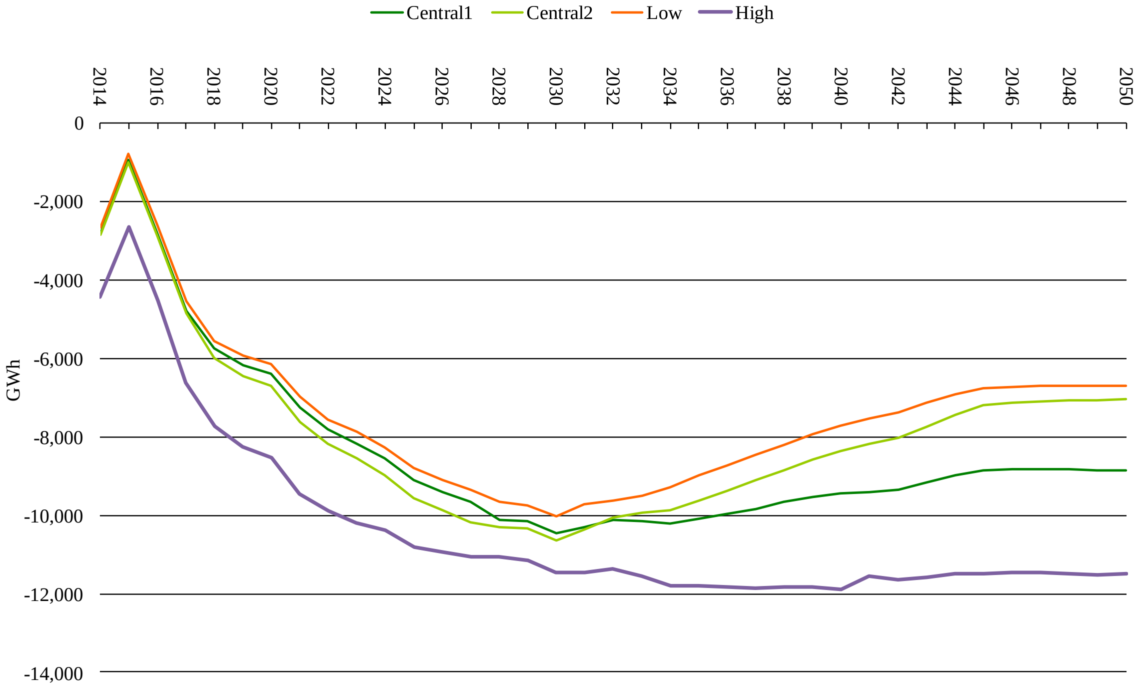
Electricity market energy savings under each of the schemes relative to the reference case are shown in Figure 4-8. To translate savings of energy efficiency in homes and businesses to sent out energy, a loss factor of 8% was assumed.

The analysis suggests that compared to the reference scenarios, the introduction of a national energy savings initiative could lead to an additional reduction in energy demand (beyond the life of the policy), although in all scenarios energy demand continues to grow.

Electricity savings amount to between 6,300 GWh and 8,500 GWh in 2020, and 10,000 GWh to 11,500 GWh in 2030. The quantum of energy savings depends on the range of relatively pessimistic and optimistic assumptions applied to key parameters in the different scenarios modelled.

Energy savings continue for a number of years after the termination of the national energy savings initiative, and then continue, albeit at a lower level than the peak. This can be attributed to energy efficiency technologies generally having an effective life of several years (in some instances this may be for the life of the building), as well as changes in purchasing behaviour assumed in the central 2 and high scenarios that lead to longer-term energy savings than in the other scenarios modelled.

- **Figure 4-8 Reduced generation by scheme**

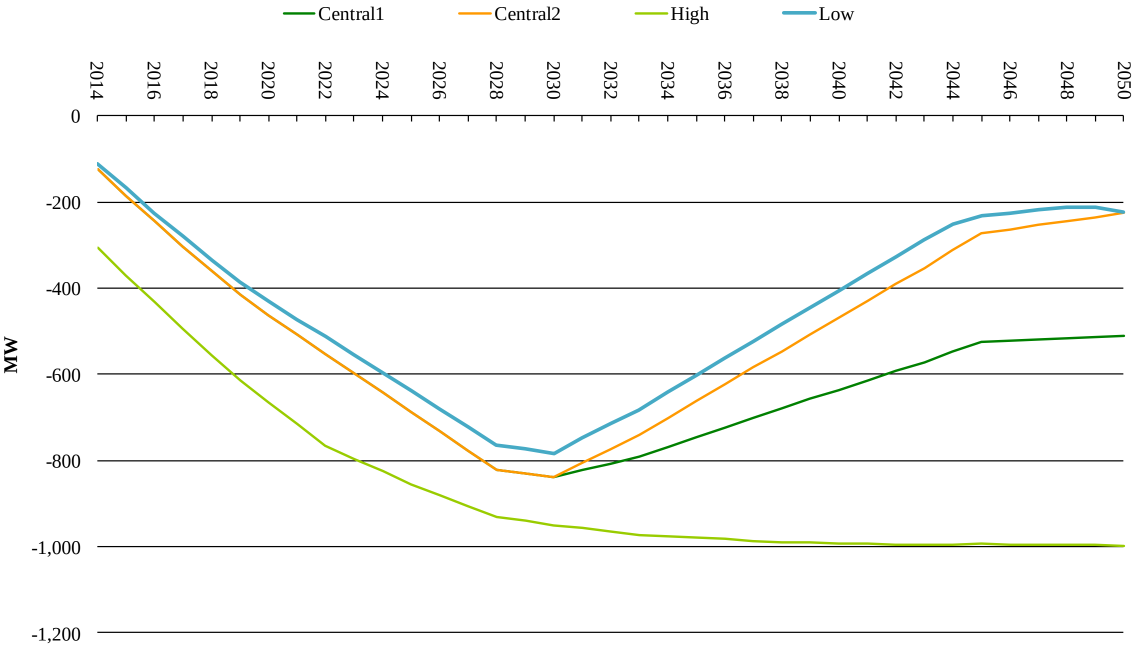


Source: SKM MMA analysis.

A national energy savings initiative is also estimated to lead to a reduction in peak electricity demand. The change to peak demand is important, as it impacts on the state of network and generation infrastructure. Network companies are providers of a monopoly service and are therefore regulated. Networks are allowed by regulators to recover the cost of servicing existing assets as well as revenue to cover forecast demand growth over the next few years. The impact of energy efficiency initiatives may therefore not be felt until some years into the scheme, until such time as a network provider can adequately forecast a drop in growth of peak demand. Peak demand was estimated from energy use data assuming a load factor of 0.3 for hot water loads and a load factor of 0.58 for space conditioning and residential lighting loads. A load factor of 1 was assumed for residential and commercial refrigeration, as well as industrial loads. A load factor of 0.42 was assumed for commercial space conditioning and lighting.

In 2020, peak demand is reduced by up to 660 MW and up to 950 MW in 2030, relative to the reference scenarios. This is equivalent to 3 to 5 efficient scale open cycle gas turbines.

■ **Figure 4-9 Change in peak electricity demand - Australia**



Source: SKM MMA analysis. Note: coincident peak demand reductions over the whole grids. The sum of peak demand reductions in each state may be greater than shown in this chart.

5. Impacts on Energy Markets

The results described in this section provide a comparison of the outcomes under different structures for the energy savings initiative against a reference case which has been adjusted for the impact of existing state schemes. Any impacts, therefore, are from a combination of both federal and state schemes.

All dollar amounts are reported in real 2010-11 dollars, excluding inflation.

5.1. Overview

The analysis indicates that the introduction of a national energy savings initiative could lead to:

- Small changes to energy prices. Retail electricity prices in both the National Electricity Market (NEM) and the South-West Interconnected System (SWIS) are estimated to be slightly lower in the period to 2020 and slightly higher in the period from 2021 to 2030. Estimated changes to gas prices are also negligible.
- Lower energy demand. Annual electricity demand is estimated to be reduced by 6,300 GWh to 8,500 GWh in 2020, and 10,000 GWh to 11,500 GWh in 2030. Annual gas demand is projected to decrease by around 3.5 million GJ in 2020, and 7 million GJ in 2030.
- Lower energy costs for participating households. Annual electricity bill savings of around $200 in 2020, rising very slightly to 2030, for an average household implementing two energy efficient options.
- Lower generator profits. Estimated at around $0.3 billion to $2.0 billion over the period 2013-14 to 2019-20 (in 2010-11 present value terms).

A summary of the results is contained in Table 5-1.

- **Table 5-1 Impact of ESI on energy markets**

	Central 1	Central 2	High	Low
Compliance costs (2014 to 2020)				
$M per annum	357	357	296	368
$/MWh equivalents	1.21	1.22	1.02	1.25
$/GJ equivalents	0.34	0.34	0.28	0.35
Electricity market impacts				
Wholesale Prices, $/MWh				
2014-2020	-1.19	-1.34	-1.92	-0.99
2021-2031	-1.30	-1.52	-0.79	-1.27
% change				
2014-2020	-2%	-2%	-2%	-1%
2021-2031	-1%	-2%	-1%	-1%
Retail Price, $/MWh				
2014-2020	-0.37	-0.53	-1.22	-0.14
2021-2031	0.44	0.21	0.70	0.49
% change				
2014-2020	-0.25%	-0.35%	-0.83%	-0.10%
2021-2031	0.23%	0.10%	0.38%	0.26%
Average weekly spend, $/week				
All Households	-0.31	-0.36	-0.23	-0.29
Households adopting EE	-3.79	-3.84	-3.71	-3.76
Generator profits, $M	-296	-298	-2,017	-132

Source: SKM MMA analysis.

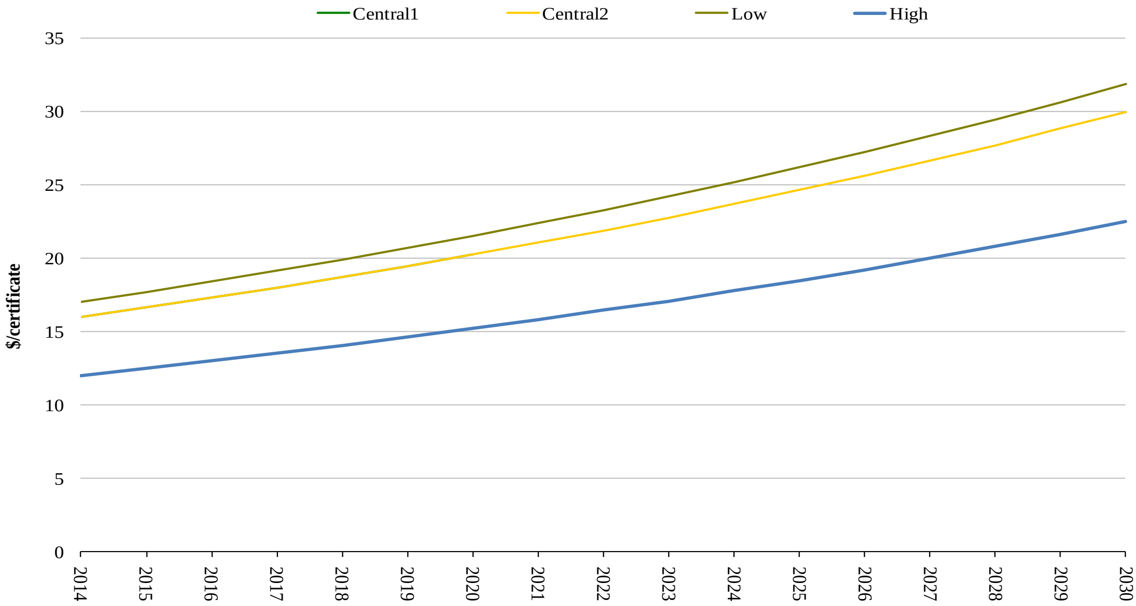
5.2. Compliance costs

Compliance costs cover the cost of purchasing the certificates. The compliance cost in each year equals the certificate price, times the target level of certificates plus government and retailer administration costs.

Under all scenarios, the target is equivalent, and so the compliance costs will generally vary according to the certificate price. Figure 5-1 shows that certificate prices range from between $12/MWh equivalents (in the high case) to $17/MWh equivalents (in the low case), with central values around $16/MWh (for the two central cases). The certificate price differences reflect the difficulty associated with obtaining reductions with differing payback periods and different maximum penetration assumptions. The lower price for the high case occurs because of the greater payback period and higher maximum penetration levels, allowing more savings from low cost options.

