DEPARTMENT OF CLIMATE CHANGE AND ENERGY EFFICIENCY

Energy Market Modelling of National Energy Savings Initiative Scheme – Assumptions Report

December 2011

SINCLAIR KNIGHT MERZ
SKM MMA

Contents

1. Introduction 1

 1.1. Making a submission 2

2. Literature Review 3

 2.1. Estimating the energy efficiency gap 3
 2.2. Modelling approaches 5
 2.3. Implications for modelling 8

3. May report – methodology and assumptions 9

 3.1. Overview 9
 3.2. ESI scheme costs 10
 3.3. ESI scheme benefits 12
 3.4. How the NEEM addresses the energy efficiency gap 15
 3.5. Underlying energy demand 16
 3.6. Estimating energy efficiency savings 16
 3.6.1. Market size considerations 16
 3.6.2. End-uses 17
 3.6.3. Payback periods and threshold payback periods 18
 3.6.4. Estimating the uptake of energy efficiency activities 19
 3.7. Residential and commercial energy efficiency activities 20
 3.8. Industrial energy efficiency 26
 3.9. Analytical approach to modelling Electricity Market Impacts 27
 3.10. Modelling energy demand reductions 28

4. Recent developments to methodology and assumptions 31

 4.1. Modelling of electricity network impacts and peak demand 31
 4.1.1. Revisions to load factors 31
 4.1.2. Treatment of electricity distribution networks 32
 4.1.3. Deferred transmission benefit 34
 4.2. Gas market impacts 35
 4.3. Changes to energy efficiency activity assumptions 36
 4.4. Summary of changes to assumptions since previous report 40

Appendix A Data sources 42

Appendix B Load factor tables 44

Appendix C Energy market modelling assumptions 46

Appendix D NSW electricity grid peak demand savings assumptions 56

List of Tables

- Table 3-1 Summary of scenarios modelled 11
- Table 3-2 Estimated rebound effects 14
- Table 3-3 Residential sector energy-efficient activities, 21
- Table 3-4 Commercial sector energy efficiency activities 24
- Table 3-5 Industry sub-sector savings potential based on DRET study 26
- Table 3-6 Industry sub-sector savings potential based on DRET study 27
- Table 4-1 Value of deferred transmission and distribution expenditure 35
- Table 4-2 Recent adjustments to residential activity assumptions 36
- Table 4-3 Recent adjustments to commercial activity assumptions 37

List of Figures

- Figure 2-1 Sample marginal cost curve 5
- Figure 3-1 Heterogeneity of the energy efficiency market and the impact on uptake 19
- Figure 3-2 Load adjustment examples 29
- Figure 4-1 Seasonal parameters employed for area heating and cooling 39
- Figure 4-2 Relationship between cost and savings for a sample of Australian industries 40

Document history and status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
1	28/11/11	W Gerardi	W Gerardi	28/11/11	Draft
2	7/12/11	L Parisot	W Gerardi	7/12/11	Final Draft

Distribution of copies

Revision	Copy no	Quantity	Issued to
1	Not applicable	Electronic	C Golding, DCCEE
2	Not applicable	Electronic	C Golding, DCCEE

Printed:	14 December 2011
Last saved:	14 December 2011 11:08 AM
File name:	SH43200 Assumptions Report Final.docx
Author:	Liisa Parisot
Project manager:	Liisa Parisot
Name of organisation:	DCCEE
Name of project:	Energy market modelling of national Energy Saving Initiative Scheme
Name of document:	Energy market modelling of national Energy Saving Initiative Scheme
Document version:	Assumptions v2
Project number:	SH43200

GLOSSARY

Item	**Definition**
Activity	In this report, an activity refers to any single energy-saving action that may reduce energy consumption, regardless of the form of that action. Examples include replacing standard efficiency equipment with high efficiency equipment, and installing equipment or materials that reduce energy requirement (eg insulation, standby power controllers, and thermostats).
Additionality	Level of energy savings attributable to an energy efficiency policy, above what may have happened without the policy.
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
CCGT	Combined Cycle Gas Turbine
CPI	Consumer Price Index
CPM	Carbon Price Mechanism
DCCEE	Department of Climate Change and Energy Efficiency
DKIS	Darwin-Katherine Interconnected System
DNSP	Distribution Network Service Provider
DRET	Department of Resources, Energy and Tourism
DSM	Demand-Side Management
Energy Efficiency Gap	A collective term identifying the amount of energy savings not available from energy efficiency activities as a result of market failures and barriers.
EEO	Energy Efficiency Opportunities program
ESI	Energy Saving Initiative
ESOO	Electricity Statement of Opportunities, a document published by AEMO to provide information on the electricity demand and supply situation in the NEM
ETS	Energy Trading Scheme
“Free riders”	Consumers who accept rebates for taking up an energy efficiency activity when they might have taken up the activity without the rebate.
GJ	Gigajoule
IMO	Western Australian Independent Market Operator

Item	Definition
kW	Kilowatt
LGC	Large-scale Generation Certificate (formerly known as Renewable Energy Certificate or “REC”)
LRET	Large-scale Renewable Energy Target
LUACs	Large User Abatement Certificate
MEPS	Minimum Energy Performance Standards
MRET	Mandatory Renewable Energy Target
NEEM	National Energy Efficiency Model
NEM	National Electricity Market
NGAC	New South Wales 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 or GEC	Queensland Gas Electricity Certificate
QNI	Queensland and New South Wales Interconnect
SHW	Solar hot water
SME	Small-to-medium enterprise
SRES	Small-scale Renewable Energy Scheme
STC	Small-scale generation trading certificate
SWIS	South-West Interconnected System (in Western Australia)
VEET	Victorian Energy Efficiency Target
VoLL	Value of lost load. It has been redefined as the “market cap price” and, as of 1 July 2010, has risen to $A12,500/MWh.
WACC	Weighted average cost of capital, defined in real terms and pre-tax in this report. It is defined as: $\frac{\text{equity} \times \text{real return on equity} + \text{debt} \times \text{real interest rate}}{\text{total capital invested}}$ and is used as a discount rate to annualise the capital costs over the expected

Item	Definition
	technical operating life of the project.
WEM	Western energy market
"White Certificate Scheme"	A policy approach that encourages the uptake of energy efficiency. Under the approach, "white certificates" are tradable documents certifying that a given reduction of energy consumption has occurred. Most schemes include an obligation from liable parties to achieve a certain target of energy savings, or pay a penalty. The certificates are a unique and traceable commodity carrying a property right over a given level of additional energy savings, and guarantee that the benefit of these savings has not been accounted for elsewhere.

1. Introduction

The Australian Government has committed to undertake further work on a national Energy Savings Initiative (ESI) as part of its Clean Energy Future Plan announced on 10 July 2011. A decision concerning whether to introduce a transitional national ESI that would replace existing and planned state energy efficiency schemes will be subject to detailed consultation on the design of such a scheme and the consideration of the Council of Australian Governments. The Department of Climate Change and Energy Efficiency (DCCEE) has commissioned SKM MMA to provide economic and energy market modelling of the impacts of this initiative.

This report outlines the assumptions and methodology employed in SKM MMA’s previous study for the DCCEE (“The Energy Savings Initiative and Energy Markets”, May 2011), as well as areas in which the assumptions have been improved and could possibly further improve. This report also includes a literature review which informs policy makers on recent updates to the study of energy efficiency policy and practice.

It is anticipated that the scheme will require energy retailers to purchase energy savings certificates, which are created when energy efficiency activities are implemented by businesses and consumers. The certificates are remitted by retailers in amounts proportional to their annual energy sales. Each certificate would represent one unit of energy or emissions saved through a recognised energy savings activity. Accredited certificate providers would have the right to create certificates by conducting one of these activities, and the certificates can be traded to liable parties.

The scheme would provide benefits from reduced fuel usage in electricity generation to reduced usage of other fuels such as gas, distillate and coal. It may also reduce overall energy usage as a result of fuel switching.

SKM MMA will:

- Review model assumptions
- Conduct modelling
- Prepare a draft and final report describing the analyses undertaken

These requirements will be undertaken in three stages. The first stage will provide greater clarity of the assumptions and enable three levels of review and adjustment of these assumptions. The second stage will involve the development of suitable scenarios and possible improvement of the energy efficiency and energy market models. These models enable, and are required to be presented as, a transparent and replicable process in the final reports and presentation to the DCCEE which make up the third stage of the work.

In parallel to this modelling project, two substantial work streams are also being undertaken to improve the inventory of energy efficiency activities available in the industrial, commercial and small/medium enterprise sectors. This expanded inventory will refine and augment the existing sets of activities (see section 3.7 and section 3.8) and enable more accurate marginal cost curves for these sectors to be derived.

1.1. Making a submission

All organisations, firms and individuals who have an interest in the modelling of a national ESI are invited to make a submission on any topic that is raised in this report. Submissions may relate to alternative approaches to the modelling methodology or its underpinning assumptions and data. Where possible, submissions should include evidence, such as relevant data and documentation, to support alternative approaches.

Anyone wishing to prepare submission in response to this report should refer to the DCCEE website for further information on how submissions should be lodged, and regarding the closing date for submissions.

2. Literature Review

This section provides a literature review of recent work in the modelling of energy efficiency policy and uptake. The review focuses on:

- broad issues concerning the modelling of energy efficiency uptake; and
- different modelling approaches that have been applied elsewhere in modelling energy efficiency policies.

2.1. Estimating the energy efficiency gap

The energy efficiency gap is defined as the difference between the actual level of energy efficiency and the level of energy efficiency believed to be achievable and affordable[1]. The potential energy efficiency is typically determined through technical studies comparing the benefits and costs of adopting more efficient appliances.

Determining the size of this gap is the most contentious issue in energy efficiency modelling work. Assumptions concerning the size of the energy efficiency gap will have direct implications for how optimistic the modelling approach is in representing the size of realisable energy efficiency gains. One overview study[2], found that realised energy efficiency savings can be as low as 25% of theoretical savings, although, as stated by the authors, "*alternative assumptions about behaviour and institutions can lead to strikingly different results, even though one applies the same assumptions about technology costs and performances.*"

Contributing factors that modellers must consider when addressing the energy efficiency gap include:

- **The rebound effect**. When some of the energy saved is instead used to increase comfort, for example, using the heater for longer because it is now affordable to do so, or purchasing other energy using appliances with the money saved from using another appliance. Estimates suggest that the direct rebound effect ranges from 10% to 30% of the improved efficiency across a range of different OECD countries[3, 4].

---

[1] Productivity Commission (2005), *The Private Cost Effectiveness of Improving Energy Efficiency*, Productivity Commission Inquiry Report No 36, 31 August.

[2] H. Huntington (2011), "The Policy Implications of Energy-Efficiency Cost Curves", *The Energy Journal*, V32 (Special Issue 1), Oct 2011, pp 7-22

[3] H. Huntington (2011), op.cit.

[4] S. Sorrell and J. Dimitropoulos (2007), UKERC Review of the Rebound Effect, *Technical Report No5: Energy, Productivity and Economic Growth Studies*, UK Energy Research Centre.

- **The existence of market barriers that impede the ability of consumers to identify and take up energy efficient options**. These may include the lack or asymmetry of information, principal/agent barriers, organisational barriers, competition for capital, and other barriers[5]. For example, a consumer may not take up an energy efficient option because they would prefer to spend money on alternative priorities, such as to purchase another product or to expand their business. Another consumer may not take up an energy efficient option because of the costs associated with the time needed to research and purchase the option, or because of the perceived loss of amenity (for instance, lighting quality) that may be associated with some activities.
- **Inertia and slow adoption of new technology**. As noted in the Stern Review,[6] individuals and firms are not always able to make effective decisions involving complex and uncertain outcomes. This can occur even when they have the necessary data, as 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.
- **Realistic upper limits to market share**. There may be segments of the population for which there will never be sufficient interest or incentive to undergo a financial evaluation of options, or to assess the degree of risk and uncertainty that may accompany a given option. Some modellers apply limits within a specified time.
- **Heterogeneity in the market**. Some activities will never be cost-effective for small energy consumers, for whom expenditure on energy is a small proportion of total household or business expenditure. Therefore, representing these consumers with an average value will yield unrealistic results and some modellers exclude customers with higher-than-average costs within any given end-user category.
- **Fuel and power market responses to large reductions in aggregate energy use**. Large aggregate reductions in energy use can reduce a consumer's energy costs, with the result that there are fewer benefits to be gained from further investments in high-efficiency technology.
- **“Free riders”**. Free riders are consumers who take advantage of rebates when they would have made the choice of a higher efficiency activity without a scheme. These consumers can reduce the energy savings achieved by the scheme and divert subsidies away from projects that provide genuine savings. Free riders reduce the additionality of energy savings provided by a given scheme.

