Insight Economics

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Energy Efficiency — Policy Measures to Reduce Greenhouse Gas Emissions

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Report prepared for the WA Greenhouse and Energy Taskforce

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EXECUTIVE SUMMARY AND CONCLUSIONS

Cost effective energy savings have potential to contribute to substantial greenhouse gas emissions reductions in Western Australia.

The potential savings

Effective government policy to increase investments in energy efficiency — offering private internal rates of return *exceeding* 15 per cent — could, as a first round impact:

- reduce energy use below projected 'business as usual' substantially — by between 12 per cent (low scenario) and 28 per cent (high scenario) by 2030 at zero carbon prices (Table ES.1);

- reduce greenhouse gas emissions in the stationary energy sector by between 9 and 22 Mt CO2e at 2030 at zero carbon prices (Table ES.1);

- reduce greenhouse gas emissions in the stationary energy sector by between 15 and 34 Mt CO2e at 2030 under the impact of a $40 per tonne CO_2e carbon price (Table ES.2).

Achieving energy savings in end use in the Stationary Energy sector delivers upstream savings additional to the above 'combustion only' estimates — through reduced transmission losses and reduced Fugitive emissions from natural gas production. Counting these additional savings further boosts the savings estimates by between 15 and 20 per cent, depending on the carbon price.

Sectoral priorities

Around 85 per cent of the total identified energy and emissions savings are available in just three sectors of the economy — the Mining, Commercial and Residential sectors. These sectors should be priorities for action.

TABLE ES.1 – STATIONARY ENERGY USE AND POTENTIAL SAVINGS – 6 YEAR PAYBACK AND ZERO CARBON PRICE – COMBUSTION ONLY EMISSIONS FACTORS

	2009-10	2014-15	2019-20	2024-25	2029-30
BAU energy use (PJ)	414.0	458.0	511.1	571.7	649.4
High savings scenario					
High savings scenario (PJ)	402.8	420.6	438.9	450.3	466.4
Total savings (PJ)	11.2	37.4	72.2	121.4	183.0
Total savings (% of BAU)	2.7	8.2	14.1	21.2	28.2
Total savings (kt CO_2e)	1405	4775	9044	14763	21635
Low savings scenario					
Low savings scenario (PJ)	409.3	441.9	479.0	518.5	569.6
Total savings (PJ)	4.7	16.1	32.1	53.1	79.8
Total savings (% of BAU)	1.1	3.5	6.3	9.3	12.3
Total savings (kt CO_2e)	613	2049	3976	6402	9376

Source: Insight Economics

Note: a) combustion only emissions factors

TABLE ES.2 – ALL SECTORS COMBINED — EFFECT OF HIGHER CARBON PRICES ON EMISSIONS SAVINGS FROM INVESTMENTS WITH UP TO 6 YEAR PAYBACKS – COMBUSTION ONLY EMISSION FACTORS

	2009-10 (kt CO_2e)	2014-15 (kt CO_2e)	2019-20 (kt CO_2e)	2024-25 (kt CO_2e)	2029-30 (kt CO_2e)
High savings scenario[a]					
\$20/t CO_2e	1870	6353	12014	19547	28555
\$40/t CO_2e	2266	7704	14545	23601	34385
Low savings scenario[a]					
\$20/t CO_2e	826	2741	5293	8484	12377
\$40/t CO_2e	1007	3328	6408	10241	14899

Source: Insight Economics

Note: a) combustion only emissions factors

Rebound effects

At constant real energy prices, uptake of ‘no regrets’ energy efficiency savings will expand economic activity. This will induce ‘rebound effects’ — where the increased income from savings on energy efficiency is spent elsewhere in the economy, resulting in increased economic activity and greenhouse gas emissions. Most studies in the Australian context suggest that the rebound effect reduces savings, from energy efficiency investments at constant prices, by around 20 per cent. On the other hand, rising domestic energy costs — such as might arise from increasing global fuel prices or from a domestic carbon price signal — will attenuate the rebound effect.

Policy options

There is no single policy 'key' to unlock the potential of cost effective energy efficiency. The complex and diverse nature of the target means that a portfolio of measures is required. The prime focus of policy should be on the non-price barriers and market failures, but fully effective policy would also improve relative pricing.

It takes decades to completely turn over the capital stock. The implication is that policy action to raise the rate of energy efficiency improvement should commence as soon as possible. Even small improvements beyond business as usual — if sustained over time — can deliver significant cumulate reductions in energy end use emissions.

Policy intervention will be required to unlock the identified savings. The majority of market failures and barriers to energy efficiency are judged to involve non-price factors, so complementary policy for energy efficiency is required even in the presence of significant carbon prices.

Relative prices

Getting energy prices right is a pre-requisite for cost effective uptake of energy efficiency. This is particularly important for efficient outcomes over the longer term.

There is scope to improve pricing signals in energy markets through improved:

- *congestion pricing* — which requires installation of smart meters in new buildings (residential and commercial) mandatory, and funding support for replacement programs for existing meters in prioritised customer classes;
- *tests for network augmentation* — to align incentives for investment, Western Power should have explicit means to 'pass on' non-network investment costs and to recover 'foregone revenues';
- *greenhouse gas pricing signals* — incorporating the cost of carbon in energy prices will increase the quantity of cost effective abatement available from energy efficiency and reduce 'rebound' effects.

Information provision

Providing public information on energy savings options, and demonstrating these, can be an effective complement to improved pricing signals and programs targeting behavioural change.

There is a clear rationale for public information on and demonstration of the benefits of energy savings best practice.

Energy rating and labelling is an important element supporting consumer action on climate change, and should be supported and extended through the current National Framework for Energy Efficiency work program.

Minimum standards

Minimum Energy Performance Standards (MEPS) provide extremely cost effective means to improve energy efficiency.

The level of national MEPS should be raised to levels that deliver energy savings with net returns to the community as a whole. Evaluations of the cost effective level of MEPS should also incorporate the prevailing economy-wide price for carbon.

Western Australia could implement additional mandatory requirements in commercial and residential buildings that deliver net benefits for the community up to the shadow price of carbon.

Beyond minimum standards

If significant reductions in greenhouse gas emissions are to be achieved, a major cross cutting policy to provide incentives to adopt energy efficiency *beyond minimum standards* is required.

Key policy options driving significant uptake of energy efficiency in Western Australia, *beyond minimum standards* are:

- *Mandatory licence conditions for firms* — a threshold for mandatory adoption of energy savings measures could be set at internal rates of return/paybacks that deliver 'no regrets' savings for the community as a whole; and
- Establishment of an *Energy Savings Fund* — which could support:
  - identification of key energy savings opportunities elsewhere in the Western Australian economy, with pilot programs to confirm savings potential and subsequent broader program delivery to access those savings;
  - through competitive tender, implementation of the best opportunities for energy savings beyond minimum standards or mandatory requirements;
  - an awareness program for energy efficiency targeting the commercial, residential and small business sectors, with support for third party energy efficiency auditing for small business and residential consumers, combined with incentives, rebates and other promotions.
  - market transformation activities, including encouraging increased penetration of performance contracting for the commercial sector;
  - targeted programs to improve energy efficiency for low income and other households; and
  - ex-post evaluation of energy saving opportunities and the barriers to their implementation — providing feedback on the true extent of the energy efficiency gap.

CHAPTER 1

Introduction

Improving the efficiency of use of factors such as energy is a key ingredient in productivity and income growth. In addition, with human induced climate change presenting a clear global threat, there is now an added reason to focus on energy efficiency as a means to reduce greenhouse gas emissions.

The Western Australian Government established the Greenhouse and Energy Taskforce, with Terms of Reference to provide advice to Government on:

(a) Practical and economically feasible policies to manage greenhouse gas emissions from the Stationary Energy sector in the short term;

(b) Longer term policies, actions and strategies that the state should consider to assist the state's efforts to reduce greenhouse gas emissions;

(c) The feasibility and implications of reducing greenhouse gas emissions by 50% by 2050;

(d) Policy options that would be complementary to a National Emissions Trading Scheme that could be adopted in Western Australia in the short term;

(e) Measures to prepare the State for such a National Emissions Trading Scheme and future integration with international emissions trading markets;

(f) Proposals for energy conservation initiatives focused on encouraging businesses and householders to make significant reductions in energy consumption; and

(g) Policy proposals for Government consideration on greenhouse offsets that would provide clear ground rules for proponents of projects that will have significant greenhouse emissions.

1.1 The requirement

The Western Australian Greenhouse and Energy Taskforce is seeking to identify energy efficiency measures with the potential to significantly reduce greenhouse gas emissions in the Stationary Energy sector in Western Australia, and the support mechanisms required to implement the measures. In particular, the Taskforce is seeking to cover the following issues:

(a) Advice is to cover the following carbon cost bands:

(1) Simple payback period between 0 and 2 years;

(2) Simple payback period between 2 and 6 years;

(3) Carbon price $0-10 per tonne;

(4) Carbon price $10-20 per tonne;

(5) Carbon price $20-30 per tonne;

(6) Carbon price over $30 per tonne.

(b) Criteria for assessing Government programs: delivering least/no cost energy efficiency, maximising results for expenditure (it appears these may be greatest in Western Australia for mining and industry), maximising emissions reductions;

(c) Priority areas for efficiency as determined by the Taskforce - industrial processes and buildings, commercial and residential buildings, Government leadership (improvements in the efficiency of Government energy use), electricity distribution;

(d) Identify options for programs in these areas using existing commercial technologies including but not limited to - consumer response, technological standards, improved construction, regulatory reform, market transformation;

(e) Consider the costs and abatement potential for each option identified in 2.2(c) above;

(f) Investigate the likely outcomes of different approaches (voluntary vs. mandatory programs, use of incentives and different program structures) relative to the total cost effective potential; and

(g) Recommend appropriate program approach in each area.

1.2 Some definitions

This report covers the efficiency of energy end use in 'stationary' (non-mobile) applications. The sectoral coverage is consistent with that used by the Australian Greenhouse Office for stationary energy combustion in the National Greenhouse Gas Inventory.[1] However, with a focus on energy *end use*, the report does not consider the efficiency of energy conversion industries, such as electricity generation. Instead, the focus is on the efficiency of use of final energy, such as electricity and direct use of gas and coal.

For the purposes of this report, improving energy efficiency is defined as improving the value of output per unit of energy input. However, whether improved *economic* efficiency results from energy efficiency measures depends on relative values of all the inputs to the production or consumption process. As the Productivity Commission observe:[2]

> Energy efficiency is generally described output per unit of energy input, where output and energy input are measured in physical units. The pursuit of energy efficiency would seem to be in the interests of any rational producer or consumer, firm or household. However, energy efficiency measures do not capture the value of energy use to the individual — an individual will not necessarily benefit from improving energy efficiency… Nevertheless, regardless of benefits accruing to individuals, some energy efficiency improvements may generate net benefits to society as a whole — such as by avoiding costs of environmental damage associated with energy generation and use.

In recognition, the report has a focus on measures to enhance energy efficiency that are economically efficient. These measures, described as having 'economic potential', are a subset of all possible measures that are technically possible (Figure 4.1). On this basis, potential measures can be divided into:

- *Technical Potential* — the improvement in energy efficiency which is possible in theory, as a result of technical advances. It represents the maximum amount of energy savings which could be achieved at any one time. Technical potential is constantly improving as a result of innovation and technological progress. Because the nature and extent of improvements in technology are difficult to predict, the future technical potential that exists in a particular sector is very difficult to quantify. Even when we can foresee an emergent technology, its eventual commercial application — and the extent to which it may economically reduce energy intensity in a sector of the economy — is often unclear.

- *Economic Potential* — refers to energy efficient improvements that deliver a net social benefit. These are savings that we would expect to occur if the market was operating efficiently, given estimates of the cost of energy, assumptions about the average return to investment and an absence of externalities.

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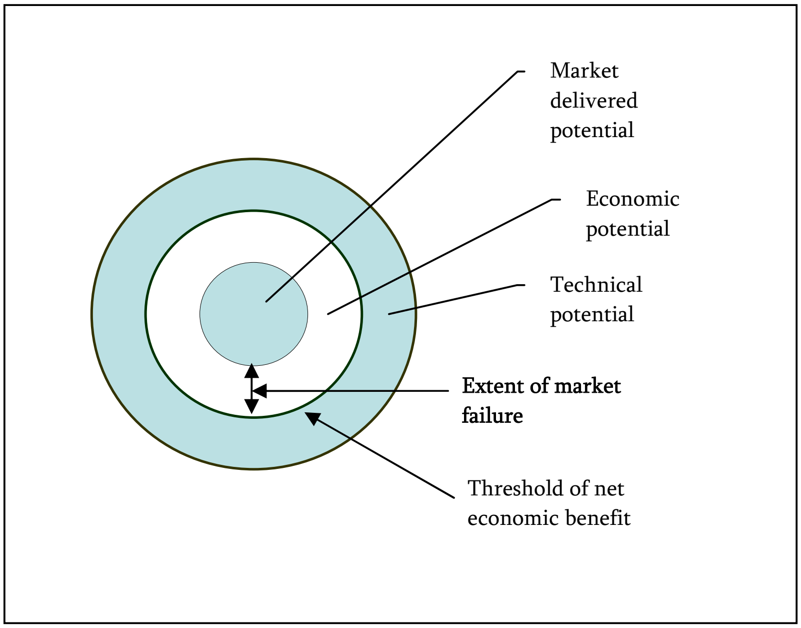
1 Australian Greenhouse Office 2006, National Greenhouse Gas Inventory 2004, www.greenhouse.gov.au, pp 6.

2 Productivity Commission 2005, *The Private Cost Effectiveness of Improving Energy Efficiency*, Report no. 36, www.pc.gov.au , pp 13.

- *Market Potential* — this is the 'business as usual' scenario. The difference between the economic potential that exists, and the level of energy savings that the market will provide, represents the extent of market failure. Reasons for market failure may include split incentives, imperfect information, and environmental externalities.

FIGURE 1.1 - TYPES OF SAVINGS



Source: National Framework for Energy Efficiency 2003, *Preliminary Assessment of Energy Efficiency Improvement Potential and Costs*, pp iii.

This report is concerned with economic potential. Hence we are interested in energy savings that can be made economically — absent market failures, including externalities in energy pricing. We examine market failure issues in more detail in Chapter 4.

1.3 This report

This report examines opportunities to reduce greenhouse gas emissions through enhanced investment in *economic* energy efficiency over two timeframes:

- the medium term — to 2015; and
- the longer term — to 2030.

The period to 2015 offers potential to implement technologies that exist now, or are near to commercialisation. For these near term opportunities and potential policy support measures, the report draws on the parallel work undertaken by Energetics for the Taskforce, which examined the opportunities and costs for enhanced energy efficiency out to 2015.[3]

Beyond 2015, the economic potential to reduce energy use below ‘business as usual’ necessarily becomes more speculative. We draw on the available literature and our best judgment to provide an informed picture through to 2030.

Chapter 2 outlines expected energy end use in Western Australia through to 2030, and assesses the broad characteristics of energy growth by sector.

Chapter 3 considers energy efficiency opportunities in detail for key sectors, to 2015 and to 2030.

Chapter 4 develops a framework for assessing energy efficiency policy, identifies options and evaluates preferred approaches in the context of the opportunities identified in Chapter 3, and recommends a preferred policy package.

3 Energetics 2006, *Energy Efficiency Potential in Western Australia — Report to the Western Australian Department of Environment.*

CHAPTER 2

Energy end use in Western Australia

Projected energy end use in Western Australia is assessed. Sectors with large or fast growing energy consumption are identified.

Driven by robust global economic growth and associated strong international demand for its commodities, the Western Australian economy is growing at a rapid rate. Over the past four years, growth in Gross State Product has averaged 5.5 per cent. Energy is a key input to this growth — driven by the rapid increase in economic activity, Western Australia's total final energy consumption has been growing at rates around 3 per cent per annum in recent years.[4]

The Western Australia economy is underpinned by economic activity in the Mining sector and by associated activity in the Manufacturing and Construction sectors. In total, it is estimated these sectors contributed 32 per cent of total value added in the Western Australian economy in 2005-06, compared to a 21 per cent contribution on average in the rest of Austalia.[5] The majority of the difference is due to the larger share of the Mining sector (14 per cent in Western Australia, compared to just 3 per cent on average in the Rest of Australia).

4 ABARE 2006, Energy Update 2006, www.abareconomics.com .

5 Derived from the MMRF-Green model base case.

2.1 ABARE energy projections to 2030

ABARE produces the most detailed projections of the expected energy usage by the various sectors of the Western Australia economy under 'business as usual' policy settings.[6] ABARE estimates the current primary and final energy consumption by industry sector and by fuel for the Western Australia economy, and projects these quantities out to 2030. These projections provide the underpinnings for the energy efficiency estimates made in this report.

Primary energy consumption use refers to the total amount of energy consumed by an economy – and is the major determinant of greenhouse gas emissions. Final energy consumption, on the other hand, is the total energy consumed in end use, and is less than primary energy use as a result of the energy lost converting one form of energy to another. For example, the production of electricity entails significant energy losses that are not encapsulated in the final energy usage figures. However, these 'supply side' efficiencies are not considered in this report. Rather, as this report is concerned with *end use* energy efficiency, we concentrate on total final energy consumption (TFEC) figures.

TABLE 2.1 - STATIONARY ENERGY TFEC FUEL CATEGORIES

	2029-30 Projected TFEC (PJ)	Stationary energy sector?	Transport sector?	Stationary energy efficiency savings estimated?
Coal	42	**Yes**	No	**Yes**
LPG – transport	26	No	Yes	No
LPG – stationary	10	Yes	No	No
Other petroleum – except in Mining	298	No	Yes	No
Other petroleum – in Mining	141	**Yes**	Yes	**Yes**
Gas	333	**Yes**	No	**Yes**
Biomass	18	Yes	No	No
Electricity	157	**Yes**	No	**Yes**
Solar	2	Yes	No	No

Source: Insight Economics

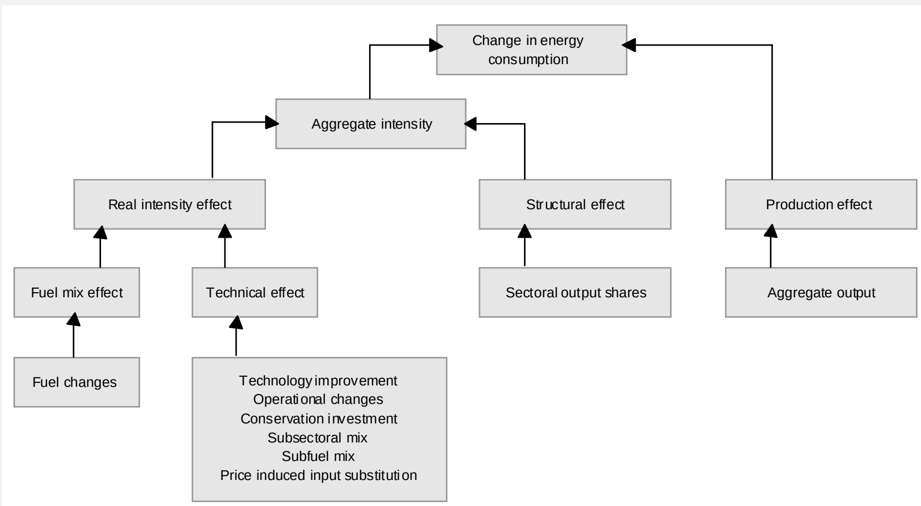
[6] Akmal, M. and Riwoe, D. 2005, *Australian Energy: National and State Projections to 2029-39*, ABARE eReport 05,9, www.abareconomics.com.au .

In this report we are interested in the *Stationary Energy* sector TFEC, so we ignore TFEC associated with transport. This report considers all energy end use related to Coal, Gas, and Electricity (Table 2.1). Energy savings from Biomass and Solar are not considered, as these do not deliver significant greenhouse gas emissions benefits. LPG is not considered, because the Stationary Energy use component is very small. Finally, Other petroleum use is included, but only for the Mining sector — given that it is significant in this sector, is largely diesel, and has characteristics of stationary energy use.[7]

BOX 2.1 - ENERGY EFFICIENCY IMPROVEMENT UNDER 'BUSINESS AS USUAL'

The efficiency of energy use improves with time — through technological advance and associated new investments in improved equipment, under the impetus of 'business as usual' economic growth.

This 'technical effect' is one component of resulting overall changes in total energy consumption — which may also be influenced by fuel switching, structural changes in the economy, and overall changes in the level of production — as illustrated in the following diagram. The 'technical effect' is also known as 'autonomous energy efficiency improvement' (AEEI).



Source: Insight Economics; Tedesco, L. and Thorpe, S. 2003, *Trends in Australian Energy Intensity, 1973-74 to 2000-01*, ABARE eReport 03.9, www.abareconomics.com.au, pp 5; Akmal, M. and Riwor, D. 2005, op. cit., pp16.

Autonomous energy efficiency improvement

The ABARE data forms our 'business as usual' scenario. In developing these estimates, ABARE assumed the demand for each fuel source declines by:

- 0.5 per cent per year as a result of efficiency improvements generally; except for
- 0.2 per cent per year in the energy intensive sectors.

[7] The whole of 'Other petroleum' use in the mining sector is diesel (see Akmal M. and Riwoe D. 2005, op. cit., . Diesel is used by the sector to generate electricity at remote sites, and also to power haul trucks, which use electric motors to provide final drive — the diesel motor essentially an electric generator set.

These correspond to annual rates of 'autonomous energy efficiency improvement' (AEEI — see Box 2.1). The ABARE estimates were derived from historic data for the period 1973-74 to 1997-98.

These assumptions are crucial for our analysis — their historic basis means that many recent policy initiatives to enhance energy efficiency, such as the current suite of Minimum Energy Performance Standards, are unlikely to be fully reflected in the ABARE's projections. Furthermore, it is reasonable to expect AEEI could accelerate in Australia under future business as usual trends — as its rate will be influenced by technology trends overseas, which in turn may be influenced by rising energy costs and by action to address climate change. We therefore take account for these potentials, in developing the 'beyond the ABARE business as usual' energy efficiency estimates, in the rest of this report.

Total final energy consumption

ABARE projects that the demand for stationary energy total final end use in Western Australia will grow at a compound average rate of 2.7 per cent per year on average through to 2029-30 (Table 2.1).

By fuel

Demand in Western Australia for:[8]

- coal is projected to grow slowly, from 35 PJ in 2005-06 to 42.3 PJ in 2029-30 — a compound average growth rate of 0.7 per cent per annum;
- gas is projected to grow from 196 PJ in 2005-06 to reach 333 PJ in 2029-30 — a compound average growth rate of 2.2 per cent per annum;
- other petroleum energy (that is covered in this report, which as noted above, is only that used in the Mining sector) is projected to grow most rapidly, from 37 PJ to 141 PJ in 2029-30 — a compound average growth rate of 5.7 per cent per annum;
- electricity is projected to grow from 82 PJ in 2005-06 to 157 PJ in 2029-30 — a compound average growth of 2.8 per cent per annum;

[8] Akmal, M. and Riwoe, D. 2005, op.cit.

TABLE 2.2 – WESTERN AUSTRALIAN — STATIONARY ENERGY GROWTH BY SECTOR

	Average Annual Growth Rate 2005-06 to 2029-30					
Sector	**Coal**	**Other Petrol. (diesel)**	**Gas**	**Electricity**	**Biomass (b)/ Solar (s)**	**Total**
Agriculture	-	-	-	1.3	-	1.3
Mining	-1.5	5.7	5.1	3.6	-	4.7
Manufacturing and Construction	1.2	-	1.9	1.8	2.1 (b)	1.8
Commercial	-	-	2.8	3.4	2.9 (s)	3.1
Residential	-	-	2.21	2.2	0.2 (b) 2.5 (s)	2.2
Total	**0.7**	**5.7**	**2.2**	**2.8**	**1.1 (b) 2.6 (s)**	**2.7**

Source: ABARE

Note: (b) = biomass; (s) = solar

- biomass energy also is projected to grow very slowly, from 14 PJ in 2005-06 to 18 PJ in 2029-30 — a compound average growth rate of just 0.2 per cent per annum;

- solar energy is projected to grow from 1 PJ in 2005-06 to 2 PJ in 2029-30 — a compound average growth rate of 2.6 per cent per annum.

It is worth noting that ABARE's energy projections assume very slow growth in the use of coal in end use in Western Australia. The corollary is a faster rate of growth in gas for end use than otherwise. However, the recent trend to higher domestic gas prices in Western Australia could constrain gas growth, and lead to faster growth in coal as a substitute fuel for direct end use.

This would increase projected emissions, but also likely increase to an extent the amount of cost effective energy efficiency opportunities available in Western Australia. However, the sensitivity of the ABARE projections to greater coal use, and the associated amount of energy savings, is not evaluated in this report.

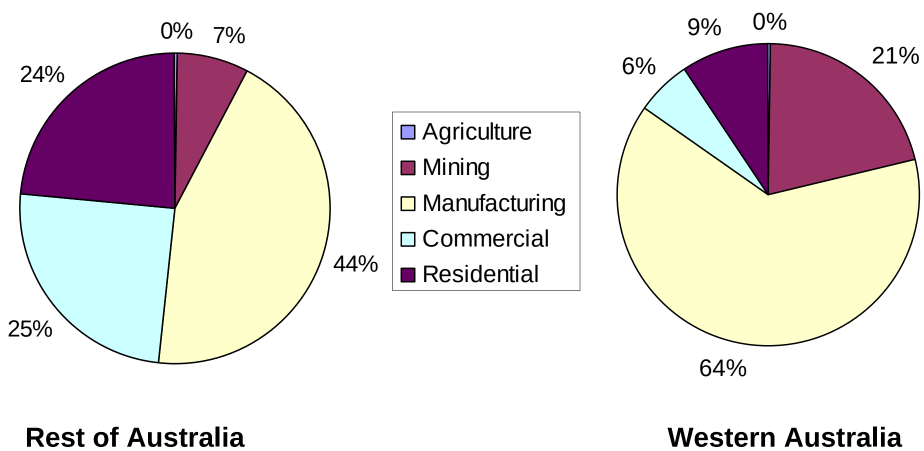
By sector

The influence of the resources sector on Western Australia's energy use can be seen by comparing the sectoral shares of total final Stationary Energy consumption in Western Australia with their corresponding shares in the Rest of Australia in 2005-06 (Figure 2.1).

- The Mining, Manufacturing and Construction sectors together are expected to account for 85 per cent of Western Australia's total final Stationary Energy consumption in 2005-06, compared to 51 per cent for the rest of Australia.

- The Commercial and Residential shares accounted for 15 per cent of Western Australia's total final Stationary Energy consumption in 2005-06, compared to 49 per cent in the rest of Australia.

FIGURE 2.1 – STATIONARY ENERGY FINAL ENERGY CONSUMPTION IN 2005-06



Source: Akmal, M. and Riwoe, D. 2005, op.cit.

Going forward, all end use sectors in Western Australia are expected to experience annual growth in total final stationary energy consumption through to 2029-30 (Table 3.1).