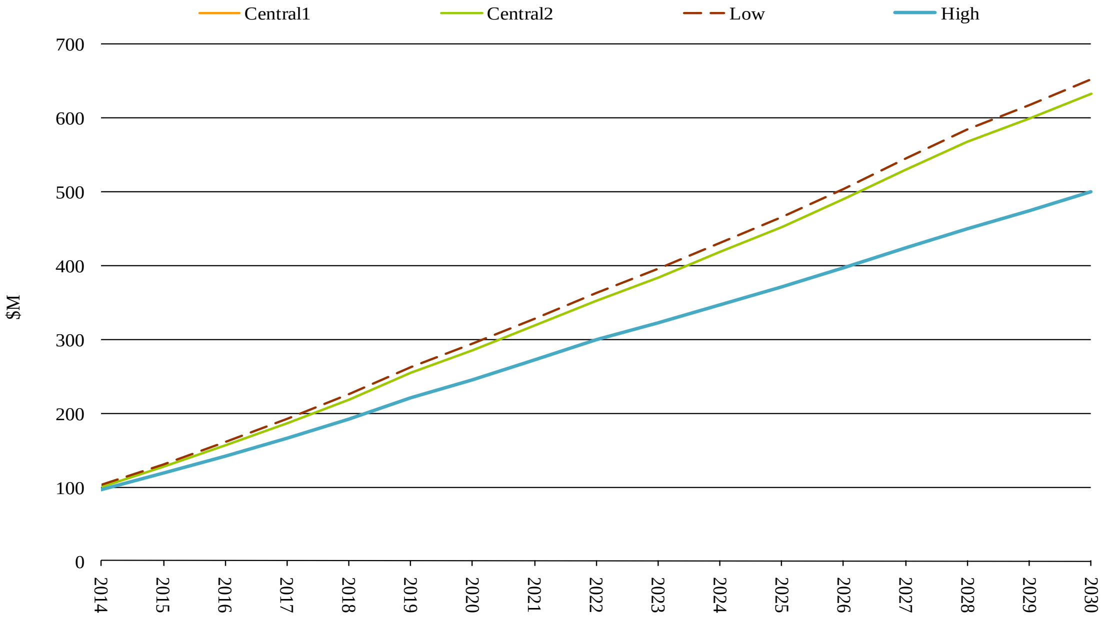
The present value of the compliance cost of implementing the scheme is calculated at between 2.4 and 2.7 billion dollars over the scheme life, assuming a discount rate of 7%. When evaluated over all energy use (which is lowest under the high scenario), this cost came out to between $1.02/MWh (for the high case) and $1.25/MWh (for the low case) on average, with values of $1.22/MWh for the central cases.

- **Figure 5-1 Certificate Prices**



Source: SKM MMA analysis.

- **Figure 5-2 Compliance costs by scheme**



Source: SKM MMA analysis.

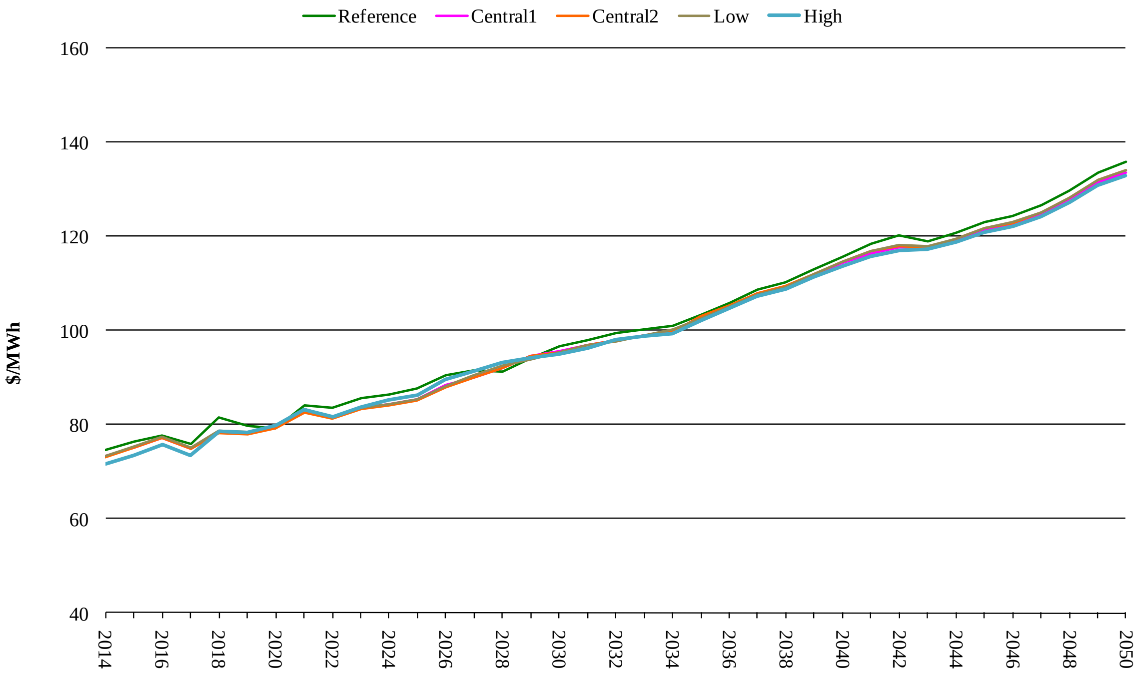
5.3. Electricity market impacts

5.3.1. Wholesale electricity prices

Wholesale electricity prices are slightly lower relative to the reference scenarios in all states. Wholesale prices fall due to the creation of a supply surplus (demand growth is slowed but capacity increases as a result of the Renewable Energy Target), and the deferral of investment in relatively expensive new thermal capacity.

Under the central scenario, price reductions in the period to 2020 were on average around $1.20/MWh, and average reductions could range from $0.99/MWh in the low case, to $1.92/MWh in the high case.

- **Figure 5-3 Australian average wholesale prices by scenario**



Source: SKM MMA analysis.

5.3.2. Retail prices

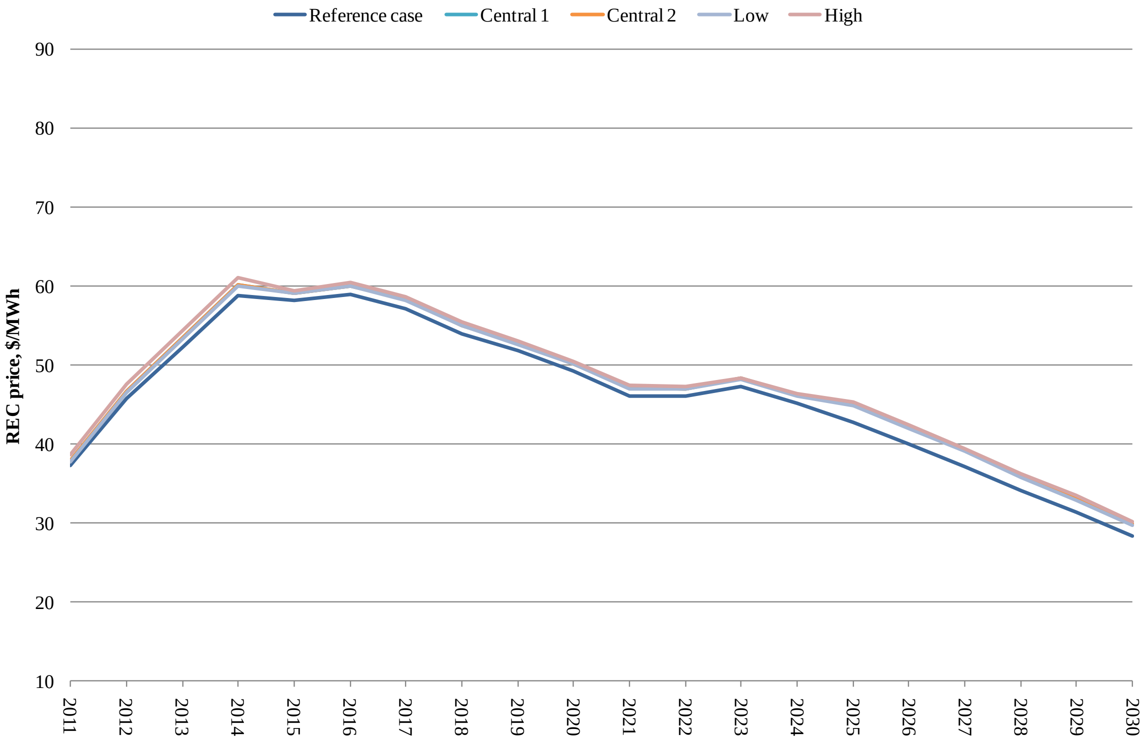
The impact on retail prices is a function of the impact on wholesale prices, the impact on other ancillary markets (for example, REC prices) and the compliance cost. The latter is assumed to be passed on fully to retail customers.

As discussed above, the wholesale prices are slightly lower, as a result of the reduced energy demand.

Renewable Energy Certificate prices are expected to rise slightly as a result of reduced wholesale prices. This rise compensates for shortfalls in wholesale prices required by renewable energy generators.

Changes in retail prices are negligible in both the NEM and the SWIS, however, as lower wholesale prices are largely offset by transaction costs associated with the national ESI.

- **Figure 5-4 REC prices, $/MWh**



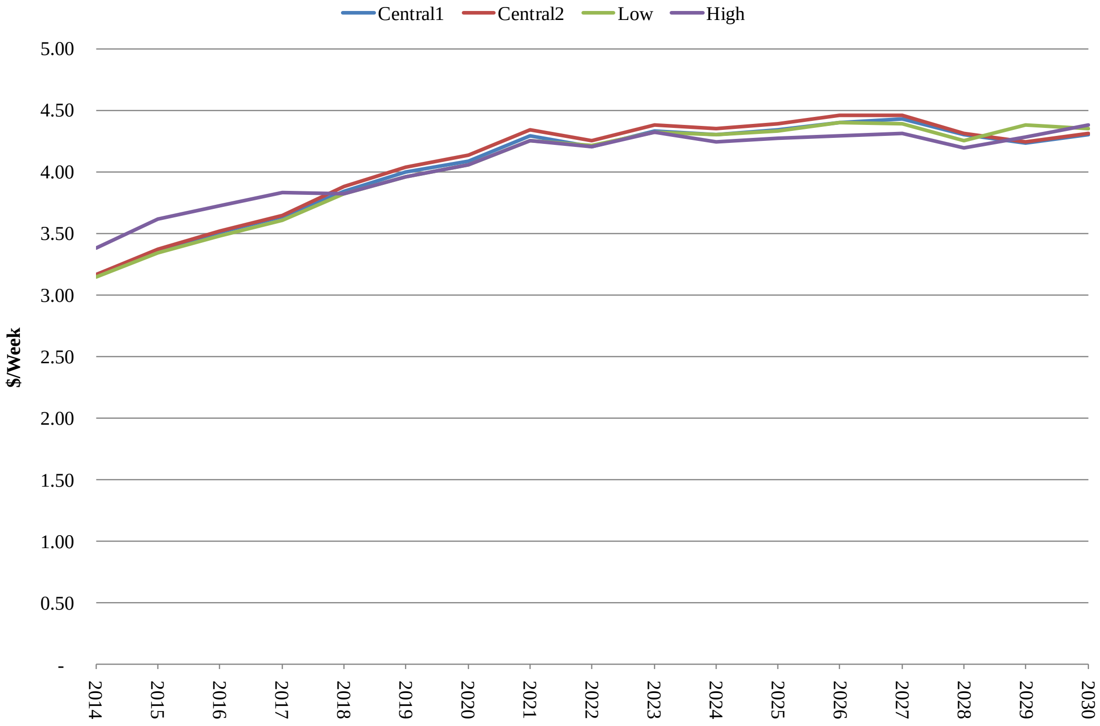
Source: SKM MMA analysis

5.3.3. Household energy expenditure

Negligible changes in retail electricity prices result in a marginal average reduction in household expenditure on electricity, when compared to the reference scenarios. For those households that implement energy savings measures, the benefits would be larger — homes would be more comfortable and use less energy and the combination of lower energy use and lower electricity prices would mean lower energy bills. On average, for a household implementing two energy savings technologies, there could be annual savings of around $150 to $200 from 2020 onwards when compared with business as usual.

The impact of an ESI on household energy bills is minor. Figure 5-5 shows that households adopting energy efficiency appliances are around $3.50/week better off, while savings for all households are less than $0.50c/week.

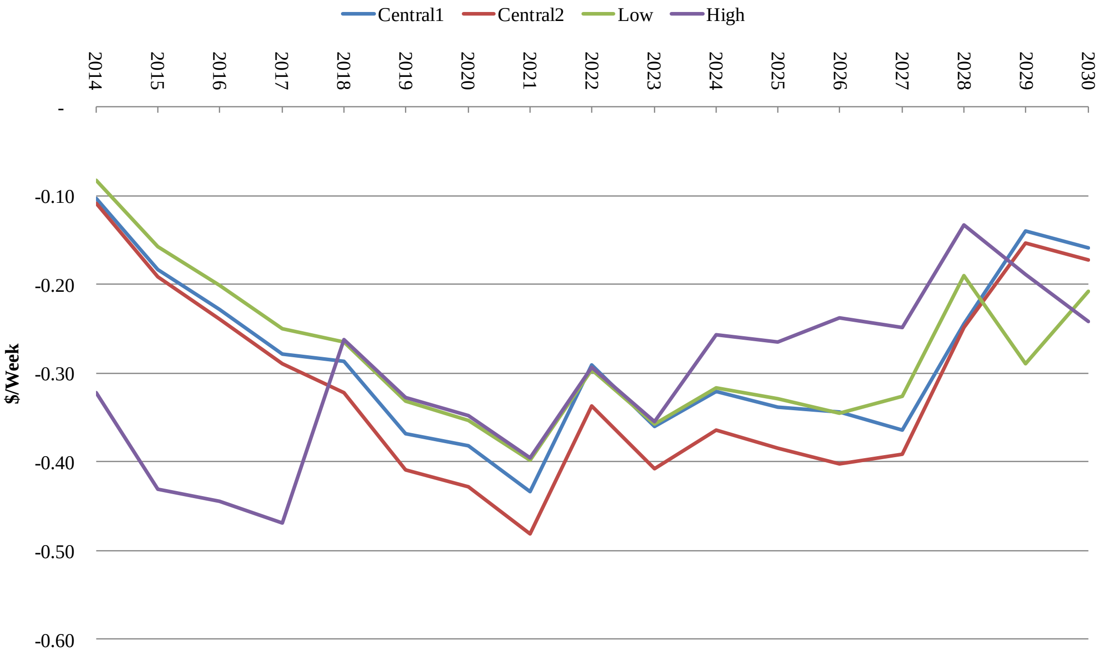
- **Figure 5-5 Reduction in electricity expenditure by households adopting energy efficient options**



Source: SKM MMA analysis.