---

[5] Productivity Commission (2005), op.cit.

[6] Stern Review (2006), Report on the Economics of Climate Change, pp 380-381.

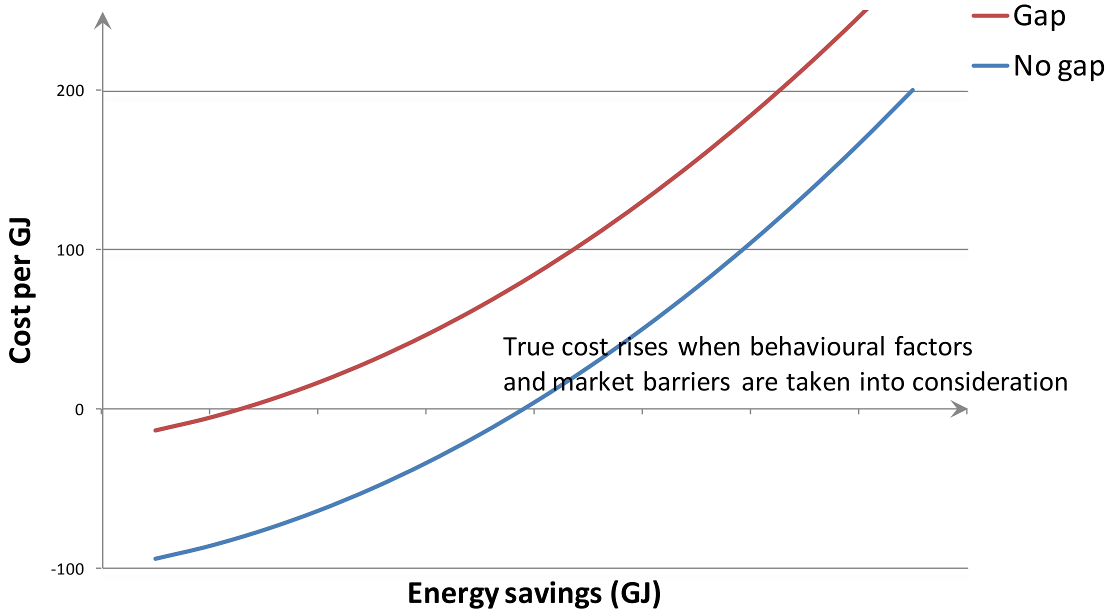
2.2. Modelling approaches

Three main types of modelling approaches are typically used: marginal cost curves, computable general equilibrium modelling and hybrid models.

2.2.1. Marginal Cost Curves

A sample marginal cost curve is provided in Figure 2-1, which also displays the resulting possible impact on cost arising from the energy efficiency gap. Marginal cost curves are based on technical or engineering cost analysis of all the energy efficient appliances and practises available. Technical cost analysis is a simple approach that outlines the technical and financial parameters of energy saving options. The analysis is based on the discounted cash flows for each option. Net returns of each option are calculated as a function of installation (capital) cost, ongoing costs and energy use. The energy savings are determined by comparing two alternative models (the less and more efficient options) and determining whether the more efficient option is cost-effective (that is, leads to lower overall energy use costs because higher energy savings outweigh the additional installation cost). A cost curve is then built by stacking up all available options from most beneficial (least net cost) to least beneficial (highest net cost). A recent example is in McKinsey (2007), which used this approach to determine abatement options for reducing greenhouse gas emissions, and found that 40% of US emissions could be reduced for less than $50/t, with a high proportion coming from energy efficient options at net negative cost.

- **Figure 2-1 Sample marginal cost curve**



The marginal cost curve approach has the advantage of being simple and easily understood. It indicates the potential for energy efficient options, with the corollary being that options with net negative costs should be adopted. Where net negative cost options are not adopted, this suggests evidence of some barrier.

However, there are several limitations to the marginal cost curve approach, including[7]:

- Marginal cost curves are based on technical and financial evaluations and do not take into account behavioural patterns. For example, they may not take into account the amenity of appliances to end-users.
- Technical estimates of energy savings may be overstated as they are typically based on trial conditions rather than the real (and varied) environments that appliances operate in.
- The approach does not consider the fact that there is a wide variation in the usage patterns of appliances across different end-users. That is, energy use and therefore energy savings will differ amongst end-users.
- Marginal cost curves do not account for other costs of adoption (such as management time in sorting and comparing various options).
- When used for policy analysis, marginal cost curves do not consider the compliance costs and administration costs of the scheme.
- Do not account for the interactions between different energy efficient options.

More recent[8] approaches have attempted to overcome these limitations by including transaction and compliance costs, consider other factors in end-user choice through application of different choice criteria (e.g. shorter payback periods) as well as using a range of technical estimates.

2.2.2. Computable general equilibrium models

Computable general equilibrium models are computer-based models of the economy as a whole which map the interactions between various sectors. The models are rich and data-intensive and are used extensively in policy analysis to estimate the economy-wide impacts of policy changes[9]. They are useful in that they can model reactions to energy efficiency policies (e.g. the rebound effect and behavioural responses) implicitly as well as the interaction between energy efficient options.

---

[7] M. Jaccard (2010), “Paradigms of energy efficiency’s costs and their policy implications: déjà vu all over again”, Workshop on Modelling the Economics of Greenhouse Gas Mitigation, US National Research Council

[8] P. Kyle et. al. (2011), “The value of advanced end-use energy technologies in meeting United States climate policy goals”, The Energy Journal, Vo1 32 (Special issue 1).

[9] An example includes: The Allen Consulting Group (2004), Economic Impacts of a National Energy Efficiency Target: Simulations Using the Monash MMRF-Green Model, report to the Sustainable Energy Authority of Victoria, Melbourne

However, computable general equilibrium models often lack technical detail, relying on simple aggregations that mask other underlying causal factors (such as rebound[10]), or on historic trends which, for a variety of reasons, may not represent the current situation[11]. Another issue is that the way the models are structured can result in widely differing outcomes even when the same assumptions are used[12]. For example, models vary in the way the production function is represented. One study found results varying on the level of rebound from an energy efficiency program as follows[13]:

- With a Cobb-Douglas production function, energy conservation programs increase energy consumption (cause "backfire" or greater than 100% rebound). This arises because the technological progress generates enough additional economic activity so that overall energy use offsets the initial efficiency improvement.
- With other types of production functions (CES, Leontiff), the results are ambiguous, relying on the parameter values of the elasticity of substitution between energy and other inputs and share of energy costs in total costs of production, but typically show low rebound rates.

2.2.3. Hybrid modelling approaches

The third approach is the so-called hybrid approach. This approach is based on the computable general equilibrium approach, but with a more sophisticated representation of the energy sector that includes varying levels of technical details[14]. The details of the energy sector models vary, but most hybrid models typically allow some detailed modelling of the energy supply sector, thus allowing for more detailed responses in investment and use patterns. Modelling of consumption and uptake of energy efficiency is also more sophisticated, allowing for non-financial factors to influence decisions (typically through parameter values)[15].

---

[10] Schipper, L. (2000), "On the rebound: the interaction of energy efficiency, energy use and economic activity", Energy Policy, Volume 28, pp. 351 to 353; Schipper, L. and Grubb, M. (2000), "On the Rebound? Feedback Between Energy Intensities and Energy Uses in IEA Countries", *Energy Policy*, Volume 28, pp. 367 to 388

[11] Grubb, M.J. (1990),"Energy Efficiency and Economic Fallacies", Energy Policy, Volume 18, pp. 783 to 785; Grubb, M.J. (1992), "Reply to Brookes", Energy Policy, Volume 20, pp. 392 to 393.

[12] Brookes L.(1990),"The Greenhouse Effect: the Fallacies in the Energy Efficiency Solution", Energy Policy, Volume 20, pp. 199 to 201

[13] Saunders, H.D. (1992), "The Khazzoom-Brookes Postulate and Neoclassical Growth", The Energy Journal, Volume 13, Number 4, pp. 131 to 148

[14] Examples include: Musters (1995) Musters, A.P.A. (1995), The Energy Economy Environment Interaction and The Rebound Effect, Report ECN-I-94-053, Netherlands Energy Research Foundation, Petten, May; and Nystrom, I. (1995), Improving Specification of the Energy Economy Link for a Systems Engineering Model - Applications for Sweden, Thesis for the Degree of Licentiate of Engineering, Chalmers University of Technology, Goteborg, Sweden

[15] See for example: R. Murphy and M. Jaccard (2011), "Modelling efficiency standards and carbon tax: simulations for the U.S. using a hybrid approach", The Energy Journal, Vol 32 (Special issue 1).

2.3. Implications for modelling

In terms of the modelling for this study, the literature review highlights a number of issues to be considered. Estimates of the quantum and net benefit of energy efficiency can vary by modelling approach used, by the extent to which non-financial behavioural parameters are used and by variations in how the end-use sector itself is modelled.

Details of the approach proposed for this study are outlined in subsequent sections. In general, the approach adopted is a hybrid approach, with a two-tiered modelling approach. The first tier is a sophisticated model of uptake of energy efficient activities, which takes into account direct and indirect rebound effects, the interaction across efficiency options in determining net energy savings, and behavioural responses in terms of uptake rates and payback criteria required. The model also has a sophisticated representation of end-users, using distribution of end-uses patterns. This overcomes many of the issues associated with simple marginal cost curve analysis.

The second tier involves sophisticated models of energy markets. Inputs from the uptake model are input into these models to determine the wider energy market impacts.

Backing the modelling approach is the use of sensitivity analysis to test the robustness of the modelling results, a factor considered highly important in the literature[16]. Sensitivity analysis is important due to the lack of consensus on the actual importance of some of the key impacts (e.g. rebound affect) and the paucity of data to support some key assumptions.

---

[16] M.Jaccard (2010), op. cit

3. May report – methodology and assumptions

This section outlines the assumptions and methods that were used in the May report compiled by SKM MMA entitled “The Energy Savings Initiative and Energy Markets”. Further details are supplied in the appendices of this report where relevant.

3.1. Overview

The May study completed by SKM MMA examined the costs and benefits of a proposed ESI scheme. The study compared benefits and costs of five scenarios against a reference case, modelling the period from 2010 to 2050. Four of the scenarios differ with respect to permanence of the uptake activities, the level of rebound effect under each activity, and maximum levels of penetration of each energy-efficient activity. The other scenario was focussed on the residential sector and small to medium enterprises. Full details of each scenario are provided in Table 3-1.

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 scenarios were evaluated with respect to net energy market benefits, where the energy market included electricity generators and the gas and electricity transmission network. Household bills were also estimated using the energy market impact as a basis and compared.

The net economic benefit to the energy industry is calculated as follows:

Energy market benefits arise from reduced fuel costs (for electricity generation and other applications); reduced operating costs (electricity generation) and delayed investment in generation and transmission network infrastructure.

3.2. ESI scheme costs

The cost of the ESI scheme was estimated using the cost of compliance as a basis. This was done by using the cost of certificates plus an administration charge. Administration charges were assumed to be $0.70/GJ[17].