The Mining, Basic Chemicals and Commercial sectors exhibit annual growth rates through to 2029-30 that are faster than the average (of 2.7 per cent per annum):

- within Mining, growth in demand for gas and other petroleum (diesel) is expected to drive an exceptionally strong overall increase for energy — at an average 4.7 per cent per annum between now and 2029-30;
- within the Basic Chemicals sector, energy growth is being driven predominantly by increased use of gas;
- in the Commercial sector, demand for electricity, solar energy and gas are growing most rapidly.

TABLE 2.3 - PROJECTED FINAL STATIONARY ENERGY CONSUMPTION FOR KEY SECTORS

Sector	2005-06 (PJ)	2005-06 share of Western Australia total (%)	2029-2030 (PJ)	2029-2030 share of Western Australia total (%)	Ann. av. growth rate 2005-06 to 29-30 (%)
Agriculture	1	<1	1	<1	**1.3**
Mining	39	21	233	34	**4.7**
Manufacturing and Construction	229	64	354	51	**1.8**
Wood paper printing	3	<1	4	<1	2.3
Basic Chemicals	22	6	64	9	4.6
Iron and steel	11	3	20	3	2.4
Basic non-ferrous metals	159	43	214	31	1.3
Non-metallic minerals products	25	7	36	5	1.5
Other manufacturing and construction	13	3	19	3	1.6
Commercial	21	6	46	7	**3.3**
Residential	34	9	53	8	**1.8**
Total for Western Australia	365	100	693	100	**2.7**

Source: ABARE

Other sectors are projected to grow more slowly than the average:

- Agriculture is a very small sector and is expected to experience only modest growth of 1.3 per cent per annum;
- the Basic non-ferrous metals sector on the other hand is responsible for just over 40 per cent of current stationary energy use, but with energy use projected to grow at a modest 1.3 per cent per annum, the share of the sector in stationary energy use is projected to decline to around 30 per cent by 2029-30;

- the share of stationary use by the Residential sector is projected to remain reasonably steady, falling from 8 per cent in 2005-06 to 7 per cent in 2029-30.

2.2 Priority sectors for action on energy efficiency

The foregoing analysis suggests that the following sectors will be responsible for the majority of stationary energy demand growth in Western Australia over the period to 2029-30, and hence should be high priority for action on energy efficiency:

- Mining — outperforming other sectors to grow to over one third of stationary energy use;
- Basic chemicals — outperforming other sectors to grow to just under 10 per cent of total stationary energy use;
- Basic non-ferrous metals — despite moderate growth, its absolute size (current share of stationary energy use is 40 per cent) makes it a priority;
- Commercial sector — outperforming other sectors to grow to 8 per cent of total stationary energy use.

Other sectors, such as Non-metallic minerals products, Iron and steel, Other manufacturing, Construction and Residential are less important in terms of overall size, or their rate of growth. These sectors could form a second tier of priority for action.

We disregard Western Australia's Agricultural sector. The sector consumes only a small, and in relative terms, declining part of Western Australia's total final stationary energy consumption. Most energy use in this sector relates to diesel use, including by mobile sources such as tractors and other farm machinery.[9]

[9] Diesel that *is* used for stationary energy offers a major opportunity to reduce greenhouse gas emissions through investment in Remote Area Power Systems, rather than just energy efficiency per se.

CHAPTER 3

Energy efficiency opportunities

This chapter focuses on improvements in end use energy technologies which have the potential to yield significant energy savings beyond the business as usual scenario. The analysis concentrates on the key energy using sectors identified as priorities in the previous chapter.

There is substantial difficulty involved in determining the extent of the technological potential to improve energy efficiency over the longer term. First, there is limited analysis. Secondly, for the analysis that has been undertaken, there are different views about the scale of the potential. Despite this, most sources acknowledge that there is significant potential for savings from enhanced energy efficiency in many sectors of the economy, which could play a substantial role in reducing greenhouse gas emissions over the longer term.

For example, the International Energy Agency's recent comprehensive survey was optimistic about the potential contribution of energy efficiency savings to achieving significant abatement. The report noted:[10]

> Improving energy efficiency is often the cheapest, fastest and most environmentally friendly way to meet the world's energy needs. Improved energy efficiency also reduces the need for investing in energy supply. Many energy efficiency measures are already economic and they will pay for themselves over their lifetime through reduced energy costs.

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10 International Energy Agency 2006, *Energy Technology Perspectives: Scenarios and Strategies to 2050*, p31.

It is generally accepted that true 'autonomous energy efficiency improvement' (AEEI) averages between 0.5 per cent and 1.0 per cent per annum, and that there is potential to increase this to around 2 per cent through policies to drive faster rates of change. Blok notes:[11]

> For energy analysis it is a commonplace that energy efficiency in society continually improves at low rates, typically 1% per year… New government policies, mainly triggered by the threat of climate change, often are directed at increasing the rate of energy efficiency improvement to, for example, 2% per year.

It may be possible to lift AEEI rates further, although this has not yet been successfully achieved. Evidence on the success of efforts to date to double the rate of AEEI is not encouraging:[12]

> In 1990, the Netherlands' government proposed to increase the national rate of energy efficiency improvement from 1% to 2% per year, which was considered a 'real test of strength'. Three years later, the goal was already reduced to 1.7% per year. Recently the realisation in the 1990s was reported to be 1.2% per year and the target until 2010 was reduced to 1.3 to 1.4% per year… This indicates that increasing the reduction rate of the specific energy consumption to 2% per year is considered ambitious.

However, overall average rates can mask much higher potentials for new equipment — the slow turnover of the capital stock and resulting slow penetration of new technologies means that it takes time to effect meaningful change (while household appliances last between 5 and 15 years, large scale industrial plant lasts for 25 years or more, and buildings can often last for 60 to 70 years). Blok notes:[13]

> After correction for structural change, a decrease of the energy intensity (due to energy efficiency improvements) of about 2%... can also be seen as a decrease of the specific energy consumption of new equipment of 5% per year.

Blok undertakes further analyses to show that sustained implementation of investments, that deliver significantly improved rates of AEEI, has the potential to deliver significant savings — improved equipment steadily replaces the existing capital stock, transforming the average performance *over time*. This is a key point:[14]

> … the reduction comes slowly. It takes several decades before the improved energy efficiency rates really take effect in the total economy… it may be concluded that in the long run the effect on energy use of an accelerated rate of energy efficiency improvement can be very substantial, even if such an accelerated rate of reduction is only maintained for some decades… In the short term it is also clear that the effects are very limited: in 10 years the energy use in the case of accelerated innovation is only 7% below the reference energy use.

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11 Blok K. 2005, 'Improving Energy Efficiency by Five Percent and More per Year?', *Journal of Industrial Ecology*, Volume 8, Number 4, pp 87.

12 Ibid.

13 Ibid.

14 Ibid, pp93.

Clearly, influencing the rate of energy efficiency improvement for new equipment will have a significant impact on future rates of improvement in energy efficiency. The long periods required for capital turnover suggest that raising the rate of improvement as soon as possible — and keeping this rate of improvement going — has the potential to deliver a significant cumulate reduction in energy use over time.

3.1 Methodology

In what follows, we evaluate this potential for improvement in the priority sectors, first discussing the technology opportunities to improve energy efficiency, then considering the amount of savings available given a requirement for uptake to be 'economic' (see Section 1.2 for a definition of 'economic potential').

As noted in Chapter 2, the baseline for each sector for the analysis is the ABARE projections of sectoral energy use in Western Australia.

The potential for energy efficiency is evaluated for two periods:

- The *medium term potentia*l through to 2015 draws on recent work for the Greenhouse and Energy Taskforce by Energetics.[15] This work assesses energy savings potential by sector and by fuel. Energetics examine three different classes of energy savings opportunities in each sector:
  - *As Is* — covers improved management and operation of energy using buildings, plant and equipment that will remain in operation essentially unchanged in the period to 2015 (except for business as usual changes to energy management);
  - *Replace* — covers the investments which will replace existing buildings, plant and equipment with new equipment or technology over the period to 2015, with energy savings flowing from improved design and operation of the replacement equipment than would otherwise be the case; and
  - *Growth* — covers those greenfields major projects or expansions that are committed or planned, requiring investment in new buildings, plant or equipment in order to allow the sector to increase production.
- The *longer term potential* over the period 2015 to 2030 builds on the Energetics appraisal. The evaluation extends the Energetics analysis in the three classes of *As Is*, *Replace* and *Growth* investments, by sector, and by fuel:
  - 'business as usual' trends through to 2015 for the *As Is, Replace* and *Growth* classes are continued through to 2030, drawing on the ABARE projections.
  - The potential for enhanced rates of energy efficiency improvement over this longer term period are considered, and their impact in terms of delivering energy savings assessed. Scenario analysis is conducted around these rates to give a conservative 'low' and optimistic 'high' improvement rates.

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15 Energetics 2006, *Energy Efficiency Potential in Western Australia*, Report for the Department of Environment Western Australia.

- The lives for equipment in each sector and fuel class adopted in the Energetics analysis through to 2015 continue to be assumed through to 2030 (resulting in the same overall capital turnover rates).

We also build on the foregoing assessments to develop corresponding 'low' and 'high' estimates for the medium and longer term:

- A sensitivity is conducted on Energetics' findings through to 2014-15 for lower energy savings assumptions — which are then used as part of the conservative 'low' scenario case;

- We adopt Energetics' estimates to 2014-15 largely unchanged for the 'high' scenario.

  - However, we do allow a slightly faster rate of growth for some of the sectoral *Growth* categories from 2011-12 on, to reflect the significant raft of new projects that are currently in 'Front End Engineering and Design', which were not included in the Energetics appraisal, and which would be expected to commence operation from around 2011-12 on.

  - For this 'high' scenario, we also allow the *Growth* category to achieve higher rates of improvement from 2011-12 on — to reflect the potential for policy to influence the energy efficiency of these new projects prior to their 'Final Investment Decision' (likely to occur in the period 2007-08 to 2009-10. (Energetics in contrast assumed that these new projects could not be changed — resulting in low rates of improvement of 0.5 per cent per annum beyond 'business as usual' right through to 2015 for the *Growth* category.)

- High and low scenarios are also developed for estimates of savings available over the longer term, 'beyond the ABARE business as usual', between 2015 and 2030.

  - These scenarios are indicative, but are considered to span the range of what is feasibly possible. In large part, the success in achieving the high scenario savings will depend on the effectiveness of policy intervention.

- Estimates are based on current fuel prices being maintained into the future (constant real 2006 dollars).

Depending in which emissions factors are used, we obtain different estimates of the greenhouse gas implications of savings from energy efficiency (Table 3.1). For the sectoral estimates in this report, we use *direct combustion* emissions factors — as these ensure the savings estimated are applicable to end use in the Stationary Energy sector.

On the other hand, *full fuel cycle* emissions factors capture all of the greenhouse gas emissions associated with reductions in energy end use. These emissions factors account for the direct emissions from combustion (incident in the Stationary Energy sector), plus the indirect emissions associated with conversion and transport losses (incident in the Stationary Energy sector), and also the upstream emissions reductions (incident in the Fugitive sector). We also report the full fuel cycle emissions impact for the estimate of total savings across all sectors (see Section 3.10).

TABLE 3.1 – FULL FUEL CYCLE EMISSIONS FACTORS – WESTERN AUSTRALIA

	Direct combustion emissions (kg CO_2e per kg)	Indirect emissions (kg CO_2e per kg)	'Full fuel cycle' Emissions (kg CO_2e per kg)
Coal	93.1	1.1	94.2
Other petroleum (ADO)	70.5	7.8	78.2
Natural gas	52.7	8.1	60.7
Electricity	239	36	276

Source: Australian Greenhouse Office 2005, Factors and Methods Workbook, www.greenhouse.gov.au .

Cogeneration allows electricity supply and thermal heat energy to be delivered concurrently. There are significant opportunities for additional cogeneration in Western Australia, particularly in the Alumina sector. As potential savings from this source have been estimated elsewhere, **savings from cogeneration opportunities are not included** in this report.[16]

Our main focus is on estimating savings that are *socially* cost effective — this is assumed to encompass any measure with a simple payback of less than 6 years (equating to a real internal rate of return of around 16 per cent). Privately cost effective savings will be a subset of the socially cost effective returns — and for energy efficiency investments are defined as any measure with a simple payback of less than 2 years (equating to a real internal rate of return of around 50 per cent).

- It is important to understand that as the estimates for energy efficiency potential developed here are 'beyond business as usual', such that some form of policy intervention will be required to realise the potential. Actual savings will depend on how effective the policy interventions are in unlocking the identified energy savings potential.

Finally, we extend the estimates of socially cost effective savings at $0 per tonne CO2e, to consider the related socially cost effective savings available at carbon prices of $10, $20, $30 and $40 per tonne CO_2e (all in 2006 dollars). To achieve this, we

- First estimate how the specified carbon prices add to fuel costs, and analyse how this *reduces* the payback of the socially cost effective investments in energy efficiency by fuel in each sector;

- increase the investment in energy efficiency, thereby returning the paybacks to the socially cost effective level of 6 years, in the presence of the carbon price;

[16] See Next Energy 2006, Supply Side Options for WA Stationary Energy — An Asssessment of Alternative Technologies and Development Support Mechanisms, Final Report to WA Greenhouse and Energy Taskforce, pp 79.

- assume a proportionate increase in energy efficiency — based on an assumption of a unitary elastic marginal cost curve for the supply of energy efficiency savings, for each sector and fuel.

3.2 Mining

The baseline total final stationary energy usage for the Mining sector includes use of Coal, Gas, Electricity and Other petroleum products (Table 3.2). Other petroleum is included as a stationary energy end use here only, because of the significant use of diesel in Mining — for remote electricity generation and other stationary power purposes.

TABLE 3.2 – BASELINE STATIONARY ENERGY FINAL USE – MINING

	2004-05 (PJ)	2009-10 (PJ)	2014-15 (PJ)	2019-20 (PJ)	2024-25 (PJ)	2029-30 (PJ)
Coal	7.0	6.8	6.2	5.7	5.3	4.9
Other petroleum	34.6	48.5	65.2	85.6	110.6	141.0
Gas	11.5	15.8	20.3	26.0	32.7	40.7
Electricity	19.0	23.6	28.5	33.9	40.0	46.8
Total stationary energy	72.1	94.8	120.2	151.2	188.7	233.4

Source: Akmal M. and Riwoe. D 2005, op.cit.

Energy savings opportunities

Energetics identifies major areas of energy use in the Mining sector in Western Australia as being:

- Mining: 20 per cent of energy use;
- Materials handling: 60 per cent of energy use;
- Initial concentration: 20 per cent of energy use.

Energetics note that 'reviewing the focus of research trends in the mining industry it becomes apparent that the step change energy improvements in these three areas are likely to only have affect post 2015'.[17] Energetics concludes that, through to 2015, the following technology advances likely will underpin *incremental* energy savings opportunities:[18]

- Mining — opportunities for improved;
  - blast management;

[17] Energetics 2006, *Energy Efficiency Potential in Western Australia*, Report for the Department of Environment Western Australia, pp 25.

[18] Ibid, pp 25.

  - digital control of machinery;
  - electricity generation efficiencies — applicable to pumping, transport of ore and overburden, and truck lifts;

- Materials handling — opportunities for improved:
  - management systems, including installation and optimal control of variable speed drives;
  - diesel electricity generation;
  - high efficiency electric motors;

- Initial concentration — opportunities for improved:
  - managemement and control of systems;
  - electricity generation utilising diesel;
  - management of mine to mill program, with improvements in crushing, grinding and milling.

BOX 3.1 - ENERGY EFFICIENCY SAVINGS IN THE WA MINING SECTOR

The Centre of Excellence in Cleaner Production at Curtin University report examples of outstanding energy savings in the Western Australian Mining sector through upgrading technology:

- Wesfarmers Coal Limited's energy efficiency improved by 44% between 1993 and 1999. In terms of production volumes, efficiency went from 49 MJ/ bank cubic metre equivalent of production in 1993 to 27MJ/ bank cubic metre equivalent of production in 1999. Over the same period, greenhouse gas emissions were reduced by 48% per bank cubic metre equivalent of production.

- The Newmont Golden Grove mining operation has two underground zinc/copper mines. These yield around 1.3 million tonnes of ore each year which are processed on-site to produce 100,000 tonnes of copper concentrate and 150,000 tonnes of zinc concentrate each year. Between 1997 and 2002 around $5 million was invested in cleaner production approaches. The associated strategy to reduce greenhouse gas emissions resulted in significant energy efficiency improvements, resulting in total energy use per tonne of resource produced falling from 87 MJ/tonne in 1998 to 58 MJ/tonne in 2002 — a decline of 33 per cent.

Source: cleanerproduction.curtin.edu.au/cecp/cecpcasestudywa.htm

The potential of these types of savings have already been demonstrated at existing mining operations in Western Australia (Box 3.1).

Beyond 2015, Energetics note that there are substantially increased opportunities to make savings over and above the ongoing incremental improvement rates, such as through step changes involving:

- replacement of diesel by alternative fuel such as compressed natural gas — which although resulting in similar efficiency outcomes to diesel generation, would deliver reduced greenhouse gas emissions;

- management of material through mine to mill programs, with potential to minimise energy used in crushing, grinding and milling.

Other studies confirm the importance of improved management and control approaches in reducing energy use in mining operations. For example, the United States Department of Energy and the National Mining Association identify key opportunities to improve energy efficiency in the Mining sector through:[19]

- improved exploration and mine planning approaches — including improved resource characterisation through;
  - advances in remote sensing and imaging technology;
  - improved control systems;
  - improved mine modelling techniques;
- advanced mining approaches;
  - remote and miniaturised machinery;
  - solution mining;
  - improved fragmentation and cutting techniques, including controlled blasting;
  - improved energy efficiency in materials handling, haulage, ventilation and dust control;
  - systems integration;
  - automation, control and robotics, allowing continuous mining operations.

Energy savings potential in the medium term

Energetics judge that there is 'socially cost effective' potential to improve energy efficiency through policy action (beyond the ABARE 'business as usual' energy projection) by 1 per cent per annum for *As Is* equipment, 2 per cent per annum for *Replace* equipment, and 0.5 per cent per annum for *Growth* equipment.

In total, Energetics estimate that there is the potential to reduce overall energy consumption by 9.3 per cent by 2014-15 — from 120 PJ to 109 PJ (Table 3.3). This is equivalent to 9.3 per cent reduction by 2014-15.

[19] U.S. Department of Energy and the National Mining Association 2002, *Mining Industry of the Future: Exploration and Mining Technology Roadmap*, www.doe.gov, pp 20.

TABLE 3.3 - ENERGETICS REDUCTION IN MINING TOTAL FINAL ENERGY USE FROM ENERGY EFFICIENCY

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	80.4	85.2	90.4	94.8	99.4	104.2	109.2	114.5	120.2
Energy Efficiency Scenario (PJ)	80.4	84.3	88.6	91.8	95.4	98.8	102.3	105.6	109.0
Percentage reduction (%)	0.0	1.0	2.0	3.1	4.1	5.2	6.3	7.8	9.3

Source: Energetics 2006, op.cit., pp 24.

Energy savings potential in the longer term

Assessments of the longer term future potential for energy efficiency improvement in mining are scant. The studies that are available tend to be roadmaps, which nominate areas for improvement, but not quantify the potential savings or their costs.

The best industry-wide assessment of energy savings potential in Mining we are aware of is the study done by the United States Department of Energy in conjunction with the United States National Mining Association. It nominates — as a *goal* — adoption of energy savings technologies to reduce energy use per unit of resource *produced,* by up to 30 per cent within 20 years, based on novel technologies.[20] This would translate to a rate of improvement of 0.8 per cent per annum on average, beyond business as usual, for the *Growth* and *Replace* categories.

While not explicitly stated in the report, this appears to be a goal that relates to privately cost effective investment — given that it is predicated on voluntary action to 'integrate environmental goals into production plans'.[21] This would tend to suggest that the socially cost effective rate could be as much as twice as high again — somewhere between 1 and 2 per cent per annum.[22]

Detailed analyses for specific industries tend to confirm the magnitude of these savings in relation to the *Growth* and *Replace* categories. For example, The Canadian Industry Program for Energy Conservation undertook a comprehensive study of the energy usage for open cut mining of gold and iron ore in Canada. It examined seven mining and initial concentration (crushing and separation) operations, and outlined the energy expended at each of these mines during the production process. By benchmarking best practice, the study estimated the total amount of energy that could be saved if mines approached best practice. In the mining operations phase, the report

20 U.S. Department of Energy and the National Mining Association 2002, op.cit., pp 21.

21 U.S. Department of Energy and the National Mining Association 2002, op.cit., pp 17.

22 Socially cost effective savings (with paybacks up to 6 years) are often about double those savings that are privately cost effective (with paybacks up to 2 years), particularly for new *Growth* technology.

estimated a potential for a reduction of 36 per cent in energy use on average.[23] Similarly, the study estimated reductions of 47 per cent were available in the milling process used to achieve initial concentration of iron ore, and 53 per cent in the milling process for gold mining operations.[24] While the study cautions that the savings are 'hypothetical and may not be achievable given the [individual] circumstances faced by each mine', it nonetheless indicates the scale of potential savings given even *existing* technologies, which might apply to the *Growth* and *Replace* category — assuming an average life for equipment in the sector of 25 years, then savings of between 1 and 2 per cent per annum for the *Growth* and *Replace* category would be available for a long period of time. New technological developments would augment these estimates.

Such assessments give a broad indication of energy savings that could be made in Australia. However, it is important to note that the Mining practices found in Australia may differ substantially from those overseas. Nevertheless, other assessments for Australia tend to confirm similar significant potential. For example, the work undertaken by Graham Armstrong and Saturn Corporate Resources for the Sustainable Energy Authority of Victoria suggests that there is potential to save as much as 50 per cent of the energy used by non-mobile sources in Mining, through high efficiency motors, variable speed drives and better control systems.[25]

Overall, therefore, we judge that it is reasonable to assume significant rates of between 1 and 2 per cent for the *Growth* and *Replace* investment categories for the medium term. For the longer term, step change technologies offer the potential to reduce energy use further in the *Growth* and *Replace* category. Accordingly, socially cost effective rates of improvement in the Mining sector for the period beyond 2015 could be sustained at average sector-wide rates of:

- *As Is* — between 0.5 per cent per annum (low scenario) and 1.0 per cent per annum (high scenario);
- *Replace* — between 1.0 per cent per annum (low scenario) and 2.0 per cent per annum (high scenario);
- *Growth* — between 1.0 per cent per annum (low scenario) and 2.0 per cent per annum (high scenario) from 2011-12 on (prior to that point, we assume savings of 0.1 (low scenario) to 0.5 (high scenario) per cent per annum to reflect that new policy will have little influence over the energy use of new projects).

In addition, in the high scenario, we allow the *Growth* and *Replace* rates to ramp up from 2020 on to 3.0 per cent (Figure 3.1), to reflect a potential for more rapid development in energy savings technology — in response to future carbon prices elsewhere in the world (so-called 'induced technical change').

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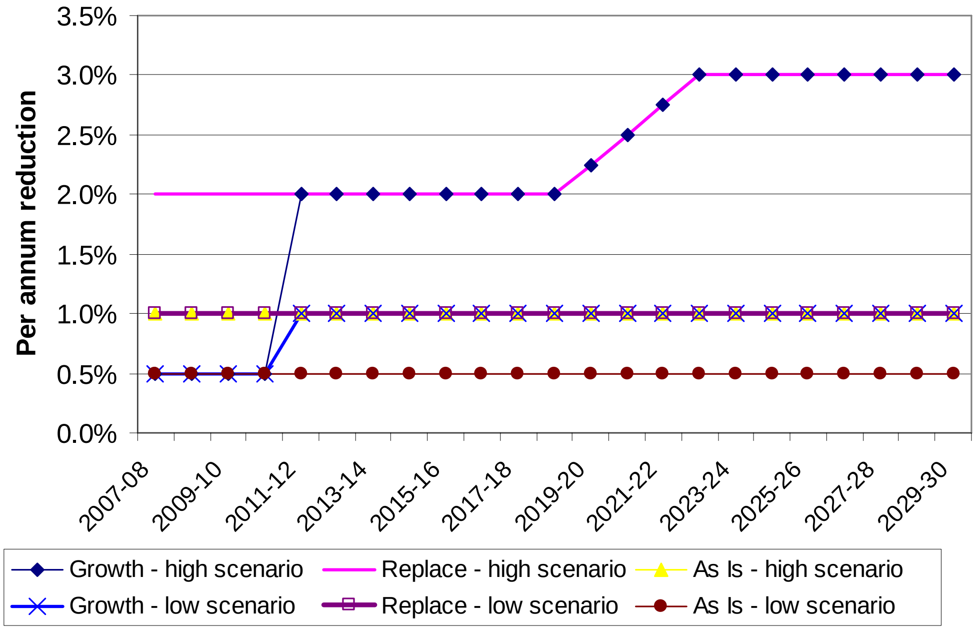
23 Natural Resources Canada 2005, *Benchmarking the Energy Consumption of Open Pit Mines*, www.nrcan.can.gov .

24 Ibid, pp55.

25 Sustainable Energy Authority of Victoria 2003, *National Framework for Energy Efficiency — Preliminary Assessment of Demand Side Energy Efficiency Improvement Potential and Costs*, Report No. 4, www.seav.vic.gov.au, pp 39.

FIGURE 3.1 – ANNUAL RATES IN ENERGY SAVINGS 'BEYOND BAU' — 6 YEAR PAYBACKS FOR MINING



Source: Insight Economics

Energy savings outcomes

Overall, there are significant (net social) cost effective energy savings available through improved energy efficiency in the Mining sector.

At zero carbon prices, savings in energy delivering between 4.3 and 8.9 Mt CO2e are potentially available by 2030 (Table 3.4).