Retail energy price determinations by state- and territory-based energy regulators would include the costs and benefits of a national energy savings initiative. For instance, state-based regulators have allowed energy retailers to pass on a small cost for similar state-based schemes. This is offset against the change in the expected wholesale electricity price (which, based on this analysis is estimated to fall on average by around the same amount as the impost associated with the initiative). So, while retailers may identify additional costs associated with the initiative, and may even list a cost associated with the initiative on energy bills, retail prices are estimated to remain roughly the same as in the reference scenario. These issues would need to be considered in detail in any subsequent scheme design consideration and analysis, including how costs and benefits associated with a national energy savings initiative are communicated.

- **Figure 5-6 Change in electricity expenditure for households due to changes in retail prices**

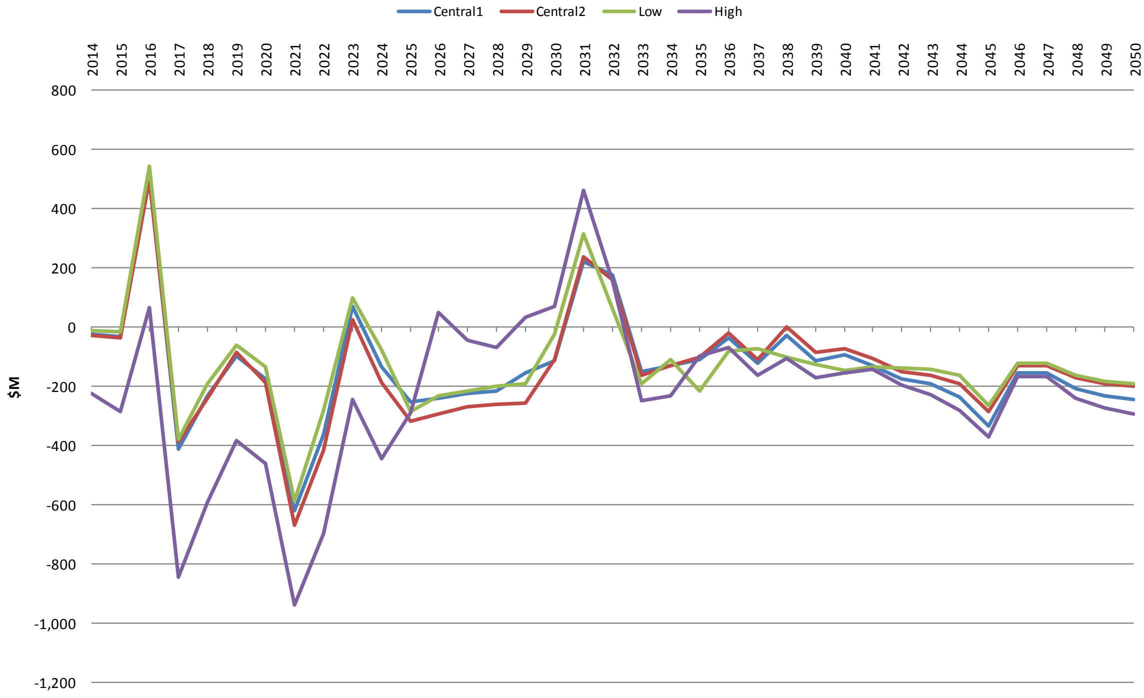


Source: SKM MMA analysis.

5.3.4. Generator profits

A corollary to the lower wholesale prices, is that profits to existing generators are also likely to fall. In present value terms (calculated to 2050 at a discount rate of 7%), profits can be expected to reduce by 1.3 billion dollars in the low case to up to 3.7 billion dollars in the high case, with mean expectations around 1.7 billion dollars. In terms of total trading profits expected, the losses represent around 3% of total profits earnt. However, this does not represent a loss to the economy, as there is a countervailing benefit to energy users through lower energy costs (although there may be distributional effects).

- **Figure 5-7 Generator profits by scenario**



Source: SKM MMA analysis.

5.4. Impact of scenarios on gas market

5.4.1. Change to gas prices

Changes in wholesale gas prices are also negligible, despite demand for gas falling as a result of the energy savings initiative. This is because the wholesale gas price is largely driven by international factors and demand for gas as a fuel in electricity generation.

Gas prices change little as a result of energy efficiency, with the price for all scenarios reducing by approximately 3c/GJ by 2030. By 2050, price reductions are expected to increase slightly more in the low case to 4c/GJ. For the other cases, these price reductions will instead retract to 1-2c/GJ by 2050.

6. Economic Value of Energy Efficiency

6.1. Net Economic Benefit

The ESI is estimated to lead to net economic benefits. Table 6-1 shows that the benefits range from $3.0 billion to $4.8 billion (in 2010-11 present value terms) assuming a 7% discount rate.

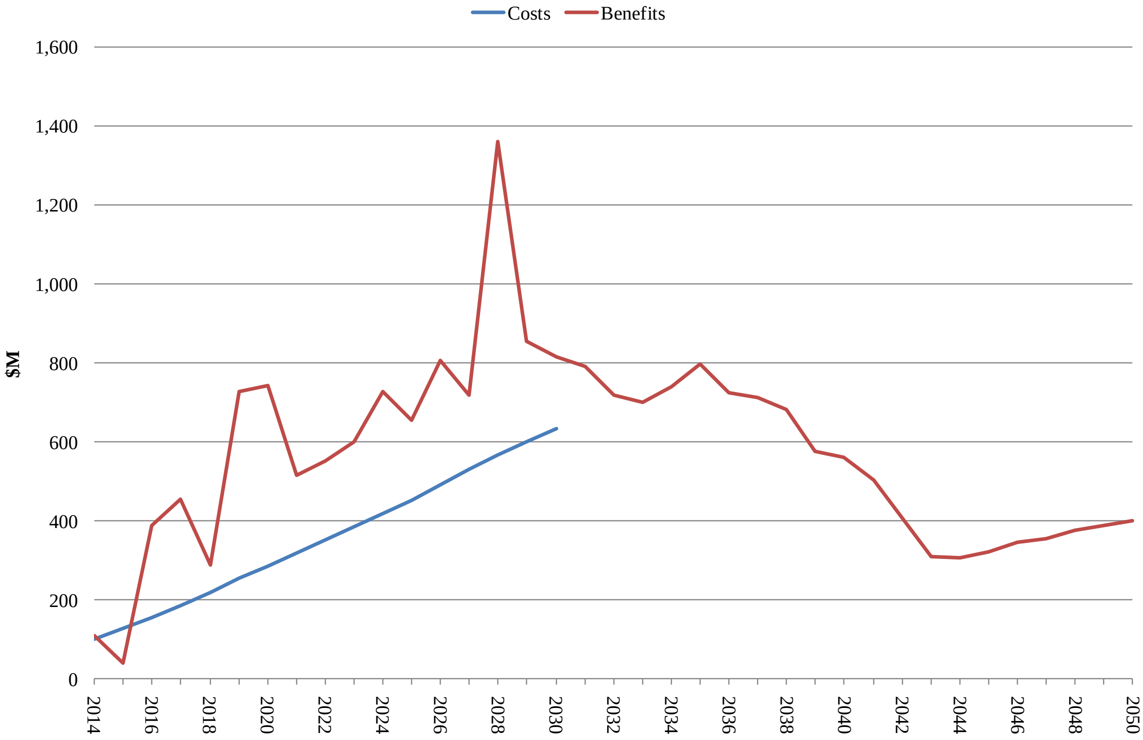
Figure 6-1 shows the change in resource cost, evaluated against the cost of compliance, by scenario. Compliance costs cease in 2031 as the modelling exercise assumed the scheme would stop running. A key result is that the benefits exceed the cost from early on after scheme implementation, highlighting the robustness of the benefits of the scheme.

- **Table 6-1 Benefits and cost of ESI on energy markets**

	Central 1	Central 2	High	Low
7% Discount rate				
Costs	2,423	2,423	2,040	2,495
Benefit	5,837	5,798	6,839	5,567
Net benefit	3,414	3,375	4,798	3,072
4% Discount rate				
Costs	3,525	3,525	2,949	3,630
Benefit	9,619	9,443	11,326	9,027
Net benefit	6,094	5,918	8,377	5,397
11% Discount rate				
Costs	1,532	1,532	1,302	1,578
Benefit	3,295	3,312	3,871	3,197
Net benefit	1,762	1,779	2,569	1,619

Source: SKM MMA analysis. Present values calculated over the period from 2014 to 2050.

- **Figure 6-1 Change in resource cost and benefits, central 1 scenario**



Source: SKM MMA analysis.

6.2. Source of benefits

6.2.1. Deferred investment

Saving energy defers the need to invest in new electricity and gas infrastructure. Consequently, investment in all generation, including gas-fired and renewable energy, is lower under a national energy savings initiative than in the reference scenarios. Over the period 2013/14 to 2039/40, savings in avoided electricity generation, transmission infrastructure and gas infrastructure investment — and avoided operating and maintenance costs — total between $4.6 billion to $5.9 billion. In the case of transmission, savings are also high and are typically around $0.9 billion. Savings in gas infrastructure are relatively modest by comparison at around $40 to $50 million.

- **Table 6-2 Present value of deferred infrastructure costs, $M**

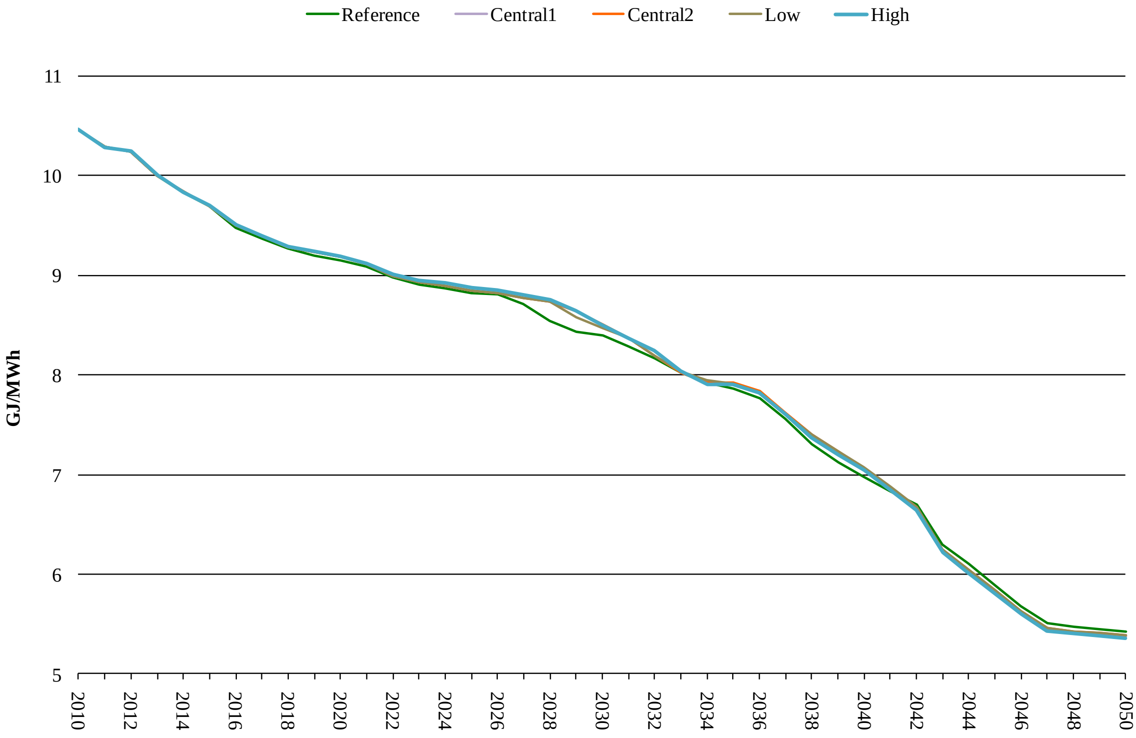
	Central 1	Central 2	High	Low
Generation fuel and operating	3,794	3,662	4,632	3,454
Generation investment	1,208	1,233	1,278	1,212
Electricity transmission	851	921	945	915
Gas infrastructure	48	46	43	51

Source: SKM MMA analysis. Assumes a 7% discount rate. Present values calculated over the period from 2014 to 2050.

6.2.2. Fuel efficiency and costs

In all scenarios, there are negligible changes in the fuel efficiency and emissions intensity of electricity generation (the amount of energy required to produce a unit of electricity). Under a national energy savings initiative with the modest 4% target modelled, fuel efficiency improves by slightly more than the underlying trend, primarily due to reduced electricity demand combined with more efficient operation of gas-fired plant and lower use of older coal-fired plant.