---

[17] This was estimated by SKM MMA from the Office of the Renewable Energy Regulator (ORER) annual report 2010, available from http://www.orer.gov.au/publications/2010-financial-report.html. However we note that the administrative charges are consistent with charges applied in the NSW scheme as reported on p. 56 in the recent IPART review of costs, published October 2011 and available at the following link: http://www.ipart.nsw.gov.au/files/IPART%20ESS%20Cost%20Effectiveness%20Analysis%20Final%20Report%20-%20For%20website%20upload%20-%20October%202011.PDF

- **Table 3-1 Summary of scenarios modelled[18]**

	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
Threshold 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 activities	n/a	-100%	-50%	-100%	-20%	-50%
Energy savings Actual/technical[19]	n/a	-15%	-15%	-15%	-15%	-15%
Rebound effect[20]	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[21]	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

---

[18] Source: DCCEE.

[19] 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

[20] Empirical data were used where available. Where these are unavailable, table values are used as default.

[21] The carbon price, provided by the Commonwealth Treasury and drawn from the “Mid Year Economic and Fiscal Outlook (MYEFO)” 2009-10, assumes a starting price of $25 (in 2010-2011 dollars), increasing at an average annual rate of 4.6 per cent.

3.3. ESI scheme benefits

Energy market benefits were estimated from:

- ***Savings in wholesale electricity generation market costs***, including fuel and carbon costs, deferred capital costs, operating costs. These items were estimated using SKM MMA's proprietary energy market models, adapted for each scenario. The models take into consideration impacts of the Renewable Energy Target (RET) scheme, energy market dispatch mechanisms and temporal impacts of the supply and demand balance. The modelling approach simulates generation and market price behaviour to provide realistic projections of fuel use, generation, emissions, wholesale electricity prices, and consequently retail electricity prices. A more detailed explanation of the wholesale electricity market models may be found in Appendix C.
- ***Savings in transmission network costs***. Two approaches were used. For interregional interconnects, the savings in upgrade costs were determined as part of the electricity market modelling. The market models choose between generation and transmission upgrades to meet load growth and reliability criteria. Data on upgrade costs for interconnects were obtained from the transmission planning statements published by the jurisdictional transmission planners. Second, deferments of intraregional upgrades were based on reductions in peak demand as a result of the energy savings initiative. Data on upgrade costs was sourced from documents published during regulatory tariff approvals for the transmission network service providers and on in-house knowledge of SKM technical staff. An estimate of $500/kW was applied to savings in projected growth of electricity demand. Alternative estimates are explored in Section 4.1.
- ***Savings in gas production and transmission costs***. The gas market models consider competitive behaviour, sources of supply, transmission networks and production capability and demand for gas, and provide realistic projections of gas prices and the impact on gas production and transmission infrastructure. Based on previous work conducted by SKM MMA an estimate of $1/GJ benefit was derived and applied to projected gas savings estimates.

Energy savings estimates were calculated using SKM MMA's National Energy Efficiency Model (NEEM). The peak demand impact of any activity in the NEEM is determined by applying load factors[22] to total energy savings of the activity. These load factors are provided in Table B-1 of Appendix B, while a more detailed explanation of how the peak demand impact is applied to the electricity market modelling is found in Section 3.10.

---

[22] A load factor represents the usage patterns of a given load type, and is measured as average energy use divided by peak energy use. Thus a load factor near to 1 is a very flat load, while a load factor near zero is a very peaky load, usually with far greater uncertainty of prediction. Peak demand savings are relatively easily derived from annual energy savings figures by dividing the annual savings by the number of hours in the year and the load factor.

NEEM estimates consumer benefit in taking up a range of policy activities, allowing for energy efficiency schemes and carbon policies that may affect adoption of each activity. Inputs to the model include policy parameters (such as carbon and certificate prices, scheme targets and deeming periods), marginal costs and energy savings associated with each activity, energy prices, underlying energy demand, stock-turn associated with each activity and numbers of residences and businesses. Further details on the NEEM assumptions specific to energy saving activities are provided in Section 3.6. These savings estimates were later converted to load reduction profiles for use in the electricity market models (for details see Section 3.10).

The NEEM categorised energy consumption by residential, commercial and industrial sector. The model adopted a relatively conservative approach with regard to uptake of activities, as it assumed that activities will be taken up when payback periods are very short – even less than the economic life of the equipment being adopted. These threshold payback periods were assumed to estimate the level of uptake that might have occurred when non-financial market barriers are overcome.

The threshold payback period reflects, in part, the market barriers affecting uptake of energy-efficient activities[23]. Threshold payback periods in most scenarios including the Central 1 scenario were assumed to be two years for activities applicable to residential customers and four years for activities applicable to commercial and industrial customers. The threshold was increased to three years for residential customers and five years for commercial and industrial customers in the high scenario only.

The threshold payback periods for commercial and industrial customers were chosen to be consistent with a price elasticity response of -0.3, based on a preliminary study conducted by SKM MMA. The preliminary study involved a simulation in which the consumption levels were monitored under a given cost curve. It was found that a payback period of 4.4 years was consistent with an electricity price elasticity response of -0.3 in that simulation for the commercial and industrial markets. The results confirmed that consumers require a short payback period, since the benefits of adoption should preferably be calculated over the economic life of the equipment.

While the rate of uptake of activities is determined using a payback approach, the order in which activities are assumed to be adopted is determined using net long run marginal costs. The order in which activities are undertaken is important as many activities are likely to interact. For example, setting a heater thermostat to a reduced maximum level will have a larger impact in an uninsulated home compared to an insulated home as energy use will be higher in the uninsulated home. The net long run marginal cost is determined to be the marginal cost of adopting the activity less the net present value (based on the lifetime of the option) of energy savings provided by the activity.

---

[23] G. Watt and D. Crossley, 2006. Case study: organizational decision making on energy efficiency. Energy Futures Australia. Source: http://efa.solsticetrial.com/Library/David/Published%20Reports/2006/OrganizationalDecisionMakingaboutEnergyEfficiency.pdg

The NEEM assumes there will be rebound effects associated with the uptake of energy efficiency, and therefore, the deemed savings are unlikely to be fully realised. Rebound effects occur when, for example, energy savings are sacrificed in favour of increased comfort, as would be the case with many space-conditioning activities. Table 3-2 displays rebound factors cited in the literature, which form the basis of the rebound assumptions used in the ESI modelling. In the Central 1 scenario, a default rebound factor of 20% is assumed for most activities except industrial (10%), residential space heating (22.5%), residential air conditioning (25%), residential lighting (8.5%) and refrigeration (0%). The default rebound factor was increased to 30% in the low case and reduced to 10% in the high case.

- **Table 3-2 Estimated rebound effects**

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

Source: IEA 1998; Greening, Green and Difiglio 2000. Cited in Geller and Attali.

To allow for technical overestimation of efficiency benefits, the rebound effect was boosted by an additional 15%. 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[24]. 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 technical bias component was estimated to be 15%.

Permanence indicates how well an activity continues to be taken up after the scheme has ended. Activities are likely to continue to have some impact even after a scheme has ended because of increased volumes and market acceptance of efficient technologies, lower replacement costs (compared with initial installation), and energy services industry capacity. This results in greater uptake of higher efficiency alternatives without the need for subsidisation. Permanence of activities

---

[24] R. G. Newell,2005, "Energy Efficiency Challenges and Policies", a paper presented at the 10-50 Solution: Technologies and Policies for a Low-Carbon Future, The Pew Centre on Global Climate Change and the National Commission on Energy Policy.

was assumed to remain at 50% to 2040 under the Central 1 and the HH and SME scenarios. However, this parameter was varied under alternate scenarios as it describes the ongoing acceptance of the merits of the scheme, so that only 20% of the impact of the scheme was lost under the high scenario and the impact of the scheme was completely lost under the low and Central 2 scenarios.

3.4. How the NEEM addresses the energy efficiency gap

The model attempts to address the energy efficiency gap issues addressed in section 2.1. of the literature review, by including parameters that will allow the modelling to more accurately represent realistic outcomes as opposed to ideal outcomes. The parameters included as they address each contributing element of the energy efficiency gap are as follows:

- **The rebound effect**. The realised energy savings are reduced by a rebound parameter (section 3.3).
- **The existence of market barriers that impede the ability of consumers to identify and take up energy efficient options**. Activities are only accepted by market participants if they have a payback period less than a nominated, threshold value.
- **Inertia and slow adoption of new technology**. The approach taken was to estimate the uptake of energy-efficient activities by considering the diversity of customer load and estimating the proportion of customers with large enough load to justify uptake. As the benefit attributable to rising power prices increases, the proportion of customers for whom the activity provides a low payback period also increases, roughly reflecting the slow but increasing adoption of energy efficiency. This approach also addresses **heterogeneity in the market**, as low energy consumers become excluded if the activity is not inexpensive.
- **Realistic upper limits to market share**. Upper limits on market share are incorporated in uptake estimates, with a default value in place.
- **"Free riders"**. This is perhaps the most difficult aspect of energy efficiency modelling because it is difficult to adequately assess how many free riders might be taking advantage of a scheme, and therefore it is also difficult to assess whether the energy savings from the scheme are additional to what might have occurred without a scheme in place. In a previous study the uptake was estimated without a scheme, and these energy savings deducted from each scenario's estimate of energy savings. However, this approach was considered to overestimate the amount of "free ridership" because market barriers can be significant. For example, one study[25] found that around half of economically beneficial activities recommended to firms are

---

[25] G. Watt and D. Crossley, 2006. Case study: organizational decision making on energy efficiency. Energy Futures Australia. Source: http://efa.solsticetrial.com/Library/David/Published%20Reports/2006/OrganizationalDecisionMakingaboutEnergyEfficiency.pdg

adopted, and that while commercial and industrial firms responded to financial factors, this could not explain the overall situation. SKM MMA assumed that only half of the savings estimated in the reference case without a scheme would have occurred without a scheme.

The energy efficiency gap includes one other element which has not so far been addressed - fuel and power market responses to large reductions in aggregate energy use. This occurs when large amounts of energy savings reduce energy prices so substantially that an elasticity response occurs and energy use does not increase as much as expected. The May study determined that small retail price reductions would occur relative to a reference case, reducing the value of energy efficiency investment, and potentially reducing the level of expected investment in energy efficiency that might have occurred. It would have been possible to model this effect further, by incorporating a feedback loop with reduced retail prices and revising the resulting savings and market benefits. However, the price reductions were relatively small compared to the year to year price increases experienced by energy consumers (as a result of increasing network and other charges) and therefore the impact of this energy efficiency gap element was considered to be immaterial in comparison to the contribution of the other elements.

3.5. Underlying energy demand

Electricity demand projections were based on AEMO 2010 demand projections, with further detail supplied in Appendix C. The 2008 Australian Bureau of Agriculture and Resource Economics (ABARE) fuel consumption data was used to segregate projections down by residential, commercial and industrial consumption. The work of DEWHA, '*Energy end use in the Australian residential sector'* (2008), which includes projections to 2020 for space conditioning, lighting, water heating, refrigeration, and consumer electronics, was used to further segregate sector loads to these end-use categories (where end-use categories describe the underlying purpose of energy use addressed by each energy saving activity).

3.6. Estimating energy efficiency savings

The aim of this section is to briefly describe the assumptions underlying the gas and electricity energy efficiency activities in the May study. The set of activities covers the residential, commercial and industrial sectors. This material was used to develop energy savings estimates which were subsequently used in the energy market models, enabling modellers to determine the impact of reductions on the energy sector.

3.6.1. Market size considerations

The first step in estimating energy savings is to determine the natural market size available to each energy efficiency activity. The rate of natural stock turnover, which was estimated from the product lifetime[26] or otherwise appropriate value[27], was used to determine the market size in any given year for each activity.

The market size calculation considers growing household numbers (in the residential sector) and growing site numbers (in the commercial and industrial sectors) over time by applying stock-turn ratios to projections of household numbers and site numbers. Where necessary, limitations on existing and new markets were made. For example, the activity of improving hot water service efficiency was applied to existing homes only, since standards require all new homes to install higher than standard efficiency hot water services.