TABLE 3.4 – MINING SECTOR ENERGY USE AND SAVINGS – 6 YEAR PAYBACK

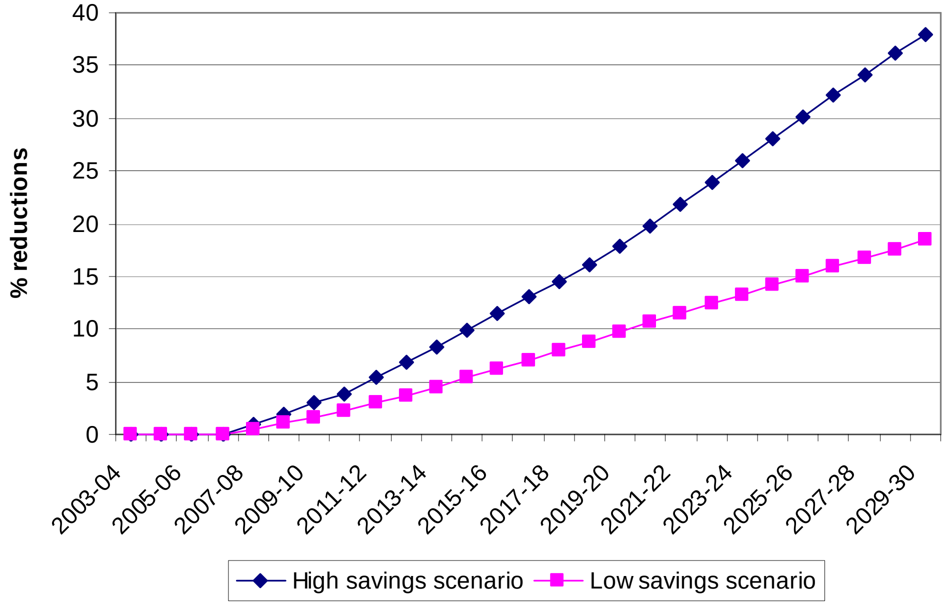
	2009-10	2014-15	2019-20	2024-25	2029-30
BAU energy use (PJ)	94.8	120.2	151.2	188.7	233.4
High savings scenario					
Coal (PJ)	6.6	5.7	5.0	4.4	3.9
Other petroleum (PJ)	47.0	58.4	69.6	78.2	85.6
Gas (PJ)	15.4	18.5	21.6	24.0	25.8
Electricity (PJ)	22.9	25.7	28.0	29.0	29.4
Total (PJ)	91.9	108.3	124.2	135.6	144.7
Total savings (PJ)	2.8	11.9	27.0	53.1	88.7
Total savings (% of BAU)	3.0	9.9	17.9	28.1	38.0
Total savings (kt CO_2e)	315	1268	2828	5438	8920
Low savings scenario					
Coal (PJ)	6.73	5.95	5.38	4.85	4.37
Other petroleum (PJ)	6.8	6.2	5.8	5.3	4.9
Gas (PJ)	15.6	19.3	23.6	28.3	33.5
Electricity (PJ)	23.3	27.0	30.7	34.5	38.3
Total (PJ)	93.2	113.7	136.5	162.0	190.4
Total savings (PJ)	1.6	6.5	14.7	26.7	43.0
Total savings (% of BAU)	1.6	5.4	9.7	14.1	18.4
Total savings (kt CO_2e)	171	690	1535	2733	4327

Source: Insight Economics

The significant difference in savings between the high and low scenarios by 2030 illustrate the compounding effect that even slightly higher rates can have if they are started early and maintained over time (Table 3. 4 and Figure 3.2).

Higher carbon prices substantially increase the amount of savings that are available over the longer term at socially cost effective returns (Table 3.5). Savings rise to between 6.2 and 12.8 Mt CO2e at 2030 under the impact of a $40 per tonne CO_2e carbon price.

FIGURE 3.2 – MINING SECTOR TOTAL CUMULATIVE REDUCTIONS BELOW BAU — UP TO 6 YEAR PAYBACKS



Source: Insight Economics

TABLE 3.5 – MINING SECTOR — EFFECT OF HIGHER CARBON PRICES ON EMISSIONS SAVINGS FROM INVESTMENTS WITH UP TO 6 YEAR PAYBACKS

	2009-10	2014-15	2019-20	2024-25	2029-30
High savings scenario					
\$0/t CO_2e (kt CO_2e)	315	1268	2828	5438	8920
\$10/t CO_2e (kt CO2e)	359	1438	3206	6161	10099
\$20/t CO_2e (kt CO2e)	394	1574	3506	6727	11012
\$30/t CO_2e (kt CO2e)	429	1711	3806	7293	11925
\$40/t CO_2e (kt CO2e)	465	1848	4106	7860	12839
Low savings scenario					
\$0/t CO_2e (kt CO_2e)	171	690	1535	2733	4327
\$10/t CO_2e (kt CO2e)	195	783	1740	3097	4900
\$20/t CO_2e (kt CO2e)	214	857	1902	3381	5343
\$30/t CO_2e (kt CO2e)	233	931	2065	3666	5787
\$40/t CO_2e (kt CO2e)	253	1006	2228	3951	6231

Source: Insight Economics

3.3 Basic chemicals

The baseline energy use for the Basic chemicals sector is dominated by gas (Table 3.6).

TABLE 3.6 – BASELINE ENERGY USE – BASIC CHEMICALS

	2004-05 (PJ)	2009-10 (PJ)	2014-15 (PJ)	2019-20 (PJ)	2024-25 (PJ)	2029-30 (PJ)
Coal	0.0	0.0	0.0	0.0	0.0	0.0
Gas	13.6	36.8	41.7	47.7	54.2	61.1
Electricity	1.8	2.1	2.4	2.6	2.9	3.2
Total stationary energy	15.5	39.0	44.0	50.3	57.1	64.3

Source: Akmal M. and Riwoe. D 2005, op.cit.

Energy savings opportunities

Energetics identify opportunities for incremental improvement in energy use in the Basic chemicals sector in Western Australia as resulting from:

- improved and optimised process control;
- improved management and enhanced management systems;
- installation and optimal control of variable speed drives;
- installation of high efficiency motors.

Energetics note that for the longer term, step changes in energy use are possible through:

- extending process design to incorporate consideration of flexibility and operability;
- different reactor sequences and regimes which have the potential to increase yields significantly, including adoption of micro-reactors (which are likely to become commercial after 2015) — where the reactions take place under tightly controlled temperature regimes to ensure that reactions proceed as close to equilibrium as possible.

Over the longer term, there is considerable potential to harness new process, membrane, bio- and nano- technologies, as well as to reduce energy losses through waste heat recovery and process integration.

The United States chemicals industry is the largest in the world. It has as a 25 year vision a goal to reduce energy use by 30 per cent by 2020 — which corresponds to 0.6

per cent per annum beyond business as usual.[26] On the basis that this equates to privately cost potential, it is reasonable to assume that socially cost effective savings could be around double this amount — for just over 1.2 per cent per annum.

To achieve this, the industry is focusing on research and development with a view to improvements in:

- separation technologies;
  - low-energy, low-capital separations; membranes;
  - hybrid separations systems;
  - aqueous separations;
- alternative fossil-based feedstocks and chemistries;
  - gasification; synthesis gas;
  - remote methane; methane activation and coupling;
  - control of selective oxidation;
  - selective conversion of paraffins;
- energy-efficient process alternatives;
  - process intensification;
  - heat integration;
  - low-temperature heat recovery systems;
  - homogeneous catalyst recovery and reuse;
  - biocatalysis;
- new materials;
  - bio-based materials;
  - nanomaterials;
  - coatings and films;
- cross-cutting capabilities;
  - high-throughput experimentation (HTE);
  - modeling methods and tools;

[26] U.S. Department of Energy 1996, *Technology Vision 2020 - The U.S. Chemical Industry*, www.eere.energy.gov/industry/chemicals/index.html .

- databases;
- interfacial science;
- tools.

Energy savings potential in the medium term

Energetics judge that there is 'cost effective' potential to improve energy efficiency in the Basic chemicals sector of 1 per cent per annum for *As Is* equipment, 2 per cent per annum for *Replace* equipment, and 0.5 per cent per annum for *Growth* equipment.

In total, Energetics estimate that there is the potential to reduce overall energy consumption by around 5.7 per cent by 2014-15 — from 41 PJ to 38 PJ (Table 3.7).

TABLE 3.7 - ENERGETICS REDUCTION IN BASIC CHEMICALS TOTAL FINAL ENERGY USE FROM ENERGY EFFICIENCY

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	20.1	33.1	34.4	35.8	36.8	37.9	38.9	39.8	40.7
Energy Efficiency Scenario (PJ)	20.1	32.9	33.9	35.0	35.8	36.5	37.2	37.8	38.4
Percentage reduction (%)	0.0	0.4	1.4	2.1	2.9	3.6	4.3	5.0	5.7

Source: Energetics 2006, op.cit., pp 29.

Energy savings potential for the longer term

The International Energy Agency observes that 'the energy intensity of key chemicals (petrochemicals and ammonia) can be reduced by at least 20 per cent, if state of the art technologies are applied'.[27] The average potential for existing ammonia plants to improve energy intensity amounts to around 10 per cent, but this varies by plant and location (Box 3.2).

[27] International Energy Agencey 2006, op.cit., pp 411.

BOX 3.2 – POTENTIAL ENERGY SAVINGS IN THE AMMONIA INDUSTRY

Global ammonia production growth is limited and is mainly concentrated in Asia, which accounts for around half of global production. About 80% of world production is based on natural gas steam reforming, 15% on coal gasification (mainly in China) and 5% on the partial oxidation of oil products (mainly in India and China). A typical coal based process uses 1.7 times more energy than a gas based process.

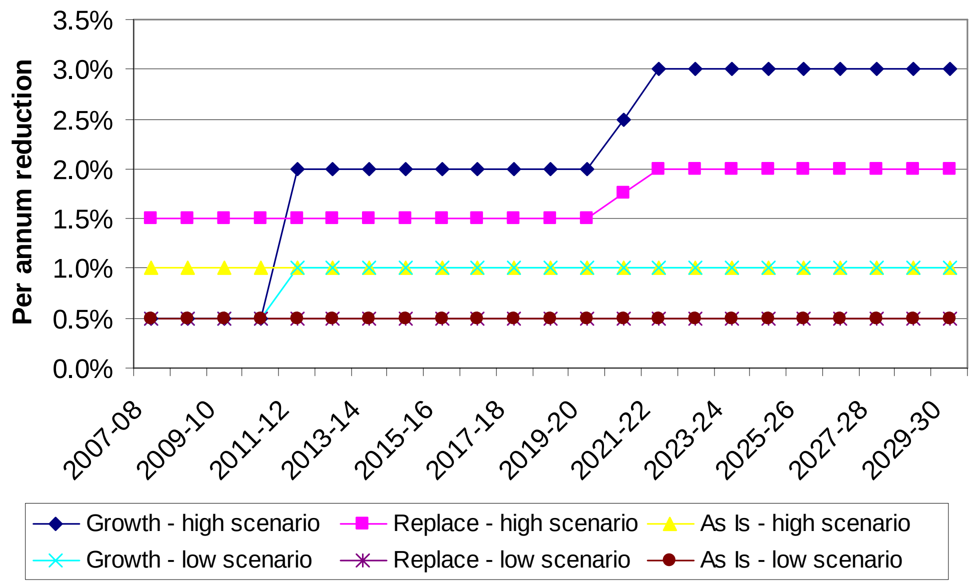
The average natural gas steam reforming plant in the United States or Europe uses 35 to 38 GJ per tonne of ammonia; the best available technology uses 28 GJ per tonne. The theoretical minimum energy and feedstock use of the process is 21.2 GJ per tonne ammonia. Given the theoretical minimum, current gas-based ammonia production achieves about 60% efficiency.

The potential for retrofitting existing ammonia production facilities, where the average potential is between 1 and 3 GJ/tonne, would mean an improvement of less than 10%.

Source: International Energy Agency 2006, op.cit., pp 419.

Overall, we judge that it is reasonable to assume fairly modest rates of improvement for the *Replace* and *As Is* investment categories for the longer term — to reflect that much of this sector's capital investment is already in place, that technology in the sector is close to developed country best practice, and also that the majority of expansions are likely to be incremental.

FIGURE 3.3 – BASIC CHEMICALS ANNUAL RATES IN ENERGY SAVINGS 'BEYOND BAU' — 6 YEAR PAYBACKS



Source: Insight Economics

Accordingly, we assume that socially cost effective rates of improvement in the Basic chemicals sector for the period beyond 2015 could be sustained at average sector-wide rates of:

- *As Is* — between 0.5 per cent per annum (low scenario) and 1.0 per cent per annum (high scenario);

- *Replace* — between 0.5 per cent per annum (low scenario) and 1.5 per cent per annum (high scenario);

- *Growth* — between 1.0 per cent per annum (low scenario) and 2.0 per cent per annum (high scenario).

- In addition, in the high scenario, we allow the *Growth* and *Replace* rates to ramp up from 2020 on to 2.0 and 3.0 per cent per annum respectively, to reflect a potential for more rapid development in energy savings technology — in response to future carbon prices elsewhere in the world (so-called 'induced technical change') (Figure 3.1).

Energy savings outcomes

Overall, there are moderate (net social) cost effective energy savings available through improved energy efficiency in the Basic chemicals sector.

At zero carbon prices, savings in energy delivering between 0.7 and 1.5 Mt CO2e are potentially available by 2030 (Table 3.8).

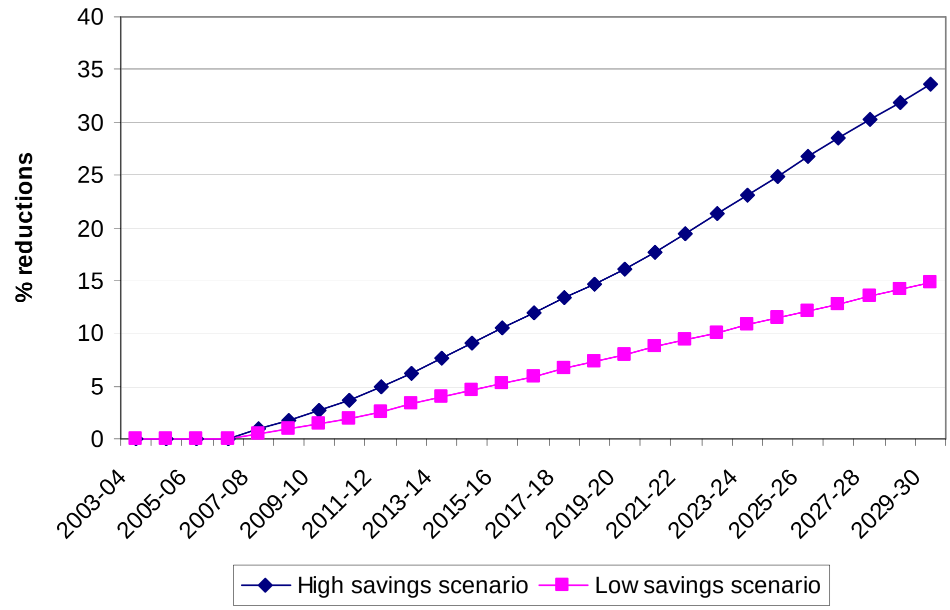
TABLE 3.8 – BASIC CHEMICALS SECTOR ENERGY USE AND SAVINGS – 6 YEAR PAYBACK

	2009-10	2014-15	2019-20	2024-25	2029-30
BAU energy use (PJ)	39.0	44.0	50.3	57.1	64.3
High savings scenario					
Coal (PJ)	0.0	0.0	0.0	0.0	0.0
Other petroleum (PJ)	0.0	0.0	0.0	0.0	0.0
Gas (PJ)	35.8	37.9	40.0	40.5	40.4
Electricity (PJ)	2.1	2.1	2.2	2.2	2.1
Total (PJ)	37.9	40.0	42.2	42.7	42.5
Total savings (PJ)	1.1	4.0	8.1	14.4	21.8
Total savings (% of BAU)	2.7	9.1	16.2	25.2	33.9
Total savings (kt CO_2e)	67	250	507	893	1349
Low savings scenario					
Coal (PJ)	0.00	0.00	0.00	0.00	0.00
Other petroleum (PJ)	0.0	0.0	0.0	0.0	4.9
Gas (PJ)	36.3	39.7	43.8	48.0	52.0
Electricity (PJ)	2.1	2.3	2.4	2.6	2.7
Total (PJ)	38.4	42.0	46.3	50.5	54.7
Total savings (PJ)	0.6	2.0	4.0	6.5	9.5
Total savings (% of BAU)	1.5	4.6	8.0	11.4	14.8
Total savings (kt CO_2e)	37	127	252	407	592

Source: Insight Economics

Again, the significant difference in savings between the high and low scenarios by 2030 illustrate the compounding effect that even slightly higher rates can have if they are started early and maintained over time (Table 3.8 and Figure 3.4).

FIGURE 3.4 – BASIC CHEMICALS TOTAL CUMULATIVE REDUCTIONS BELOW BAU — UP TO 6 YEAR PAYBACKS



Source: Insight Economics

TABLE 3.9 – BASIC CHEMICALS SECTOR — EFFECT OF HIGHER CARBON PRICES ON EMISSIONS SAVINGS FROM INVESTMENTS WITH UP TO 6 YEAR PAYBACKS

	2009-10	2014-15	2019-20	2024-25	2029-30
High savings scenario					
$0/t CO_2e (kt CO_2e)	67	250	507	893	1349
$10/t CO_2e (kt CO2e)	102	381	774	1366	2065
$20/t CO_2e (kt CO2e)	119	445	905	1596	2414
$30/t CO_2e (kt CO2e)	136	509	1035	1826	2762
$40/t CO_2e (kt CO2e)	153	573	1166	2057	3111
Low savings scenario					
$0/t CO_2e (kt CO_2e)	37	127	252	407	592
$10/t CO_2e (kt CO2e)	56	194	384	622	906
$20/t CO_2e (kt CO2e)	65	226	449	727	1059
$30/t CO_2e (kt CO2e)	74	259	514	832	1212
$40/t CO_2e (kt CO2e)	84	291	579	937	1365

Source: Insight Economics

Higher carbon prices substantially increase the amount of savings that are available over the longer term at socially cost effective returns (Table 3.9). Savings rise to between 1.4 and 3.1 Mt CO2e at 2030 under the impact of a $40 per tonne CO_2e carbon price.

3.4 Iron and steel

The baseline energy use for the Iron and steel sector is dominated by coal use (Table 3.10).

TABLE 3.10 – BASELINE ENERGY USE – IRON AND STEEL

	2004-05 (PJ)	2009-10 (PJ)	2014-15 (PJ)	2019-20 (PJ)	2024-25 (PJ)	2029-30 (PJ)
	PJ	PJ	PJ	PJ	PJ	PJ
Coal	6.2	14.8	15.2	15.6	15.6	15.7
Gas	0.1	1.5	1.6	1.7	1.7	1.7
Electricity	2.5	2.6	2.6	2.7	2.7	2.7
Total stationary energy	8.9	18.8	19.4	19.9	20.0	20.2

Source: Akmal M. and Riwoe. D 2005, op.cit.

Energy savings opportunities

Since the closure of BHP's Boodarie Direct Reduced Iron plant, the only Iron and steel plant currently in operation in Western Australia is Rio's HI-smelt operation at Kwinana. This plant uses an advanced smelt technology — which in its current form has significantly reduced the energy and emissions intensity of the production of pig iron, compared to traditional approaches:[28]

> A commercial HIsmelt facility equipped with ore preheating can be expected to reduce carbon dioxide emissions per tonne of hot metal by close to 20% when compared to the typical blast furnace route.

The Western Australian operation thus equates to existing global best practice. Future expansions of the Kwinana operation also are likely to be at the frontier of global best practice. In the meantime, there are opportunities for incremental improvement in energy use resulting from:

- improved management and enhanced management systems;
- improved and optimised process control.

[28] Goldsworthy T. and Gull S. 2002, *HIsmelt® - The New Technology for Iron Production*, Paper presented to SEAISI 2002, pp 6.

Energy savings potential in the medium term

Energetics judge that there is 'cost effective' potential to improve energy efficiency in the Iron and steel sector of between 0.5 per cent per annum (coal) and 1 per cent per annum (gas) for *As Is* equipment, 2 per cent per annum for *Replace* (gas) equipment, and 0.5 per cent per annum for *Growth* (coal) equipment.

In total, Energetics estimate that there is the potential to reduce overall energy consumption by around 5.1 per cent by 2014-15 — from 16.7 PJ to 15.9 PJ (Table 3.11).

TABLE 3.11 - REDUCTION IN IRON AND STEEL TOTAL FINAL ENERGY USE FROM ENERGY EFFICIENCY

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	13.2	15.2	16.2	16.3	16.4	16.4	16.6	16.6	16.7
Energy Efficiency Scenario (PJ)	13.1	15.0	15.9	15.9	15.9	15.9	15.9	15.9	15.9
Percentage reduction (%)	0.2	1.0	1.6	2.2	2.8	3.4	4.0	4.5	5.1

Source: Energetics 2006, op.cit., pp 38.

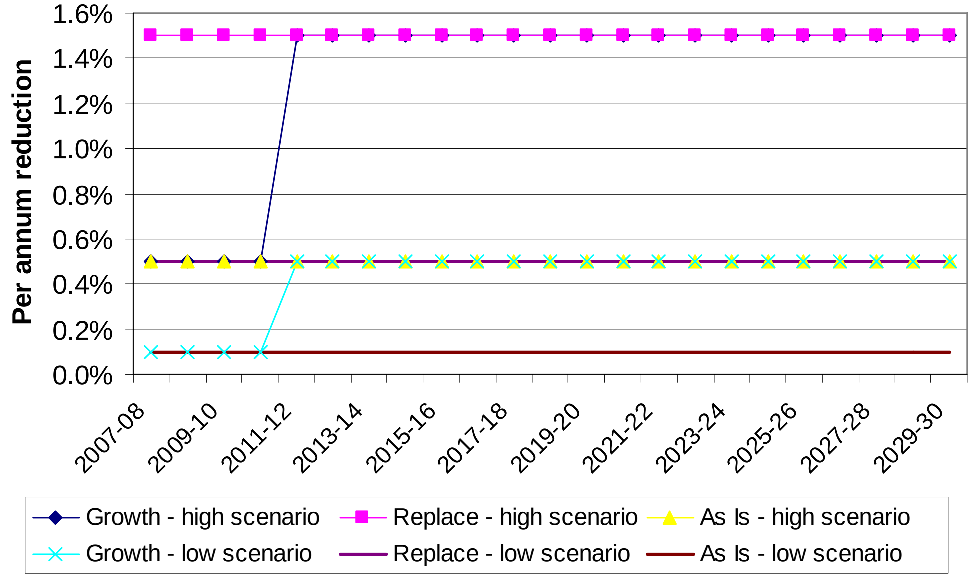
Energy savings potential for the longer term

As noted above, the Kwinana HI-smelt operation is on the frontier of global best practice in iron making. Future expansions are likely to continue this trend.

Overall, we judge that the potential for additional energy savings are modest. We assume rates similar those adopted by Energetics for the *Growth* and *As Is* investment categories for the longer term. Accordingly, socially cost effective rates of improvement in the sector for the period to 2030, beyond business as usual, could average (Figure 3.5):

- *As Is* — between 0.1 per cent per annum (low scenario) and 0.5 per cent per annum (high scenario);
- *Replace* — between 0.5 per cent per annum (low scenario) and 1.5 per cent per annum (high scenario);
- *Growth* — between 0.5 per cent per annum (low scenario) and 1.5 per cent per annum (high scenario).
- In addition, in the high scenario, we allow the rates for the *Replace* and *Growth* classes to ramp up from 2011-12 on.

FIGURE 3.5 – IRON AND STEEL ANNUAL RATES IN ENERGY SAVINGS 'BEYOND BAU' — 6 YEAR PAYBACKS



Source: Insight Economics

Energy savings outcomes

Overall, there are small (net social) cost effective energy savings available through improved energy efficiency in the Iron and steel sector.

At zero carbon prices, savings in energy delivering between 0.1 and 0.2 Mt CO2e are potentially available by 2030 (Table 3.12).

TABLE 3.12 – IRON AND STEEL SECTOR ENERGY USE AND SAVINGS – 6 YEAR PAYBACK

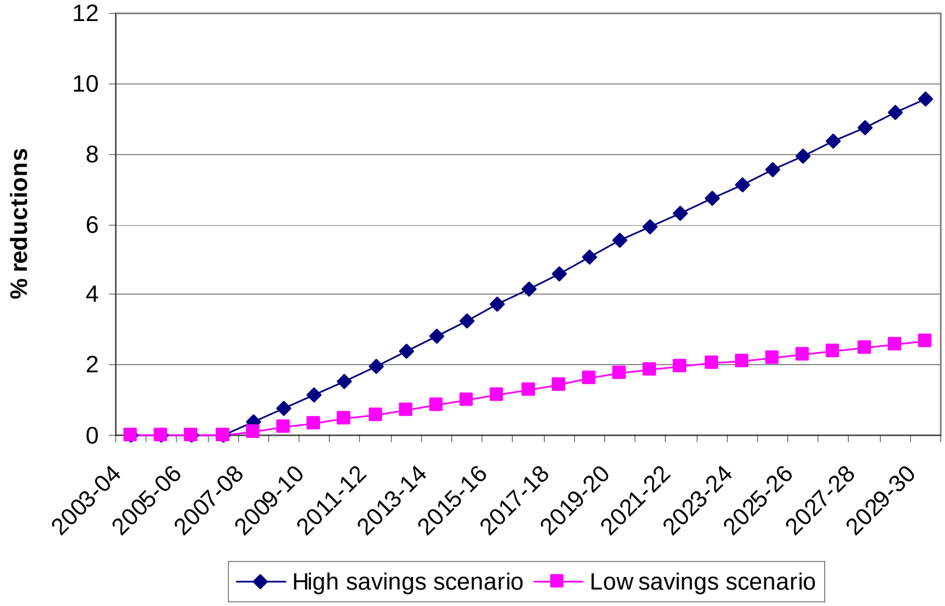
	2009-10	2014-15	2019-20	2024-25	2029-30
BAU energy use (PJ)	18.8	19.4	19.9	20.0	20.2
High savings scenario					
Coal (PJ)	14.7	14.8	15.0	14.8	14.7
Other petroleum (PJ)	0.0	0.0	0.0	0.0	0.0
Gas (PJ)	1.4	1.5	1.5	1.5	1.5
Electricity (PJ)	2.5	2.5	2.4	2.2	2.1
Total (PJ)	18.6	18.7	18.8	18.5	18.3
Total savings (PJ)	0.2	0.6	1.1	1.5	1.9
Total savings (% of BAU)	1.1	3.3	5.5	7.5	9.6
Total savings (kt CO_2e)	23	70	125	179	236
Low savings scenario					
Coal (PJ)	14.8	15.1	15.4	15.4	15.4
Other petroleum (PJ)	8.0	8.1	8.1	8.2	8.2
Gas (PJ)	1.4	1.5	1.6	1.7	1.8
Electricity (PJ)	2.6	2.6	2.6	2.5	2.5
Total (PJ)	18.8	19.2	19.5	19.6	19.6
Total savings (PJ)	0.1	0.2	0.4	0.4	0.5
Total savings (% of BAU)	0.3	1.0	1.8	2.2	2.7
Total savings (kt CO_2e)	6	21	39	56	75

Source: Insight Economics

Again, the significant difference in savings between the high and low scenarios by 2030 illustrate the compounding effect that even slightly higher rates can have if they are started early and maintained over time (Table 3.12 and Figure 3.6).

Higher carbon prices slightly increase the amount of savings that are available over the longer term at socially cost effective returns (Table 3.13). Savings rise to between 0.2 and 0.5 Mt CO2e at 2030 under the impact of a $40 per tonne CO_2e carbon price.

FIGURE 3.6 – IRON AND STEEL SECTOR TOTAL CUMULATIVE REDUCTIONS BELOW BAU — UP TO 6 YEAR PAYBACKS



Source: Insight Economics

TABLE 3.13 – IRON AND STEEL SECTOR — EFFECT OF HIGHER CARBON PRICES ON EMISSIONS SAVINGS FROM INVESTMENTS WITH UP TO 6 YEAR PAYBACKS

	2009-10	2014-15	2019-20	2024-25	2029-30
High savings scenario					
\$0/t CO_2e (kt CO_2e)	23	70	125	179	236
\$10/t CO_2e (kt CO2e)	30	91	161	230	302
\$20/t CO_2e (kt CO2e)	36	110	194	277	363
\$30/t CO_2e (kt CO2e)	43	129	228	324	424
\$40/t CO_2e (kt CO2e)	50	148	261	371	485
Low savings scenario					
\$0/t CO_2e (kt CO_2e)	6	21	39	56	75
\$10/t CO_2e (kt CO2e)	8	27	51	71	94
\$20/t CO_2e (kt CO2e)	10	33	62	86	113
\$30/t CO_2e (kt CO2e)	12	39	72	101	133
\$40/t CO_2e (kt CO2e)	14	45	83	116	152

Source: Insight Economics

3.5 Non-ferrous metals

The Non-ferrous metals sector in Western Australia involves concentration, smelting and refining of copper, nickel, alumina and gold. Energy use in the sector is dominated by alumina production.