- **Figure 6-2 Fuel efficiency by scenario**

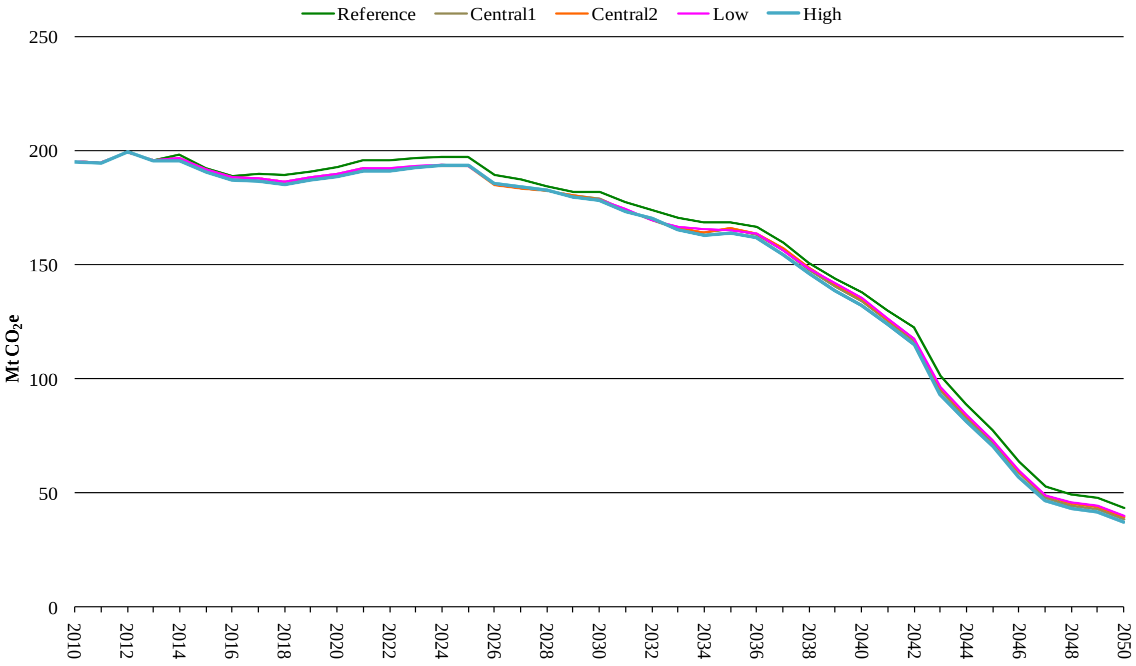


Source: SKM MMA analysis.

6.2.3. Emissions

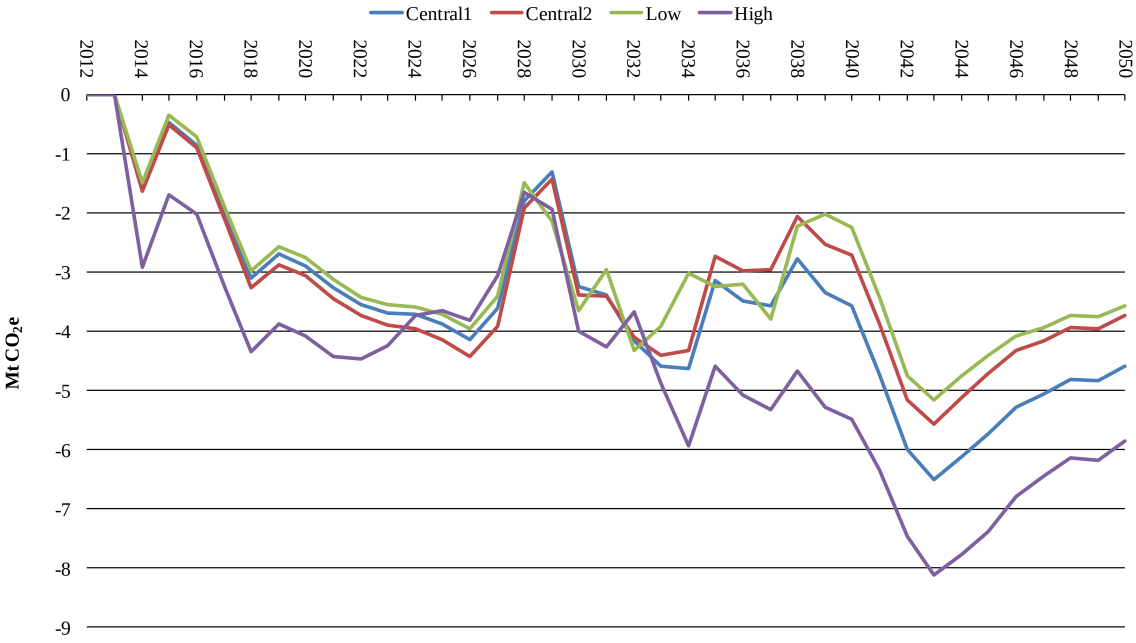
In all scenarios, emissions were reduced. Figure 6-4 displays emissions reductions by scenario in terms of millions of tonnes. The chart indicates that emissions reductions of up to 8 Mt CO_2e per annum can be achieved under the high scenario, with typical reductions in the order of 4 Mt CO_2e per annum. In a cumulative sense emissions reductions are between 117 and 175 Mt CO_2e for the low and high cases respectively, and expected mean reductions of 135 Mt CO_2e.

Figure 6-3 Emissions by scenario



Source: SKM MMA analysis.

Figure 6-4 Change in emissions reductions by scenario



Source: SKM MMA analysis.

7. Conclusions

Although energy efficiency measures are apparently cost-effective, many are still not undertaken because of barriers to their uptake. Energy efficiency investments may bind consumers to make a commitment in the face of uncertain performance and payback periods, and may not even be in the forefront of consumer preferences. Split incentives of landlords and tenants may result in cheaper, non energy efficient appliances being installed in rented accommodation, as well as reduced insulation and weather proofing in these homes.

In this study, the benefits and costs have been estimated for a tradable certificate scheme designed to overcome these market barriers. The approach taken to estimate the benefits and costs accounted for a number of issues that may have led to an overestimate of the benefits in previous studies. These issues include:

- The heterogeneity of customers, which recognises the energy savings from adopting an energy efficient option, will differ between customers.
- The observation that energy efficiency savings are not fully realised, either because consumers tend to divert saved funds to other energy consuming activities (the rebound effect), or because there is a systematic bias in the technical estimates of potential energy savings, or because the options would have been adopted in the absence of the scheme (additionality).
- The fact that high payback periods, rather than reflecting market failures, are a proxy for legitimate barriers, to uptake such as high transaction costs, uncertainty over future energy prices or the perception among some end energy consumers that energy efficient appliances result in lower quality energy services.

Despite accounting for these issues, the analysis demonstrated that there were still strong benefits from a program to encourage energy efficiency. The results indicate that, even when considering all these mitigating factors, the net benefit of undertaking the scheme is expected to be positive, at around $3 billion to $4 billion in present value terms. Net benefits are robust to plausible variations in the range of assumptions on rebound, uptake parameters and persistence. And the net benefits estimated may under-represent the total benefits, as the rebound effect referred to above is due to end users spending some of the income saved from energy efficiency to purchase additional goods and services with energy component embodied. This provides an additional benefit to end-users not captured in this modelling.

The net benefits to the energy market accrue due to lower fuel consumption in generation and deferment of investment in transmission and generation capacity. Accelerated improvement in energy efficiency also led to lower emissions of greenhouse gases, but this was not accrued in the calculation of benefits, as this would only have led to less abatement in other sectors of the economy or more domestic action to reduce emissions so offsetting purchase of permits overseas that may occur under an internationally linked emissions trading scheme.

The net benefits are reflected in lower wholesale and retail prices for electricity, which occur even after the costs of complying with the scheme are added to retail prices. Households who elect to adopt an energy efficient option under the scheme particularly benefit, saving between $3/week to $4/week on their energy bills.

However, existing generators (both gas and coal-fired), experience a reduction in their profits due to the lower wholesale prices and, in some cases, a reduction in the level of generation.

Certificate trading schemes for energy efficiency achieve benefits by providing a directed financial incentive to overcome the market barriers to go beyond the minimum standards typically achieved by a regulatory approach. A well functioning certificate market should lead to the adoption of the least cost options for energy efficiency.

Although the estimated benefits are strong, there are other factors which may impact on the effectiveness of the scheme to realise these benefits. To work effectively, tradable certificate schemes require liquid and transparent price discovery processes to maximise the benefits.   The exercise of market power could limit the benefits and lead to suboptimal uptake of energy efficiency, although this does not appear to have been an issue with current state based schemes. One advantage of a national scheme is that the scope for the exercise of market power is minimised due to greater liquidity. Further, careful thought would need to be given to the design of the scheme to ensure that only options which are unlikely to be adopted without incentives are eligible. Rewarding activity that would have been adopted in the absence of the scheme would reduce the net energy savings and the potential benefits of the scheme. Finally, arrangements governing the operation of the scheme should be developed carefully, to optimise the effective administration of the scheme.

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Appendix A The Energy Efficiency Gap

A brief review of the literature on the economics of energy efficiency is provided in this appendix, focusing on the purposes for energy efficiency policies and the issues that should be considered in the design of such policies.

A.1 Market barriers

Uptake of energy efficiency measures has historically been significantly lower than the economically efficient level. That is, consumers do not always adopt energy efficiency measures that will benefit them economically. The phenomenon of such economically inefficient investment has been called the "energy efficiency gap". There are many possible reasons for this gap[11].

Electricity prices not reflecting supply side externalities

Electricity prices may not currently take full account of environmental externalities (for example carbon pollution) and as a result, the price fails to reflect the full cost to society of consumption.

The Australian government has now committed to introducing an emissions trading scheme as the vehicle for abating greenhouse gas emissions, thereby internalising the cost of this primary externality from electricity generation in Australia. The policy shift requires a reconsideration of the role of energy efficiency in greenhouse policy, as energy efficiency measures will only indirectly affect overall emissions reductions when implemented alongside emissions trading.

Emissions trading provide for a regulatory cap on greenhouse gas emissions that cannot be exceeded and therefore, the adoption of energy efficiency improvements simply displaces other abatement sources (such as the deployment of renewable technologies).[12]

Nonetheless, energy efficiency policy can still be part of Australia's response to climate change to the extent that such policies reduce abatement costs to the economy. Taking advantage of energy efficiency opportunities is one way in which market participants can adjust to the new carbon constraint and it is likely that some energy efficiency opportunities will be taken up as a result of emissions trading. Increases in the price of energy, resulting from the emissions trading scheme, will lead to some of the socially cost effective improvements in energy efficiency opportunities being taken up.

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[11] K. Gillingham, R.G. Newell, and K. Palmer, 2009.

[12] Even in the absence of an emissions trading scheme, it is important to bear in mind that improved energy efficiency does not necessarily correlate directly with emissions reductions. The emissions reduction impact of an improvement in energy efficiency is highly dependent on the mix of energy generation technologies present in the economy.

However, there are a range of significant non-price market failures and other barriers to the development and uptake of socially cost effective energy efficiency opportunities even under an emission trading scheme[13]. The role for energy efficiency policies alongside emissions trading, is to address these market failures and other barriers. In the absence of interventions to complement emissions trading, many cost-effective energy efficiency opportunities will not be exploited.

Retail prices may not reflect marginal costs

Retail energy tariffs may not reflect the marginal cost of supplying energy (for example, in an ideal market, electricity prices would be higher at times of high demand, since at these times more electricity is being produced by expensive peaking plants). In addition, the choice made by end users may not be directly affected by prices either because payment for energy is removed from the time of use of energy, or because the cost of energy is only one component in the provision of energy services.

Information problems

Consumers often do not have enough information to make an optimal choice about energy efficiency when choosing appliances. There is often asymmetry between the supply and demand sides of the energy equation – energy demand is a derived demand and so the end users' response to price rises tends to be more inelastic.

In making decisions regarding the energy efficiency characteristics of goods and services purchased, or of production and distribution systems, market participants have to obtain and process a large amount of information. Data regarding the energy use of different appliances is often poor, making it hard to compare without adequate information that a consumer can understand.

Difficulties in obtaining and interpreting information are due to high transactions costs, incentive misalignments, the public good nature of information and a host of limitations facing decision makers such as bounded rationality, and other relevant behavioural barriers.

Behavioural barriers

As noted in the Stern Review,[14] individuals and firms are not always able to make effective decisions involving complex and uncertain outcomes. Difficulties may arise when consumers do not know how to make a rigorous cost-benefit analysis, or, for whatever reason, do not make decisions based on such an analysis.

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[13] PM Task Group on Emission Trading (2007), page 137.

[14] Stern 2006, pages 380-381.

When faced with complexity, uncertainty or risk, the full understanding of which would require significant investments of time and energy, individuals and firms may adopt simple decision rules that lead to *satisfying* rather than *optimising* behaviour.[15] In the context of energy efficiency opportunities, such complexity, uncertainty or risk may appear to arise from factors such as difficulties in calculating the long run value of energy savings, determining appropriate responses to the risks and uncertainties around future energy costs or a lack of understanding of new energy efficiency technologies.

The adoption of simple decision rules or rules of thumb is most likely where a reasonable outcome is sufficient or the difference between a reasonable outcome and an optimal outcome is not large (for example, individuals purchasing household appliances where energy efficiency is only one amongst a number of relevant factors) as compared to situations where energy efficiency is a primary consideration to the profitability of an enterprise. The use of simple decision rules that lead to non-efficient outcomes has been documented even in the commercial sector.[16]

The decision rules adopted by individuals and firms will often be strongly influenced by social and institutional norms. There is a tendency for individuals and firms to continue to take decisions in the same way they have taken such decisions in the past despite changed circumstances (e.g. individuals and firms may continue to place little emphasis on energy efficiency because they are accustomed to low energy prices even though it is clear that energy prices may increase in the near future).[17] Social and institutional norms are not static and will change over time. However, there will often be a lag between changed circumstances and changing social and institutional norms. This is one of the key justifications for awareness raising measures as well as a more ‘coercive’ set of interventions in the transition period.

Once the social and institutional norms – and as a result the decision rules – have had a chance to adapt to the new circumstances (in this case a binding emissions constraint) , the case for more ‘coercive’ interventions is significantly reduced and information measures may be adequate in addressing remaining behavioural and non-price barriers.

Organisational barriers may also prevent the adoption of cost-effective energy efficiency measures by firms. Managers may choose not to adopt a potentially cost-effective energy efficiency measure because they perceive it to be risky and the personal consequences of failure are more costly than the pay-off from success, or because the performance is assessed on a shorter time frame than the

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[15] Productivity Commission 2005, page 55.