The market size determines the number of consumers that will be considering either a standard or energy-efficient alternative. For example, the market size for replacing a clothes washing appliance is the number of consumers that will consider purchasing a clothes washer in a given year, energy efficient or otherwise. These consumers will be purchasing a clothes washer because they are replacing their old clothes washer or they are new to the market. In instances when existing market penetration of a given technology is not complete, appropriate adjustments to reduce market size are made using ABS data. One example where this occurred is the activity of purchasing a high efficiency dishwasher over a standard dishwasher. In this case, the appliance market share was only 60% of all homes so the energy efficiency market penetration was limited to 60% of all homes rather than using a default value. Where these limits were difficult to quantify, a default uptake limit of 85% was used.

3.6.2. End-uses

All activities are allocated to a given end-use. For example, draught proofing would be allocated to the space conditioning end-use because draught proofing reduces space conditioning energy consumption, while water heater insulation would be allocated to the water heating end-use because water heater insulation reduces water heating consumption. The underlying end-use consumption projections are then used as a baseline for quantifying the energy savings for each activity. For example, if insulation is going to reduce a household’s heating and cooling consumption by 30%, then 30% of the average space conditioning consumption is modelled as saved when a single household takes up insulation.

---

[26] The product lifetime dictates the natural time at which an appliance may be replaced. For example the market size for an appliance that lasts 10 years will be approximately 10% of all existing homes that own that appliance plus 100% of all new homes. If only 90% of all homes own a given appliance then the market size estimate will be reduced to 90% x 10% = 9% of all existing homes plus 90% of all new homes.

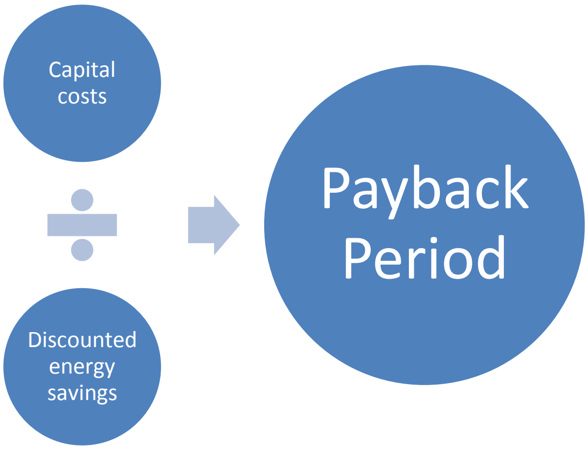
[27] In the case of insulation product lifetime was not viewed as an appropriate means of estimating market size. In this case a value of 50 years was assumed.

3.6.3. Payback periods and threshold payback periods

Payback periods are calculated for each energy efficiency activity. Inputs to the payback calculation include the following:

- The average percent energy savings for the respective energy end-use (before rebound effects). This is held constant over the projection period.
- Retail energy prices (including adjustments for carbon schemes in relevant scenarios).
- The average marginal cost of taking up an energy-efficient option relative to an alternative baseline option (ie ***not*** the cost of installing an energy-efficient option, but the difference in cost incurred relative to a baseline). The marginal cost is also held constant over the projection period.
- Any rebates applicable to the cost of taking up an energy-efficient option, arising from cash flows from sale of white certificates.
- The life of the option.

The payback period calculation does not include other gains that may occur as a result of taking up an activity. Examples of other gains include positive publicity, reduced water use, reduced operating and maintenance costs / increased productivity, reduced waste requiring disposal and reduced emissions. The payback period calculation is provided as shown below:



A threshold payback period is specified at which uptake will occur. The model then estimates the proportion of the market for which consumption is high enough to support a payback period at or less than the threshold payback period. This estimation method is described further in Section 3.6.4 and threshold payback periods for residential, commercial and industrial energy users are outlined at Section 3.3. Note that rebates that reduce the capital cost associated with an activity from the sale of white certificates are estimated using a nominated deeming period. If the life of the option is less than the nominated deeming period, then the life of the option will be used instead. Similarly the rebate is calculated on estimated energy reductions before rebound effects occur.

Energy savings are calculated for each projection year in the following forms:

- Deemed energy savings (pre-rebound) by fuel, for each of the years of the scheme.
- Realised savings (post-rebound) by fuel, for each of the years of the projection period.

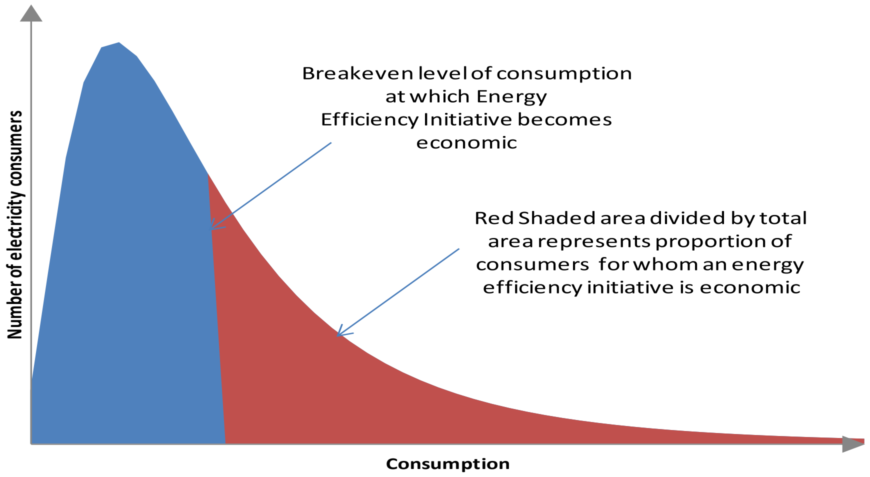
3.6.4. Estimating the uptake of energy efficiency activities

The level of uptake is determined as a function of the payback period of adoption. It is assumed that customers achieving or bettering required payback periods will take up the activity; that is, the proportion of the market for which the activity is cost effective in terms of payback is the proportion of the market assumed to adopt the activity. This method allows the heterogeneity of energy consumers to be considered explicitly.

The distribution chosen to represent consumption was the log normal distribution. The log normal distribution reflects the skewed nature of electricity consumption and is suitable for estimating data structures on series naturally bounded by zero. IPART survey data[28] was reviewed to determine reasonable approximations to the spread of the distribution used relative to average values.

This approach considers that energy consumers with the greatest benefit (ie those with largest levels of energy use), are more likely to take up energy efficiency activities before consumers with lower benefit. An illustration of this concept is provided in Figure 3-1.

- **Figure 3-1 Heterogeneity of the energy efficiency market and the impact on uptake**



Source: SKM MMA

---

[28] "Residential energy and water use in Sydney, the Blue Mountains and Illawarra, Report from the 2010 household survey", http://www.ipart.nsw.gov.au/files/Report%20-%202010%20HH%20survey%20report%20FINAL%20website%20-%20APD.PDF

3.7. Residential and commercial energy efficiency activities

A list of activities for the residential and commercial sectors, with a selection of cost-benefit assumptions, is provided in Table 3-3 and Table 3-4. The treatment of the industrial sector is outlined in Section 3.8. These activities have been updated since the May report, as outlined in Section 4.3.

The model is run for each of the activities in the domestic, commercial and industrial consumer market sectors. In each sector, the activities are run in ascending order according to net long run marginal cost. This is important as each subsequently applied activity will reduce the baseline average consumption to which energy efficiency activities will be applied, reducing the energy savings. If the energy savings of subsequently employed activities is reduced so too will the net economic benefit to consumers, possibly reducing uptake. A simple example of this can be made by comparing a wall insulation activity with the purchase of a high efficient space heater. If both activities are considered to reduce energy use for heating by twenty percent at the same incremental cost, then whichever activity is chosen first will reduce original heating energy use by twenty percent while the second activity will only reduce original heating energy use by sixteen percent, since 20% x (1 - 20%) = 16%. Even though both activities are equally attractive when considered in isolation, the second activity would be deemed to be more expensive.

The net economic benefit to consumers of taking up any activity will be impacted by the rebate received on sale of any white certificates. That rebate will of course depend on the white certificate price. For any given certificate price, the NEEM will estimate uptake of all relevant activities to each market sector and determine whether the target has been met. If the target is not met then the certificate price will be adjusted until the target is reached.

- **Table 3-3 Residential sector energy-efficient activities**[29],[30]

Energy efficiency option ***Definition***	**Life of activity, years**	**Stock turn (pa)**	**Efficiency improvement per site %**[31]	**Marginal cost of efficiency improvement (average site), $**	**Average associated annual site energy use, GJ**	**Average impacted electricity use per site, GJ**[32]	**Average impacted gas use per site, GJ**	**Average payback period**	**% of homes affected by activity**	**Limit on market penetration %**
Combined gas/electric space conditioning options										
Exceed building code *Increase minimum rating of shell*	50	2%	20%	2,000	12.3	8.6	3.7	10.6	100%	100%
Retrofit window shading *Shading to west and north faces of existing houses*	15	7%	6%	500	12.3	6.0	2.6	7.1	70%	100%
Retrofit roof space insulation *Retrofit of insulation to roof cavities*	50	2%	15%	1,920	12.3	2.7	1.2	>10	32%	100%
Sealing window draughts *Draught proofing*	20	5%	6%	209	12.3	6.9	2.9	2.0	80%	100%
Sealing door draughts *Draught proofing*	20	5%	6%	369	12.3	6.9	2.9	4.9	80%	100%
Retrofit wall insulation *Insulation in wall cavities*	50	2%	10%	1,569	12.3	0.9	0.4	>10	10%	100%
Retrofit floor insulation *Retrofit of insulation under floors*	50	2%	6%	1,920	12.3	0.9	0.4	>10	10%	100%
Film on windows	20	5%	8%	2,500	12.3	6.9	2.9	>10	80%	100%
Double glazing	20	5%	10%	25,000	12.3	7.7	3.3	>10	90%	100%

---

[29] Gas options highlighted in grey

[30] Refer to Appendix A for source lists

[31] Efficiency improvements are measured on the associated energy use. For example, if draft proofing is viewed as an activity to improve space conditioning consumption, then space conditioning demand will be reduced by draft proofing, rather than all household demand.

[32] Adjusted for the proportion of homes with appliance

Energy efficiency option ***Definition***	**Life of activity, years**	**Stock turn (pa)**	**Efficiency improvement per site %[31]**	**Marginal cost of efficiency improvement (average site), $**	**Average associated annual site energy use, GJ**	**Average impacted electricity use per site, GJ[32]**	**Average impacted gas use per site, GJ**	**Average payback period**	**% of homes affected by activity**	**Limit on market penetration %**
Double glazing with film	20	5%	15%	30,000	12.3	6.0	2.6	>10	70%	100%
Electricity saving space conditioning options										
Install high-efficiency ducted air conditioner	20	5%	15%	500	12.3	0.3	-	8.5	3%	12%
Replace electric radiator with stand-alone RC air conditioner *Savings apply only to the heating function*	15	7%	10%	710	12.3	0.3	-	>10		11%
Replace stand-alone air conditioner with solar air conditioner *Savings apply only to the heating function*	15	7%	80%	500	12.3	0.2	-	14.1		47%
Replace electric fan-forced heater with stand-alone RC air conditioner	15	7%	10%	690	12.3	0.3	-	>10		11%
Reduction of thermostats	15	7%	15%	5000	12.3	0.3				
Improve stand alone air conditioner efficiency	15	7%	20%	1000	12.3	0.3	-			
Improve efficiency of stand-alone electric heater	15	7%	10%	10	12.3	0.5	-	0		23%
Gas space conditioning options										
Install high-efficiency ducted space gas heater	20	5%	15%	400	12.3	-	4.1	>10	2%	4%
Replace electric radiator with gas heater	15	7%	10%	800	12.3	0.3	-	>10	2%	11%
Install high-efficiency stand-alone gas heater	15	7%	10%	65	12.3	-	2.0	5.8	16%	24%
Water heating options (both gas and electricity)										