The baseline energy use for the Non-ferrous sector is dominated by gas, a primary heat input for alumina production (Table 3.14).

TABLE 3.14 – BASELINE ENERGY USE – NON FERROUS METALS

	2004-05 (PJ)	2009-10 (PJ)	2014-15 (PJ)	2019-20 (PJ)	2024-25 (PJ)	2029-30 (PJ)
	PJ	PJ	PJ	PJ	PJ	PJ
Coal	12.5	13.4	13.4	13.3	13.2	13.2
Gas	122.9	158.1	159.8	162.4	164.7	174.9
Electricity	15.5	19.4	20.8	22.3	23.9	26.4
Total stationary energy	150.9	190.8	194.0	198.1	201.8	214.5

Source: Akmal M. and Riwoe. D 2005, op.cit.

Energy savings opportunities

Energetics consider that the opportunities for energy savings in the Non-ferrous metals sector are similar to those in Mining, and are dominated by:[29]

- improved management systems and process control;
- improved management of mine to mill to minimise energy used in crushing, grinding and milling.

Step change opportunities over the longer term relate to changes in mining and processing technologies.

The 'Alumina Technology Roadmap' outlines potential cost savings that could be achieved by 2020 in the processing of alumina.[30] The suggested areas for improvement are broad, and the potential energy gains are not quantified, although the report does rank the potential positive payoff from each area of innovation as high, medium or low. The report states that the goal is to reduce energy consumption by 25 per cent on current best practice by 2020. This would equate to privately cost effective savings averaging 0.6 per cent per annum beyond business as usual. Socially cost effective savings could go close to double this amount.

The report notes that substantial potential for energy savings exist in:

29 Energetics 2006, op.cit., pp 50.

30 AMIRA International 2001, *Alumina Technology Roadmap*.

- improved precipitation processes;
- converting monohydrate bauxite to a more easily processed state would allow for lower temperature processing and also adoption of more efficient techniques to remove impurities from bauxite;
- more efficient management of 'scale', a substance which builds up on the sides of precipitation tanks, and which inhibits heat transfer;
- utilization of waste products to generate heat, *particularly through cogeneration*; and
- process control strategies and full automation.

Energy savings potential in the medium term

Energetics judge that there is 'cost effective' potential to improve energy efficiency in the Non-ferrous metals sector of between 0.25 per cent per annum for *As Is* equipment, 0.25 per cent per annum for *Replace* equipment, and 0.25 per cent per annum for *Growth* equipment.

In total, Energetics estimate that there is the potential to reduce overall energy consumption by around 5.1 per cent by 2014-15 — from 16.7 PJ to 15.9 PJ (Table 3.15).

TABLE 3.15 - REDUCTION IN NON-FERROUS METALS TOTAL FINAL ENERGY USE FROM ENERGY EFFICIENCY

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	165.7	169.7	189.8	190.8	190.8	191.6	192.4	193.1	194.0
Energy Efficiency Scenario (PJ)	165.7	169.2	188.8	189.4	188.9	189.2	189.4	189.7	190.1
Percentage reduction (%)	0.0	0.3	0.5	0.8	1.0	1.3	1.5	1.8	2.0

Source: Energetics 2006, op.cit., pp 49.

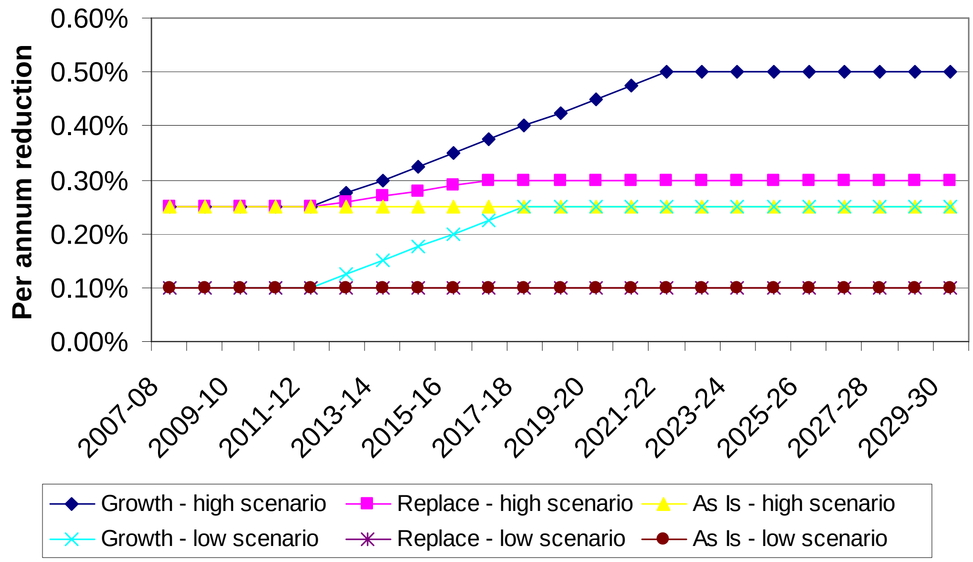
Energy savings potential for the longer term

Overall, we judge that the potential for additional energy savings, *excluding cogeneration*, are modest.[31] Accordingly, we assume that socially cost effective rates of improvement in the sector for the period beyond 2015 will average:

[31] As noted in Section 3.3 — Methodology, we exclude cogeneration estimates from this report.

- *As Is* — between 0.1 per cent per annum (low scenario) and 0.25 per cent per annum (high scenario);
- *Replace* — between 0.2 per cent per annum (low scenario) and 0.3 per cent per annum (high scenario);
- *Growth* — between 0.25 per cent per annum (low scenario) and 0.5 per cent per annum (high scenario).
- In addition, in the high scenario, we allow the rates for the *Replace* and *Growth* classes to ramp up from 2011-12 on (Figure 3.7).

FIGURE 3.7 – NON-FERROUS METALS ANNUAL RATES IN ENERGY SAVINGS 'BEYOND BAU' — 6 YEAR PAYBACKS



Source: Insight Economics

Energy savings outcomes

Overall, there are moderate (net social) cost effective energy savings available through improved energy efficiency in the Non-ferrous metals sector.

At zero carbon prices, savings in energy delivering between 0.4 and 1.5 Mt CO2e are potentially available by 2030 (Table 3.16).

TABLE 3.16 – NON-FERROUS METALS SECTOR ENERGY USE AND SAVINGS – 6 YEAR PAYBACK

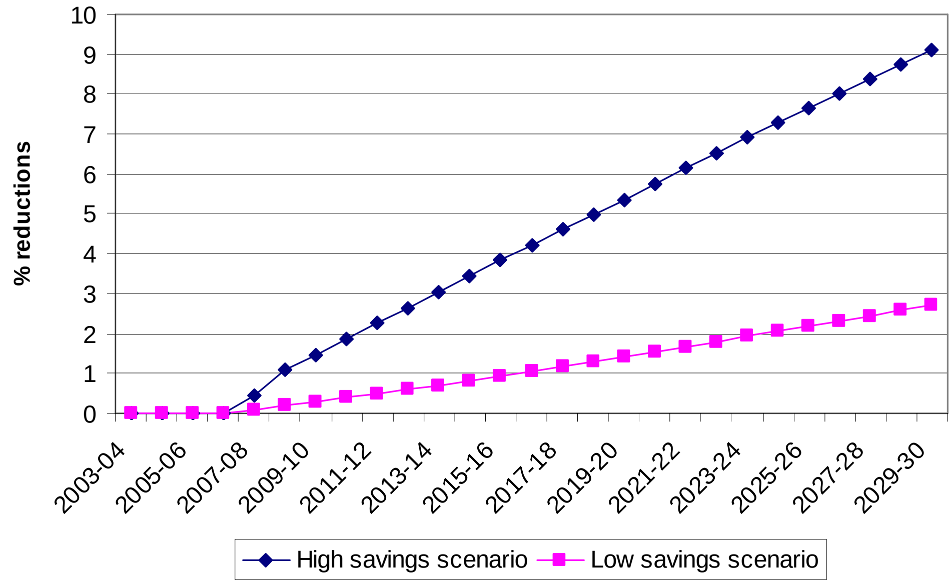
	2009-10	2014-15	2019-20	2024-25	2029-30
BAU energy use (PJ)	190.8	194.0	198.1	201.8	214.5
High savings scenario					
Coal (PJ)	11.9	10.3	9.0	7.8	6.8
Other petroleum (PJ)	0.0	0.0	0.0	0.0	0.0
Gas (PJ)	156.9	156.6	156.9	156.7	163.7
Electricity (PJ)	19.3	20.4	21.6	22.7	24.5
Total (PJ)	188.0	187.3	187.5	187.3	195.0
Total savings (PJ)	2.8	6.7	10.6	14.6	19.5
Total savings (% of BAU)	1.5	3.4	5.3	7.2	9.1
Total savings (kt CO_2e)	202	485	781	1092	1481
Low savings scenario					
Coal (PJ)	13.3	13.3	13.1	12.9	12.9
Other petroleum (PJ)	0.0	0.0	0.0	0.0	0.0
Gas (PJ)	157.6	158.5	160.1	161.3	170.1
Electricity (PJ)	19.3	20.6	22.0	23.5	25.7
Total (PJ)	190.3	192.5	195.3	197.7	208.6
Total savings (PJ)	0.6	1.6	2.8	4.1	5.8
Total savings (% of BAU)	0.3	0.8	1.4	2.1	2.7
Total savings (kt CO_2e)	42	117	209	314	444

Source: Insight Economics

Again, the significant difference in savings between the high and low scenarios by 2030 illustrate the compounding effect that even slightly higher rates can have if they are started early and maintained over time (Table 3.16 and Figure 3.8). Even modest rates of savings, as per the low scenario, can deliver significant percentage reductions over time.

Higher carbon prices slightly increase the amount of savings that are available over the longer term at socially cost effective returns (Table 3.17). Savings rise to between 1.9 and 2.6 Mt CO2e at 2030 under the impact of a $40 per tonne CO_2e carbon price.

FIGURE 3.8 – NON-FERROUS METALS SECTOR TOTAL CUMULATIVE REDUCTIONS BELOW BAU — UP TO 6 YEAR PAYBACKS



Source: Insight Economics

TABLE 3.17 – NON-FERROUS METALS SECTOR — EFFECT OF HIGHER CARBON PRICES ON EMISSIONS SAVINGS FROM INVESTMENTS WITH UP TO 6 YEAR PAYBACKS

	2009-10	2014-15	2019-20	2024-25	2029-30
High savings scenario					
\$0/t CO_2e (kt CO_2e)	247	608	992	1403	1921
\$10/t CO_2e (kt CO2e)	272	674	1106	1571	2160
\$20/t CO_2e (kt CO2e)	296	740	1220	1739	2400
\$30/t CO_2e (kt CO2e)	321	806	1333	1907	2639
\$40/t CO_2e (kt CO2e)					
Low savings scenario	42	117	209	314	444
\$0/t CO_2e (kt CO_2e)	59	164	294	441	624
\$10/t CO_2e (kt CO2e)	68	188	338	507	717
\$20/t CO_2e (kt CO2e)	76	213	382	573	811
\$30/t CO_2e (kt CO2e)	85	237	426	639	905
\$40/t CO_2e (kt CO2e)	247	608	992	1403	1921

Source: Insight Economics

3.6 Non-metallic minerals products

The Non-metallic minerals products sector in Western Australia is dominated by cement and lime production, brick manufacturing and a range of other manufacturing of refractory products for the construction and mining industries.

The baseline energy use for the Non-ferrous sector is dominated by gas, although coal use is also significant (Table 3.18).

TABLE 3.18 – BASELINE ENERGY USE – NON-METALLIC MINERALS PRODUCTS

	2004-05 (PJ)	2009-10 (PJ)	2014-15 (PJ)	2019-20 (PJ)	2024-25 (PJ)	2029-30 (PJ)
	PJ	PJ	PJ	PJ	PJ	PJ
Coal	7.5	7.8	8.0	8.2	8.4	8.5
Gas	14.8	17.2	18.8	20.9	23.0	25.1
Electricity	1.8	2.0	2.1	2.2	2.4	2.5
Total stationary energy	24.2	27.1	29.0	31.3	33.7	36.2

Source: Akmal M. and Riwoe. D 2005, op.cit.

Energy savings opportunities

Opportunities for energy savings in the Non-metallic minerals products sector will be influenced by potential energy management improvements, productivity enhancements and technology replacement:[32]

- replacement of old kilns with newer technology, incorporating improved combustion technology, automated process controls, increased throughput, better heat distribution and recovery;
- burner upgrade/replacement
- enhancement of burner controls and heat recovery for existing kilns and dryers;
- plant utilisation/availability improvements;
- increased contribution of supplementary cementitious materials in cement.

Energetics note that 'Cockburn Cement, Midland Bricks and Brickworks Austral account for two-thirds to three-quarters of total energy use in the sector', and caution that 'with a few sites dominating energy use and potential energy efficiency improvement, and with plant having a relatively long service life, it is likely that the

32 Energetics 2006, op.cit., pp 58.

true nature, timing and scope of improvement will be best identified through direct consultation with major uses'.[33]

In the case of cement, over the longer term, the Cement Industry Federation of Australia believes that there are likely to be emerging opportunities to improve the efficiency of cement production in Australia by further:[34]

- substituting pre-calcined material, such as blast furnace slag, for limestone in the raw mix;
- introducing more energy efficient equipment and practices, reducing fuel and electricity use;
  - known low energy technologies include vertical roller mills, high efficiency classifiers, rolls presses, low pressure drop cyclones, high efficiency coolers and low energy materials transfers systems;
  - new process technologies under development, such as fluidised bed kilns for producing clinker;
  - improved heat transfer and lower heat losses in vessels and reactors;
- extending use of 'substitute cementitious materials' in cement and concrete; and
- moving to alternative cementitious products such as geopolymers or mineral polymers formed from industrial waste materials, with lower energy requirements in production.

In relation to brick making, Western Australia's brickworks are among the largest in the world. One of Western Australia's largest building groups, BGC, has sought for some time to add to this capacity. The Group was recently granted land for brickworks by the Commonwealth Government, adjacent to Perth airport. However, the actual plant is already in Western Australia, so the opportunity to significantly improve the efficiency of the industry through influencing the *Growth* category is judged to be limited.

Energy savings potential in the medium term

Energetics judge that there is 'cost effective' potential to improve energy efficiency in the Non-metallic minerals products sector of 1.0 per cent per annum for *As Is* equipment, 2.0 per cent per annum for *Replace* equipment (Energetics do not include a *Growth* category for this sector).

In total, Energetics estimate that there is the potential to reduce overall energy consumption by around 10.0 per cent by 2014-15 — from 26.8 PJ to 24.2 PJ (Table 3.19).

33 Ibid.

34 Cement Industry Federation 2005, Cementing our Future 2005-2030: Technology Pathway for the Australian Cement Industry, www.cement.org.au .

TABLE 3.19 - REDUCTION IN NON-METALLIC MINERALS PRODUCTS TOTAL FINAL ENERGY USE FROM ENERGY EFFICIENCY

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	23.5	24.1	24.7	25.1	25.5	25.8	26.2	26.5	26.8
Energy Efficiency Scenario (PJ)	23.5	23.8	24.1	24.2	24.3	24.3	24.3	24.2	24.2
Percentage reduction (%)	0.0	1.1	2.2	3.4	4.7	5.9	7.3	8.6	10.0

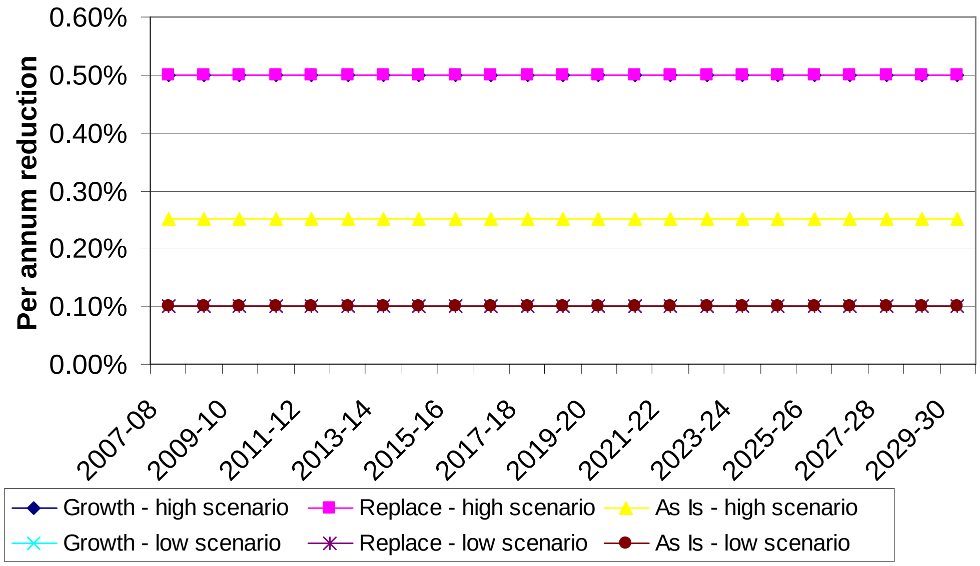
Source: Energetics 2006, op.cit., pp 49.

Energy savings potential for the longer term

Overall, we judge that the potential for additional energy savings in the Non-metallic mineral products sector is modest. Accordingly, socially cost effective rates of improvement in the sector for the period to 2030, beyond business as usual, could average (Figure 3.9):

- *As Is* — between 0.1 per cent per annum (low scenario) and 0.25 per cent per annum (high scenario);
- *Replace* — between 0.1 per cent per annum (low scenario) and 0.5 per cent per annum (high scenario);
- *Growth* — between 0.1 per cent per annum (low scenario) and 0.5 per cent per annum (high scenario).

FIGURE 3.9 – NON-METALLIC MINERALS PRODUCTS SECTOR – ANNUAL RATES IN ENERGY SAVINGS 'BEYOND BAU' — 6 YEAR PAYBACKS



Source: Insight Economics

Energy savings outcomes

Overall, there are moderate (net social) cost effective energy savings available through improved energy efficiency in the Non-metallic minerals products sector.

At zero carbon prices, savings in energy delivering between 0.1 and 0.2 Mt CO2e are potentially available by 2030 (Table 3.20).

TABLE 3.20 – NON-METALLIC MINERALS PRODUCTS METALS SECTOR ENERGY USE AND SAVINGS – 6 YEAR PAYBACK

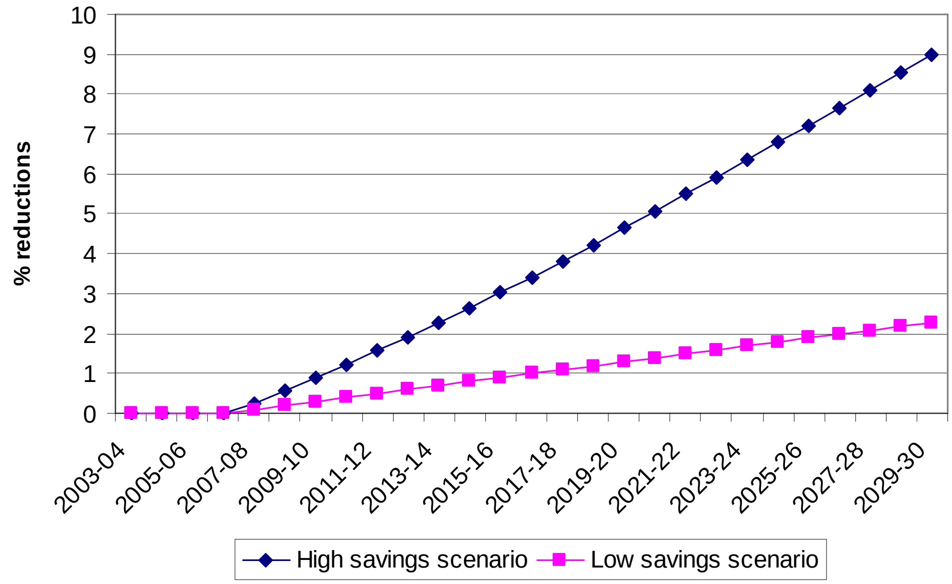
	2009-10	2014-15	2019-20	2024-25	2029-30
BAU energy use (PJ)	27.1	29.0	31.3	33.7	36.2
High savings scenario					
Coal (PJ)	7.8	7.8	7.8	7.8	7.8
Other petroleum (PJ)	0.0	0.0	0.0	0.0	0.0
Gas (PJ)	17.0	18.3	19.9	21.4	22.8
Electricity (PJ)	2.0	2.1	2.1	2.2	2.3
Total (PJ)	26.8	28.2	29.8	31.4	32.9
Total savings (PJ)	0.3	0.8	1.5	2.3	3.3
Total savings (% of BAU)	0.9	2.6	4.6	6.8	9.0
Total savings (kt CO_2e)	17.3	54.8	103.3	161.5	228.2
Low savings scenario					
Coal (PJ)	7.8	7.9	8.1	8.2	8.3
Other petroleum (PJ)	0.0	0.0	0.0	0.0	0.0
Gas (PJ)	17.2	18.7	20.6	22.6	24.6
Electricity (PJ)	2.0	2.1	2.2	2.3	2.4
Total (PJ)	27.0	28.7	30.9	33.1	35.3
Total savings (PJ)	0.1	0.3	0.4	0.6	0.8
Total savings (% of BAU)	0.3	0.8	1.3	1.8	2.3
Total savings (kt CO_2e)	5.8	16.4	28.6	42.3	57.4

Source: Insight Economics

Again, the significant difference in savings between the high and low scenarios by 2030 illustrate the compounding effect that even slightly higher rates can have if they are started early and maintained over time (Table 3.19 and Figure 3.20). Even modest rates of savings, as per the low scenario, can deliver significant percentage reductions over time.

Higher carbon prices slightly increase the amount of savings that are available over the longer term at socially cost effective returns (Table 3.21). Savings rise to between 0.1 and 0.5 Mt CO2e at 2030 under the impact of a $40 per tonne CO_2e carbon price.

FIGURE 3.10 – NON-METALLIC MINERALS PRODUCTS SECTOR TOTAL CUMULATIVE REDUCTIONS BELOW BAU — UP TO 6 YEAR PAYBACKS



Source: Insight Economics

TABLE 3.21 – NON-METALLIC MINERALS PRODUCTS SECTOR — EFFECT OF HIGHER CARBON PRICES ON EMISSIONS SAVINGS FROM INVESTMENTS WITH UP TO 6 YEAR PAYBACKS

	2009-10	2014-15	2019-20	2024-25	2029-30
High savings scenario					
$0/t CO_2e (kt CO_2e)	17	55	103	161	228
$10/t CO_2e (kt CO2e)	25	78	147	230	325
$20/t CO_2e (kt CO2e)	29	92	173	270	381
$30/t CO_2e (kt CO2e)	33	106	199	310	437
$40/t CO_2e (kt CO2e)	38	119	224	350	492
Low savings scenario					
$0/t CO_2e (kt CO_2e)	6	16	29	42	57
$10/t CO_2e (kt CO2e)	8	23	41	60	82
$20/t CO_2e (kt CO2e)	10	28	48	71	96
$30/t CO_2e (kt CO2e)	11	32	55	82	111
$40/t CO_2e (kt CO2e)	13	36	63	92	125

Source: Insight Economics

3.7 Other manufacturing and construction

The Other manufacturing and construction sectors in Western Australia comprise the remaining manufacturing sectors plus the Construction sector. The manufacturing sectors include:

- Food, beverages and tobacco;
- Textiles, clothing and footwear;
- Wood and paper products;
- Printing and publishing;
- Metal products;
- Machinery and equipment;
- Other manufacturing.

In terms of fossil fuel use, the baseline energy use for the Other manufacturing and construction sectors is dominated by electricity, although gas use is also significant (Table 3.22). The greater proportion of electricity in these sectors reflects use of electric motors and drives.

There is also a substantial proportion of stationary energy derived from biomass. While this is counted in the stationary energy base, we do not count in the subsequent analysis or apply energy efficiency savings to its use, as there is an insignificant greenhouse gas emissions benefit derived.

TABLE 3.22 – BASELINE ENERGY USE – OTHER MANUFACTURING AND CONSTRUCTION

	2004-05 (PJ)	2009-10 (PJ)	2014-15 (PJ)	2019-20 (PJ)	2024-25 (PJ)	2029-30 (PJ)
	PJ	PJ	PJ	PJ	PJ	PJ
Coal	0.0	0.0	0.0	0.0	0.0	0.0
Gas	2.6	2.9	3.1	3.4	3.6	3.9
Biomass	5.9	6.8	7.6	8.4	9.2	10.1
Electricity	5.5	6.0	6.5	6.9	7.4	7.9
Total stationary energy	14.1	15.7	17.1	18.7	20.3	21.9

Source: Akmal M. and Riwoe. D 2005, op.cit.

Energy savings opportunities

Given the predominance of traditional manufacturing industries in the Other manufacturing and construction sector, opportunities for energy savings will be influenced by improvements in 'cross cutting' technologies.

Key opportunities, for example, will relate to improvements in and application of electric motors and drives technology. The Lawrence Berkeley National Laboratory, in a review of energy efficient technologies, estimated that there are large energy savings to be realized as a result of maintaining and optimizing traditional electric motors. The power consumption of fans and belts varies at the cube of speed, while output varies linearly.[35] As a result, a small alteration in speed can yield large savings of energy. Moreover, purchasing a motor better suited to the load will further increase energy efficiency as a smaller motor is generally more energy efficient when running at its full capacity then a large motor running at only part of its capacity. The paper estimates that through optimization, energy savings of 20 per cent of a motor's power requirements could be achieved at individual workplaces, regardless of the initial energy consumption levels of the motor.[36] Industry wide savings depend on the rate at which industry adopts this practice, as well as the proportion of motors being used that are not running at optimal capacity.

There also are potential savings to be made from downsizing and optimizing pumping equipment. Large pumps require a significant amount of energy, and are put to a variety of uses. It is estimated that savings of up to 17 per cent are possible, if pumps are optimized to their particular use.[37]

The International Energy Agency estimates that potential improvements in steam supply systems and motor systems could reduce energy usage by 15 to 30 per cent.[38]

Energy savings potential for the longer term

Overall, we judge that the potential for additional energy savings in the Other manufacturing and construction sector could be substantial. Accordingly, socially cost effective rates of improvement in the sector for the period to 2030, beyond ABARE business as usual, could average (Figure 3.11):

- *As Is* — between 0.5 per cent per annum (low scenario) and 1.5 per cent per annum (high scenario);
- *Replace* — between 1.0 per cent per annum (low scenario) and 2.5 per cent per annum (high scenario);
- *Growth* — between 1.0 per cent per annum (low scenario) and 3.0 per cent per annum (high scenario).