[16] See Productivity Commission 2005, page56.

[17] Stern 2006, page 381.

energy efficiency measure will take to pay off. Coordination problems within firms may also lead to a failure to realise cost-effective energy efficiency measures.[18]

Split incentives

Split incentives arise when the party making a decision is not the one benefiting directly from the decision. Landlords are unlikely to make energy efficiency improvements because the energy savings are not evident to tenants to induce them to pay more rent. In an ideal market, investing in energy efficiency would be just as worthwhile for landlords as for homeowners, because landlords would be able to charge higher rents to compensate for the savings in tenants' power bills. This may not happen in practice, because tenants generally do not consider the effect of energy efficiency measures on power bills (for a variety of reasons, mainly that there are other important factors to consider when looking for a rental). For this reason, rental homes tend to be less energy efficient than owner-occupied ones.[19] This is really a kind of information problem: if tenants knew with certainty how much they would save on power bills, they may be willing to pay this extra amount in rent.

Technology market issues

There are barriers for companies producing energy efficiency technologies. Innovators in energy efficiency are likely to create positive externalities as other companies copy their techniques. Therefore, there is a disadvantage to being one of these innovators. Assuming the innovation cannot be patented, there is a disadvantage to investing in innovation if the cost is too high relative to the market value of being the first to do something.

Capital constraints

Consumers and firms may be capital constrained. This applies particularly to low income households who might find it difficult to finance the initial higher cost of more efficient appliances and other energy efficiency improvements, even though this would lead to a lower total cost to the household in the long-term.

Budgeting practices can also lead to energy efficiency opportunities with high internal rates of return from going unexploited within firms. This is because operating and capital budgets are often handled separately with ensuing persistent barriers to substitution between budget items.

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[18] Productivity Commission 2005, pages 58-59.

[19] H. Geller and S. Attali, 2009.

A.2 Estimating the size of the energy efficiency gap

In designing policy to close the energy efficiency gap, it is important to accurately estimate the extent of the problem. There are several reasons to be conservative in calculating this estimate.

Some economists argue that traditional analysis of the costs and benefits of energy efficiency measures neglects certain factors that may reduce the level of uptake. For example, analyses of consumer behaviour at the aggregate level may be misleading, because while a particular energy saving measure might be cost-effective for the *average* consumer, there may be a significant number of consumers for whom it is not cost-effective.

Some analyses may have under estimated the appropriate discount rate that should be applied to investments in energy efficiency technology, because they have under estimated the uncertainty of the benefits of energy efficiency measures, and the uncertainty of future electricity prices.

Energy savings from efficiency measures are often overestimated[20]. One reason for this, is because that appliance testing often occurs under a standard set of testing conditions, and therefore may not reflect real world use.

A.3 Experience from past and existing schemes

Several studies have found links between energy efficiency programs and reduced energy consumption.

NSW IPART conducted a household survey in 2010. In comparison with an earlier survey in 2006, the study found that average household electricity use in NSW fell by 4%, from an average of 7.5 MWh to 7.2 MWh per annum.[21] The study cited data from the electricity networks showing a similar trend whereby the combined use in the Energy Australia and Integral Energy network area fell by 6% from 2005/06 to 2009/10.

Although the study did not investigate the reasons for the fall in average consumption, the possible explanations that were given include:

- changes in the sample structure.
- impact of the household insulation program.
- fall-off in direct load (off-peak hot water) services, perhaps in part because they were replaced by solar water heaters.

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[20] G.E. Metcalf and K.A. Hassett, 1997.

[21] IPART, 2010.

Evidence from past energy efficiency schemes show that they can have a significant effect on uptake rates. In the Netherlands, an energy efficiency program increased the market share of refrigerators with an "A" efficiency rating from 26% to 67%, in only three years.[22] A similar result was achieved for clothes washers: the market share of those rated "A" more than doubled, going from 40% to 88%. A long-term subsidy scheme in the UK was also able to save around 31 PJ per year, and the benefits far exceeded the costs (taking into account both the free rider and rebound problems).

A review of the Victorian Energy Efficiency Target (VEET) scheme results for 2009 found:[23]

- Around 440,000 Victorian residential premises over the 13 month period from 1 January 2009 to 31 January 2010 undertook activities under the VEET scheme.
- The most common activity undertaken was installing energy efficient lighting. This accounted for over 76% of the certificates created.
- Most of the activity occurred in the Melbourne metropolitan area.

Rigorous data on the energy savings attributable to each program is not available.

A 2010 report published by DRET on energy efficiency opportunities found that the majority of industrial energy efficiency savings were available in the mining sector, followed by manufacturing, metals and the services sector.[24] Around 6.6% of savings were identified in the targeted areas of energy use overall, with 9.1% available in the mining sector, 5.4% in the metals sector, 7.4% in the manufacturing sector and 12.3% available in the services sector.

- **Table A-1 Industry sector savings potential**

Industry sector	Savings as a percentage of total sector energy use	Savings as a percentage of assessed energy use
Mining	5.5	9.1
Metals manufacturing	3.3	5.4
General manufacturing	3.4	7.4
Transport	4.0	4.9
Services	4.3	12.3
Other	0.8	5.6
All sectors	3.8	6.6

Source: DRET, 2010.

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[22] H. Geller and S. Attali, 2009.

[23] Essential Services Commission, 2010.

[24] DRET, 2010.

Appendix B Energy Savings Model

This section details the assumptions and methodology used to develop cost curves for energy efficiency initiatives and to determine the level of aggregated savings in electricity and gas demand as used for the electricity market modelling.

The market for energy efficient initiatives is assumed to follow times of natural stock turn, when new premises are built and require fit-out, or when an appliance or fitting ends needs to be replaced. Such a process is natural in the case of essential appliances, for example as area and water heaters, where the appliance requires replacement and a do nothing alternative is not feasible. In the case of roof insulation, the natural life is assumed to be quite long. Where the appliance is a dishwasher or washing machine, recent estimates of appliance penetration were used to limit the impact of these appliances on water heating end use energy savings.

To account for split incentives, the market size is also reduced by the proportion of homes being rented, as determined from ABS data.

Demand is segregated as follows:

- By sector - residential, commercial and industrial sectors.
- By residential end use - includes space conditioning, water heating, refrigeration, lighting and consumer electronics.
- By commercial sector end use - The model is segregated into premise type and function. For example, retail and wholesale premises, hospitals, education facilities and offices. The number of premises is determined by the number of businesses as recorded by the ABS and thus the results are unaffected by mixed business sites.
- For the industrial sector, activities are broken down by industry type.

To estimate the segregated loads for this study, published projections (AEMO, ABARE) of energy demand by sector were used. The model of energy end use was then used to determine the proportion of this energy demand that could be reduced through energy efficiency programs, based on the relative benefits to each sector of adoption of more efficient appliances and practices subject to commercial and other barriers to this uptake. For the residential sector, end use by appliance was determined using the work of the DEWHA, specifically the 2008 publication entitled *Energy end use in the Australian residential sector*, which includes projections to 2020.

Each initiative was defined by costs of program (capital costs of the energy efficient initiative over and above the costs of a standard initiative), life of the initiative, and energy savings associated with uptake of the initiative (before and after rebound). Assumptions were also made regarding the nature of cost variability, with different levels of consumption of energy embodied services.

SKM MMA has used a payback period which is less than the economic life of the equipment being adopted. Preliminary simulations indicated that a payback period of 4.4 years was consistent with an electricity price elasticity response of -0.3. The results confirmed that consumers require a short payback period, since the benefits of adoption should be calculated over the economic life of the equipment. The short payback period reflects in part the market barriers affecting uptake of energy efficient initiatives (see Appendix A). The payback periods used vary by scenario and end use sector and are listed in Table 2-2.

SKM MMA uses a model of energy end use by customer class to estimate the energy efficiency potential – called NEEM. The model determines a cost curve for energy efficiency initiatives, which maps the potential amount of energy saving for each energy efficiency initiative in ascending order of the net long run marginal costs of the initiatives. The net long run marginal cost of each initiative, in relation to a default initiative, is equal to the additional cost of adopting the initiative (based on incremental capital cost) minus the value of energy savings provided by the initiative (based on market prices).

The incremental cost of each initiative associated with energy efficiency, and the efficiency improvement of each initiative relative to a standard alternative, where possible, have been estimated from current market data on websites such as *Choice*, http:\\www.*comparison.com.au* and http:\\www.*getprice.com.au*. Some cost information was also obtained from the NFEE Background Report v4.1. There are occasionally instances for some energy efficient appliances in which there is no clear correlation between the level of energy efficiency and the price of appliances. Where this has occurred the cost has been estimated at a suitably low value of $10, which helps to ensure that the appliance is ranked early in the list of possible measures to adopt. Some energy efficient initiatives, especially those where there is no apparent cost to uptake, may have a negative long run marginal cost. That is, they have a net benefit to energy users over the technical life of the initiative. The fact that these initiatives are not universally adopted indicates that market failures exist.

B.1 Residential sector energy efficiency initiatives

Table B-1 shows the assumptions for key energy initiatives for the residential sector. Rebound estimates specific to particular end uses were applied, based on the data shown in Table B-1, unless they were unavailable, in which case the default values provided in Table 2-2 were used. Because the modelling was adapted to consider varying levels of consumption, capital cost estimates were assumed to be partially fixed and partially variable, depending on the level of consumption, with average costs as shown in the last column of Table B-1.

- **Table B-1 Residential sector energy efficient initiatives**

Energy efficiency initiative	Definition	Life of initiative, years	Efficiency improvement before rebound, %	Efficiency improvement after rebound, %	Additional cost, $
Space conditioning					
Building code	Increase minimum rating of shell	50	20	13	2,000
Roof space insulation - existing homes	Retrofit of insulation to roof cavities	50	15	10	1,920
Better wall insulation - new homes	Retrofit of insulation to wall cavities	50	10	7	1,569
Floor insulation	Retrofit of insulation under floors	50	6	4	1,920
Window shading	Shading to west and north faces of existing houses	15	6	4	500
Stand alone air-conditioning efficiency	Appliances with world best practice efficiency rating	20	20	13	1,000
Sealing of window drafts		20	6	4	209
Sealing of door drafts		20	6	4	369
Film on windows		20	8	5	2,500
Double glazing		20	10	7	25,000
Double glazing with film		20	15	10	30,000
Ducted space gas heater efficiency		20	15	10	400
Improve ducted air-conditioner		20	15	10	500
Replace electric radiator with gas heater		15	10	7	800
Replace electric radiator with stand alone RC air-conditioner	Savings apply only to the heating function	15	10	6	710

Energy efficiency initiative	**Definition**	**Life of initiative, years**	**Efficiency improvement before rebound, %**	**Efficiency improvement after rebound, %**	**Additional cost, $**
Replace electric fan forced heater with stand alone RC air-conditioner	Savings apply only to the heating function	15	10	6	690
Replace stand alone air-conditioner with solar air conditioner		15	80	54	7,500
Improve efficiency of standalone gas heater		15	10	7	65
Improve efficiency of standalone elec heater		15	10	7	10
Reduction of thermostats	Set thermostats to 21º Celsius in winter and 25º Celsius in summer	15	15	10	5,000
Water heating					
Water heater code	Requires new gas water heating to move from 4.5 to 5 star	15	20	14	500
Water heater replacement	Replacement of electric hot water services with gas	15	20	14	130
Water heater insulation	Fitting insulation to pipes and tanks in existing systems	15	20	14	200
Improve efficiency of top loader clothes washer		17	27	18	350
Improve efficiency of front loader clothes washer		17	27	18	110

Energy efficiency initiative	Definition	Life of initiative, years	Efficiency improvement before rebound, %	Efficiency improvement after rebound, %	Additional cost, $
Improve efficiency of dishwasher		10	30	20	300
Lighting					
Lighting code	Lights in new homes to be the most efficient available	15	75	58	260
Time switching outdoor lights	Fit time switches and motion sensors to all exterior lighting	15	75	58	200
Appliances					
Improve efficiency of freezer		20	17	15	10
Refrigeration efficiency		25	23	20	10
Remove spare refrigerator		25	100	85	200
Remove spare freezer		20	100	85	200
Consumer electronics efficiency		15	5	4	1,000
Standby power controllers		15	4	3	200

Note: Additional cost does not refer to the cost of purchasing an appliance, but to the additional cost incurred from purchasing an energy efficient appliance or fixture.

A key issue is the modelling of the maximum uptake or penetration rates for more efficient appliances and the speed at which uptake increases towards the maximum. Maximum rates are typically not 100% saturation rates. The assumed maximum penetration rates are provided in Table 2-2. In the reference case, these values are further reduced by the proportion of premises which are leased.

The speed at which uptake increases towards the maximum is modelled using a probability distribution to determine the proportion of the population that will find the measure to be cost effective based on energy consumption levels. This approach recognises that larger consumers are more likely to take up measures than smaller consumers, as a result of the greater energy savings likely to be experienced by this group of consumers.

The level of uptake is determined as a function of the payback period from adoption, and it is assumed that customers achieving or bettering required payback periods will take-up the initiative. The proportion of the market for which the initiative is cost-effective in terms of payback is assumed to be the proportion of the market that will uptake the initiative. This method allows heterogeneity of consumption to be considered explicitly. The consumption distribution chosen to reflect the skewed nature of electricity consumption was the log normal distribution, because it is suitable for estimating data structures on series naturally bounded by zero. IPART survey data was reviewed to determine reasonable approximations to the spread of the distribution used relative to average values. This approach considers that customers with the greatest benefit (i.e. those with largest levels of energy use), are more likely to take-up energy efficiency initiatives before customers with lower benefit. An illustration of this concept is provided in Figure B-1.