Energy efficiency option ***Definition***	**Life of activity, years**	**Stock turn (pa)**	**Efficiency improvement per site %[31]**	**Marginal cost of efficiency improvement (average site), $**	**Average associated annual site energy use, GJ**	**Average impacted electricity use per site, GJ[32]**	**Average impacted gas use per site, GJ**	**Average payback period**	**% of homes affected by activity**	**Limit on market penetration %**
Water Heater Insulation *Fitting insulation to pipes and tanks in existing system*	15	7%	20%	200	10.9	7.6	3.3	0	100%	100%
Purchase High Efficiency Top Loader Clothes Washer	17	6%	27%	350	10.9	1.1	-	6.5	11%	74%
Purchase High Efficiency Front Loader Clothes Washer	17	6%	27%	110	10.9	0.2	-	5.8	2%	15%
Purchase High Efficiency Dishwasher	10	10%	30%	300	10.9	0.2	-	>10	2%	45%
Install High Efficiency gas water heater (electricity to gas)	15	7%	20%	500	10.9	8.2	-	0	75%	100%
Install High Efficiency gas water heater (gas to gas) *Replacement of existing electric hot water services with gas*	15	7%	20%	130	10.9	-	2.7	>10	25%	100%
Lighting options (electricity only)										
Lighting Code *Lights in new homes to be most efficient available*	15	7%	75%	260	3.3	3.3	-	0	100%	100%
Replace Inefficient Lights with High Efficient Lights	15	7%	75%	260	3.3	3.3	-	0	100%	100%
Time Switching Outdoor Lights *Fit time switches and motion sensors to all exterior lighting*	15	7%	75%	200	3.3	0.2	-	0	5%	30%
Refrigeration options (electricity only)										
Purchase High Efficiency Refrigerator	25	4%	23%	10	3.5	2.6	-	0	73%	100%

Energy efficiency option *Definition*	Life of activity, years	Stock turn (pa)	Efficiency improvement per site %[31]	Marginal cost of efficiency improvement (average site), $	Average associated annual site energy use, GJ	Average impacted electricity use per site, GJ[32]	Average impacted gas use per site, GJ	Average payback period	% of homes affected by activity	Limit on market penetration %
Purchase High Efficiency Freezer	20	5%	17%	10	3.5	0.7	-	0	19%	34%
Remove Spare Refrigerator	25	4%	100%	200	3.5	0.3	-	0	8%	34%
Remove Spare Freezer	20	5%	100%	200	3.5	0.7	-	0	19%	34%
Consumer electronics options (electricity only)										
Purchase High Efficient Consumer Electronics	15	7%	5%	1000	9.9	4.9	-	2.5	50%	100%
Install Standby Power Controllers	15	7%	4%	200	9.9	4.9	-	5.8	50%	100%

- Table 3-4 Commercial sector energy efficiency activities[33]

Energy efficiency option	Life of activity, years	Stock turn	Efficiency improvement per site%	Marginal cost of efficiency improvement (average site), $	Average site use, GJ	Impacted electricity use per site, GJ	Impacted gas use per site, GJ	Average payback years	Maximum penetration %
Exceed commercial building code	30	7%	5%	110,000	177	154	23	30	100%
Small retail options									
Small Retail Refrigeration	30	7%	15%	5,000	138	138	-	1.9	100%

---

[33] 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).

Energy efficiency option	Life of activity, years	Stock turn	Efficiency improvement per site%	Marginal cost of efficiency improvement (average site), $	Average site use, GJ	Impacted electricity use per site, GJ	Impacted gas use per site, GJ	Average payback years	Maximum penetration %
Small Retail Lighting	30	7%	50%	200	42	42	-	0	100%
Small Retail Space Conditioning (electricity to electricity)	30	7%	7%	8000	80	69	-	2.1	100%
Large retail options									
Large Retail Refrigeration	30	7%	15%	10,000	1,771	1,771	-	2.6	100%
Large Retail Lighting	30	7%	7%	1,000	535	535	-	1.3	100%
Large Retail space conditioning (electricity to electricity)	30	7%	7%	20,000	1,022	889	-	2.0	100%
Wholesale options									
Wholesale Lighting	30	7%	7%	1,000	63	63	-	0	100%
Wholesale Refrigeration	30	7%	7%	10,000	63	63	-	3.7	100%
Hospital options									
Hospital lighting	30	7%	5%	2,000	2,252	2,252	-	1.2	100%
Hospital Space Conditioning	30	7%	7%	10,000	2,252	2,252	-	1.2	100%
Education options									
Education Lighting	30	7%	7%	2,000	29	29	-	0	100%
Education Space Conditioning	30	7%	7%	200,000	60	52	-	3.2	100%
Office options									
Office Lighting	30	7%	7%	2,000	45	45	-	5.7	100%
Office Space Conditioning	30	7%	7%	10,000	25	22	-	>10	100%

3.8. Industrial energy efficiency

The industrial sector was modelled in a slightly different manner to the residential and commercial sectors, because the collected information for this sector is not as detailed. For the industrial sector, the activities are defined only by 'categories' of aggregate savings appropriate to each sub-sector of industry, rather than by individual activities that can be undertaken. For instance, the NEEM may consider one industrial activity as 'an improvement in the overall efficiency of a typical mining site by X per cent'.

In order to model using this approach, the NEEM requires information, for each industrial sub-sector, about the possible energy savings that can be generated at a typical industrial site; the cost of achieving those savings; and the market size within the sub-sector (that is, the number of industrial sites). In the May study, information about the potential savings in each industrial sub-sector was drawn from a 2010 report on the Energy Efficiency Opportunities (EEO) program published by the Department of Resources, Energy and Tourism (DRET), which found that the mining and agriculture sub-sectors consume the largest proportion of energy used. The EEO report found that the majority of industrial energy efficiency savings (when taken relative to assessed energy use) were available in the mining sector, followed by the general manufacturing and manufacturing metals sub-sectors.[34] Around 6.6% of savings were identified in the targeted areas of industrial energy use overall, with 9.1% available in the mining sub-sector, 7.4% in the manufacturing sub-sector, and 5.4% in the metals sub-sector as shown in Table 3-5. These savings potentials were assumed to be potential electricity and gas savings in each of the sub-sectors modelled.

- **Table 3-5 Industry sub-sector savings potential based on DRET study**

Industry sector	Savings as a percentage of sub-sector/site energy use
Mining	9.1
General manufacturing (used for wood, paper and printing, petroleum, coal and chemical, non.-metallic mineral products, and machinery and equipment sub-sectors)	7.4
Metals manufacturing	5.4
All sectors	6.6

Source: DRET, 2010 available from http://www.ret.gov.au/energy/Documents/energyefficiencyopps/PDF/EEO_FirstOpportunitiesReport_2010_FINAL.pdf

---

[34] DRET. 2010. *First Opportunities – A look at results 2006-2008*. Also EEO statements provided by participating loads.

Costs were assumed as shown in Table 3-6. These were based on previous work done by SKM MMA. Since the completion of the May report costs were reviewed using more recent data. See Figure 4-2.

- **Table 3-6 Industry sub-sector savings potential based on DRET study**

Sector	Life of activity, 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

Source: SKM MMA Analysis, based on data provided by the EEO program and DRET

The market size approach from the residential and commercial sector was adapted to this market, although the uptake method was adjusted to incorporate a significantly wider range of consumption levels, because it is the nature of the industrial sector to be dominated by a small number of very large participants (industrial site numbers were drawn from ABS data). There is one important difference in the modelling approach employed however, pertaining to the cost and availability of energy efficiency activities. This difference is that efficiency gains were assumed to be more expensive as time goes by and the least expensive opportunities have been taken up. At the time the May report was produced, SKM MMA did not have sufficient data available on the potential improvement and cost of energy efficiency activities on the diverse range of production methods and techniques being employed by industry. Various functions had been developed based on previous work conducted by SKM MMA, in which the cost of energy efficiency activities increased as the uptake of options increased.

3.9. Analytical approach to modelling Electricity Market Impacts

This section provides an overview of the electricity market modelling concepts, and should therefore assist the reader in understanding the main generation and price drivers in the electricity market. More detailed information about market modelling assumptions is provided in Appendix C. The models are designed to create predictions of wholesale electricity price and generation that are driven by the supply and demand balance, with long-term prices capped near the cost of the cheapest new market entrant. Price drivers therefore include carbon prices, fuel costs, unit efficiencies and capital costs of new plant. This occurs on the premise that prices above this level provide economic signals for new generation to enter the market.

The exact timing of new market entrants will impact on how far prices will deviate from the long run marginal cost of the lowest cost new entrant. 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 take into account regional and temporal demand forecasts, generating plant performance, and timing of new generation, including renewable projects, interconnection limits, and potential for interconnection development.

Timing of new generation is determined by a generation expansion plan, and is important to the study in that it quantifies any deferred generation infrastructure benefits. SKM MMA uses the PROVIEW module of Strategist for this. A plan is developed to minimise the total cost of the generation system, similar to the outcome of a competitive market. A number of iterations of PROVIEW are undertaken to develop a workable expansion plan, and the 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. The final expansion plan must also meet reserve constraints in each region.

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 the “value of lost load”, to represent strategic bidding of these resources.

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

The modelling paradigm described is likely to experience the following impacts from reduced demand from energy efficiency activities:

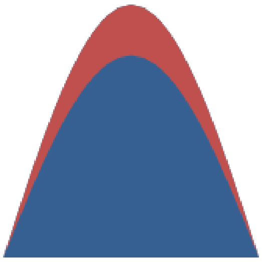
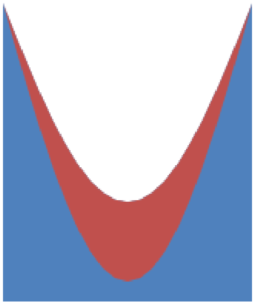
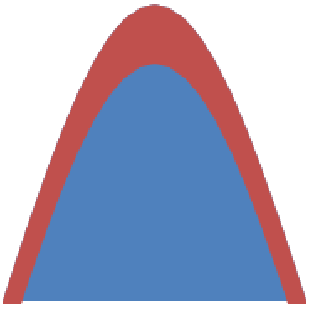
- Reduced demand may increase competition among existing generators.
- Delayed new entrant generators.
- Reduced wholesale prices.
- Reduced emissions occurring as a result of reduced generation.

3.10. Modelling energy demand reductions

The NEEM model does not directly build a projection of energy use, but builds a projection of energy savings using a bottom-up approach. The projection of energy savings will be deducted from the reference case total to achieve a final estimate of scenario demand.

The electricity market modelling also deducts energy savings from an underlying demand forecast, using one of three load shaving methods in the software (Strategist). Two of the methods – peak and off-peak shaving – require a peak input and an energy input. Under peak shaving, load above median demand is shaved in proportion to the load shape so the shaved load is consistent with the peak and energy values input by the user. Off-peak shaving works in a similar way, where load below median demand is shaved in proportion to the load shape so the shaved load is consistent with the peak and energy values input by the user. Flat shaving requires either a peak input or an energy input, and will reduce the load by a fixed quantity evenly over the profile, adjusting it so that the load never becomes negative. These methods are illustrated in Figure 3-2.

- **Figure 3-2 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*
		

For the electricity market modelling component of this work, the software deducts the energy efficiency savings from the total as appropriate for each activity. For example, space conditioning demand is most likely to occur in peak periods, so peak shaving was employed for this demand reduction.

By contrast, industrial load exhibits relatively little variation, and therefore, the software made a flat deduction over all time periods. This approach allowed modellers to realistically assess impacts on the electricity market, accounting for the fact that reductions to peak demand are likely to be more economically efficient for the generation industry. A more complete list of load shaving methods for each activity type, as employed for the May 2011 modelling for the DCCEE, is provided in Table B-1. Note that these values have been updated since this work was completed, and is shown in Table B-2.

4. Recent developments to methodology and assumptions

This section describes changes to the modelling assumptions and approach that have been developed since the May 2011 report.

4.1. Modelling of electricity network impacts and peak demand

4.1.1. Revisions to load factors

As before, electricity network impacts are determined using a two-step approach, in which the impact on the load shape is assessed, and the effect of reduced peak demand on transmission network infrastructure is evaluated.