In addition, in the high scenario, we allow the higher rates to ramp up rapidly from 2011-12 on (Figure 3.11)

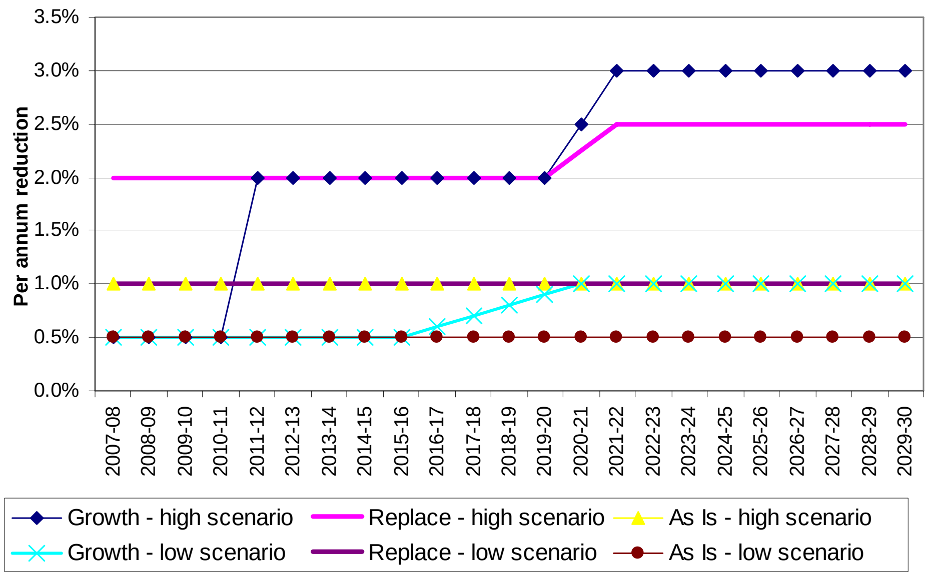
[35] Martin N. et al 2000, *Emerging Energy Efficient Industrial Technologies*, LBNL 46690, ies.lbl.gov/iespubs/ieuapubs.html .

[36] Ibid.

[37] Ibid.

[38] International Energy Agency 2006, op.cit., pp385.

FIGURE 3.11 – OTHER MANUFACTURING AND CONSTRUCTION ANNUAL RATES IN ENERGY SAVINGS 'BEYOND BAU' — 6 YEAR PAYBACKS



Source: Insight Economics

Energy savings outcomes

Overall, there are moderate (net social) cost effective energy savings available through improved energy efficiency in the Other manufacturing and construction sector.

At zero carbon prices, savings in energy delivering between 0.4 and 0.7 Mt CO_2e are potentially available by 2030 (Table 3.23).

TABLE 3.23 – OTHER MANUFACTURING AND CONSTRUCTION SECTOR ENERGY USE AND SAVINGS – 6 YEAR PAYBACK

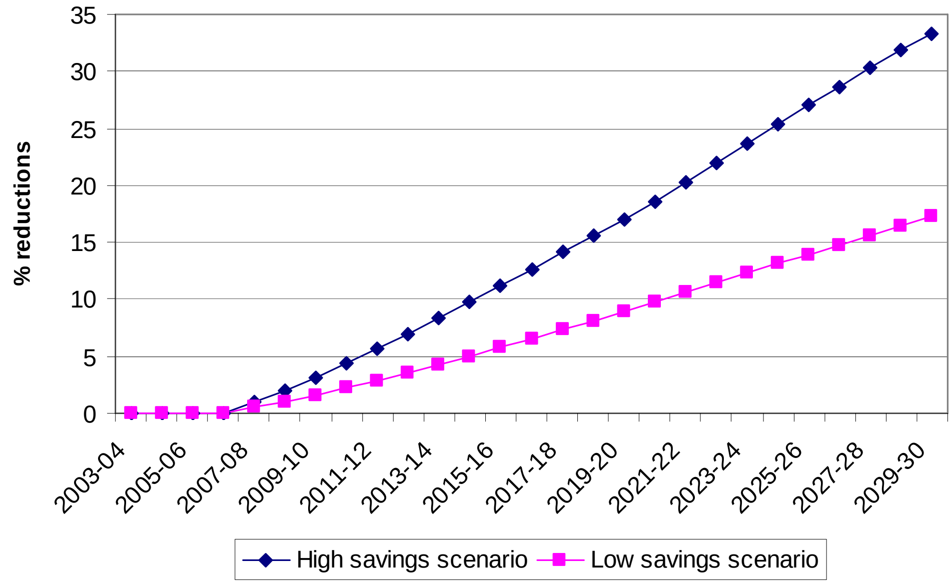
	2009-10	2014-15	2019-20	2024-25	2029-30
BAU energy base (PJ)	9.0	9.6	10.3	11.1	11.8
High savings scenario					
Coal (PJ)	0.0	0.0	0.0	0.0	0.0
Other petroleum (PJ)	0.0	0.0	0.0	0.0	0.0
Gas (PJ)	2.8	2.8	2.8	2.8	2.7
Electricity (PJ)	5.8	5.8	5.7	5.5	5.2
Total (PJ)	8.7	8.7	8.6	8.3	7.9
Total savings (PJ)	0.3	0.9	1.8	2.8	3.9
Total savings (% of BAU)	3.2	9.8	17.1	25.3	33.2
Total savings (kt CO_2e)	51	169	318	506	708
Low savings scenario					
Coal (PJ)	0.0	0.0	0.0	0.0	0.0
Other petroleum (PJ)	0.0	0.0	0.0	0.0	0.0
Gas (PJ)	2.9	3.0	3.1	3.2	3.2
Electricity (PJ)	5.9	6.1	6.3	6.4	6.5
Total (PJ)	8.8	9.1	9.4	9.6	9.8
Total savings (PJ)	0.1	0.5	0.9	1.4	2.0
Total savings (% of BAU)	1.6	5.0	9.0	13.1	17.3
Total savings (kt CO_2e)	26	87	167	262	368

Source: Insight Economics

Again, the significant difference in savings between the high and low scenarios by 2030 illustrate the compounding effect that even slightly higher rates can have if they are started early and maintained over time (Table 3.23 and Figure 3.12). Even modest rates of savings, as per the low scenario, can deliver significant percentage reductions over time.

Higher carbon prices slightly increase the amount of savings that are available over the longer term at socially cost effective returns (Table 3.24). Savings rise to between 0.7 and 1.3 Mt CO2e at 2030 under the impact of a $40 per tonne CO_2e carbon price.

FIGURE 3.12 – OTHER MANUFACTURING AND CONSTRUCTION SECTOR TOTAL CUMULATIVE REDUCTIONS BELOW BAU — UP TO 6 YEAR PAYBACKS



Source: Insight Economics

TABLE 3.24 – OTHER MANUFACTURING AND CONSTRUCTION SECTOR — EFFECT OF HIGHER CARBON PRICES ON EMISSIONS SAVINGS FROM INVESTMENTS WITH UP TO 6 YEAR PAYBACKS

	2009-10	2014-15	2019-20	2024-25	2029-30
High savings scenario					
$0/t CO_2e (kt CO_2e)	51	169	318	506	708
$10/t CO_2e (kt CO2e)	63	208	391	622	869
$20/t CO_2e (kt CO2e)	73	241	453	721	1008
$30/t CO_2e (kt CO2e)	83	275	516	821	1148
$40/t CO_2e (kt CO2e)	93	308	579	921	1287
Low savings scenario					
$0/t CO_2e (kt CO_2e)	26	87	167	262	368
$10/t CO_2e (kt CO2e)	32	107	205	322	452
$20/t CO_2e (kt CO2e)	37	124	238	373	524
$30/t CO_2e (kt CO2e)	42	141	271	425	597
$40/t CO_2e (kt CO2e)	47	158	304	476	669

Source: Insight Economics

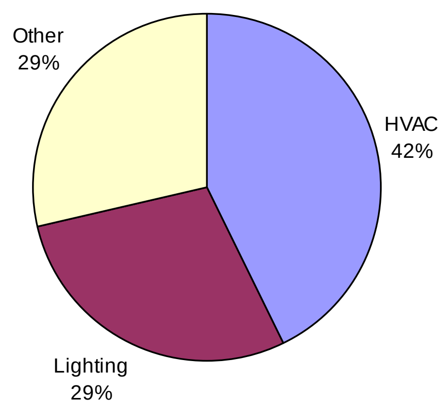
3.8 Commercial sector

The Commercial sector is diverse, covering:

- Finance, Insurance and Business Services (ANZSIC Division K and L);

- Wholesale and Retail Trade Services (ANZSIC Division F and G);
- Government, Education and Community Services (ANZSIC Division M, N and O);
- Accomodation, Cafes and Restaurants (ANZSIC Division H);
- Recreation, Personal and Other Services (ANZSIC Division P and Q);
- Communication Services (ANZSIC Division J).

FIGURE 3.13 - COMMERCIAL SECTOR GHG EMISSIONS BY ACTIVITY - WESTERN AUSTRALIA - 1999



Source: George Wilkenfeld and Associates and Energy Strategies 2002, op.cit.

Energy use relates largely to the heating, ventilation and cooling (HVAC) of buildings, and to a lesser extent, energy use by lighting and equipment and appliances. In 1999, HVAC end uses accounted for 62 per cent of energy use Australia-wide in the sector, while lighting and other energy consumed a further 18 per cent of energy each.[39]

In Western Australia, a more favourable climate means that cooling and heating loads are less than the Australian average. The share from lighting and other energy use in emissions is proportionately greater. Lighting was responsible for close to 30 per cent of emissions in the State in 1999 (Figure 3.13).[40]

Reflecting these shares, baseline energy use in Western Australia for the Commercial sector is dominated by electricity use — which is responsible for more than three quarters of total energy use in Western Australia (Table 3.25). Gas is also important

39 George Wilkenfeld and Associates and Energy Strategies 2002, *Australia's National Greenhouse Gas Inventory: End Use Allocation of Emissions*, Volume 1, www.greenhouse.gov.au, pp 123.

40 Ibid, pp 126.

for hot water and other heating loads. A small proportion of energy needs is supplied by solar energy, primarily solar hot water.

TABLE 3.25 – BASELINE ENERGY USE – COMMERCIAL

	2004-05 (PJ)	2009-10 (PJ)	2014-15 (PJ)	2019-20 (PJ)	2024-25 (PJ)	2029-30 (PJ)
	PJ	PJ	PJ	PJ	PJ	PJ
Coal	0.0	0.0	0.0	0.0	0.0	0.0
Gas	2.9	3.5	4.0	4.6	5.2	5.9
Electricity	17.3	21.4	25.3	29.8	34.8	40.3
Solar	0.0	0.0	0.0	0.0	0.1	0.1
Total stationary energy	20.3	24.9	29.4	34.4	40.1	46.2

Source: Akmal M. and Riwoe. D 2005, op.cit.

Energy savings opportunities

There are substantive opportunities to save energy in the Commercial sector, based on existing cost effective technologies. Opportunities to achieve greenhouse gas emissions reductions are fairly equally divided between:

- heating ventilation and cooling (HVAC);
- lighting; and
- other energy use.

Heating ventilation and cooling

Existing commercial buildings in the office and retail sectors commonly offer privately cost effective savings of 10 to 20 per cent following a standard energy audit — largely due to poorly functioning air conditioning systems. Beyond that, it can be costly to upgrade HVAC systems in existing buildings unless this is undertaken at the time of major refurbishment — generally around every 20 years or so.

At the point of major refurbishment significant savings can be made — energy efficient air conditioners now use 30 to 40 per cent less energy than ten years ago, while ventilation systems have improved and new systems can lead to reductions of 10 to 15 per cent.[41]

The new Australian Building Codes inclusion for Commercial buildings is expected to deliver savings of 18 per cent over the medium term from new Commercial buildings. This equates to an improvement of around 0.4 per cent per annum beyond business as

[41] International Energy Agency 2006, op.cit., pp 329.

usual for the *Replace* building stock. These changes deliver savings that are privately cost effective, at paybacks less than one year (Box 3.3).

BOX 3.3 - BUILDING CODES OF AUSTRALIA MINIMUM STANDARDS

The Australian Building Codes Board has been developing minimum standards for commercial buildings for inclusion in the Building Codes of Australia (BCA). The development of the BCA energy efficiency provisions for commercial buildings has proceeded in two stages. Firstly, provisions for Class 2, 3 and 4 buildings (eg, apartments and hotels) were developed for inclusion in BCA 2005. Secondly, provisions for Class 5, 6, 7, 8 and 9 buildings (eg, offices, shops, warehouses, factories, health care buildings, auditoriums and schools) were developed for inclusion in BCA 2006.

Class 2 to 4 buildings

BCA energy efficiency provisions for Class 2, 3, and 4 buildings were finalised and included in BCA 2005. The final provisions cover the following:

- the ability of the roof, walls and floor to resist heat transfer;
- the resistance to heat flow and solar radiation of the glazing;
- sealing of the building;
- the provision of air movement for free cooling, in terms of openings and breeze paths;
- the efficiency and energy saving features of:
  - heating, ventilation and air-conditioning systems
  - hot water supply
- power allowances for lighting and electric power saving features;
- access to certain energy efficiency equipment for maintenance purposes.

Class 5 to 9 buildings

Energy efficiency provisions for Class 5 to 9 buildings are to be included in BCA 2006.

These provisions extend the current provisions, in Sections I and J for Class 2 to 4 buildings, to all other building classifications. This means that the Verification Methods have been extended to allow thermal calculation methods, including building energy analysis software, to be used to determine the compliance of certain commercial buildings. The Deemed-to-Satisfy Provisions have also been extended and include significant changes to the building fabric, external glazing, HVAC and lighting and power requirements.

Savings

The Regulatory Impact Statement for Class 5 to 9 buildings expects energy savings of 18 per cent below business as usual for new buildings from about 2010 on, through to 2016. The payback of the additional costs of the provisions is achieved in less than one year, implying that these measures are privately cost effective.

Source: Australian Building Codes Board, www.abcb.gov.au and ABCB 2006, *Regulation Impact Statement for Proposal to Amend the Building Code of Australia to include Energy Efficiency Requirements for Class 5 to 9 Buildings*, pp 35.

Over the longer term, changes in design, improved thermal performance and more energy efficient equipment and appliances have the potential to deliver large energy savings.

- demonstration buildings such as the 60L building in Melbourne use less than a third of the energy use of a typical office building in the city;

- improved insulation, in conjunction with advanced cooling systems such as chilled beam systems, can dramatically reduce energy use for cooling;

- integrated design, combining passive solar principles, use of thermal mass, improved venting and airflow management, low energy lighting and better management of unavoidable internal heat sources such as IT equipment can all contribute to significant energy reductions.

As noted by the IEA:[42]

> The potential for new buildings is enormous because it is easier and cheaper to build in more efficient technologies than to retrofit. It is also possible to integrate building components more effectively in order to reduce energy demand to a mere fraction of average energy use. The availability of more energy efficient technologies for the building envelope allows for significant improvements from previous generations of buildings and, when done in combination with micro-generation technologies, can make buildings become virtually zero net users of energy.

Lighting

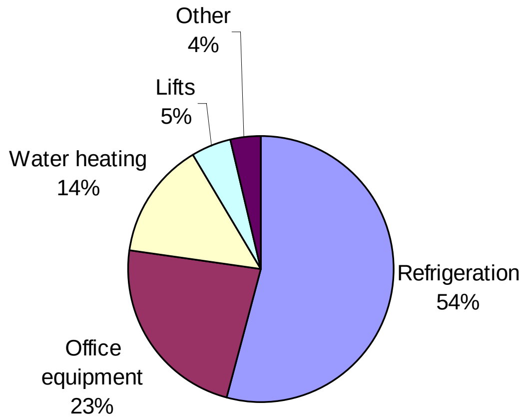
Lighting technologies are undergoing rapid change, offering enormous potential to slash energy use over the medium to longer term.

Since the 1980s, the efficiency of fluorescent lighting typically used in commercial space has improved by more than two thirds. Emerging technologies such as LED lighting and piped daylight have the potential to reduce energy use by a similar factor again.

Combined with improved lighting controls, there is potential to reduce the energy use of lighting in commercial and retail buildings by a factor of four or more over the period to 2030.

[42] International Energy Agency 2006, op.cit., pp 334.

FIGURE 3.14 – END USE SHARES OF COMMERCIAL 'OTHER ENERGY' USE



Source: George Wilkenfeld and Associates and Energy Strategies 2002, op.cit.

Other energy use

Other energy use in the Commercial sector is dominated by refrigeration, and to a lesser extent office equipment and water heating (Figure 3.14)

Commercial refrigeration is generally highly inefficient. Large amounts of refrigeration are used by the retail sector, but this is generally designed with display as a priority, rather than energy efficiency — open displays are common at the local supermarket. Smaller drink vending machines are often inefficient (and add to air conditioning loads). In recent years this type of equipment has grown rapidly, due to increased sales of frozen and other pre-packaged food and drink.

Minimum energy performance standards for commercial refrigeration should eliminate the worst performers over coming years, but there are significant opportunities to reduce energy use in this area (see Box 3.4 in the next Section on Minimum Energy Performance Standards).

Office equipment energy use has grown rapidly, driven by the ICT revolution. Centralised computer servers and desktop computers are large energy users in aggregate. The move to LCD screens and increased use of more energy efficient laptops has potential to offer savings of more than 50 per cent over the next 25 years.

Energy savings potential in the medium term

TABLE 3.26 - REDUCTION IN COMMERCIAL TOTAL FINAL ENERGY USE FROM ENERGY EFFICIENCY

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	22.0	23.0	24.0	24.8	25.7	26.6	27.5	28.4	29.3
Energy Efficiency Scenario (PJ)	22.0	22.2	22.9	23.3	23.8	24.3	24.9	25.4	26.0
Percentage reduction (%)	0.0	3.2	4.7	6.1	7.3	8.5	9.5	10.5	11.3

Source: Energetics 2006, op.cit., pp 64.

Energetics, based on EMET's work for the NFEE, judge that there is 'cost effective' potential to improve energy efficiency in the Commercial sector of 1.9 per cent per annum for *As Is* equipment, 1.9 per cent per annum for *Replace* equipment, and 0.0 per cent per annum for *Growth* equipment.[43]

In total, Energetics estimate that there is the potential to reduce overall energy consumption by around 11.3 per cent by 2014-15 — from 29.3 PJ to 26.0 PJ (Table 3.26).

Energy savings potential for the longer term

Overall, we judge that the potential for additional energy savings are substantial over the longer term. Socially cost effective rates of improvement in the sector for the period to 2030, beyond business as usual, could average (Figure 3.15):

- *As Is* — between 0.5 per cent per annum (low scenario) and 2.0 per cent per annum (high scenario);
- *Replace and Growth*
  - between 1 per cent per annum (low scenario) and 4.5 per cent per annum (high scenario) for the weighted average improvement of *appliances and lighting*;

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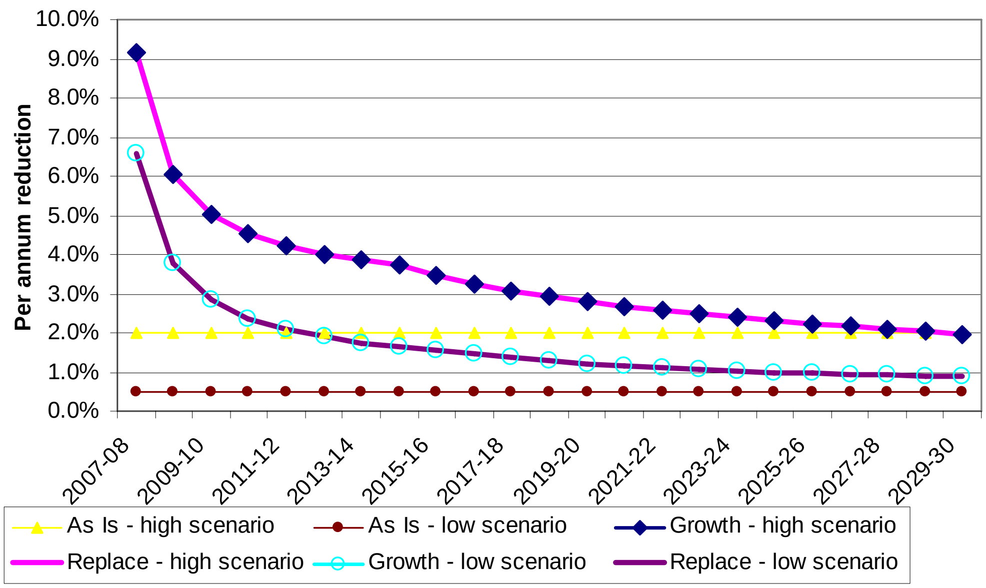
[43] Energetics note that 'in the Growth' area of influence the EMET study suggests that just 6% of the total raw EEI potential exists, and that this is available at less than a 1 year payback', on which basis it is assumed this will be implemented under a BAU scenario. This would suggest that all of the beyond-BAU potential will be realised via improvements as equipment is replaced, or via retrofit or behavioural improvement. We disagree with this conclusion to an extent — market failures may prevent uptake of even 1 year payback opportunities. On the other hand, the implementation of the MEPS for commercial buildings will soak up a significant proportion of this potential. However, the key point is that ABARE have not taken the commercial buildings MEPS into account in their projections, so these savings should be added in as (privately cost effective) potential.

- between an almost immediate 20 per cent per annum (low scenario) and 60 per cent per annum (high scenario) for the *building shell/HVAC* category — with the 20 per cent figure reflecting the impact of the Australian Building Codes standards for commercial buildings recently implemented;

- the combined weighted impact of improvements for the building shell, HVAC, appliances and lighting is for a total improvement of 1.2 per cent per annum (low scenario) and 2.8 per cent per annum (high scenario) beyond the ABARE business as usual projection for the sector, by the end of the period.

FIGURE 3.15 – COMMERCIAL ANNUAL RATES IN ENERGY SAVINGS 'BEYOND BAU' — 6 YEAR PAYBACKS



Source: Insight Economics

Energy savings outcomes

Overall, there are significant (net social) cost effective energy savings available through improved energy efficiency in the Commercial sector.

At zero carbon prices, savings in energy deliver between 2.07 and 5.3 Mt CO2e are potentially available by 2030 (Table 3.27).

TABLE 3.27 – COMMERCIAL SECTOR ENERGY USE AND SAVINGS – 6 YEAR PAYBACK

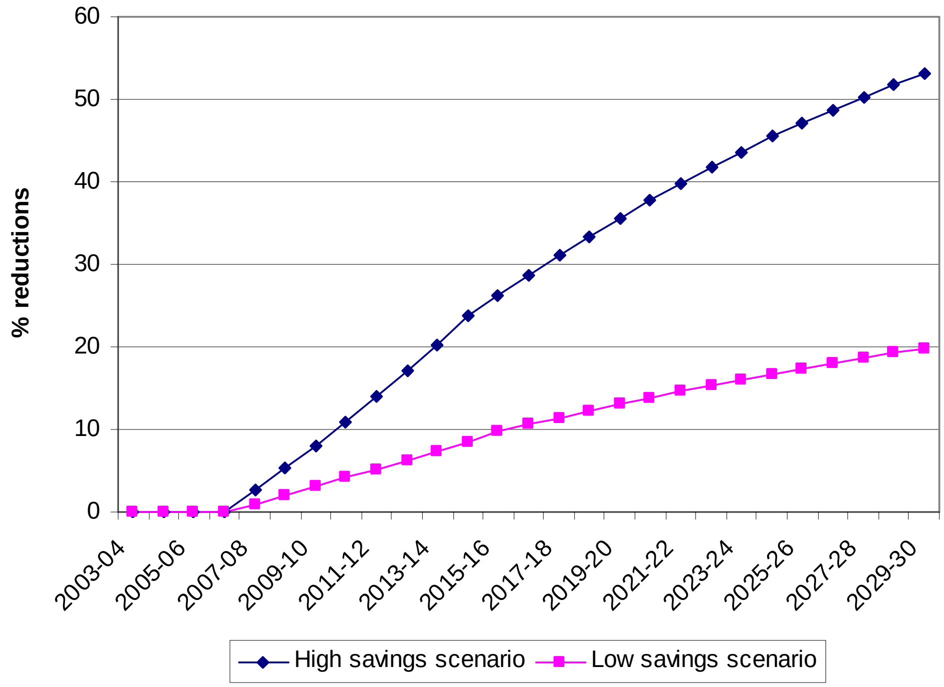
	2009-10	2014-15	2019-20	2024-25	2029-30
BAU energy use (PJ)	24.8	29.3	34.4	40.0	46.2
High savings scenario					
Coal (PJ)	0.0	0.0	0.0	0.0	0.0
Other petroleum (PJ)	0.0	0.0	0.0	0.0	0.0
Gas (PJ)	3.2	3.1	3.0	2.9	2.8
Electricity (PJ)	19.6	19.3	19.2	19.0	18.9
Total (PJ)	22.8	22.4	22.1	21.8	21.6
Total savings (PJ)	2.0	7.0	12.3	18.2	24.5
Total savings (% of BAU)	8.0	23.7	35.7	45.4	53.1
Total savings (kt CO_2e)	426	1490	2634	3914	5287
Low savings scenario					
Coal (PJ)	0.0	0.0	0.0	0.0	0.0
Other petroleum (PJ)	0.0	0.0	0.0	0.0	0.0
Gas (PJ)	3.4	3.6	4.0	4.3	4.7
Electricity (PJ)	20.7	23.2	25.9	29.0	32.3
Total (PJ)	24.1	26.8	29.9	33.3	37.0
Total savings (PJ)	0.8	2.5	4.5	6.7	9.1
Total savings (% of BAU)	3.1	8.5	13.0	16.7	19.8
Total savings (kt CO_2e)	163	537	964	1440	1973

Source: Insight Economics

Again, the significant difference in savings between the high and low scenarios by 2030 illustrate the compounding effect that higher rates can have if they are started early and maintained over time (Table 3.27 and Figure 3.16). The high scenario potential delivers a reduction in energy use below business as usual of 53 per cent by 2050 — which is sufficient to completely offset the growth in energy use in the sector.

Higher carbon prices substantially increase the amount of savings that are available over the longer term at socially cost effective returns (Table 3.28). Savings rise to between 2.9 and 7.7 Mt CO2e at 2030 under the impact of a $40 per tonne CO_2e carbon price.

FIGURE 3.16 – COMMERCIAL SECTOR TOTAL CUMULATIVE REDUCTIONS BELOW BAU — UP TO 6 YEAR PAYBACKS



Source: Insight Economics

TABLE 3.28 – COMMERCIAL SECTOR — EFFECT OF HIGHER CARBON PRICES ON EMISSIONS SAVINGS FROM INVESTMENTS WITH UP TO 6 YEAR PAYBACKS

	2009-10	2014-15	2019-20	2024-25	2029-30
High savings scenario					
$0/t CO_2e (kt CO_2e)	426	1490	2634	3914	5287
$10/t CO_2e (kt CO2e)	482	1684	2978	4422	5973
$20/t CO_2e (kt CO2e)	533	1862	3292	4890	6604
$30/t CO_2e (kt CO2e)	584	2040	3607	5357	7235
$40/t CO_2e (kt CO2e)	635	2218	3922	5825	7867
Low savings scenario					
$0/t CO_2e (kt CO_2e)	163	537	964	1440	1973
$10/t CO_2e (kt CO2e)	184	607	1090	1627	2229
$20/t CO_2e (kt CO2e)	203	672	1205	1799	2465
$30/t CO_2e (kt CO2e)	223	736	1320	1971	2701
$40/t CO_2e (kt CO2e)	242	800	1436	2143	2936

Source: Insight Economics

Emissions savings in this sector, compared to the reduction in energy use, are proportionately more — because of the predominance of electricity in energy end use in the sector. Electricity is relatively more than four times as emissions intense as natural gas (refer back to Table 3.1).