Consumers may require short payback periods because the value of the future energy savings is uncertain. Firms typically use higher hurdle rates for energy efficiency investments than the cost of capital to the firm, and this is equivalent to requiring a short payback period.[25] Uncertainty does not represent a market failure.

In this study, payback periods for each initiative are calculated by dividing the additional costs over the sum of energy savings over the initiative's estimated effective life. A 2006 study on organisational decision making about energy efficiency found that around half of economically beneficial measures recommended to firms are adopted.[26] In particular they reported that while commercial and industrial firms responded as expected to financial factors – payback periods, implementation costs, annual energy savings, energy prices – this could not explain the situation in total. There was evidence that the firms were more responsive to implementation costs than annual

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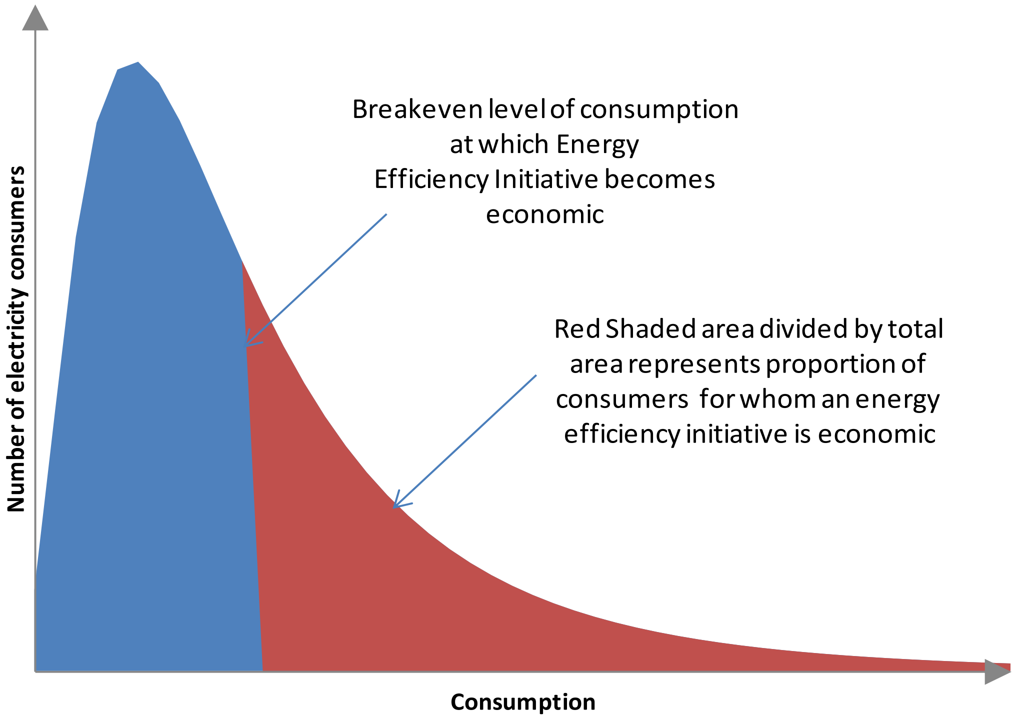
[25] S. DeCanio, 2009.

[26] Source: http://www.efa.com.au/Library/David/Published%20Reports/2006/OrganizationalDecisionMakingaboutEnergyEfficiency.pdf

savings, and to energy savings rather than to energy prices. Payback periods of two years or less were demanded and other barriers (including those defined as organisational), were described as not playing a large role in rejecting information provided under the programme.

Figure B-1 Heterogeneity of the energy efficiency market and the impact on uptake



In the commercial and industrial sector, there is also some evidence that the rate of uptake is a function of firm size. Larger firms were more likely to adopt energy efficient practices with higher payback periods as larger firms were more willing to take on risks .[27]

An IEA review study found that "in practice, the procedure to estimate potential energy savings requires detailed information about the population of existing equipment, their efficiencies, the patterns of usage, costs of various efficiency improvements and other factors affecting the cost-effectiveness of investments". This information is needed to create a supply curve for energy efficient initiatives.[28]

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[27] G. Watt and D. Crossley, 2006.

[28] IEA, 2007.

Many studies simplify the analysis by assuming similar attributes for residential and business customers. However, in practice the potential savings will vary among customers, depending on how they use their appliances.

In this study, differences in energy use profiles are considered by using the probability method previously described. The analysis has been broken down into different states and territories which have their own usage characteristics.

Sources for the data behind the assumptions on energy efficiency potential include:

- Australian Bureau of Statistics: Household numbers (Catalogue Number 4102) and appliance uptake proportions (Catalogue Number 4602: Environmental Issues: Energy Use and Conservation).
- National Framework for Energy Efficiency, 2003. *Background Report: Assessment of Demand-Side Energy Efficiency Improvement Potential and Costs*.
- George Wilkenfield and Associates. RIS reports to the NFEE on various proposals for MEPS.
- EMET, 2004. *Energy Efficiency Improvement in the Residential Sector*, report to Sustainable Energy Authority of Victoria.
- I. McNichol, 2003. *Residential Sector EEI Potential*, Sustainable Energy Authority of Victoria.
- Energy Rating Agency, which contains data on the energy use of appliances with different star ratings.
- *Choice* (various issues published over the last three years).
- Beacon, 2009.
- Energy ratings website (www.energyrating.gov.au).
- Prices for appliances from www.comparison.com.au and www.getprice.com.au.

B.2 Commercial sector

The technique for modelling the commercial sector mirrors that used in the residential sector and is therefore not repeated here. For the commercial sector, the model captured the following energy efficiency initiatives as shown in Table B-2, assuming a reference case default rebound estimate.

A description of each measure is provided below:

- *Retail refrigeration efficiency improvement*. This initiative involved increasing the rate of replacement of refrigeration facilities to world's best practise models.
- *Retail lighting efficiency*. This initiative involved the replacement of existing lighting in commercial buildings with the most efficient lighting available.

- *Retail air-conditioning upgrades*. This initiative comprised upgrades to air-conditioning systems (for both heating and cooling) on retail premises to higher efficiency systems.
- *Hospital lights replacement*. This initiative involved the replacement of existing lighting systems with more efficient alternatives.
- *Hospital air-conditioning replacement*. This initiative involves the replacement of existing hospital heating and cooling systems with a more efficient alternative.
- *Hospital wall insulation replacement*. This initiative involved upgrading wall and ceiling insulation in a hospital.
- *Other commercial building lighting upgrade*. This initiative involved the adoption of high efficiency lighting in other commercial buildings.
- *Other commercial building air-conditioning upgrade*. This initiative involved the adoption of high efficiency air-conditioning systems in other commercial buildings.

Table B- 2 Commercial sector energy efficiency initiatives[29]

Name	Energy end use category	Life of initiative, years	Efficiency improvement before rebound, %	Efficiency improvement after rebound, %	Additional cost per installation, $
Building Code – Com	Space	30	5	3	100,000
Retail Refrigeration Small	Refrigeration	30	15	10	5,000
Retail Lighting Small	Lighting	30	7	5	200
Retail Space Conditioning Small	Space	30	7	5	8,000
Retail Refrigeration Large	Refrigeration	30	15	10	10,000
Retail Lighting Large	Lighting	30	7	5	1,000
Retail Space Conditioning Large	Space	30	7	5	20,000
Wholesale Lighting	Lighting	30	7	5	1,000
Wholesale Refrigeration	Refrigeration	30	7	5	10,000
Hospital Lighting	Lighting	30	5	3	2,000
Hospital Space Conditioning	Space	30	7	5	200,000
Education Lighting	Lighting	30	7	5	2,000
Education Space Conditioning	Space	30	7	5	200,000
Office Lighting	Lighting	30	7	5	2,000
Office Space Conditioning	Space	30	7	5	10,000

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[29] Sources include: EMET, 2004. *The Impact of Commercial and Residential Sectors'* EEI's on Electricity Demand, report to Sustainable Energy Authority of Victoria, EMET, 2004. *Energy Efficiency Improvement in the Commercial Sub-Sectors*, report for Sustainable Energy Authority of Victoria, February, Australian Bureau of Statistics (various catalogues dealing with number of business enterprises), Report by PB Associates. 2008, to the Tasmanian Government highlighting energy use in Government buildings, EEO documents (2009 and 2010).

B.3 Industry

The technique for modelling the industrial sector mirrors that used in the residential sector and is therefore not repeated here.

The industrial, mining and agriculture sectors consume the largest proportion of energy used. These sectors account for 60% of total energy use in stationary energy activities. A 2010 report published by DRET on energy efficiency opportunities found that the majority of industrial energy efficiency savings were available in the mining sector, followed by manufacturing, metals and services sector.[30] Around 6.6% of savings were identified in the targeted areas of energy use overall, with 9.1% available in the mining sector, 5.4% in the metals sector, 7.4% in the manufacturing sector and 12.3% available in the services sector.

The energy efficiency potential in these sectors was modelled as a function of the level of energy improvement rather than on specified programs. On the basis of the DRET work, it was assumed that each sector could improve efficiency by 5% plus an additional scheme-based factor. Cost of take-up of a measure was estimated to approximate the potential described. This is because of the large range of initiatives available to reduce emissions and the lack of data on the potential improvement and the cost of each initiative, which can vary considerably by sub-sectors within industry and by plants within sub-sectors. The sectoral cost assumptions are outlined in Table B-3.

- **Table B-3 Industry sector energy efficiency assumptions**[31]

Sector	Life of initiative, years	Additional cost per installation, $
Agriculture	12	284,427
Mining	12	95,431,880
Wood, Paper and Printing	12	3,227,150
Petroleum, Coal, Chemicals	12	34,176,873
Non-Metallic Mineral Products	12	2,543,103
Metals	12	25,601,687
Machinery and Equipment	12	19,708,528

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[30] DRET. 2010. *First Opportunities – A look at results 2002-2008*.

[31] Source: SKM MMA analysis based on the potential for efficiency improvement described in DRET. 2010. *First Opportunities – A look at results 2002-2008*.

Appendix C Modelling of Energy Market Impacts

C.1 Analytical approach

Energy market modelling is to be conducted using SKM MMA's energy market database and modelling tools in conjunction with use of probabilistic market modelling software 'Strategist', licensed from Ventyx. Strategist represents the major thermal, hydro and pumped storage resources, and the interconnections between grid regions. Economic optimisation tools (both internal and external to Strategist) are employed to adjust interrelated elements of the model and iteratively derive a solution that is economically efficient. These elements may include thermal plant bids, uptake of renewable or thermal generation, and appropriate retirement of existing generation. Average hourly pool prices are determined based on thermal plant bids derived from marginal costs. Large-scale generation certificate prices are estimated outside of Strategist in SKM MMA's Renewable Energy Market Management Model (REMMA), and are based on the long run average cost of renewable generation.

Predictions of price and generation are driven by the supply and demand balance, with long-term prices being effectively capped near the cost of new entry on the premise that prices above this level provide economic signals for new generation to enter the market. Consequently, price drivers include carbon prices, fuel costs, unit efficiencies and capital costs of new plant. Prices will deviate from the new entry cost level based on the timing of new entry. In periods when new entry is not required, the market prices reflect the cost of generation to meet regional loads, and the bidding behaviour of the market participants as affected by market power. The market predictions developed take into account regional and temporal demand forecasts, generating plant performance, timing of new generation including renewable projects, existing interconnection limits, and potential for interconnection development.

Timing of new generation is determined through a generation expansion plan. SKM MMA used the PROVIEW module of Strategist for this task. A plan is developed that minimises the total cost of the generation system, similar to the outcome afforded by a competitive market. A number of iterations of PROVIEW are undertaken to develop a workable expansion plan, based upon an initial estimate of renewable generation. The expansion plan is refined to achieve a sustainable price path, applying market power where it is evident, and to obtain a consistent set of renewable and thermal new entry plant mix. The final expansion plan must meet reserve constraints in each region, and fall within maximum emergency energy and maximum loss of load hours outcomes. Generators are assumed to behave rationally: uneconomic capacity is withdrawn from the market and bidding strategies are limited by the cost of new entry. Infrequently used peaking resources are bid near Value of Lost Load, to represent strategic bidding of these resources.

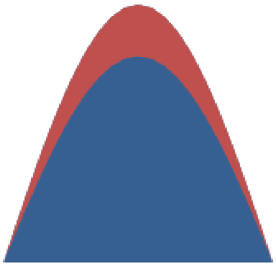
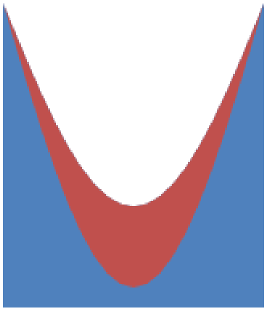
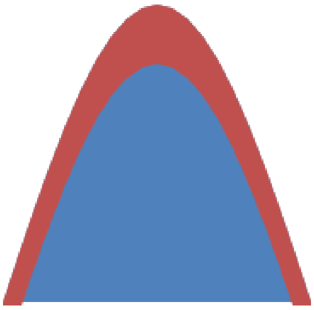
It is assumed that carbon capture and storage is not available until 2025/26. Generation from any nuclear process is assumed not to be available in the study period.

C.2 Modelling energy demand reductions

The NEEM model does not directly build a projection of energy use *per se*, but rather builds a projection of energy savings using a bottom up approach. The projection of energy savings is then deducted from the reference case total to achieve a final estimate of scenario demand.