However a recent improvement to the modelling approach provides a more detailed and informed assessment of the change to load shape, effectively modifying the load factors[35] used to convert saved energy estimates to estimates of saved peak demand. The modified load factors are provided in Table B-2. It is also possible to conduct chronological load profiling adjustments, in which a given profile of energy savings can be applied, to more accurately derive the benefit of time specific applications (such as lighting). However, this will be applied in the modelling to be undertaken only after information from stakeholders has been obtained.

In determining peak demand saving factors, SKM MMA assumed network peaks are summer daytime, and strongly coincident with hot weather events. While this is true for the Australian system as a whole, there are some areas of the network that still exhibit a winter evening (heating) peak. However, many of these areas are moving towards a summer peak, and the experience of the NSW DNSPs is that summer peaks drive the bulk of growth related expenditure.

Some of the complexities of peak demand savings that have been considered in SKM MMA's analysis for Table B-2 are:

- Some activities can save energy without reducing peak demand. Examples include lighting controls in commercial buildings (that will turn the lights off at night, but not during the day when peak demands occur), HVAC controls such as economy cycles (that reduce cooling load during mild weather but will have no impact on hot-day peaks), and hot water savings (with the bulk of electric water heating coming from off-peak water heaters).

---

[35] A load factor represents the usage patterns of a given load type, and is measured as average energy use divided by peak energy use. Thus a load factor near to 1 is a very flat load, while a load factor near zero is a very peaky load, usually with far greater uncertainty of prediction. Peak demand savings are relatively easily derived from annual energy savings figures by dividing the annual savings by the number of hours in the year and the load factor.

- For simple energy efficiency activities (higher efficiency lights, motors, chillers, etc), the savings will tend to be a uniform percentage of consumption at all times, and therefore, the profile of demand savings will match the energy consumption profile of that end-use. Fuel-switching activities will also have demand savings profiles that match the end-use load profile. The load factors of these end-uses are reasonably well established (within the energy industry), and are always between 0 and 100%.

For controls, load-shifting, interruptibility, and storage hot-water activities, the demand savings are more complex, and produce savings load factors that can range from 0% (high demand impact with no energy savings) to > 100% (energy savings with low peak demand impact – up to infinity for activities with no peak demand impact). No activities in this study required these load factors.

4.1.2. Treatment of electricity distribution networks

In addition to improved load factors, a new technique is now employed to estimate the impact of energy efficiency on the distribution network (as well as the transmission network). The methodology described has been used in other work for NSW only, and may be extended nationally as part of the current work for DCCEE. The approach effectively establishes three alternative estimates of distribution benefit per kW of avoided energy consumption, and, as there isn't a definitive figure for the value of network peak demand savings, uses the average of the three figures to represent typical network savings.

The value of peak demand reductions to the electricity network is a complex issue. While peak demands are responsible for driving a large proportion of network expenditure, their linkage is not always direct. Network capacity investments tend to be large due to inherent economies of scale, and, therefore, there will always be parts of the network with some spare capacity and where demand savings will have negligible impact or benefit. In other constrained parts of the network facing imminent capacity expansion the short-term marginal benefits can be very large.

Demand reductions will only have a practical benefit if they are sufficient to delay capacity investments. For example, in an area experiencing demand growth of 2 MW per annum, a demand reduction of 1 MW would be insufficient to allow the investment to be deferred in the short term, but may have a medium- to long-term effect.

Likewise, demand reductions must occur (and be known) within the planning and implementation timeframe of the networks businesses. Demand reductions that occur after a project is committed will generally have little benefit. Unless network planners are aware of the demand reductions there will again be a reduced practical benefit. For these reasons, some demand reductions will not always have a direct benefit (avoiding or deferring a local capacity investment to alleviate a network constraint), though may be of benefit in deferring the next investment, or another capacity constraint higher up in the network (for example, a regional sub-transmission or transmission constraint).

Some network projects are classified as “growth”, but underlying the project will be a range of planning issues, including security (to ensure grid reliability) or replacement of aged assets – that means expenditure cannot be deferred even if demand is reduced, though the replacement equipment may have a lower rating than would otherwise have been used.

Timing issues are also complex. Where demand is increasing steadily, reductions will tend to only defer expenditure, and the economic benefit is the time value of this deferral. If demand reductions are sufficient to halt growth, investments may be deferred indefinitely or avoided completely.

Due to the complexities discussed, there is no definitive approach to produce a value per kW of peak demand reduction. Depending on the timing and location in the network, the value can vary from zero up to several times the average capacity cost, with large project deferral values tending to lie within this range. To derive a representative figure that can be used for economic analysis, SKM MMA took a simple average of three alternative estimates. For further detail, see Appendix D.

- **Major project deferrals**. Using demand management screening tests published by the three NSW Distribution Network Service Providers (DNSPs), SKM MMA determined a range of savings per kilowatt of peak demand in locations where major expansion projects are imminent. Sixty-nine major projects from across the three NSW DNSPs were analysed to determine the value of project deferrals per kilowatt of peak demand reduction. Sufficiency (whether sufficient demand reduction is achieved to allow for a one-year deferral) was not considered. The range of costs determined reflected the value that can be achieved in constrained areas of the network facing an imminent capacity expansion. This is a forward-looking economic value of deferral (marginal cost of constraints).
- **Implied total system deferral value**. In determining the network peak demand impact of each of the NEEM energy efficiency activities, SKM MMA relied on several sources of representative demand impacts for various activities. During 2006 and 2007, SKM assisted the NSW Demand Management and Planning Project (DMPP), which was established to determine the potential for demand management to reduce network peak demands in the greater Sydney region[36]. As part of this project, 800 audits were conducted on large energy users; it was similar to an energy audit but with a focus on peak demand reductions rather than energy savings. SKM MMA considers this to be the most reliable source of data available on peak demand savings, and has used judgement and experience in measuring and verifying

---

[36] http://www.transgrid.com.au/network/nsdm/Documents/Standby%20Partial%20Load%20CBD%20Survey%20Report.pdf

energy and demand savings to determine appropriate load factors for activities not included in the DMPP studies. More specifically, a (simplified) model of an electricity network consists of a number of layers – low voltage, primary distribution, and sub-transmission. These layers are overlaid, each having to deliver sufficient capacity to the layer below to maintain reliable and secure supplies. Therefore, demand savings have the potential to reduce or defer expenditure in each of these layers. By classifying the major projects analysed above, SKM MMA determined an average deferral value for each layer, and added these values to determine the overall system deferral value. It is unlikely that all three layers would experience a constraint in any given area at the same time, so the practical impact would be deferred (and the economic impact discounted), but this approach estimates total potential system benefit.

- **Overall network average cost of growth expenditure**. SKM MMA also determined network average costs of meeting increasing peak demand, using the most recent Australian Energy Regulator (AER) NSW DNSP determination (for the period 2009-2014) to calculate the average growth expenditure per kilowatt of peak demand growth for each of the DNSPs. The data was used to determine the five-year peak demand increase and related growth expenditure for each of the NSW DNSPs. From these figures, SKM MMA derived an overall average per-unit cost of peak demand growth. This is a system average that reflects the growth that can occur at no cost in parts of the network with spare capacity as well as the cost of capacity investments. Essentially, it is a historical average cost per kilowatt of meeting growth in demand at the margin.

4.1.3. Deferred transmission benefit

An alternative source of the value of deferred transmission and distribution expenditure is provided by ISF and Energetics[37], shown in Table 4-1. These values are based on 5 year proposed system *augmentation* capital expenditure estimates for a large range of transmission network service providers. The report also qualifies that the NSW estimate is based on 'growth related' rather than augmentation expenditure, and hence may be somewhat less conservative than the estimates from the other states.

If averaged over system peak demand in each state, these estimates average to $m 0.7/MW approximately, which is slightly higher than the $m 0.5/MW used in the May study. It could be argued that the transmission benefit be increased. However, SKM MMA caution against this without appropriate further research into how conservative the NSW estimate actually is.

---

[37] http://www.climatechange.gov.au/what-you-need-to-know/~/media/publications/buildings/building_our_savings-pdf.pdf

- **Table 4-1 Value of deferred transmission and distribution expenditure**

	Capital expenditure applicable to growth in transmission capacity,$M per MW
QLD	0.26
NSW	0.90
SA	2.44
WA	0.51
VIC	0.10
ACT	0.90
TAS	1.17

4.2. Gas market impacts

Gas market impacts may now be more explicitly modelled using the Eastern Australian version of SKM MMA's gas market model, MMAGas (Market Model Australia – Gas), by comparing a base case with cases that reflect the changes in gas demand due to implementation of each of the scheme scenarios. Impacts now include deferrals of production as well as deferred gas transmission infrastructure. Distribution impacts and impacts on retailers are not modelled.

Reconsideration of the treatment of gas for electricity generation has now also been made. In the May study gas demand benefit was estimated on the basis of change to gas demand excluding gas for electricity generation. However it is now thought that it is more appropriate for all avoided gas consumption to be considered in the determination of avoided gas infrastructure benefit.

The gas market factors considered include:

- Wholesale market prices
- Capital expenditure on gas production
- Capital expenditure on gas transmission

The MMAGas model has been developed to provide realistic assessments of long-term outcomes in the Eastern 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 modelled using a game theory[38] technique, 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.

---

[38] Specifically a Nash-Cournot game

The underlying base case domestic gas demand for the Eastern gas market may be based on AEMO 2011 GSOO projections which will be published in the near future, or may alternatively be based on Treasury projections. As a gas model does not explicitly exist for the Western Australian market, it is intended that a cut down version be created to represent it. This is possible because the grids in these areas are relatively simple compared to the Eastern Australian grid.

Capital expenditure on gas production and transmission are now updated in the MMAGas as follows:

- Capital expenditure on production costs are estimated by first estimating the incremental capacity required from new contracts (assuming capacity life of 15 years). This is then multiplied by the unit capacity cost. Unit capacity cost is estimated assuming 80% of total production cost is capital and 20% operating. Total production costs assumed are $A 3.50/GJ for CSG and the Gippsland Basin conventional gas and $A 4/GJ for other conventional gas (information on production costs is extremely limited and no further differentiation is possible).
- Capital expenditure on transmission is estimated by first estimating the incremental capacity required from throughput less existing capacity. This is then multiplied by the unit capacity cost, based on pipeline replacement cost. No account is taken of whether the next increment is cheap (compression) or expensive (looping).

4.3. Changes to energy efficiency activity assumptions

Minor modification of residential sector energy efficiency activities' costs and savings estimates were also made. Refer to Table 4-2. In addition it was decided to apply separate estimates of asset life to estimate stock-turn (and consequently market size), and for financial calculations.

- Table 4-2 Recent adjustments to residential activity assumptions

Energy Efficiency Activity	Pre-rebound energy efficiency	Revised efficiency	Additional cost per installation for high efficiency alternative	Revised cost
Roof Space Insulation - Existing Homes	15%		$1,920	$1,200
Better Wall Insulation - New Homes	10%		$1,569	$1,000
Floor Insulation	6%		$1,920	$1,000
Film on Windows	8%		$2,500	$1,000

Energy Efficiency Activity	Pre-rebound energy efficiency	Revised efficiency	Additional cost per installation for high efficiency alternative	Revised cost
Double Glazing	10%		$25,000	$15,000
Double Glazing with Film	15%		$30,000	$16,000
Install high efficiency gas water heater (gas to gas)	20%		$130	$130
Water Heater Replacement (electricity to gas)	20%		$500	$1,000
Consumer Electronics Efficiency	5%	20%	$1,000	$500
Standby Power Controllers	4%		$200	$100
New activities				
New - Replace shower head	20%		100	
Removed activities				
Reduction of Thermostats	15%		$5,000	
Stand Alone Air Conditioning Efficiency	20%		$1,000	

Source: SKM MMA analysis

SKM MMA has expanded the number of categories of commercial use in the modelling work using data from the Australian Bureau of Statistics (ABS). The categories now included are small and large retail, wholesale, hospital, education, offices, hospitality, health and recreation. Where possible, these categories' energy use estimates are further divided to include space conditioning, water heating, lighting, and refrigeration end-uses. Refer to Table 4-3.