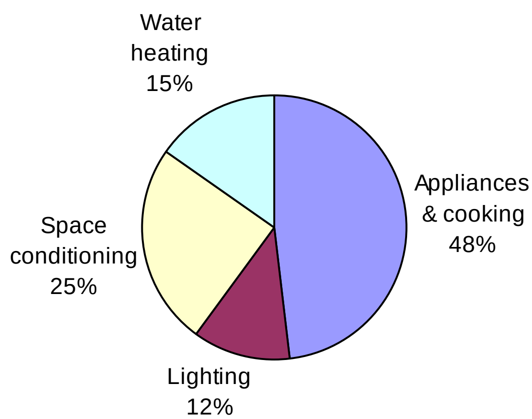
3.9 Residential sector

The Residential sector shares many features in common with the Commercial sector. As a result, similar opportunities for substantial energy savings exist. However, the transactions costs of achieving savings can be higher in the Residential sector compared to the Commercial sector.

Wilkenfeld notes that for Australia as a whole:[44]

> The largest share of energy use in the Residential sector is for space heating and cooling (44.7%), followed by water heating (24.6%) and appliances (22.3%). However, the share of emissions is quite different: appliances account for the largest share (42.1%), followed by water heating (26.9%) and then space heating and cooling (19.7%). The difference is caused by the electricity-intensity of the various end uses. All appliance energy is electric, whereas less emissions-intensive fuels (gas, LPG and wood) account for 92% of space heating and 50% of water heating energy.

FIGURE 3.17 - RESIDENTIAL SECTOR GHG EMISSIONS BY ACTIVITY - WESTERN AUSTRALIA – 1999



Source: George Wilkenfeld and Associates and Energy Strategies 2002, op.cit., pp 129.

Western Australia has a different pattern to the Australian average in its residential emissions (Figure 3.17). It has a higher share for space heating and cooling (25 per cent compared to 20 percent), a higher share for appliances and cooking (48 per cent

44 George Wilkenfeld and Associates and Energy Strategies 2002, op.cit., pp127.

compared to 31 per cent), but a lower share of energy use for water heating (15 per cent compared to 27 percent). The majority of this difference reflects the relatively higher penetration of gas-fired and solar hot water in the Western Australian market, compared to the rest of Australia.[45]

Baseline energy use in Western Australia for the Residential sector is dominated by electricity use — which is responsible for around half of total energy use (Table 3.29). As noted, gas is also important for hot water, and also for other heating loads. The significant share of biomass energy is largely wood fires for space heating.

TABLE 3.29 – BASELINE ENERGY USE – RESIDENTIAL

	2004-05 (PJ)	2009-10 (PJ)	2014-15 (PJ)	2019-20 (PJ)	2024-25 (PJ)	2029-30 (PJ)
	PJ	PJ	PJ	PJ	PJ	PJ
Coal	0.0	0.0	0.0	0.0	0.0	0.0
Gas	9.0	9.4	9.6	10.0	10.4	10.6
Electricity	15.7	16.2	16.6	17.1	17.6	18.0
Biomass	7.6	7.7	7.7	7.7	7.7	7.8
Solar	1.1	1.1	1.2	1.2	1.2	1.3
Total stationary energy	33.4	34.4	35.1	36.0	36.9	37.6

Source: Akmal M. and Riwoe. D 2005, op.cit.

Energy savings opportunities

There is great potential to reduce the energy use of the Residential sector. From the analysis of end use in Western Australia above, the greatest abatement is likely to be achieved if significant savings can be made in energy use by:

- household and cooking appliances;
- space conditioning.

On the other hand, lighting and water heating offer smaller potential savings.

Household and cooking appliances

Household and cooking appliances tend to be sourced from outside Western Australia. Thus Western Australia is to a large degree hostage to underlying design trends elsewhere in Australia and the world.

45 Western Australia has more than double the share of solar water heaters in the overall state water heater market (12 per cent) compared to the Australian average (5 per cent). See WASEA 2003, *The Western Australian Government Solar Water Heater Subsidy: Net Benefi ts for Consumers, the Environment and the WA Economy*, www.wasea.com.au .

Recent trends have seen rapid growth in demand for in new classes of household appliances and equipment, driven by a shift in tastes towards ICT consumer goods — computers, plasma televisions, surround sound systems and the like. These have augmented traditional household demands for labour saving white goods.

The relatively short lives of many household appliances (5 to 15 years) mean that energy efficiency improvements can penetrate rapidly into overall stocks of these appliances.

BOX 3.4 – APPLIANCE LABELLING AND MEPS

Mandatory energy performance labelling for appliances commenced in Australia in the 1980s. A fully nationally coordinated scheme was implemented from 2000. Labelling provides for star ratings and a kwh/yr consumption number.

Australia's program of national MEPS are made mandatory in Australia by state government legislation and regulations which give force to the relevant Australian Standards. It is mandatory for the following products manufactured in or imported into Australia to meet the MEPS levels specified in the relevant Australian Standards:

- refrigerators and freezers (from 1 October 1999, revision 1 January 2005);
- mains pressure electric storage water heaters (from 1 October 1999);
- small mains pressure electric storage water heaters (<80L) and low pressure and heat exchanger types (from 1 October 2005) (Refer to AGO letter regarding levels and test methods);
- three phase electric motors (0.73kW to <185kW) (from 1 October 2001, revision April 2006);
- single phase air conditioners (from 1 October 2004, revision 1 April 2006 and 2007 and 2008);
- three phase air conditioners up to 65kW cooling capacity (from 1 October 2001, revision 1 October 2007);
- ballasts for linear fluorescent lamps (from 1 March 2003);
- linear fluorescent lamps - from 550mm to 1500mm inclusive with a nominal lamp power >16W (from 1 October 2004);
- distribution transformers - 11kV and 22kV with a rating from 10kA to 2.5MVA (from 1 October 2004);
- commercial refrigeration (self contained and remote systems) (from 1 October 2004).

The Ministerial Council on Energy has undertaken through Stage One of the National Framework for Energy Efficiency to extend national labelling and MEPS programs. Among others, there will be new appliance energy performance standards for gas water heating, TVs, home entertainment systems and computers, as well as new appliance labelling standards for televisions, computing and power supplies. In addition, the 'One Watt' standby program will aim to ensure that standby power consumption is not excessive (estimated at more than 10 per cent of some household's electricity use).

Source: www.energyrating.gov.au/meps1.html

Minimum Energy Performance Standards should engender significant increased savings over time, by removing the worst performers from the market (Box 3.4). Both labelling and MEPS have negative costs, so are considered to be privately cost effective on average. Estimates suggest that appliance and equipment MEPS should reduce Australia's stationary energy emissions by around 3.5 per cent by 2020.[46]

Over the longer term, there is a substantial opportunity to increase savings beyond minimum standards in areas such as:

- refrigerators and freezers — there is potential to cut the energy use of the current average standard refrigerator and freezers by more than a third, at very little additional cost; and

- televisions and computers — increasing use of laptops (one fifth the energy use of a conventional computer) and LCD screens (less than a half the energy use of a conventional TV monitor).

One estimate has put the potential for savings over existing average energy use at between 37 and 68 per cent.[47] This translates to energy efficiency improvement rates of between 2 and 4 per cent per annum beyond ABARE's business as usual.

BOX 3.5 – BASIX

Developed in NSW, the Building Sustainability Index (BASIX) provides a flexible on-line planning tool that calculates the energy, water and thermal comfort levels of residential designs. BASIX scores are calculated according to percentage savings on greenhouse gas (GHG) emissions and water usage benchmarks. The tool allows targets to be set for energy and water use.

In NSW, from 1 July, BASIX targets aim to reduce GHG emissions by 40 per cent below business as usual. Introduced progressively, BASIX now applies to all:

- new residential dwellings, including single dwellings, villas, townhouses and low-rise, mid-rise and high-rise developments in NSW;

- residential alterations and additions throughout NSW.

Western Australia is currently undertaking a study to determine appropriate benchmarks and to evaluate costs and benefits. A recent cost benefit evaluation estimated that meeting targets for energy:

- 20 per cent below the average business as usual new dwelling — can be achieved for a cost of $1,000;

- 40 per cent below the average business as usual new dwelling — can be achieved at a cost of around $3,850.

Even at the 40 per cent target, the interest payments on the additional expenditure are more than outweighed by the energy savings — *rendering the savings privately cost effective*.

Source: sustainability.nsw.gov.au and Pracsys 2006, *WA Basix Triple Bottom Line Cost Benefit Assessment*, www.dpi.wa.gov.au/13871.asp , pp 10.

Space conditioning

Space conditioning efficiency is a function of the building thermal performance, as well as the efficiency of the space conditioning equipment. Good building thermal

46 Some of this estimate will apply to the commercial sector. See Australian Greenhouse Office 2005, *Stationary Energy Greenhouse Gas Emissions Projections*, www.greenhouse.gova.au, pp 29.

47 Armstrong G. and Saturn Energy Resources 2003, *National Framework for Energy Efficiency — Preliminary Assessment of Demand Side Energy Efficiency Improvement Potential and Costs*, Report No. 4, pp28.

performance can virtually eliminate heating and cooling requirements in Western Australia at low cost, such that gains in space conditioning efficiency become marginal — this suggests the appropriate policy focus should be on the thermal performance of the building shell.[48]

Integrated design combining orientation, passive solar principles, use of thermal mass, shading, improved venting and airflow management, and low energy lighting and other appliances can all contribute to significant energy reductions in space conditioning energy use.

However, accessing the totality of these savings is really only possible at the time of construction or major refurbishment. These events are the key to major savings in the Residential sector, as houses are relatively long lived (30 years or more), and the transactions costs of retrofitting existing housing can significantly reduce return on investment.

BOX 3.6 – TRANSFORMING THE MARKET FOR SOLAR WATER HEATERS

The Western Australian Government provides subsidies for installation of solar hot water systems:

Type of Solar Water Heater	*Eligible Household*	*Amount of subsidy*
Gas-boosted	Any home in WA	$600
Electric-boosted	New home in WA	$300

Additionally:

- first home-owners receive $200 additional subsidy;
- solar hot water systems installed in off-grid areas receive $200 more subsidy; and
- one panel solar hot water systems receive $200 less subsidy.

The subsidy augments that received for Renewable Energy Certificates under the Mandatory Renewable Energy Target.

The WA subsidy has been extremely successful in overcoming first-home buyers' reluctance to spend more upfront, despite clear private cost effectiveness in most situations. The major building companies in Western Australia now offer solar hot water as a standard feature on their new homes. Consumers need to 'opt out' if they want an alternative hot water system. As a result, the number of solar hot water systems installed on new homes more than doubled in Western Australia in the three years to 2004, driven by an annual growth rate twice that in the rest of Australia.

Increasing the uptake of solar hot water systems on new homes, and gas-boosted systems, is also a key to overcoming a further barrier — the propensity for consumers to replace their failed hot water system with a newer version of the existing type of system.

Programs such as BASIX recognise this relationship by focusing on both the building shell performance and appliance efficiency, providing targets for new dwellings and renovations (Box 3.5). This translates to an almost immediate 40 per cent reduction for the buildings/space conditioning component of the *Growth* and *Replace* categories. Given the estimate that these savings come at paybacks of around 4 years

[48] As residential energy air conditioning loads are the major contributor to growth in peak summer loads, such savings also provide for broader economic and energy efficiency savings.

for the standard dwelling, greater savings targets could be justified on grounds of social cost effectiveness.[49]

Lighting

As in the Commercial sector, there is potential to reduce the energy use of lighting in residences by a factor of four or more over the period to 2030.

Hot water

Western Australia already uses relatively less energy for hot water heating, due to a greater share for solar hot water and gas. Again, ensuring that more efficient appliances increase their penetration of the new buildings stock is a key to longer term savings. The solar hot water subsidy is an example of a successful ‘market transformation’ program which has helped to win acceptance of gas-boosted solar hot water in the Western Australian new homes market (Box 3.6).

Energy savings potential in the medium term

Energetics, based on EMET and George Wilkenfeld’s work for the NFEE, judge that there is ‘cost effective’ potential to improve energy efficiency in the Residential sector to around 10 per cent below business as usual for electricity by 2015, and an 18 per cent reduction in gas use.

TABLE 3.30 - REDUCTION IN RESIDENTIAL TOTAL FINAL ENERGY USE FROM ENERGY EFFICIENCY- ENERGETICS ESTIMATES

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	26.2	27.1	28.0	28.6	29.3	29.9	30.6	31.2	31.9
Energy Efficiency Scenario (PJ)	26.2	26.5	26.9	27.1	27.3	27.4	27.6	27.7	27.8
Percentage reduction (%)	0.0	2.3	3.9	5.4	6.9	8.4	9.8	11.3	12.6

Source: Energetics 2006, op.cit., pp 64.

In total, Energetics estimate that there is the potential to reduce overall energy consumption by around 12.6 per cent by 2014-15 — from 31.9 PJ to 27.8 PJ (Table 3.30).

Energy savings potential for the longer term

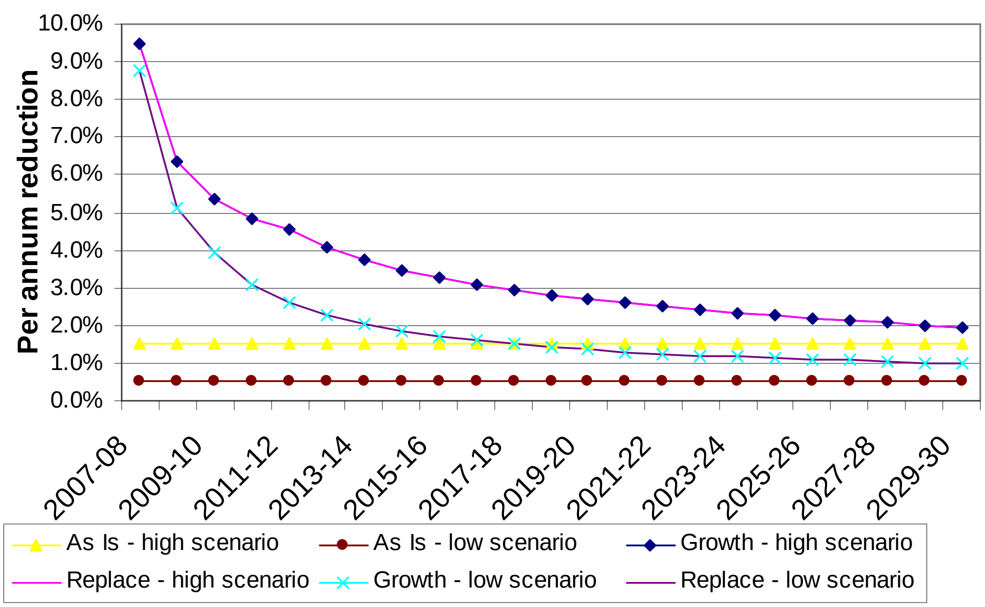
Overall, similar to the Commercial sector, we judge that the potential for additional energy savings are substantial over the longer term in the areas of *Growth* and

49 Pracsys 2006, *WA Basix Triple Bottom Line Cost Benefit Assessment*, www.dpi.wa.gov.au/13871.asp , pp 10

Replace, but are modest in the *As Is* area. Socially cost effective rates of improvement in the sector for the period to 2030, beyond business as usual, could average (Figure 3.18):

- *As Is* — between 0.5 per cent per annum (low scenario) and 1.5 per cent per annum (high scenario);
- *Replace and Growth*
  - between 1 per cent per annum (low scenario) and 3.5 per cent per annum (high scenario) for the weighted average improvement of *appliances and lighting*;
  - between an almost immediate 40 per cent per annum (low scenario) and 60 per cent per annum (high scenario) for the *building shell/HVAC* — to reflect the potential impact of a program such as BASIX;
- the combined weighted impact of improvements for the building shell, HVAC, appliances and lighting is for a total improvement of 1.2 per cent per annum (low scenario) and 2.4 per cent per annum (high scenario) beyond the ABARE business as usual projection for the sector, by the end of the period.

FIGURE 3.18 – RESIDENTIAL ANNUAL RATES IN ENERGY SAVINGS 'BEYOND BAU' — UP TO 6 YEAR PAYBACKS



Source: Insight Economics

Energy savings outcomes

Overall, there are significant (net social) cost effective energy savings available through improved energy efficiency in the Commercial sector.

At zero carbon prices, savings in energy delivering between 1.6 and 3.7 Mt CO2e are potentially available by 2030 (Table 3.31).

TABLE 3.31 – RESIDENTIAL SECTOR ENERGY USE AND SAVINGS – 6 YEAR PAYBACK

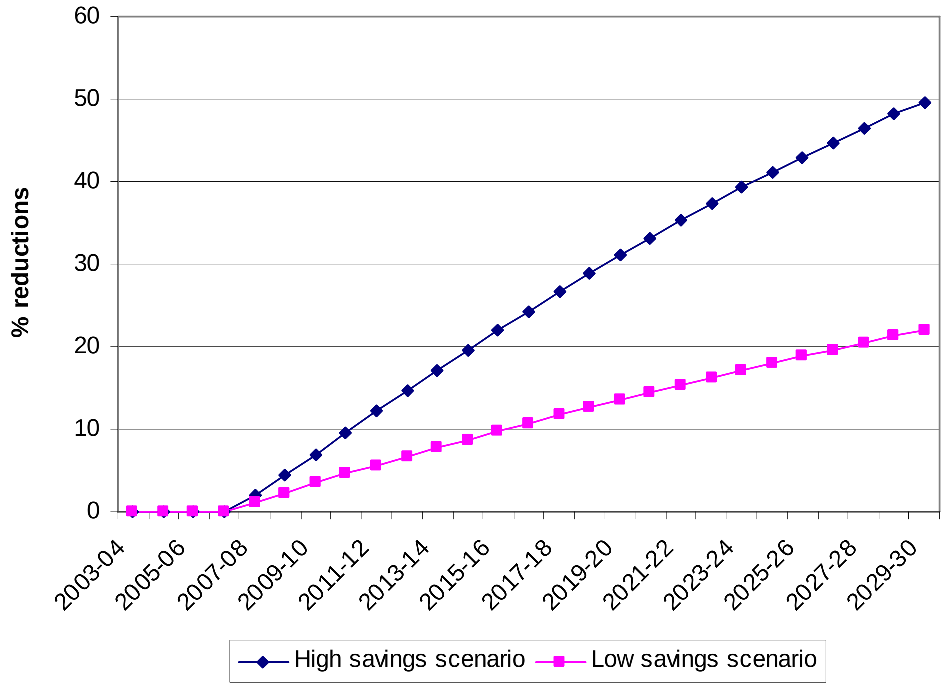
	2009-10	2014-15	2019-20	2024-25	2029-30
BAU energy use (PJ)	28.6	31.9	35.5	39.3	43.2
High savings scenario					
Coal (PJ)	0.0	0.0	0.0	0.0	0.0
Other petroleum (PJ)	0.0	0.0	0.0	0.0	0.0
Gas (PJ)	9.9	9.4	8.9	8.4	7.9
Electricity (PJ)	16.8	16.3	15.5	14.7	13.9
Total (PJ)	26.7	25.6	24.5	23.1	21.8
Total savings (PJ)	1.9	6.2	11.0	16.2	21.4
Total savings (% of BAU)	6.8	19.5	31.0	41.1	49.5
Total savings (kt CO_2e)	328	1066	1885	2769	3666
Low savings scenario					
Coal (PJ)	0.0	0.0	0.0	0.0	0.0
Other petroleum (PJ)	0.0	0.0	0.0	0.0	0.0
Gas (PJ)	10.2	10.6	11.2	11.7	12.2
Electricity (PJ)	17.4	18.5	19.5	20.5	21.5
Total (PJ)	27.6	29.1	30.7	32.2	33.7
Total savings (PJ)	1.0	2.8	4.8	7.1	9.5
Total savings (% of BAU)	3.5	8.7	13.6	18.0	21.9
Total savings (kt CO_2e)	169	477	826	1211	1623

Source: Insight Economics

Again, the significant difference in savings between the high and low scenarios by 2030 illustrate the compounding effect that higher rates can have if they are started early and maintained over time (Table 3.31 and Figure 3.19). The high scenario potential delivers a reduction in energy use below business as usual of around 50 per cent by 2050 — which is more than offsets the growth in energy use in the sector.

Higher carbon prices substantially increase the amount of savings that are available over the longer term at socially cost effective returns (Table 3.32). Savings rise to between 2.1 and 4.7 Mt CO2e at 2030 under the impact of a $40 per tonne CO_2e carbon price.

FIGURE 3.19 – RESIDENTIAL SECTOR TOTAL CUMULATIVE REDUCTIONS BELOW BAU — UP TO 6 YEAR PAYBACKS



Source: Insight Economics

TABLE 3.32 – RESIDENTIAL SECTOR — EFFECT OF HIGHER CARBON PRICES ON COMBUSTION ONLY EMISSIONS SAVINGS FROM INVESTMENTS WITH UP TO 6 YEAR PAYBACKS

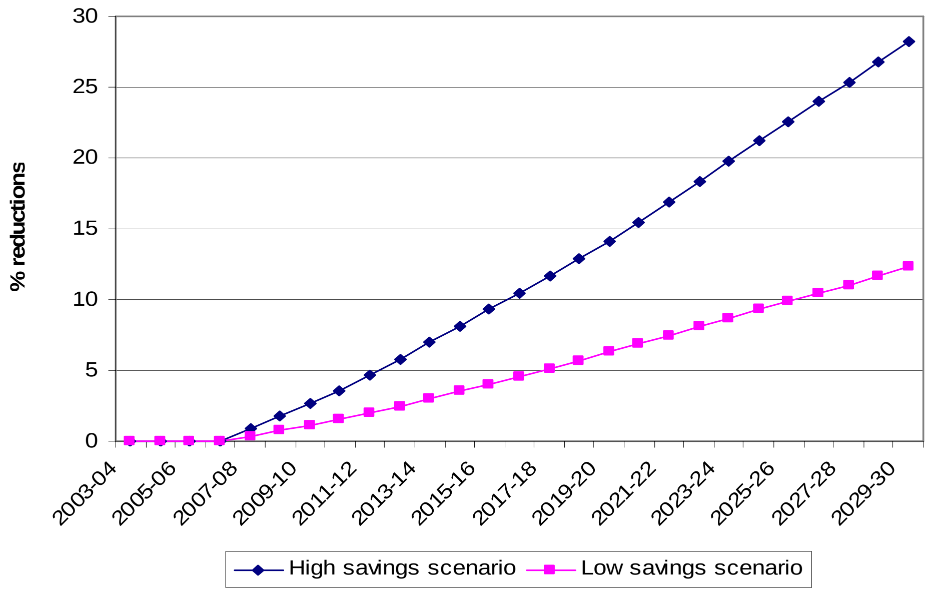
	2009-10	2014-15	2019-20	2024-25	2029-30
High savings scenario					
\$0/t CO_2e (kt CO_2e)	328	1066	1885	2769	3666
\$10/t CO_2e (kt CO2e)	362	1172	2074	3046	4033
\$20/t CO_2e (kt CO2e)	382	1239	2192	3219	4262
\$30/t CO_2e (kt CO2e)	403	1305	2309	3392	4491
\$40/t CO_2e (kt CO2e)	423	1372	2427	3564	4720
Low savings scenario					
\$0/t CO_2e (kt CO_2e)	169	477	826	1211	1623
\$10/t CO_2e (kt CO2e)	187	525	908	1332	1785
\$20/t CO_2e (kt CO2e)	197	555	960	1408	1886
\$30/t CO_2e (kt CO2e)	208	585	1011	1484	1988
\$40/t CO_2e (kt CO2e)	218	614	1063	1559	2089

Source: Insight Economics

3.10 Combined impacts — all sectors

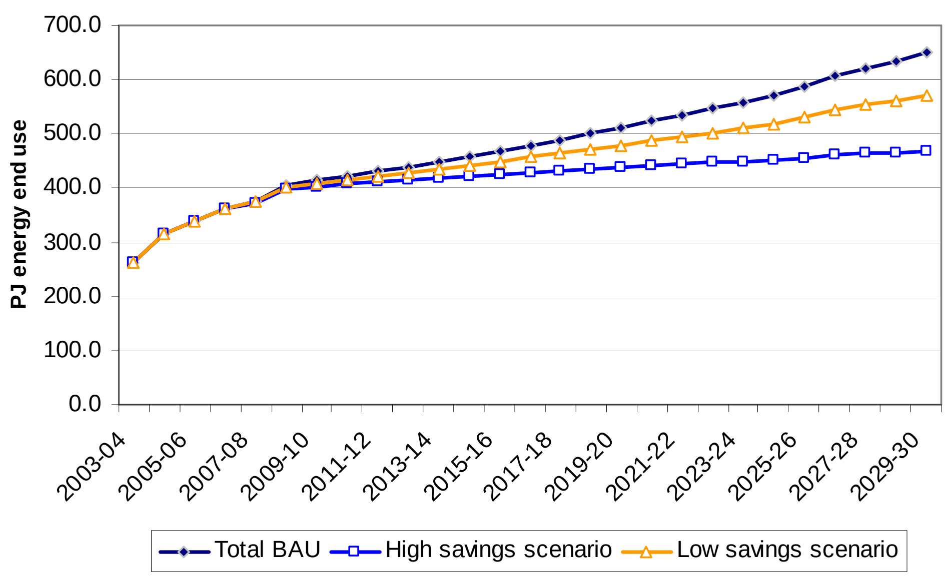
Overall, there are significant socially cost effective energy savings available through improved energy efficiency — offering internal rates of return at 15 per cent per annum or better (up to simple paybacks of less than or equal to 6 years).

FIGURE 3.20 – TOTAL ALL SECTORS TOTAL CUMULATIVE REDUCTIONS BELOW BAU — UP TO 6 YEAR PAYBACKS — $0 PER TONNE CO_2E CARBON PRICE



Source: Insight Economics

FIGURE 3.21 – SUMMARY OF ENERGY USE – ALL SECTORS – BAU, HIGH AND LOW SCENARIOS – $0 PER TONNE CO_2E CARBON PRICE



Source: Insight Economics

Energy savings

The high scenario potential delivers a reduction in energy use below business as usual of 28 per cent by 2030 (Table 3.33 and Figure 3.20) — which almost offsets the growth in energy use in Western Australia after 2010 (Figure 3.21). The low scenario delivers savings of 12 per cent in Stationary Energy use by 2030.

A reasonable best estimate for 2030 might lie midway between the high and low scenarios — for a reduction in energy use of 20 per cent below business as usual. The 'no regrets' component of these savings (at zero carbon prices) is strongly expansionary for the Western Australia economy (see Appendix B).