This approach is also mimicked in the electricity market modelling, where the software will deduct the energy efficiency savings from the total in a manner that is appropriate for these savings. For example, space conditioning demand is most likely to occur in peak periods, and the software will allocate load deductions for this component of savings by peak shaving. Similarly, industrial load is more likely to occur in a 24-7 fashion, and therefore the load deductions will occur over all time periods. This approach allows modellers to realistically assess impacts on the electricity market as reductions to peak demand are likely to be more economically efficient for the generation industry.

- **Figure C-2 Load adjustment examples**

Peak Shave	***Off-Peak Shave***	***Flat Shave***
Used for residential water heating, space conditioning electronics, commercial lighting and space conditioning	*Used for residential water heating*	*Used for residential and commercial refrigeration, industrial applications*
		

Appendix D Modelling Assumptions

D.1 General assumptions

This section details the electricity market assumptions underlying the reference scenario for this study. This scenario will take into account:

- projections of State energy use by sector (based on work currently being completed for other Government departments including the DCCEE)
- current trends in the installation of energy efficient equipment and appliances
- efficiency of equipment in existing establishments
- trends in the efficiency of equipment installed
- current regulations (Federal and State) affecting energy efficiency (for example, MEPS)

D.2 Demand projections

Demand projections for the NEM were obtained from the AEMO, the market operator. Demand projections for the South -West Interconnected System (SWIS) in WA were obtained from the WA IMO, the market operator for the SWIS. Demand projections for NWIS were obtained from Horizon Power, while demand for DKIS and Mt Isa were obtained from published reviews.

The projections for the medium demand growth case show:

- demand growing at 2% per annum from 2011 onwards, reducing to 1.5% per annum from 2020 in the NEM
- demand growing at just under 3% per annum for the SWIS
- demand growing at 7% per annum in the NWIS until 2015, and then declining to 2% per annum to 2050
- demand for the DKIS was based on a review done in March 2010 by the Utilities Commission of Northern Territory, which employed a growth rate of 2.4% per annum until 2020
- demand for Mt Isa was obtained from an independent review of the region commissioned by the Queensland Government.[32] The majority of demand for Mt Isa comes from industrial mining load with underlying contractual agreements. Hence, demand generally grows over the contracting period then drops every 4 to 6 years, which is likely to correspond to expiration of contracts. Taking this into account, the overall average annual growth rate for the region up to 2030 is around 1% per annum.

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[32] Port Jackson Partners Limited (2009), page 21.

D.3 Gas prices

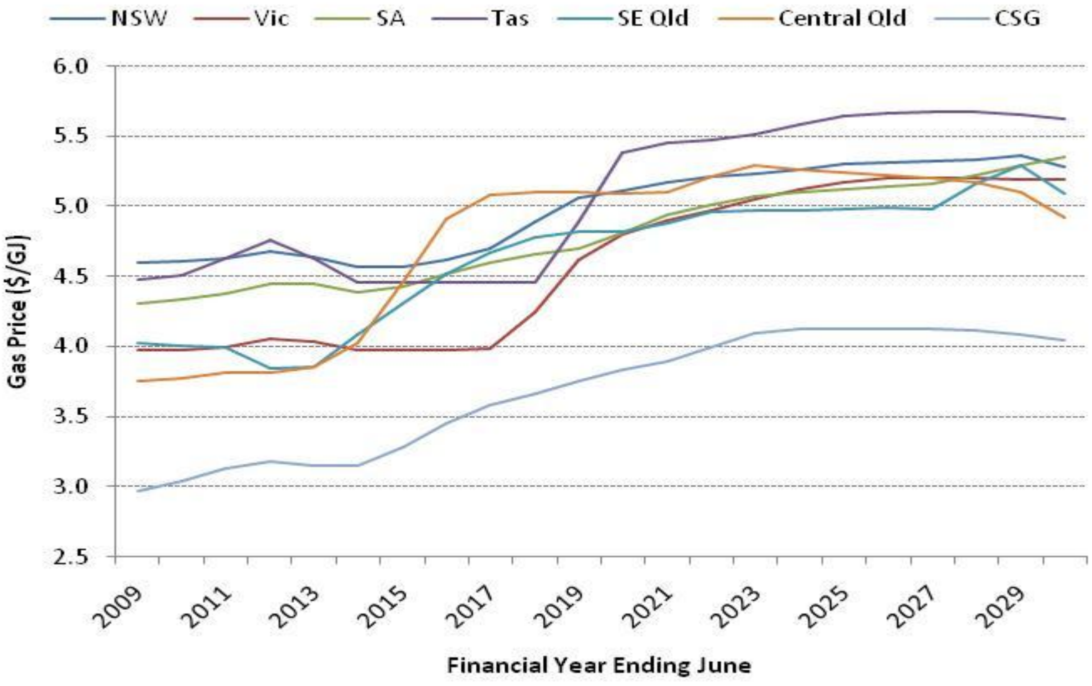
SKM MMA’s gas price are detailed in this section. SKM MMA’s in-house model, MMAGas (Market Model Australia–Gas), replicates the essential features of the Australian wholesale gas market. It has:

- a limited number of gas producers, with opportunities to exercise market power
- dominance of long-term contracting and limited short term trading
- a developing network of regulated and competitive transmission pipelines
- market growth driven by gas-fired generation and large industrial projects

MMAGas has been developed to provide realistic assessments of long term outcomes in the Australian gas market, including gas pricing and quantities produced and transported to each regional market. The “gas market” in MMAGas is the market for medium to long term gas contracts between producers and buyers, such as retailers or generators. Competition between producers is represented as a Nash-Cournot game, in which each producer seeks to maximise its profit subject to constraints imposed by its competitors. The role of buyers is replicated by modelling the activities of an arbitrage agent. Transmission costs are treated as cost inputs.

The gas prices for the Standard LNG scenario derived from the MMAGas model input into Strategist are shown in Figure D-1.

- **Figure D-1 City node gas price assumptions, base load factor**



Gas prices in the Western Energy Market are not widely published and often confidential in nature. SKM MMA has assumed prices to range between \$6/GJ and \$9/GJ for *new* base-load contracts. Existing contracts are at assumed contract price levels.

D.4 Abatement schemes

A major development with respect to renewable energy generation has been the expansion of the RET scheme to 45,000 GWh of additional renewable generation by 2020. The scheme is legislated, and its design has not changed substantially from the MRET scheme. The recent separation of small and large-scale targets will likely see an increase in the adoption of small-scale and large-scale renewable energy technologies in the period to 2020.

The Large-Scale Renewable Energy Target (LRET) is likely to encourage significant wind and biomass capacity over the next decade, which will meet a large proportion of demand growth. Substantial penetration of wind may necessitate additional open cycle gas turbine plants to provide reserve capacity for when the wind is not blowing. LRET has been legislated as a 41,000 GWh target with a maximum penalty for non-performance of \$65/MWh. This penalty is not indexed to CPI. The penalty is also not tax deductible, meaning that under current company tax rates, a liable party would be indifferent about the choice between paying the penalty and purchasing certificates at a price of \$93/MWh. To model the LRET scheme, we have assumed that the current scheme parameters under MRET would continue to operate with an increased target from 2010 onwards, and with an increase in the penalty price for non-compliance. The 41,000 GWh target continues until 2030.

The Small-Scale Renewable Energy Scheme (SRES) provides a fixed nominal price of \$40/MWh for small-scale systems such as solar water heaters and rooftop PV systems.[33]

Additional to the RET is Green Power, a scheme enabling any electricity purchaser to ensure that the energy they use is offset by the same amount of renewable generation. The energy covered by this scheme is additional to the RET.

D.5 Generation and market assumptions – NEM

D.5.1 Marginal costs

The marginal cost of a thermal generators consists of the variable costs of fuel supply (including fuel transport), plus the variable component of operations and maintenance cost. The indicative variable costs for various types of existing thermal plants are shown in Table D-1. SKM MMA also include the net present value of changes in future capital expenditure that would be driven by fuel

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[33] Uptake of solar and heat pump water heaters and rooftop PV systems under the SRES is treated in the model as a load modifier; that is, the amount these systems generate is subtracted from the total load.

consumption for open-cut mines that are owned by the generator. This applies to coal in Victoria and South Australia.

- **Table D-1 Indicative average variable costs for existing thermal plant ($June 2010)**

Technology	Variable cost $/MWh	Technology	Variable cost $/MWh
Brown coal – Victoria	$7 - $11	Brown Coal – SA	$23 - $29
Gas – Victoria	$45 - $65	Black Coal – NSW	$21 - $24
Gas – SA	$38 - $183	Black Coal - Qld	$8 - $23
Oil – SA	$268 - $330	Gas - Queensland	$26 - $103
Gas peak – SA	$103 - $185	Oil – Queensland	$258

D.5.2 Plant performance and production costs

Thermal power plants are modelled with planned and forced outages, such that overall availability is consistent with indications of current performance. Coal plants have available capacity factors between 86% and 95%, and gas-fired plants have available capacity factors between 87% and 95%.

D.5.3 Market structure

We assume the current market structure continues under the following arrangements:

- Victorian generators are not further aggregated
- NSW generators remain under the current structure in public ownership
- the generators' ownership structure in Queensland remains as public ownership
- the SA assets continue under the current portfolio groupings

Mt Isa is located in north-west Queensland and is not currently connected to the NEM.

Bidding of capacity depends on the contracting position of the generator. Capacity under two-way contracts will either be self-committed for operational reasons or bid at marginal cost to ensure that the plant is earning pool revenue whenever the pool price exceeds the marginal cost.[34] Capacity which backs one-way hedges will be bid at the higher of marginal cost and the contract strike price, again to ensure that pool revenue is available to cover the contract pay-out.

Contracts are not explicitly modelled. Rather, half to three-quarters of the capacity of base load and intermediate plants are bid at marginal cost to represent the contracted level. If this produces

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[34] Self-committed means that the generator specifies the timing and level of dispatch, rather than NEMMCO, and this is taken as a zero bid when setting pool prices. If generators are required to off-load below their self-commitment level, a negative pool price will be declared for generators and customers.

very low pool prices, then bid prices are set at a level higher than marginal cost to represent periods of price support that would be necessary to support the spot and contract market.

SKM MMA formulates future NEM development ensuring that the reserve requirements are met in each region at least cost. The minimum reserve levels assumed for each state are based on values specified in the 2010 ESOO and are summarised in Table D-2. The minimum reserve level for Victoria and South Australia combined is 615 MW, of which 50 MW has been allocated to South Australia to minimise the local reserve requirement. This means that Victoria must carry 665 MW when South Australia is fully relying on Victoria.

- **Table D-2 Minimum reserve levels assumed for each state**

Region	Qld	NSW	Vic	SA	Tas
Reserve level 2006/07	480 MW	-1490 MW	665 MW	-50 MW	144 MW
Reserve level 2007/08 – 2009/10	560 MW	-1430 MW	665 MW	-50 MW	144 MW

New entry prices include the impact of emission abatement schemes such as Gas Electricity Certificates (GECs) in Queensland throughout the period and the NSW Gas Abatement Certificates (NGACs).

Cost and financing assumptions used to develop the long term new entry prices are provided in Table D-3. The real pre-tax real equity return was 17% and the CPI applied to the nominal interest rate of 9% was 2.5%. The capital costs are generally assumed to escalate at CPI-1% until they reach the long term trend. New technologies have higher initial costs and greater rates of real cost decline up to -1.56% pa for IGCC. The debt /equity ratio is assumed to be 60%/40%. This gives a real pre-tax weighted average cost of capital (WACC) of 10.60 % pa. It is assumed that the higher risks emerging in the electricity generation sector from CPRS will require these higher equity returns.

The capacity factors in Table D-3 are deliberately high, to allow us to approximate a time-weighted new entry price in each state that can rapidly be compared to the time-weighted price forecasts to determine whether or not new entry would be encouraged to enter the market. These capacity factors do not necessarily reflect the levels of duty that we would expect from the units. The unit's true LRMC measured in $/MWh is higher than this level. For example, we would be more likely to find a new CCGT operating in Victoria with a capacity factor of around 60% to 70% rather than the 92% as indicated in Table D-3. Ideally, in determining the timing of new entry of such a plant we would compare the new entry cost of a CCGT operating at this level against the time-weighted prices forecast in the top 60% to 70% of hours. However, this would require more detailed and time-consuming analysis, and in our experience, it does not yield a significantly different price path.