- **Table 4-3 Recent adjustments to commercial activity assumptions**

Energy efficiency activity	Life of activity, years	Original life estimate, years	Efficiency improvement per installation, %	Original efficiency improvement estimate, %	Additional cost per installation, $	Original additional efficiency cost estimate, $
Exceed commercial building code	15	30	5%	5%	110,000	100,000

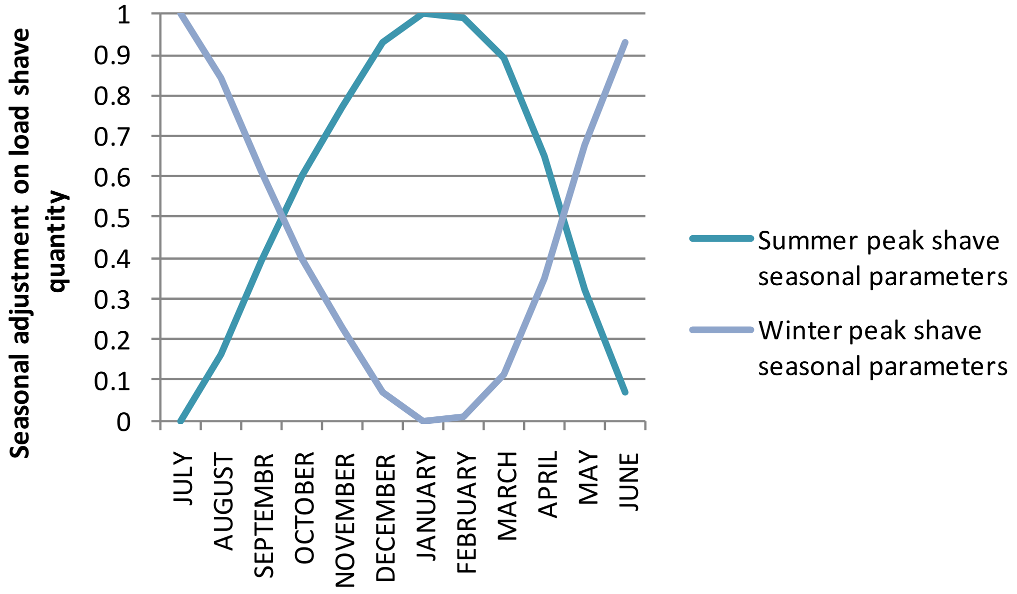
Energy efficiency activity	**Life of activity, years**	**Original life estimate, years**	**Efficiency improvement per installation, %**	**Original efficiency improvement estimate, %**	**Additional cost per installation, $**	**Original additional efficiency cost estimate, $**
Small retail options						
Small Retail Refrigeration	10	30	15%	15%	3,850	5,000
Small Retail Lighting	10	30	50%	7%	2,200	200
Small Retail Space Conditioning (electricity to electricity)	20	30	7%	7%	440	8000
Small Retail fuel switching (electricity to gas)	20		10%		440	
Large retail options						
Large Retail Refrigeration	10	30	15%	15%	36,300	10,000
Large Retail Lighting	10	30	30%	7%	36,300	1,000
Large Retail space conditioning (electricity to electricity)	20	30	16%	7%	6,375	20,000
Large Retail Space conditioning (electricity to gas)	20		10%		6,375	
Wholesale options						
Wholesale Lighting	10	30	30%	7%	4,400	1,000
Wholesale Refrigeration	10	30	7%	7%	8,800	10,000
Hospital options						
Hospital Space Conditioning	20	30	16%	7%	150,473	200,000
Hospital fuel switching	20		50%		1,000	
Education options						
Education Lighting	10	30	30%	7%	1,650	2,000

Energy efficiency activity	Life of activity, years	Original life estimate, years	Efficiency improvement per installation, %	Original efficiency improvement estimate, %	Additional cost per installation, $	Original additional efficiency cost estimate, $
Education Space Conditioning	20	30	16%	7%	4,026	200,000
Education fuel switching	20		10%		697	
Office options						
Office Lighting	10	30	30%	7%	2,750	2,000
Office Space Conditioning	15	30	10%	7%	4,634	10,000
Office fuel switching	20		10%		4,634	
Removed						
Hospital Lighting	30		5%		2,000	

Source: SKM MMA Analysis

Because the demand reduction for space heating in particular is most likely to occur in winter months, some seasonal parameters were employed to ensure the benefits were being realised at the appropriate time of year. These seasonal parameters are displayed in Figure 4-1. A similar adjustment occurred for summer peak shaving activities.

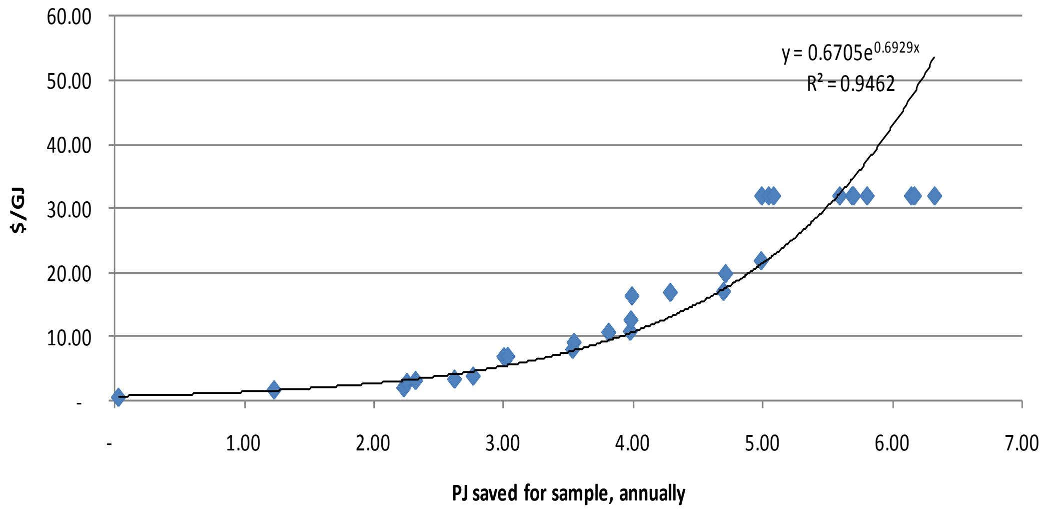
- **Figure 4-1 Seasonal parameters employed for area heating and cooling**



Source: SKM MMA

The industrial cost/efficiency function has also been updated. The function is now derived from 2010 EEO data[39], and is shown in Figure 4-2.

Figure 4-2 Relationship between cost and savings for a sample of Australian industries



Source: SKM MMA analysis of 2010 EEO data

4.4. Summary of changes to assumptions since previous report

Changes to assumptions since delivery of the May 2011 report to the DCCEE are summarised below:

- Re-development of peak demand load factors, used to convert energy savings impact to peak demand savings impact. Refer to section 4.1.
- Development of electricity distribution network estimates of the value of deferred peak demand. Refer to section 4.1.
- Update of gas modelling parameters, and reconsideration of the treatment of gas demand for electricity generation so that gas demand for electricity generation is now included in the calculation of avoided gas infrastructure benefit. We will, however, avoid double counting of any savings.
- Minor modification of residential sector energy efficiency activities costs and savings estimates. Refer to Table 4-2. Decided to use physical life to estimate stock-turn and consequently market size, and separated this from asset book life which was used for financial calculations.

---

[39] DRET 2010. First Opportunities – A look at results from 2006-08 for the Energy Efficiency Opportunities Program

- Extension of commercial sector energy efficiency activities to include a greater range of businesses and applications. Refer to Table 4-3.
- Inclusion of seasonal parameters to more appropriately model space heating activities
- Updated cost/efficiency function in the industrial sector.

Appendix A Data sources

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, published in 2011).
- 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.
- Sustainable Energy Authority of Victoria, by I. McNichol, 2003. *Residential Sector EEI Potential*,
- 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.
- Sustainable Energy Authority of Victoria, Ian McNicol, "Commercial Sector EEI Potential", Available from http://www.ret.gov.au/documents/mce/energy-eff/nfee/_documents/mwp_06_ian_min.pdf
- 2006 NFEE – EMET report on EEI Potential in commercial sub-sectors, available from http://www.ret.gov.au/documents/mce/energy-eff/nfee/_documents/consreport_04_.pdf
- 2010 UTS – Energetics report on energy efficiency in buildings, http://www.climatechange.gov.au/what-you-need-to-know/~/media/publications/buildings/building_our_savings-pdf.pdf
- 2010 Carbon Trust Australia response to the Prime Ministers Task Force on Energy Efficiency, http://www.climatechange.gov.au/government/submissions/pm-task-group/~/media/submissions/pm-taskforce/papers/174-carbon-trust-australia.ashx
- DRET 2010. First Opportunities – A look at results from 2006-08 for the Energy Efficiency Opportunities Program (NFEE)
- NFEE – Energetics report on Energy Efficiency improvements on the industrial sector, March 2004, http://www.ret.gov.au/documents/mce/energy-eff/nfee/_documents/consreport_03_.pdf

Where possible, the incremental cost of each activity associated with energy efficiency, and the efficiency improvement of each activity relative to a standard alternative, have been estimated from current market data on websites such as *Choice*, http:\\www.*comparison.com.au* and http:\\www.*getprice.com.au*, as well as the Government's Energy Rating Website. Some cost information was also obtained from the NFEE Background Report v4.1. There are occasional instances of energy-efficient appliances for which there is apparently no 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 $A 10, which helps to ensure the appliance is ranked early in the list of possible activities to adopt. Some energy-efficient activities, especially those where there is no apparent cost of uptake, may have a negative long-run marginal cost. That is, they have a net benefit to energy users over the physical life of the activity. The fact that these activities are not universally adopted indicates that market failures exist.

Appendix B Load factor tables

- **Table B-1 Load shave method by activity type (May report assumptions)**

Activity type	Load Factor used in May report	Method of load shave
Residential space conditioning	0.58	Peak shave
Residential lighting	0.58	Peak shave
Residential water heating	0.30	Peak shave
Residential refrigeration	1.00	Flat
Residential consumer electronics	0.70	Peak shave
Commercial space conditioning	0.42	Peak shave
Commercial refrigeration	1.00	Flat
Commercial lighting	0.42	Peak shave
Industrial	1.00	Flat

Table B-2 Revised load factors for energy efficiency activities (post May assumptions)