TABLE 3.33 – TOTAL ALL SECTORS ENERGY USE AND SAVINGS – 6 YEAR PAYBACK

	2009-10	2014-15	2019-20	2024-25	2029-30
BAU energy use (PJ)	414.0	458.0	511.1	571.7	649.4
High savings scenario					
Coal (PJ)	26.3	23.9	21.9	20.1	18.5
Other petroleum (PJ)	47.0	58.4	69.6	78.2	85.6
Gas (PJ)	241.1	246.6	253.1	256.6	266.1
Electricity (PJ)	88.5	91.7	94.4	95.3	96.2
Total (PJ)	402.8	420.6	438.9	450.3	466.4
Total savings (PJ)	11.2	37.4	72.2	121.4	183.0
Total savings (% of BAU)	2.7	8.2	14.1	21.2	28.2
Total savings[a] (kt CO_2e)	1405	4775	9044	14763	21635
Low savings scenario					
Coal (PJ)	27.9	27.2	26.6	26.0	25.6
Other petroleum (PJ)	47.7	61.5	76.9	94.4	114.2
Gas (PJ)	243.1	253.5	266.4	279.4	300.3
Electricity (PJ)	90.7	99.7	109.1	118.8	129.4
Total (PJ)	409.3	441.9	479.0	518.5	569.6
Total savings (PJ)	4.7	16.1	32.1	53.1	79.8
Total savings (% of BAU)	1.1	3.5	6.3	9.3	12.3
Total savings[a] (kt CO_2e)	613	2049	3976	6402	9376

Source: Insight Economics

Note: a) combustion only emissions factors

Rebound effects

At constant real energy prices, uptake of cost effective savings on energy efficiency will expand economic activity. This will induce 'rebound effects' — where the increased income from savings on energy efficiency is spent elsewhere in the economy, resulting in increased economic activity and greenhouse gas emissions. Most studies in the Australian context suggest that the rebound effect reduces first round savings, from energy efficiency investments at current prices, by around 20 per cent. On the other hand, rising domestic energy costs — such as might arise from increasing global fuel prices or from a domestic carbon price signal — will attenuate the rebound effect.[50]

Emissions savings

At zero carbon prices, corresponding (combustion only) savings in emissions are between 9.4 and 21.6 Mt CO2e are potentially available by 2030 (Table 3.33).

Higher carbon prices substantially increase the amount of savings that are available over the longer term at socially cost effective returns (Table 3.34). Savings rise to between 14.9 and 34.4 Mt CO2e at 2030 under the impact of a $40 per tonne CO_2e carbon price.

TABLE 3.34 – ALL SECTORS COMBINED — EFFECT OF HIGHER CARBON PRICES ON EMISSIONS SAVINGS FROM INVESTMENTS WITH UP TO 6 YEAR PAYBACKS – COMBUSTION ONLY EMISSION FACTORS

	2009-10	2014-15	2019-20	2024-25	2029-30
High savings scenario[a]					
$0/t CO_2e (kt CO_2e)	1405	4775	9044	14763	21635
$10/t CO_2e (kt CO2e)	1672	5678	10749	17520	25639
$20/t CO_2e (kt CO2e)	1870	6353	12014	19547	28555
$30/t CO_2e (kt CO2e)	2068	7028	13280	21574	31470
$40/t CO_2e (kt CO2e)	2266	7704	14545	23601	34385
Low savings scenario[a]					
$0/t CO_2e (kt CO_2e)	613	2049	3976	6402	9376
$10/t CO_2e (kt CO2e)	736	2447	4736	7606	11116
$20/t CO_2e (kt CO2e)	826	2741	5293	8484	12377
$30/t CO_2e (kt CO2e)	917	3034	5851	9363	13638
$40/t CO_2e (kt CO2e)	1007	3328	6408	10241	14899

Source: Insight Economics

Note: a) combustion only emissions factors

50 For example, the Phase 1 macro-economic modelling of energy efficiency savings for the National Framework for Energy Efficiency, which has cumulative paybacks similar to this study, found rebound effects reduced first round emissions savings by 21 per cent (see Adams P. and Begley R 2004, *Modelling Opportunities for Improved Energy Efficiency — Presentation to NFEE Workshop*, www.seav.vic.gov.au.

TABLE 3.35 – ALL SECTORS COMBINED — EFFECT OF HIGHER CARBON PRICES ON EMISSIONS SAVINGS FROM INVESTMENTS WITH UP TO 6 YEAR PAYBACKS – FULL FUEL CYCLE EMISSIONS FACTORS

	2009-10	2014-15	2019-20	2024-25	2029-30
High savings scenario[a]					
\$0/t CO_2e (kt CO_2e)	1613	5487	10386	16928	24774
\$10/t CO_2e (kt CO2e)	1943	6604	12492	20322	29689
\$20/t CO_2e (kt CO2e)	2204	7498	14164	22997	33533
\$30/t CO_2e (kt CO2e)	2465	8391	15837	25673	37376
\$40/t CO_2e (kt CO2e)	2727	9284	17510	28349	41220
Low savings scenario[a]					
\$0/t CO_2e (kt CO_2e)	705	2355	4565	7343	10743
\$10/t CO_2e (kt CO2e)	856	2846	5501	8823	12878
\$20/t CO_2e (kt CO2e)	976	3234	6237	9983	14542
\$30/t CO_2e (kt CO2e)	1095	3622	6973	11142	16206
\$40/t CO_2e (kt CO2e)	1215	4011	7710	12302	17870

Source: Insight Economics

Note: a) full fuel cycle emissions factors

Achieving energy savings in end use in the Stationary Energy sector delivers additional upstream savings in terms of reduced transmission losses and reduced Fugitive emissions from natural gas production. If the emissions boundary is extended to incorporate these savings, Western Australia could expect to benefit from additional emissions savings, yielding combined total emissions reductions from investments in energy efficiency of between 17.9 and 41.2 Mt CO_2e by 2030 (Table 3.35). This equates to additional greenhouse gas emissions reductions from the above savings of up to 20 per cent, depending on the carbon price.[51]

Sectoral savings

The most significant savings are available in the Mining, Commercial and Residential sectors — together these three sectors account for around 85 per cent of the available savings at 2030 at zero carbon prices (Table 3.36). These sectors should be priorities for policy action to address greenhouse gas abatement in Western Australia. The Non-ferrous metals, Basic chemicals and Other manufacturing sectors could form a second priority tier.

51 This result assumes that reduced volumes of domestic gas are not offset by increased exports of LNG.

TABLE 3.36 – SECTORAL SAVINGS – BEST ESTIMATES[a]

	2019-20			2029-30		
	Energy savings @ $0/t (PJ)	Emissions savings[b] @ $0/t ($ktCO_2e$)	Emissions savings[b] @ $40/t ($ktCO_2e$)	Energy savings @ $0/t (PJ)	Emissions savings[b] @ $0/t ($ktCO_2e$)	Emissions savings[b] @ $40/t ($ktCO_2e$)
Mining	21	2181	3167	66	6624	9535
Chemicals	6	379	872	16	970	2238
Iron and steel	1	82	172	1	156	318
Non-ferrous metals	7	495	880	13	962	1772
Non-metallic minerals products	1	66	144	2	143	309
Other mfg. & construction	1	234	425	3	532	968
Commercial	8	1799	2679	17	3630	4968
Residential sector	8	1355	1745	15	2645	3404

Source: Insight Economics

Note: a) Best estimates derived from the mid-point of low and high scenario estimates b) Combustion only emissions factors

CHAPTER 4

Policy for energy efficiency

Energy efficiency is a contentious area. The case for government policy rests on the premise that there are significant market failures preventing investment in economic energy efficiency measures. There have been numerous studies over the years analysing causes and cures of this so-called ‘energy efficiency gap’.

On the other hand, critics contend that investments in cost effective energy efficiency *are* generally taken up — to the same degree as other cost effective investment opportunities elsewhere in the economy — and that there is limited rationale for public policy intervention. For example, the recent Productivity Commission report on energy efficiency argued:[52]

> Energy efficiency improvements that are privately cost effective are true ‘no regrets’ measures — the individual producer or consumer concerned saves costs and the global community benefits from reduced pollution, including greenhouse gas abatement. There is no doubt that such opportunities exist. But the potential for making such improvements, and the scope for governments to efficiently intervene to address barriers and impediments preventing their uptake, appears to be modest. In many cases, the improvements are not as cost effective for individual producers and consumers as they might seem, once all of the costs (including the opportunity costs of using those funds elsewhere) are considered. And few of the many perceived barriers and impediments are areas where government intervention is justified.

52 Productivity Commission 2005, *The Private Cost Effectiveness of Improving Energy Efficiency*, Report No. 36, www.pc.gov.au , pp v.

The Productivity Commission concluded that some government intervention to address these problems is appropriate, including mandatory labelling. But the Commission was not convinced on the need for further intervention could be justified, arguing that other mandatory measures may not be privately cost effective.

4.1 A rationale for policy intervention

The Productivity Commission's conclusions were driven in large part by the narrow terms of reference which the Commission addressed, particularly the requirement that the measures be 'privately cost effective'. This allowed the Commission to question any measure that was not cost effective for *every* individual or firm. For example, the Commission:

- questioned the value of Minimum Energy Performance Standards (MEPS) — recommending that future policy should 'include a more comprehensive analysis of … the extent to which MEPS prevent consumers from buying products that are more cost effective for them';[53] and

- concluded that 'the policy of mandating assessments of energy efficiency opportunities is not warranted on private cost-effectiveness grounds', arguing that the program would 'distort investment decisions and adversely affect the private cost effectiveness of firm's operations.[54]

Rejecting measures on the basis that they might make *any* consumer worse off is known as a 'strict Pareto improvement' test. The concern with the Commission's approach is that the strict Pareto test would not be met in practice by almost any government policy. As noted by Gaudi:[55]

> A problem for the strict Pareto approach, that any change must benefit at least one person and harm no one, is that it is so restrictive to be of little practical use.

Economists have developed approaches to work around the impracticality of the strict Pareto criteria. Stavins et al point the way to an oft-adopted solution:[56]

> Actual Pareto-improvements are exceptionally rare, of course, perhaps even non-existent. Hence, the strict Pareto criterion is virtually never taken as a guide for public policy, despite its considerable normative appeal. Economists resort instead to seeking 'potential Pareto-improvements' in the Kaldor-Hicks sense — the world is viewed as being made better off if the magnitude of gains and the magnitude of losses are such that the gainers can fully compensate the losers for their losses and still be better off themselves.

This 'potential Pareto-improvement' approach has been the foundation of public policy for almost 60 years. Once this 'net private benefits' approach is accepted, measures such as Minimum Energy Performance standards are easily justified —

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53 Ibid, pp xlix.

54 Ibid. pp 150.

55 J.M. Gowdy 2004, *Toward a New Welfare Foundation for Sustainability*, Rensselaer Working Papers in Economics, www.rpi. edu/dept/economics/.

56 R.N. Stavins, A.F.Wagner and G. Wagner 2003, Interpreting Sustainability in Economic Terms: Dynamic Efficiency plus Intergenerational Equity, *Economics Letters* 79 (2003) 339-343.

regulatory impact statements show large net benefits for the community *as a whole*. From this perspective, these measures are classic 'no regrets'.

Policy to address greenhouse further widens the calculus for justifiable policy on energy efficiency — to what might be *socially* cost effective. Such policy recognises the existence of a greenhouse 'externality' — that creates a 'divergence' between net private returns and the net returns to society as a whole. Cost effective policies to internalise the costs of greenhouse — that deliver *net* social benefits (again, a potential Pareto improvement) — can be justified.

In this context, where action on greenhouse is proposed with a non-trivial economy-wide (social) marginal cost of abatement, then:

- 'no regrets' energy efficiency opportunities with *net private benefits*, that are not taken up due to market failures, could justify substantial costs of policy intervention (*at least* up to the economy-wide marginal cost of abatement on a per tonne equivalence basis);
  - such a policy would be justified even at a zero marginal cost of abatement, provided that the cost of intervention was more than outweighed by the net private benefit — which would imply that society was still better off;
- other energy efficiency opportunities — with *net private costs*, could justify policy intervention if the *total* costs per tonne of abatement of the measures (comprising the sum of the private cost per tonne and the policy program cost per tonne) were lower than the economy-wide marginal cost of abatement.

Policy that met these conditions would deliver a net social benefit, and would thus be deemed to be *cost effective*.

4.2 Criteria for policy

The previous section established that one criteria for policy intervention in energy efficiency outcomes is that policy intervention should be cost effective, ensuring a net social benefit.

This criteria sits comfortably within a standard set of criteria for policy. Policy instruments may be assessed on these standard dimensions:

- *effectiveness* — does the policy instrument improve energy efficiency outcomes significantly in Western Australia?
- *efficiency* — is the increased energy efficiency achieved in the most economic way?
  - are *net social benefits* maximised — after the costs of the policy intervention have been taken into account?

- as a corollary, are 'by-product' distortions minimised (delivering '*allocative efficiency*') — implying the need to address the market failure or barrier as close as possible to its source through 'first best' policy?[57]

- is the policy sufficiently flexible to respond to changing circumstances (delivering '*dynamic efficiency*' though time) — does the policy change provide incentives to encourage ongoing uptake of cost effective energy efficiency, while adapting to changes in technologies and consumer tastes; is the policy capable of complementing other policies, such as an emissions trading scheme?

▪ *equity* — while assessment of a 'potential Pareto improvement' is unaffected by the distribution of costs and benefits in the community, considerations of equity can be important in affecting the *political feasibility* of a policy or program.

4.3 Market failures and barriers to energy efficiency

Key market failures and barriers impeding uptake of cost effective investments in energy efficiency include:[58]

Related to issues of incorrect relative prices:

▪ incorrect relative prices in markets for energy;

  - regulated energy prices set below the incremental costs of generation, transmission and distribution, particularly for peak and remote loads;

  - inadequate institutional arrangements for considering energy efficiency as an alternative to network augmentation;

▪ lack of incorporation of externalities in energy pricing — particularly the external costs of greenhouse gas emissions;

Not related to issues of energy prices

▪ information failures;

  - imperfect information, including under-provision due to its 'public good' characteristics;

  - asymmetric information, including 'adverse selection' problems;

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57 Economic theory suggests that the costs of policy intervention can be minimised by adopting 'first best' policies. First best policy involves making an appropriate policy intervention as close as possible to the point of 'divergence' or market failure (intervening further from the point of divergence imposes additional by-product distortions, reducing the economic efficiency of intervention). Where a first best policy is not available due to constraints on the form of intervention, or where other market failures exist, it is still possible to design a policy that is welfare improving, even if welfare is not optimised (this is the theory of 'second best', whereby second best policies improve welfare but do not deliver the optimum outcomes associated with first best policies).

58 This classification draws on that in The Allen Consulting Group 2004, *The Energy Efficiency Gap: Market Failures and Policy Options*, Report to the Business Council for Sustainable Energy, the Australasian Energy Performance Contracting Association and the Insulation Council of Australia and New Zealand.

- principal/agent problems;
  - split incentives;
  - ‘moral hazard’ issues;
- externalities from energy innovation;
- multiple decision makers;
  - firm/ external agent organisational constraints; and
  - internal to the firm principal/agent problems, including ‘bounded rationality’ constraints.

In what follows, each category of market failure or impediment is considered. Existing measures deemed to address these failures are discussed briefly. Additional policy options are identified and evaluated.

Relative energy prices

Decisions to invest in energy efficiency will be influenced by the relative price of energy. Efficient energy prices in turn will be a function of:

- the effectiveness of market competition in delivering efficient energy supply;
- the effectiveness an efficiency of regulation of elements of markets where competitive outcomes are constrained due to small numbers of market participants, or because of natural monopoly characteristics;
- the incorporation of externalities in pricing.

Energy market reform

The reform of energy markets through introduction of competition has done much to improve allocative efficiency. In Western Australia, gas markets have been competitive for a number of years, and the reform of electricity markets is just coming to fruition.

Under the new competitive markets regime, prices for energy are influenced by competitive forces. However, government regulation has an important role in energy pricing — focusing on the ensuring efficient outcomes in relation to the monopoly elements of energy supply, such as the electricity networks and the major gas pipelines.

- ‘Cost reflective network pricing’ is a pre-requisite for efficient pricing of energy, and hence for efficient uptake of opportunities for energy efficiency. However, network tariffs are still 'largely uniform throughout a distribution area and do not signal peak or location costs to consumers'.[59]

- Decisions on whether to augment the network or to invest in demand side options such as energy efficiency are influenced by the incentive structure created by network price regulation, and also by the associated decision criteria used to assess the augmentation.

This has a number of implications for uptake of cost effective energy efficiency:

- *Peak load congestion* — air conditioner loads are driving a rapid growth in the summer peak electricity demand, but do not face the full costs of their energy requirements.[60]
- *Locational signalling* — governments pursue average or 'postage stamp' pricing of distribution network costs as a means of addressing equity issues for rural consumers. This prevents consumers seeing the higher costs of electricity on the fringes of the grid, creating a barrier to investments in distributed resources such as energy efficiency and embedded generation.[61] This is a particular issue in Western Australia, which has an extensive rural network, covering very large areas.
- *Network augmentation* — distribution network service providers (DNSPs) may not receive adequate recompense for initiating cost effective demand side investments under network pricing structures. Explicit recognition is required of the impact on returns of investments in cost effective demand side alternatives to network augmentation.

Policy options are available to improve the cost reflective aspect of electricity prices.

Congestion pricing

The emergence of 'smart meters' provides a opportunity to improve price signals for consumers and small business, by allowing 'time of use' prices. Importantly, better information provided by smart meters has been shown to change behaviour, leading to energy efficiency savings.

Simple approaches to time of use pricing have been adopted in various jurisdictions in the past (a classic being off-peak hot water tariffs). However, it is likely that smart

59 Independent Pricing and Regulatory Tribunal of NSW 2002, *Inquiry into the Role of Demand Management and Other Options in the Provision of Energy Services Final Report*, www.ipart.nsw.gov.au, pp 76.

60 For example, peaks lasting only 3.2 per cent of the year were responsible for 36 per cent of total annual spot market costs in 2002 in the National Electricity Market (Department of Prime Minister and Cabinet 2004, *Securing Australia's Energy Future*, www.pmc.gov.au/securing_future , pp 68. It has been estimated that the average new household air conditioner receives a subsidy of $365 from other users due to the averaging of electricity costs in New South Wales (Charles River Associates 2003, *Impact of Air Conditioning on Integral Energy's Network*, www.ipart.nsw.gov.au/submiss/ENR_DNSPs_03)

61 The Western Australian Electricity Networks Access Code 2004 states at Section 7.7 'the tariff applying to a standard tariff user in respect of a standard tariff exit point must not differ from the tariff applying to any other standard tariff user in respect of a standard tariff exit point as a result of differences in the geographic locations of the standard tariff exit points' (see State of Western Australia 2004, *Gazette — Electricity Industry Act 2004 — Electricity Networks Access Code 2004*, www.era.wa.gov.au/electricity/networkAccess.cfm .

meters offer the opportunity to implement time of use pricing in the most cost effective and productive way. As the Productivity Commission noted:[62]

> The most significant impediment to more cost-reflective retail prices and network tariffs is the absence of 'smart' metering among residential and small business customers. 'Smart' meters provide energy users, retailers and distributors with the means of obtaining information about energy consumption and network use. 'Smart' meters also provide a means by which retailers and distributors con set time of use for different locations and to provide various demand-side management services such as direct load control.

The Commonwealth Governments Solar Cities Program intends trial smart metering as a means to reduce peak load demand and enhance signals for energy efficiency.

Location signalling

The government does not need to rely on a uniform tariff policy to achieve its equity objectives for rural energy consumers. Postage stamp pricing could be eliminated for rural networks, with consumers receiving a fixed (lump sum) discount on their quarterly electricity bill funded by an explicit 'Community Service Obligation', which would be funded by a levy on metropolitan customers.

This would reinstate incentives to invest in distributed energy solutions. Customers would have the option to invest in energy efficiency up to the marginal cost of their electricity (which would be much higher for some customers). Combined with incentives for DNSPs to contract for energy efficiency (see below), a key regulatory barrier to cost effective energy efficiency would be removed.

Incentives for DNSPs to contract for energy efficiency

Clearly identifying the test for cost effective alternatives to network augmentation, and ensuring that DNSPs have appropriate incentives to invest in those alternatives — where they are more efficient — is a prerequisite for efficient expansion of networks.

In Western Australia, these arrangements are still being developed. The Western Australian Electricity Network Access Code 2004 includes arrangements for a 'regulatory test' for major augmentations to ensure that alternatives are considered, and that the subsequent investment maximises net benefits.[63] However, the Economic Regulation Authority, which administers the Code, does not explicitly recognise the need to provide incentives for cost effective alternatives to augmentation, despite this being an objective of the Access Code.

This contrasts with New South Wales Independent Pricing and Regulatory Tribunal (IPART), which has adopted a range of incentives for network driven demand management, including the ability for DNSPs to:[64]

- 'pass through' demand management costs, up to the avoided distribution costs;

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62 Productivity Commission 2005, op.cit., pp 331.

63 State of Western Australia 2004, op.cit, pp 5598.

64 Independent Pricing and Regulatory Tribunal of NSW 2004, *Treatment of Demand Management in the Regulatory Framework for Electricity Distribution Pricing 2004/05 to 2008/09*, www.ipart.nsw.gov.au, pp 1.

- recover foregone revenue as a result of demand management programs; and
- recover these costs and revenue through an explicit 'D-factor' in the weighted average price cap formula.

Greenhouse externalities

Incorporating greenhouse externalities will raise energy prices and encourage energy efficiency (investing in energy efficiency involves substituting capital for energy use). Ultimately, it is expected that an emissions trading scheme or a carbon tax would be applied to energy use. This represents a 'first best' policy approach that addresses the source of the greenhouse externality at source.

However, energy demands are highly inelastic (apart from demand by energy intensive industrial customers). Hence, the existence of widespread opportunities to improve energy efficiency hinges as much on non-price factors as on relative prices.

The following sections consider market failures and barriers that are not related to energy pricing. These are likely to be just as important for energy efficiency, if not more important, than relative prices (particularly at low to moderate carbon prices). As a result, while getting energy prices right, including through measures such as an NETS, is important, it will also be necessary to implement a range of complementary policies to address energy efficiency opportunities that are caused by non-price failures and barriers.

Information failures

Imperfect information is an oft-cited reason why markets may not deliver optimal outcomes. In the case of energy efficiency, information failures may arise due to:

- *public good characteristics* — information can be costly to obtain, but often then becomes available to others at no cost, resulting in under-investment in information provision;
- *information asymmetries* — buyers find it difficult to distinguish between the energy efficiency performance of different products, resulting in a 'race to the bottom', as demonstrated by Akerlof in his classic analysis of the 'market for lemons' in used cars.[65]

'First best' policy involves public subsidies to develop and disseminate information on energy efficiency for consumers and business. As a result, most jurisdictions have a dedicated agency to provide information. The Sustainable Energy Development Office provides this function in Western Australia, particularly through its web-based services. It also has a substantial program to support innovative projects (such as the Subiaco Sustainable Demonstration Home), and to advertise and otherwise promote energy efficiency.

[65] G.A. Akerlof 1970, The Market for "Lemons": Quality Uncertainty and the Market Mechanism, *Quarterly Journal of Economics*, Vol. 84, No. 3 (Aug., 1970), pp. 488-500.

Mandatory labelling is another key means to inform consumers. The National Framework for Energy Efficiency has undertaken to extend appliance labelling to cover a greater range, and also to cover the energy performance of buildings.

BOX 4.1 - LABELLING AND MEPS IN AUSTRALIA

Mandatory energy performance labelling for appliances has been in operation in Australia in one form or another since the mid 1980s. A nationally coordinated scheme for major appliances was agreed in 1992, but was not fully adopted until 2000. The Energy Rating label has two main features:

- a star rating which gives a quick comparative assessment of the model's energy efficiency; and
- a comparative energy consumption (kwh/year) rating which provides an estimate of the annual energy consumption of the appliance based on the tested energy consumption and information about the typical use of the appliance in the home.

Australia's national Minimum Energy Performance Standards (MEPS) program commenced with standards for refrigerators, freezers and electric storage water heaters in 1999. Since then the scope of the MEPS program has been steadily expanded and a rolling update program for the existing standards commenced.

- MEPS programs are implemented through coordinated state based regulation for technical standards, with offences and penalties for lack of compliance.
- National standards ensure that costly differences do not arise between state based requirements.

Mandatory standards for the ratings of new residential and commercial buildings are being implemented through the Australian Building Code. Development of ratings tools for residences and commercial buildings is a key prerequisite for buildings energy ratings, and available tools now include:

- NAThers, and more recently Accu-rate and First Rate for residences; and
- Australian Buildings Greenhouse Ratings tool developed by SEDA and the Green Star ratings tool developed by the Green Building Council.

Recognition of the benefits of labelling and MEPS has led to the recent announcement by the Ministerial Council on Energy (MCE) that Stage One of the National Framework for Energy Efficiency will, among other things:

- extend national labelling and MEPS programs to gas appliances;
- expand the MEPS program through the introduction of new or more stringent MEPS for residential, commercial and industrial products, with a key focus on increasing the number of commercial and industrial products regulated;
- institute MEPS for government buildings;
- require mandatory disclosure of the energy performance of residential and commercial buildings;
- ensure that benchmark data is provided on consumers energy bills (thereby widening information to include a comparison of the individual's consumption with that of a standard consumer with similar characteristics).

Source: The Allen Consulting Group 2004, op.cit., pp 58.

However, making informed decisions about complex trade-offs in energy investments — even with reliable information available — can be difficult, unless one is an expert. While the cost of an irrational decision may be small for an individual consumer (where energy expenditures are a small proportion of overall expenditure), they may add up to a significant lost opportunity for the community as a whole. This adds to the rationale for economy-wide programs — such as Minimum Energy Performance Standards (MEPS) and other cross-cutting measures to drive energy efficiency (Box 4.1) .

Principal-agent problems

Principal-agent problems arise in part from information asymmetries, which prevent optimum contracting arrangements between different parties.

The classic principal-agent example creating a barrier for energy efficiency is the split incentives problem in tenancy — where a landlord is responsible for the capital investment in a property, while the tenant receives the flow of services. The landlord has incentives to minimise up-front costs (for example, the insulation and other elements contributing to the thermal performance of the building shell), often to the detriment of the tenant (who then has higher energy bills). In theory, the problem could be solved through appropriate cost recovery in the rent. However, information asymmetries can create difficulties — the performance of the building shell, and the resulting comparative reduction in costs, can be hard for the tenant to ascertain and analyse prior to signing a contract.

Information asymmetries also can lead to 'moral hazard' situations where a seller may actually dupe the buyer — for example, there is some anecdotal evidence to suggest that many air conditioner sales are at sizes larger than required. This is to the detriment of efficient provision of energy services.

Policies such as buildings and appliance labelling and MEPS indirectly overcome these problems by eliminating the poorest performers from markets for new appliances and buildings.

BOX 4.2 - COMMONWEALTH GOVERNMENT SUPPORT FOR R&D

The Department of Industry, Technology and Resources has a range of programs to encourage and support business expenditure on R&D. The R&D Tax Concession enables eligible companies to claim a tax deduction for their eligible R&D expenditure. A 125 per cent deduction is available for expenditure on R&D; a 175 per cent premium deduction supports additional R&D expenditure above the previous three year average, and the R&D Tax Offset allows eligible small companies to 'cash out' their R&D tax losses. At 30 June 2005, more than 5,500 companies, with a reported R&D expenditure of more than $6.55 billion, were registered for the R&D Tax Concession for the 2003–04 income year.