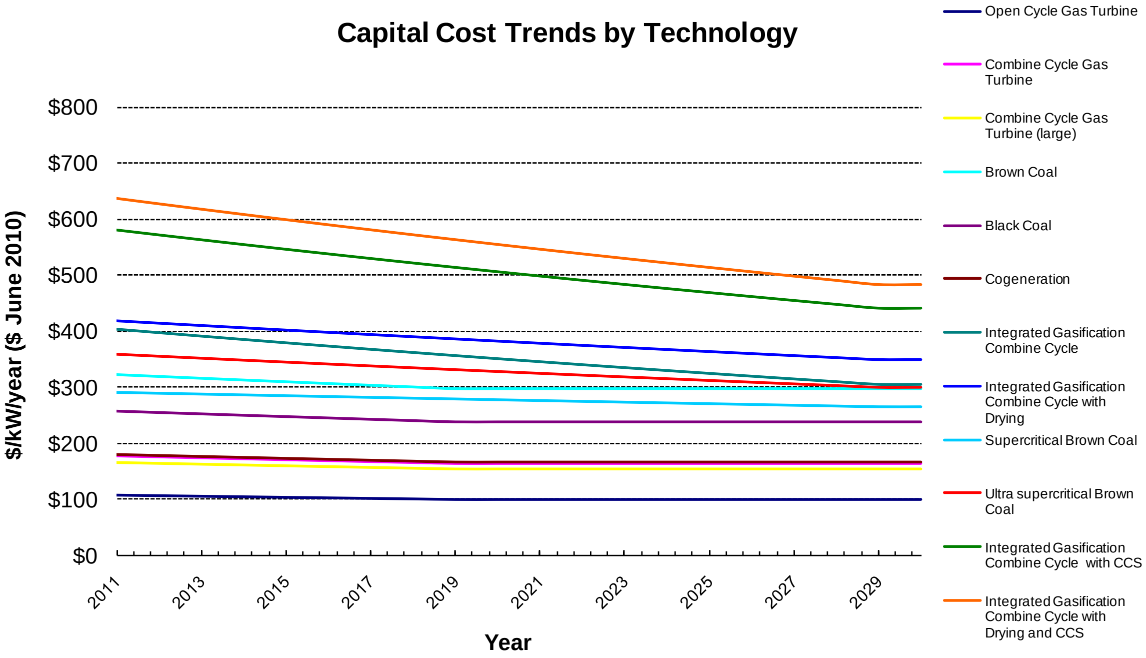
- **Table D-3 New entry costs and financial assumptions ($June 2010) for 2010/11**

	Type of plant	Capital cost, $/kW	Available capacity factor	Fuel cost, $/GJ	Weighted cost of capital, % real	Interest rate, % nominal	Debt level	LRMC $/MWh (c)
SA	CCGT (a)	$1,440	92%	$5.02	10.60%	9%	60%	$65.67
Vic	CCGT (a)	$1,367	92%	$4.40	10.60%	9%	60%	$56.00
NSW	CCGT (c)	$1,367	92%	$4.53	10.60%	9%	60%	$66.29
NSW	Black coal (b)	$2,143	92%	$1.51	10.60%	9%	60%	$57.41
Qld	CCGT	$1,369	92%	$4.58	10.60%	9%	60%	$43.27
Qld	Black coal (b)	$2,255	92%	$0.75	10.60%	9%	60%	$50.65

Note: fuel cost shown is indicative only. Gas prices vary according to the city gate prices.
(a) extension to existing site
(b) not regarded as a viable option due to carbon emission risk
(c) excluding abatement costs or revenues

Figure D-2 shows the trend in new entry fixed costs represented in the new entry cost modelling in June 2010 dollars.

- **Figure D-2 Trends in capital recovery costs for new plant ($/kW/year), June 2010 dollars**



D.6 Generation and market assumptions – Other Markets

The South West Interconnected System (SWIS) is the main electricity grid in Western Australia. This section details the assumptions underlying the scenarios for this study. The key assumptions for the scenarios are outlined in Table D-4. The gas prices are in accordance with the projections from the MMA-Gas model.

- **Table D-4 Key assumptions for the SWIS**

Feature	**Base**
Load growth	WA IMO medium economic growth
Gas prices	Standard forecast at world benchmark prices, which sees gas prices increase by 1% per annum in real terms (according to the IEA)
New entry capital costs	40% initial increase to base costs, declining at CPI-3% until they reach a CPI-1% long-term trend in real capital costs

The current high new entry costs are not expected to be sustained indefinitely. We expect prices to decline back at about CPI-3%, which means about constant in nominal terms, until they fall back to the long term trend of CPI-1%.

D.6.1 Trading arrangements

The wholesale market for electricity in the WEM is structured into:

- an energy trading market, which is an extension of the existing bilateral contract arrangements
- an ancillary services market to trade spinning reserve and other services which ensure supply reliability and quality.

The WEM is relatively small, and a large proportion of the electricity demand is from mining and industrial use, which is supplied under long term contracts. Because of these features, the bilateral contracts market continues to underpin trading in the WEM, with a residual day-ahead trading market (called the STEM) supporting bilateral trades. This residual trading market allows contract participants to trade out any imbalances, and also allows small generators to compete, despite their inability to secure contracts. Market participants have the option of either entering into bilateral contracts or trading in the STEM.

The ancillary services market is the responsibility of system management (WA IMO). The WA IMO is required to determine the least cost supplies to satisfy the system security requirements. Both independent generators and Verve Energy could be ancillary reserve providers, but at least initially it is envisioned that Verve will need to provide all spinning reserve under contract with system management.

All market participants pay for the ancillary services. In SKM MMA's WEM model, it is assumed that there is a market for trading spinning reserve. Providers receive revenue for this service, and the cost is allocated to all generators above 115 MW, with the largest cost disproportionately allocated to the largest unit.

In the SKM MMA model of the WEM, we ignore bilateral contracts and allow all generation to be traded in the market. The reasoning behind this is that the contract quantities and prices will be very similar to the market dispatch – otherwise one or other party would not be willing to enter the contract. Admittedly, contracts provide benefits from hedging that will not be reflected in the trading market. However, in the long run, the differences between contracts and the trading market will be minimal.

D.6.2 Generation assumptions – existing units

Verve Energy

Verve Energy has 11 power stations operating in the SWIS, as shown in Table D-5. The Muja stations operate as baseload stations with capacity factors of 70% to 95%. The Kwinana steam plants and the Mungarra gas turbine operate as intermediate plants with capacity factors of about 40%, while the Pinjar gas turbines operate as peaking plant with 10% to 20% capacity factor. Cogeneration plants are assumed to operate as must-run plants due to steam off-take requirements.

The South West Cogeneration Joint Venture is comprised of 50% Origin Energy and 50% Verve - Energy. Approximately, 30 MW of electricity in supplied to the alumina refinery, with the remainder being supplied to domestic customers. Steam from the cogeneration plant is used in the alumina refinery process and also in its own station. There is a 130 MW coal-fired plant owned by Worsley Alumina.

The Kwinana C power station burns both coal and gas, but this station is assumed to close in 2013.

The physical characteristics and the fixed and variable operating and maintenance costs for each plant are shown in the following tables.

- **Table D-5 Power plant operating assumptions**

Station	**Type**	**Capacity in summer peak, MW sent out**	**Fuel**	**Maintenance (%)**	**Forced outage (%)**	**Heat rate GJ/MWh**
Albany	Wind turbine	12 x 1.8	renew.	-	3	-
Collie A	Steam	304	coal	6	2	10.0
Muja C	Steam	2 x 185.5	coal	4	4	11.0
Muja D	Steam	2 x 200	coal	4	3	10.5
Kwinana C	Steam	2 x 180.5	coal, gas	4	6	10.8
Kwinana GT	Gas turbine	16	gas, dist	2	3	15.5
Pinjar A,B	Gas turbine	6 x 29	gas	6	3	13.5
Pinjar C	Gas turbine	2 x 91.5	gas	6	3	12.5
Pinjar D	Gas turbine	123	gas	6	3	12.5
Mungarra	Gas turbine	3 x 29	gas	6	3	13.5
Geraldton	Gas turbine	16	gas, dist	2	3	15.5
Kalgoorlie	Gas turbine	48	dist	2	3	14.5
Worsley	Cogeneration	70	gas	4	2	8.0
Tiwest	Cogeneration	29	gas	6	3	9.0

Note: Heat rates at maximum capacity and on a sent-out basis (that is, GJ of energy delivered per unit of electricity sent-out in MWh). Heat rates are on a higher heating value basis. Source: Western Power. *Annual Report, 2005-06*, Perth (and previous issues); estimates of maintenance time, unforeseen outages and heat rates for OCGTs and CCGTs are based on information supplied by General Electric and the IEA.

- **Table D-6 Fixed and variable operating costs**

Station	**Unit**	**Fixed costs ($000s/year)**	**Variable costs ($/MWh)**
Albany	0	0	
Collie	A	10,000	4.00
Muja	C	10,500	5.50
	D	11,000	5.00
Kwinana	C	16,000	7.00
	GT	1,000	9.00
Pinjar	A,B	1,000	4.00
	C	3,000	4.50
	D	3,000	4.50
Mungarra		1,000	4.00
Geraldton		500	5.00
Kalgoorlie		500	5.00
Wellington		0	5.00
Worsley		3,000	4.00
Tiwest		1,000	4.00

Source: Derived by SKM MMA to match operating and maintenance cost data contained in Verve Energy’s Annual Reports.

Other generators

Private generating capacity, including major cogeneration, is detailed in Table D-7. The capacity is mostly comprised of gas-fired generation. There has been a large increase in privately-run generating capacity due to substantial falls in gas costs and the gradual deregulation of the generation sector. Over the 1996-97 periods, some 324 MW of privately-owned generation capacity was commissioned, at Kwinana and the Goldfields.

The 116 MW BP cogeneration project commenced operation in 1996. The BP host takes 40 MW of power, with the remaining 74 MW of power being taken by Synergy under a long term take or pay agreement. About 3 PJ pa of fuel for the 40 MW portion of output will be natural gas purchased directly from the North-West Shelf Joint Venture, and other inputs will be refinery gas.

Power generation from gas in the Goldfields commenced in 1996. Southern Cross Power generates from 4 x 38 MW LM6000 gas turbine stations for its Mount Keith, Leinster, Kambalda nickel mines and its Kalgoorlie nickel smelter. The stations are expected to use about 14 PJ of gas pa (37 TJ/d), sourced from the East Spar field. Goldfields Power has constructed 110 MW of capacity (3 x LM6000 gas turbines) east of Kalgoorlie to supply the SuperPit, Kaltails and Jubilee gold projects.

- **Table D-7 Privately owned generating plant over 10 MW capacity in the SWIS**

Company	Fuel	Capacity in summer peak, MW sent out	Maintenance (weeks per year)	Forced outage (%)	Heat rate GJ/MWh
Alcoa	gas	212	3.8	2	12.0
BP/Mission	gas	100	3.8	2	8.0
Southern Cross	gas	120	3.8	4	11.7, 12.7
Goldfields Power	gas	90	3.8	1	9.5
Worsley	gas	27	3.8	2	8.0
Wambo Power	gas	350	3.0	2.0	7.4
Kemerton	gas, liquid fuel	308	1.0	1.5	12.2
Alinta Wagerup	gas	351	3.0	2.0	11.2
Alinta Pinjarra	gas	266	2.0	2.0	6.5
Bluewaters	coal	400	3.0	3.0	9.7

Source: Capacity data from publications published by the WA Office of Energy, SKM MMA analysis based on typical equipment specifications published in *Gas Turbine World*.

Most of the plants are located near major industrial loads. BP/Mission's cogeneration plant at Kwinana supplies electricity to Synergy. This cogeneration plant is treated as a must-run unit. Other units treated this way include Tiwest and Worsley. Both Southern Cross Power and Goldfield Power's plant in Kalgoorlie sell power to other industrial loads within the SWIS.

D.6.3 Generation assumptions – new units

To meet the anticipated growth in demand in the SWIS beyond 2011, additional generation plants will be required. Furthermore, Verve Energy has committed to retiring old and inefficient units: Kwinana B and Kwinana A have already been retired, and Kwinana C is mooted for retirement in 2013. However, Muja A/B has recently been recommissioned after an extensive refit program.

The additional capacity required could be met from a number of generation options:

- Open cycle gas turbines (OCGTs), which have low capital costs but require a premium fuel.

- Combined cycle gas turbines (CCGTs), which have lower operating costs than OCGTs due to their high efficiency.
- Coal-fired plant, which has the highest capital cost but low operating costs due to the competitive price of coal. These are likely to be similar to the two 200 MW units recently commissioned by Griffin Energy (the Bluewater Project).
- Cogeneration, which is efficient like CCGTs but also has an additional benefit from the steam supply.
- New CCGTs at Cockburn owned and operated by Verve Energy.

Additional renewable generation is determined as part of the renewable energy model for Australia as a whole. Additional renewable energy generation in WA competes with options in other states in Australia to secure additional revenue from the LGC market or from the emissions trading market.

Table D-8 Assumptions for new thermal generation options

Option	Life, years	Sent-out capacity, MW	Capital cost, $/kW so	De-escalator, %pa	Heat rate at maximum capacity, GJ/MWh	Variable O&M cost, $/MWh	Fixed O&M cost, $/kW
Black coal							
Subcritical coal	35	184	1,879	0.5	9.6	3	30
IGCC	30	187	2,673	1.5	9.1	2	44
IGCC with CC	30	180	4,688	1.5	11.4	3	50
Natural gas							
CCGT	30	235	1,467	0.5	7.4	3	22
Cogeneration	30	235	1,740	0.5	5.0	3	20
CCGT with CC	30	216	2,201	1.0	8.6	4	44
OCGT with CC	30	135	742	1.0	11.0	4	29

Note: CC = carbon capture. Sources: IEA and SKM MMA database of project capital costs.

D.6.4 Fuel assumptions

All assumptions on fuel usage and unit costs are based on the higher heating value (or gross specific energy) for each fuel.

Coal prices after 2010 are assumed to be $45/t on a delivered basis with an energy content of 19.3 GJ/t. This coal price is SKM MMA data based on market knowledge. Coal prices are assumed to increase by 1% per annum in real terms.

Gas supply will be priced at $7.00/GJ in 2010, with the price escalating at 1% per annum in real terms. These assumptions are based on market data, with the gas price escalations based on IEA projections of real world gas prices. The transport charge is $1.10/GJ escalating at 75% of CPI.

All stations owned by Goldfields Power and Southern Cross Power are modelled to use gas with a well head price $7.00/GJ in 2010, escalating at 1% per annum in real terms. The gas transmission charge is assumed to be $3/GJ for gas supplied to the Goldfields region, reflecting the distances gas needs to be transmitted in this region, deflating at 75% of the CPI.

For more information please contact:

AUSTRALIA - Walter Gerardi

T: +61 3 8668 3081 E: wgerardi@skm.com.au

www.skmconsulting.com

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