Sector	Sub-sector	End-use	Measure	Savings load factor (%)	Per unit demand reduction (kW / annual MWh)
Commercial	Office	Space	Building Code - Com	45%	0.25
Commercial	Retail	Refrigeration	Retail Refrigeration Small	80%	0.14
Commercial	Retail	Lighting	Retail Lighting Small	55%	0.21
Commercial	Retail	Space	Retail Space Conditioning Small	45%	0.25
Commercial	Retail	Refrigeration	Retail Refrigeration Large	80%	0.14
Commercial	Retail	Lighting	Retail Lighting Large	55%	0.21
Commercial	Retail	Space	Retail Space Conditioning Large	45%	0.25
Commercial	Wholesale	Lighting	Wholesale Lighting	55%	0.21
Commercial	Wholesale	Refrigeration	Wholesale Refrigeration	80%	0.14
Commercial	Hospital	Lighting	Hospital Lighting	55%	0.21
Commercial	Hospital	Space	Hospital Space Conditioning	45%	0.25
Commercial	Hospital	Lighting	Education Lighting	55%	0.21
Commercial	Other	Space	Education Space Conditioning	45%	0.25
Commercial	Other	Lighting	Office Lighting	55%	0.21
Commercial		Space	Office Space Conditioning	45%	0.25
Industrial		Agriculture	Agriculture	55%	0.21
Industrial		Mining	Mining	65%	0.18
Industrial		Wood, Paper and Printing	Wood, Paper and Printing	55%	0.21
Industrial		Petroleum, Coal, Chemicals	Petroleum, Coal, Chemicals	65%	0.18
Industrial		Non-Metallic Mineral Products	Non-Metallic Mineral Products	55%	0.21
Industrial		Metals	Metals	55%	0.21
Industrial		Machinery and Equipment	Machinery and Equipment	55%	0.21
Residential		Space conditioning	Building Code	38%	0.30
Residential		Residential Lighting	Lighting Code	100%	0.11
Residential		Water Heating	Water Heater Code	150%	0.08
Residential		Water Heating	Water Heater Replacement	150%	0.08
Residential		Water Heating	Water Heater Insulation	150%	0.08
Residential		Space conditioning	Roof Space Insulation - Existing Homes	38%	0.30
Residential		Space conditioning	Window Shading	38%	0.30
Residential		Residential Lighting	Replacement of Inefficient Lights	100%	0.11
Residential		Residential Lighting	Time Switching Outdoor Lights	500%	0.02
Residential		Residential Refrigeration	Refrigeration Efficiency	80%	0.14
Residential		Residential Consumer Electronics	Consumer Electronics Efficiency	80%	0.14
Residential		Space conditioning	Stand Alone Air Conditioning Efficiency	38%	0.30
Residential		Space conditioning	Reduction of Thermostats	30%	0.38
Residential		Space conditioning	Sealing of Window Drafts	38%	0.30
Residential		Space conditioning	Sealing of Door Drafts	38%	0.30
Residential		Space conditioning	Better Wall Insulation - New Homes	38%	0.30
Residential		Space conditioning	Floor Insulation	38%	0.30
Residential		Space conditioning	Film on Windows	38%	0.30
Residential		Space conditioning	Double Glazing	38%	0.30
Residential		Space conditioning	Double Glazing with Film	38%	0.30
Residential		Residential Consumer Electronics	Standby Power Controllers	80%	0.14
Residential		Space conditioning	Ducted Space Gas Heater Efficiency	9999%	0.00
Residential		Space conditioning	Improve Ducted Air Conditioner	38%	0.30
Residential		Space conditioning	Replace Electric Radiator with Gas Heater	150%	0.08
Residential		Space conditioning	Replace Electric Radiator with Stand Alone RC Air Conditioner	150%	0.08
Residential		Space conditioning	Replace Stand Alone Air Conditioner with Solar Air Conditioner	63%	0.18
Residential		Space conditioning	Replace Electric Fan Forced Heater with Stand Alone RC Air Conditioner	150%	0.08
Residential		Space conditioning	Improve Efficiency of Stand Alone Gas Heater	9999%	0.00
Residential		Space conditioning	Improve Efficiency of Stand Alone Elec Heater	150%	0.08
Residential		Water Heating	Improve Efficiency of Top Loader Clothes Washer	150%	0.08
Residential		Water Heating	Improve Efficiency of Front Loader Clothes Washer	150%	0.08
Residential		Residential Refrigeration	Improve Efficiency of Freezer	80%	0.14
Residential		Water Heating	Improve Efficiency of Dishwasher	150%	0.08
Residential		Residential Refrigeration	Remove Spare Refrigerator	80%	0.14
Residential		Residential Refrigeration	Remove Spare Freezer	80%	0.14
Residential		Water Heating	Replace Shower Head	150%	0.08

Appendix C Energy market modelling assumptions

This section details the electricity market assumptions influencing the reference scenario for the May study. This scenario has taken into account:

- Projections of state energy use by sector (based on AEMO demand from the 2010 ESOO)
- 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)

C.1 Gas market

The gas market benefits in the May study were derived from previous SKM MMA work.

SKM MMA employs the latest version of the gas model, consistent with the market assumptions described in the now publically available report entitled “2011 Gas Market Review, Queensland”. This is available at http://www.deedi.qld.gov.au/documents/energy/1-24_2011_Annual_Gas_Market_Review_Web.pdf.

C.2 Abatement schemes

The electricity market modelling has incorporated the expanded renewable energy target (RET) scheme, which now boasts a target of 45,000 GWh of additional renewable generation by 2020. The scheme is legislated, and its design now includes the separation of small- and large-scale targets which will likely see an increase in the adoption of small-scale and large-scale renewable energy technologies until 2020.

Additional to the RET is “Green Power”, a scheme enabling any electricity purchaser to ensure the energy they use is offset by the same amount of renewable generation.

C.3 Generation and market assumptions – NEM

C.3.1 Marginal costs

The marginal cost of a thermal generator 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 C-1.

Error! Reference source not found.. SKM MMA also included the net present value of changes in future capital expenditure that would be driven by fuel consumption for open-cut mines owned by the generator. This applied to coal in Victoria and South Australia.

C.4 Plant performance and production costs

Thermal power plants were modelled with planned and forced outages, so overall availability is consistent with indications of current performance. Coal plants have availability between 86% and 95%, and gas-fired plants have availability between 87% and 95%.

C.5 Market structure

The work assumed the current market structure will continue under the following arrangements:

- Victorian generators will not be further aggregated.
- NSW generators will remain under the current structure in public ownership.
- The generators' ownership structure in Queensland will remain as public ownership.
- The South Australian assets will continue under the current portfolio groupings.
- Mt Isa is not currently connected to the NEM.

In formulating the future NEM development, SKM MMA optimises the new entry plan so that the reserve requirements are met in each region at least cost. The minimum reserve levels assumed for each state in the May report were based on values specified in the 2010 ESOO, although work has now been undertaken to update values to those specified in the 2011 ESOO.

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). It is assumed that these schemes are in place in the absence of a carbon scheme.

Cost and financing assumptions used to develop the long-term new entry prices are provided in Table C-1. 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 was assumed that the higher risks emerging in the electricity generation sector from the carbon price mechanism will require these higher equity returns.

The capacity factors in Table C-2 are deliberately high, to allow a time-weighted new entry price in each state to be approximated, so it could 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 long run marginal cost (LRMC) measured in A$/MWh is higher than this level. For example, it would be more likely to find a new CCGT operating in Victoria with a capacity factor of around 60% to 70% than the 92% indicated in Table C-2. Ideally, to determine the timing of new entry of such a plant, we would compare the new entry cost of a CCGT operating at this level with the time-weighted prices forecast in the top 60% to 70% of hours. However, this would require more detailed and a time-consuming analysis which, in our experience, does not yield a significantly different price path.

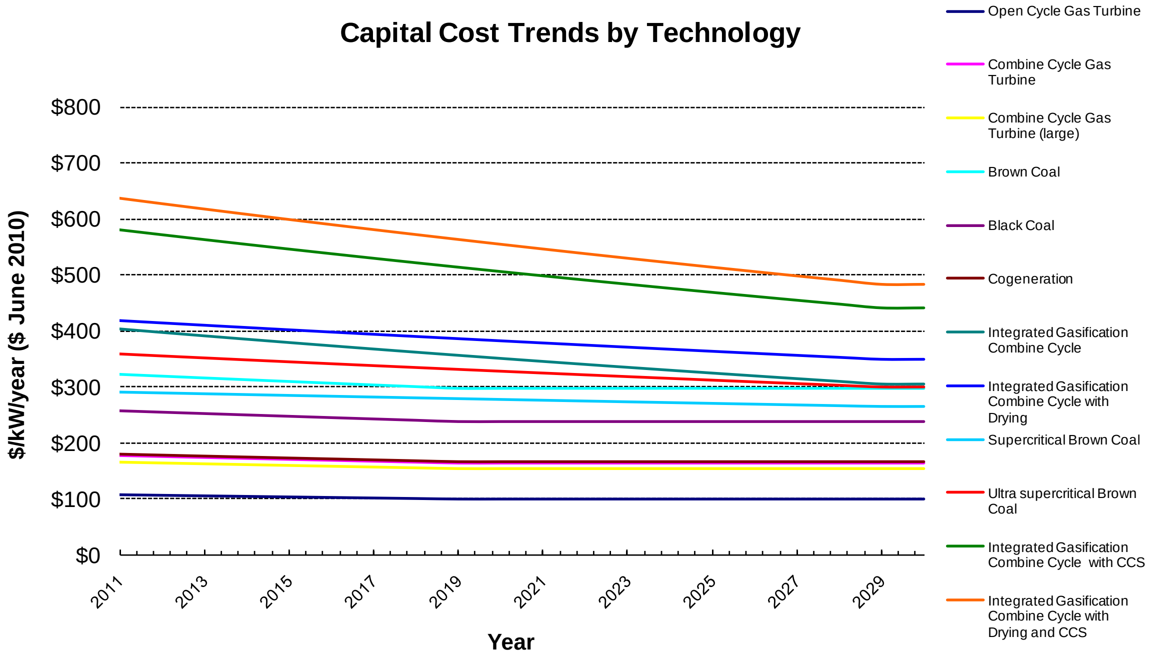
- **Table C-1 New entry costs and financial assumptions ($June 2010) for 2010/11**

	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 C-1 shows the trend in new entry fixed costs represented in the new entry cost modelling in June 2011 dollars.

- **Figure C-1 Trends in capital costs for new plant ($/kW/year), June 2011 dollars**



Source: SKM MMA

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 C-2 Assumptions for new thermal generation options ($2011)**

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.

C.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 C-3. The gas prices are in accordance with the projections from the MMA-Gas model.

- **Table C-3 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%.

C.6.1 Trading arrangements

The wholesale market for electricity in the Western Electricity Market (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 ignored 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.

C.6.2 Generation assumptions – existing units in the WEM

Verve Energy

Verve Energy has 11 power stations operating in the SWIS, as shown in Table C-4. 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 C-4 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	Renewable.	-	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 C-5 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 C-6. 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 C-6 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.

C.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 C-7 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.

C.6.4 Fuel assumptions

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

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

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

All stations owned by Goldfields Power and Southern Cross Power were 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 was 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.

Appendix D NSW electricity grid peak demand savings assumptions

NSW Electricity grid peak demand savings were estimated from actual project cost data of three NSW Distribution Network Service Providers (DNSPs). It is anticipated that this work will be extended to other Australian states depending on information availability.

Electricity grid peak demand savings were estimated by taking the average of savings from major project deferrals, implied total system deferrals and system average capex/kVA. These are described below:

- **Major project deferrals** – the average of costs/kVA of deferring major projects. This only applies in a constrained area (eg. 10-15% of the network at any given time) and assumes the project will proceed. Actual major project costs were taken from published AusGrid (54 projects), Endeavour (4 projects) and Essential (11 projects) distribution grids, covering low-voltage, distribution and sub-transmission projects. SKM MMA collated and averaged the project data applicable to each grid, and the resulting averages for each grid are shown in Table D-1.
- **Implied total system deferrals** – the average cost of projects at low-voltage, distribution and sub-transmission levels added together to provide an implied total network cost/kVA. These values were calculated from the same set of major projects used to calculate the cost of deferring major projects. The resulting values for each grid are shown in Table D-1.
- **System average capex / kVA** –the system-wide total growth capital expenditure (discounted by 50% because it also includes customer connections) divided by forecast demand growth as estimated from the 2009-2014 final AER determination. This represents the average growth in costs/kVA across the whole network. Note: this is actual capital expenditure, not deferral value (which would be around 10% of the figures presented). The resulting values for each grid are shown in Table D-1.

There is no definitive answer for which cost estimate is best to use, so the average of all three figures has been used: $1,135/kVA[40] ($1,419/kW). Given the range of actual economic benefits is large (from close to zero in an area with no impending constraints, to approximately double that figure for average system wide capital expenditure), this appears to be a reasonable estimate.

---

[40] Converted to $/kW using http://dieselserviceandsupply.com/Power_Calculator.aspx

- **Table D-1 Average network cost/kVA associated with delayed peak demand**

	Major project deferrals $/kVA	Implied total system deferrals $/kVA	System average capital expenditure $/kVA	Typical average figure $/kVA
AusGrid	$ 202	$ 505	$ 1,955	
Essential energy	$ 904	$ 1,680	$ 1,942	
Endeavour energy	$ 406		$ 1,528	
NSW average	$ 504	$ 1,093	$ 1,808	$ 1,135

achieve outstanding client success

SINCLAIR KNIGHT MERZ