The Australian Government is providing more than $1.4 billion from October 2004 to 2010-11 for the new Commercial Ready program, which builds on the successful R&D Start program, the Biotechnology Innovation Fund and elements of the Innovation Access Program. Commercial Ready commenced in October 2004 and is assisting an increasing number of small and medium sized firms to undertake R&D and commercialise the outcomes.

The Industry Cooperative Innovation Program (ICIP) encourages business to business cooperation on innovation projects that enhance the productivity, growth, and international competitiveness of Australian industries. To assist industry consortia to raise industry capability through cooperative projects, $25 million will be provided between June 2005 and June 2011.

Source: Department of Industry, Technology and Resources 2006, http://www.industry.gov.au/content/itrinternet/cmscontent.cfm?objectID=D1B8B525-15D4-4033-8C8C99E155319140, accessed 24 September.

Externalities in energy innovation

Innovators can find it difficult to capture the full benefit of their investment — the public good aspects of new ideas and other 'positive externalities' mean that there is under-provision of innovation, below that which might be socially optimal. Governments support research and development, as well as processes to establish intellectual property rights, in recognition of the broader benefits to the community of innovation. For example the 125 per cent tax deduction applies to eligible expenditure, and a number other programs provide subsidies on a competitive basis (Box 4.2).

Targeting innovation in the energy efficiency field could be justified given the potential for low cost abatement and the significant positive externalities associated with greenhouse. Assessing energy efficiency proposals on their merits should incorporate the future expected value of carbon in the returns calculus. This will help to ensure that funds flow to opportunities with returns higher than the opportunity cost of investment elsewhere in the economy.

Organisational failures

In a strict economic sense, organisational shortcomings within firms and across the economy do not qualify as market failure *per se* — they are simply part of the dynamic of competitive markets. Nevertheless, these barriers represent an opportunity for policy to reduce energy use cost effectively, so as to contribute to an overall greenhouse reduction objective.

Organisational barriers external to the firm

Energy efficiency can be complex to organise. A chain of market participants often is required to achieve a successful project for energy efficiency — and may include, for example, the consumer, the designer, the engineer, the supplier, the local regulatory authority and so on. While the 'invisible hand' of the market can help to organise these outcomes, the complexity of the inputs required and the high level of coordination can create a problem for energy efficiency. The usual market solution in these situations is for specialist firms to make it their business to take on the role of coordinating and delivering the energy services.

The 'energy services' industry comprises firms that organise the most efficient means to deliver 'energy services' to customers For example, energy performance contractors are energy services companies (Box 4.3). The term 'energy services' recognises that the ultimate objective from the use of energy is the services that it provides — cool houses or hot water — rather than simply 'energy supply'.

BOX 4.3 - ENERGY PERFORMANCE CONTRACTING

The 'performance contracting' industry provides an example of a business which is organised to provide energy services. Through a performance contract, an 'energy services company' can:

- identify and evaluate energy-saving opportunities;
- develop engineering designs and specifications;
- manage the project from design to installation to monitoring;
- arrange for financing if required;
- train staff and provide ongoing maintenance services; and
- guarantee that savings will cover all project costs.

Source: Insight Economics and www.aepca.asn.au

However, institutions and history matter — leading to 'path dependence'.[66] This means that past and current approaches (and resulting sunk investments) may create inefficiencies and barriers for new ways of doing things.

Policies for economic development in the past, *and* recent energy market reform, have focused on the supply side of the energy equation, with limited attention paid to developing appropriate incentives for competitive demand side solutions (see Section 4.4 — Relative energy prices). As a result, there tends to be a 'culture' of energy 'supply' that is focused on centralised 'build and generate' solutions.

The corollary is that the 'energy services industry' has struggled to gain widespread support, despite the significant potential to reduce consumer's energy bills. Yet development of the industry will be vitally important if the potential for energy efficiency and associated low cost abatement opportunities is to be realised.

The complex nature of organisational failure means that a portfolio of policies is required. Contributing policies range from MEPS — which remove the poorer practises and appliances from the market, thereby *indirectly* overcoming organisational barriers — through to policies which seek to improve *directly* the capacity of firms and consumers to organise for energy efficiency.

An example of the latter *direct* policy approach is a 'market transformation' program. Market transformation refers to the ability of catalytic policy intervention to change the dynamics of a market, allowing cost effective solutions to gain scale, overcome barriers and gain familiarity and acceptance (again, 'path dependency' matters).

Market transformation involves governments providing *short term* encouragement for the energy services industry — to address sectoral savings opportunites with large potential — thereby overcoming the lack of awareness and 'cultural' resistance to a

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66 Path dependency recognises that current outcomes based on a set of conditions applying in the past may create a barrier to more efficient future outcomes. See for example P. A. David, Path dependence, its critics and the quest for 'historical economics', in P.Garrouste and S.Ioannides 2001, *Evolution and Path Dependence in Economic Ideas: Past and Present*, Elgar Publishing (available at http://www-econ.stanford.edu/faculty/workp/swp00011.pdf).

new approach. These approaches have been successful overseas. Market transformation can help to overcome the path dependent inertia preventing uptake of clearly cost effective energy efficiency technologies (Box 4 .4, also see Box 3.6 on the Western Australian solar water heater market).

BOX 4.4 - ELECTRIC MOTOR MARKET TRANSFORMATION

The Energy Efficiency Team of the Australian Greenhouse Office (AGO) and the End Use Efficiency Committee under the Ministerial Council on Energy works in partnership with stakeholder groups to introduce programs that encourage market transformation — by promoting highly efficient equipment or by identifying selected energy efficient products through appliance labelling. The AGO is developing voluntary programs to accelerate acceptance of 'smart buying' when consumers choose new electric motors systems, airconditioning systems, commercial and home lighting and other major capital investment items which are heavy electricity users.

The aim is to demonstrate that energy efficient products and systems are wise to purchase and install - not only because they consume less energy and thus decrease the amount of greenhouse gasses emitted - but because they in most every case will result in whole-of-life cost savings due to lower electricity charges. The current focus in this area is electric motor repair. A new Code of Rewinding Practice will ensure that motor efficiency is retained in the repair process.

Like all machines, electric motors wear out or fail at some stage. When this happens, a choice between replacement or rewinding (repairing) needs to be made. If the motor is rewound, losses in motor efficiency may be experienced. Efficiency losses can generally be avoided through the use of proper materials and quality repair methods. A poorly conducted rewind could result in a loss of several percentage points in efficiency, while with a first-class job, the difference will not be measurable.

The expected one percent improvement in efficiency of rewound motors will save Australian industry 12,000 MWh of electricity annually after the first year. As more motors are rewound to the new standards, this saving will eventually increase to as much as 120,000 MWh per year, displacing the energy use and greenhouse gases put out by 15,000 homes.

Source: http://www.energyrating.gov.au/transformation.html

An further example of a market transformation approach in Western Australia is the funding by the Western Australia Sustainable Energy Development Office for energy performance contracting for government agencies:

- *Facilitation Grants* are available to agencies to identify energy saving opportunities; and

- *Capital Advances* are available to agencies to invest in energy saving capital projects. The funding is in the form of an interest free advance from the Treasurer and is repayable. Repayments are based on the estimated average annual cost savings anticipated from the project and are therefore designed to be budget neutral to agencies.

This approach helps to establish a track record for the industry in Western Australia.

Consideration could be given to supporting market transformation for cost effective *and significant* demand side options elsewhere in the Western Australian economy (this issue is further addressed in Section 4.10 — Cross cutting policy options). The analysis elsewhere in this report suggests that the priority sectors — Mining, Commercial and Residential — could provide priorities for market transformation approaches.

Internal to the firm organisational failures

Similar challenges of organisation can occur within firms or even for individuals. Energy efficiency may be overlooked either because it not 'core' business, or because the rewards are small relative to the complexity of making the correct decision. Larger firms may lack the systems required to coordinate across the various decision makers required to implement energy efficiency investments. Smaller firms or individuals may find it all just too hard.

Aggregated across the economy, such energy savings represent a sizable opportunity to save on greenhouse gases at low or even negative (no regrets) cost. The challenge is to develop cost effective policies to harness these savings.

As with external organisational failures, a range of policies that work directly and indirectly to improve decision making are important.

A specific policy that works directly to overcome internal organisational failures in larger firms is the Commonwealth's Mandatory Energy Efficiency Opportunity Assessments (MEEOA) program. The program requires companies with energy use greater than 0.5 PJ per annum to identify, evaluate and report on energy efficiency opportunities. If the program proves successful in driving increased uptake of energy efficiency opportunities (implementation is voluntary), it is also likely to provide a significant stimulus to the energy services industries in Western Australia.

4.4 Cross-cutting policy options

There is no single magic 'can opener' to unlock the potential for cost effective energy efficiency. The complex and diverse nature of the target means that a portfolio of measures is required. These will address issues of relative prices, and also barriers that are not related to relative prices.

Relative prices

Policies to improve relative prices are addressed in Section 1.4 above. Correct pricing is a pre-requisite for cost-effective uptake of energy efficiency in the presence of a greenhouse objective.

Other policy measures that operate on relative prices faced by firms and consumers include taxes and subsidies. However, to the extent that market failures are non-price in nature, then taxes and subsidies that operate on end-user prices are less effective as measures. Nevertheless, taxes and subsidies may important instruments for transforming markets, for example encouraging research and development, or for supporting demonstration or aggregation approaches.

Non-price market failures

Key existing measures to address non-price market failures include:

- *Information programs* — the Commonwealth and States and Territories fund information provision for consumers and small business through a range of labelling, information and demonstration programs.

    - Labelling programs are coordinated by the Commonwealth and all States and Territories under the Ministerial Council on Energy. Current efforts are seeking to extend labelling from appliances to mandatory labelling for buildings.

    - Training and accreditation programs are offered by the Commonwealth and all States and Territories under the Ministerial Council on Energy.

    - Information and demonstration services specific to Western Australia are offered by the Sustainable Energy Development Office.

    - Social marketing approaches can be successful in providing information and creating sustained changes in behaviour (the successful TravelSmart program in the transport sector provides an example).

- *Minimum Energy Performance Standards* — remove equipment and building designs with the worst energy performance and indirectly help to overcome split incentives and information asymmetries.

    - There are clear benefits in a national approach to MEPS. This is recognised by all States and Territories through their work under the Ministerial Council on Energy to develop the National Framework for Energy Efficiency. Current efforts are working to extend MEPS.

    - Western Australia is currently examining the BASIX framework, which provides a measuring tool and standard to achieve reductions in energy and water use in buildings. The system has been adopted in New South Wales. Chapter 3 noted that large savings are available from a BASIX style approach at socially cost effective rates of return.

Many of these programs currently operate on a 'no regrets' basis — there is no cost of carbon included in the evaluation of the appropriate (cost effective) level for the standards. This could be one area where Western Australia could push to have more stringent standards implemented, if it chose to adopt a positive shadow price for carbon. However, 'rail gauge' problems associated with different (unilateral) standards in the State could detract from the overall benefits. A first best approach would be for Western Australia to push to extend the existing measures through the processes and committees under the Ministerial Council on Energy.

Beyond minimum standards

Improving the set of incentives to develop and implement energy efficiency investments that *are beyond minimum standards* is an area where perhaps there is greatest scope for new policy.

Existing policies in this area include:

- *Mandatory audits and uptake requirements*

    - provide incentives to invest in information and to overcome organisational failures;

- for example, the Commonwealth's MEOAA program requires large energy users to undertake energy audits, evaluate the results and report on decisions (or otherwise) to implement energy savings with paybacks up to four years.

TABLE 4.1 - POLICY MECHANISMS FOR ENERGY EFFICIENCY

Type	Description
Control mechanisms	
Mandatory sourcing of energy efficiency	
Energy efficiency license conditions	
Integrated resourced planning	
Energy efficiency and load management as alternatives to network expansion	
Monopoly regulation and pricing	
Codes and standards (building codes, MEPS)	
Licences, permits and trading schemes for greenhouse gas emissions	
Funding mechanisms	
Public benefits charge for energy efficiency	
Financing of energy efficiency by energy retailers or ESCOs	
Support mechanisms	
Sustainable energy training schemes for practitioners	
Energy centres	
Creating entrepreneurial energy organizations	
Developing the ESCO industry	
Promotion of energy efficiency by industry associations	
Aggregating electricity purchases to achieve energy efficiency	
Voluntary agreements for energy efficiency	
Market mechanisms	
Taxes on energy	
Tax exemptions, subsidies and incentives for energy efficiency	
Providing consumption information on customers' electricity bills	
Communicating pricing and other information for energy efficiency	
Energy performance labelling	
Developing an energy efficiency brand	
Cooperative procurement of energy efficiency appliances and equipment	
Market transformation approaches	
Energy performance contracting	
Competitive sourcing of energy services	
Competitive sourcing of demand-side resources	
Demand side bidding in competitive markets	

Source: Based on a similar table in E. Vine, J. Hamrin, N. Eyre, D. Crossley, M. Maloney, G.Watt 2003, Public policy analysis of energy efficiency and load management in changing electricity businesses, *Energy Policy* 31 (2003) 405-430.

- Victoria's *State Environment Protection Protocol — Air Quality Management* requires Victorian businesses to undertake energy audits, and to implement projects with a payback of less than three years. The program is reported to have reduced Victoria's greenhouse gas emissions by 1 per cent, at an average payback of 17 months (yielding an internal rate of return exceeding 70 per cent).[67]

Given the analysis in Section 1.2 — Rationale for policy, a greenhouse objective provides a rationale to extend a 'no regrets' definition for such programs to internal rates of return closer to economy wide rates — around 15 per cent in real terms (equivalent to paybacks of up to six years) and potentially even longer if a positive price for carbon was to be adopted as a target for the Western Australian economy. The analysis in Chapter 3 suggests that there are substantial savings available at this rate of return, and even more if a shadow price for carbon is factored in.

Major new cross-cutting policy

Given potential to gain significant savings from energy efficiency in Western Australia, what major cross cutting policies could harness savings beyond basic information provision and minimum standards?

Instruments to encourage significant uptake of energy efficiency can be classified according to whether they are regulatory control, funding/support, or market based mechanisms (Table 4.2).

A number of existing control mechanisms (energy regulation, codes and standards) and support mechanisms (information provision) have already been discussed. As noted, these are necessary pre-requisites for optimum uptake of energy efficiency.

The most promising policy approaches to encourage uptake of energy efficiency, *beyond* basic information provision and minimum standards, are:

- energy efficiency license conditions;
- financing of energy efficiency by electricity businesses or ESCOs, perhaps in conjunction with a public benefits charge for energy efficiency;
- cooperative procurement of energy efficiency appliances and equipment (including market transformation approaches); and
- competitive sourcing of energy services.

[67] EPA Victoria 2006, *The EPA Victoria Industry Greenhouse Program — The Story So Far*, www.epa.vic.gov.au .

Energy efficiency license conditions

Energy efficiency license conditions for large firms mandate specific practices and targets for energy efficiency. The Commonwealth's MEEOA and Victoria's SEPP-AQM policies are existing examples.

Given that a significant proportion of energy efficiency savings in Western Australia appear to be in a number of key Mining and Manufacturing sectors (Mining. Chemicals, Non-ferrous metals processing), involving large firms, this approach has the potential to access a significant proportion of the energy efficiency savings on offer. The policy could build on the existing MEEOA process, but extend it to require voluntary reporting on longer paybacks (reflecting the greenhouse objective), or further, mandating action up to a lower specified internal rate of return/longer payback period (as in Victoria's SEPP-AQM). The threshold for the program also could be set to pick up smaller firms, thereby ensuring that the majority of commercial and industrial load in Western Australia is covered.

The alternative to applying license conditions to end users is to apply energy efficiency license conditions to distribution network service providers (DNSPs) or to energy retailers.

- License conditions on DNSPs could build on the appropriate regulation outlined in Section 1.4 — Relative energy prices, which sought to ensure that DNSPs only implement cost effective network augmentation.
  - DNSPs could be encouraged to become energy efficiency aggregators, either directly, or by contracting with third party energy service companies. DNSPs could be required to make standing offers to third party energy aggregators (which would then be rolled into their capital base as per a D-factor arrangement outlined in Section 1.4 — Relative energy prices). Such an approach could incorporate a price for carbon in the calculus of cost effective energy efficiency.
- The alternative is to apply mandatory energy demand growth reductions to energy retailers. Recent proposals for a 'national energy efficiency target', to be implemented through a 'white certificates' trading scheme for energy retailers, was an example of this approach.[68]
  - A mechanism relying on retailers is attractive, particularly because these entities are closest to customers, and hence are best placed to benchmark energy use by customer class to identify likely excessive energy use. The retailers could either build an energy services capability themselves to implement energy savings with end use customers, or else contract with third parties.
  - A 'white certificates' scheme could form the basis of an energy efficiency 'offsets' program. However, as noted by the National Emissions Trading

[68] See for example The Allen Consulting Group 2004, *The Economic Impacts of a National Energy Efficiency Target: Simulations Using the MMRF-Green Model*, Report to the Sustainable Energy Authority of Victoria, www.seav.vic.gov.au .

Taskforce (NETT) 'there is inherent difficulty in allowing offsets to be created in the same sectoral scope as the liable parties'.[69] While mechanisms are available to work around these problems, these add complexity and uncertainty. The NETT observe that other targeted policy mechanisms for energy efficiency, that address the non-price barriers not influenced by the ETS, would provide a better complement to an ETS.

- Key weaknesses of the retailer white certificates scheme is its complexity, its reliance on a hypothetical baseline against which energy reductions are 'credited' over time, and the uncertain costs associated with such a fixed 'quantity' target. Also, by not targeting the underlying barriers in the behaviours of end-users, but instead seeking to influence these through relative prices, it is questionable as to whether the policy would be a 'first best' approach.

Funding and support mechanisms

A broader alternative approach to the mandated license conditions approach is to establish a major energy savings fund to provide support for a range of activities. This approach works to provide subsidies to activities that support uptake of energy efficiency, including:

- cooperative procurement of energy efficiency appliances and equipment (including market transformation approaches); and
- competitive sourcing of energy services, including by electricity businesses or ESCOs.

The mechanism can be funded either from consolidated revenue, or else through a small 'public benefits' charge on energy distribution.

- A public benefits charge involves a small levy on all energy users. The public benefits charge would be very small, and could be justified as a small step towards internalising the greenhouse externality. It could later be replaced by auction revenue from an emissions trading scheme.
- Regressive characteristics of such a charge can be addressed through targeting a portion of program funds to reduce energy use in low income households, to ensure these households benefited overall. Major energy users — whose competitiveness might be affected unduly — could be exempted from the levy.

New South Wales recently established its Energy Savings Fund, which provides $200 million over five years for energy savings projects which:

- reduce overall electricity consumption in NSW and related greenhouse gas emissions,
- reduce peak electricity demand,

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[69] National Emissions Trading Taskforce 2006, Possible Design for a National Greenhouse Gas Emissions Trading Scheme, www.emissionstrading.net.au, pp 75.

- stimulate investment in innovative measures, and
- increase public awareness in energy savings.

The Energy Savings Fund complements the New South Wales Government's *Energy Savings Order 2005* legislation, which requires firms with energy use greater than 10GWh per year to prepare energy savings plans. The program involves competitive sourcing of energy services.

Such a fund could be established in Western Australia. Potential activities for a Western Australian Energy Savings Fund could be to support:

- through a competitive tender, energy savings opportunities with paybacks that are *greater* the mandatory threshold for firms subject to energy efficiency licence conditions, but *less* than the rate that equates to the prevailing economy-wide marginal cost of abatement (or better, base this on an equivalent internal rate of return criteria);
- identification of key energy savings opportunities elsewhere in the Western Australian economy, pilot programs to confirm savings potential, and subsequent broader program delivery to access those savings;
- innovative pilot projects to demonstrate new energy savings opportunities in key energy end-use activities in Western Australia (for example, working with the Mining and Non-ferrous metals industries, undertaking trials of congestion pricing through smart metering etc);
- market transformation activities, including encouraging increased penetration of performance contracting for the commercial sector;
- targeted programs to improve energy efficiency for low income and other households, including working with HomesWest; and
- ex post evaluation of energy saving opportunities and the barriers to their implementation — providing feedback on the true extent of the energy efficiency gap (current data is sadly lacking).

An energy savings fund could also complement an emissions trading scheme — as noted some of the revenues from the auction of emissions permits could be channelled to support the energy savings fund. Estimated savings from the Energy Savings Fund could be taken into account when setting the cap for the emissions trading scheme.

4.5 A policy package for energy efficiency

The analysis in Chapter 3 has set out the potential for socially cost effective abatement. It suggests that enhanced uptake of energy efficiency, beyond business as usual, can reduce energy use by between 13 per cent (low scenario) and 30 per cent (high scenario) by 2030:

- corresponding (combustion only) emissions reductions are between 10 Mt CO_2e (low scenario) and 24 Mt CO_2e (high scenario) by 2030 at $0 per tonne CO_2e; and

- corresponding (combustion only) emissions reductions are between 17 Mt CO_2e (low scenario) and 39 Mt CO_2e (high scenario) by 2030 at a carbon price of $40 per tonne CO_2e.

It takes decades to completely turn over the capital stock. The implication is that policy action to raise the rate of energy efficiency improvement should commence as soon as possible. Even small improvements beyond business as usual — if sustained over time — can deliver significant cumulate reductions in energy end use emissions.

Policy intervention will be required to unlock the identified savings. The majority of market failures and barriers to energy efficiency are judged to involve non-price factors, so complementary policy for energy efficiency is required even in the presence of significant carbon prices.

Relative prices

Getting energy prices right is a pre-requisite for cost effective uptake of energy efficiency. This is particularly important for efficient outcomes over the longer term.

There is scope to improve pricing signals in energy markets through improved:

- *congestion pricing* — which requires installation of smart meters in new buildings (residential and commercial) mandatory, and funding support for replacement programs for existing meters in prioritised customer classes;
- *tests for network augmentation* — to align incentives for investment, Western Power should have explicit means to 'pass on' non-network investment costs and to recover 'foregone revenues';
- *greenhouse gas pricing signals* — incorporating the cost of carbon in energy prices will increase the quantity of cost effective abatement available from energy efficiency and reduce 'rebound' effects.

Information provision

Providing public information on energy savings options, and demonstrating these, can be an effective complement to improved pricing signals and programs targeting behavioural change.

There is a clear rationale for public information on and demonstration of the benefits of energy savings best practice.

Energy rating and labelling is an important element supporting consumer action on climate change, and should be supported and extended through the current National Framework for Energy Efficiency work program.

Minimum standards

Minimum Energy Performance Standards (MEPS) provide extremely cost effective means to improve energy efficiency.

The level of national MEPS should be raised to levels that deliver energy savings with net returns to the community as a whole. Evaluations of the cost effective level of MEPS should also incorporate the prevailing economy-wide price for carbon.

Western Australia could implement additional mandatory requirements in commercial and residential buildings that deliver net benefits for the community up to the shadow price of carbon.

Beyond minimum standards

If significant reductions in greenhouse gas emissions are to be achieved, a major cross cutting policy to provide incentives to adopt energy efficiency *beyond minimum standards* is required.

Key policy options driving significant uptake of energy efficiency in Western Australia, *beyond minimum standards* are:

- *Mandatory licence conditions for firms* — a threshold for mandatory adoption of energy savings measures could be set at internal rates of return/paybacks that deliver 'no regrets' savings for the community as a whole; and
- Establishment of an *Energy Savings Fund* — which could support:
  - identification of key energy savings opportunities elsewhere in the Western Australian economy, with pilot programs to confirm savings potential and subsequent broader program delivery to access those savings;
  - through competitive tender, implementation of the best opportunities for energy savings beyond minimum standards or mandatory requirements;
  - an awareness program for energy efficiency targeting the commercial, residential and small business sectors, with support for third party energy efficiency auditing for small business and residential consumers, combined with incentives, rebates and other promotions.
  - market transformation activities, including encouraging increased penetration of performance contracting for the commercial sector;
  - targeted programs to improve energy efficiency for low income and other households; and
  - ex-post evaluation of energy saving opportunities and the barriers to their implementation — providing feedback on the true extent of the energy efficiency gap.

APPENDIX A
Abbreviations

AEEI	Autonomous energy efficiency improvement
BASIX	Building Sustainability Index
MEPS	Minimum Energy Performance Standards
NETS	National Emissions Trading Scheme
NETT	National Emissions Trading Taskforce
TFEC	Total Final Energy Consumption

APPENDIX B

Results of economic modelling

The 'best' estimates of identified 'no regrets' opportunities were modelled to assess the economic impacts of effective policies to drive implementation.

B.1 Methodology

The economic impacts of investing in 'no regrets' energy efficiency opportunities in Western Australia were estimated using the MMRF-GREEN model, which is run by the Centre of Policy Studies at Monash University. MMRF-GREEN is a multi sector, dynamic general equilibrium model of the Australian economy. MMRF-GREEN has the advantage of being able to analyse economic impacts at the State level.

A more detailed description of the MMRF-GREEN model, and of the modelling assumptions for the (High Gas Price) base case used in the modelling, is presented in a separate report on emissions trading.[70]

Input data

'Best' estimates of the 'no regrets' energy efficiency savings identified in this report (calculated as the mid-point of the high and low scenario 'no regrets' savings estimate for each sector) — at zero carbon costs — were mapped to a time series of $ energy savings by sector (utilising assumptions about real fuel prices going forward).

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[70] Insight Economics 2006, *National Emissions Trading — Impacts with Higher WA Domgas Prices*, Report prepared for the WA Office of Energy.

Estimates of the pay-back rates in each sector were then used to derive a corresponding time series of annual capital investment (by sector) required to achieve the savings. These data were used as the input 'shock' for the economic modelling.

TABLE B.1 – ESTIMATED ECONOMIC IMPACTS AT 2020 AND 2030 – WESTERN AUSTRALIA

	2020		2030	
	Base Case (Scenario High Gas Price	Energy Efficiency Scenario	Base Case (Scenario High Gas Price	Energy Efficiency Scenario
Gross State Product				
Absolute level ($ m 2005)	160,182	160,810	234,118	236,430
Percentage dev. from Base Case level (%)	-	+0.4	-	+1.0
Private consumption				
Absolute level ($ m 2005)	68,943	69,035	92,642	92,969
Percentage dev. from Base Case level (%)	-	+0.1	-	+0.4
Labour market				
Absolute level ('000s)	1,303	1,305	1,565	1,570
Per cent dev. from Base Case level (%)	-	+0.5	-	+1.0
Real wage dev. from Base Case level (%)	-	+0.0	-	+0.1

Source: MMRF-Green model

B.2 Results

Effective policies to drive uptake of energy efficiency opportunities in Western Australia — with internal rates of return exceeding 15 per cent at zero carbon prices — could by 2030 (Table B.1):

- boost Western Australia's GDP by 1.0 per cent in level terms compared to the base case;
- increase private consumption in Western Australia by 0.4 per cent;
- create an additional 4,690 jobs;
- work to offset the costs of policies to reduce the emissions intensity of energy supply.