REPORT

ENERGY EFFICIENCY POTENTIAL IN WESTERN AUSTRALIA

DEPARTMENT OF ENVIRONMENT WESTERN AUSTRALIA

October 2006

J/N 106684

Report

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greenhouse
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REPORT	PDE	MSW	PDE	Oct 2006

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1. Executive Summary

OVERVIEW OF SCOPE

Energetics was engaged to assist the WA government to establish estimated Energy Efficiency Improvement (EEI) potential across the WA economy in the area of stationary energy use. Per the brief:

"The contracted service provider will provide estimates of the potential for reductions in energy use from energy efficiency from now to 2015 in the commercial, residential and industrial (including resource extraction and processing) sectors of Western Australia and include a discussion on major factors that may contribute to the accuracy of the estimates. The estimates are to be carried out under the following scenarios:

- *Simple payback period between 0 and 2 years;*
- *Simple payback period between 2 and 6 years;*
- *Carbon price $0-10 per tonne;*
- *Carbon price $10-20 per tonne;*
- *Carbon price $20-30 per tonne; and*
- *Carbon price over $30 per tonne.*

The intent of this exercise is to provide high level input regarding EEI potential, that can inform or augment other parallel work related to the identification and selection of policy instruments / measures that could be applied to aid achievement of this potential.

LEVEL OF ASSESSMENT

This work is more analogous to the preliminary estimates that were developed for the NFEE (by Graham Armstrong/Saturn Corporate Resources (*National Framework for Energy Efficiency Background Report (V4.1), Preliminary Assessment of Demand-Side Energy Efficiency Improvement Potential and Costs, 20 November 2003*) than more detailed, bottom-up estimates that were developed by Energetics and others in a subsequent NFEE development step. That is, the estimates are strictly high-level and draw primarily on our experience in relevant sectors, and results are developed using a generic methodology that seeks to relate the level of EEI potential to primary areas of influence.

The ability of this work to present information in other than this high-level context is influenced by two primary factors:

1. Firstly, Western Australia's energy consumption is dominated by a very small number of sectors, by a small number of participants in these sectors, and in some cases by a small number of individual sites operated by these participants. To present information as other than high-level estimates would imply site-specific knowledge of EEI potential that, in some cases, we do not possess.
2. Secondly (and conversely) Energetics does work with a number of companies with major energy-using facilities in WA, either direct on site or via corporate activities such as reporting. Via this work we do have some site-specific

knowledge of EEI potential and/or of how energy is used. At a corporate level we also have sound knowledge of directions that many companies are taking with respect to energy management. The presentation of information here with any bottom-up context would convey knowledge of site-specific opportunities at sites that are material to energy use within some sectors.

GENERAL APPROACH – INDUSTRIAL SECTORS

EEI potential is taken, at a high level, to apply in three key areas of influence. These are:

1. **Growth**: Energy growth at a sector level, driven by major projects that are committed or planned – that is, improvements in technology, design, and subsequent operation of new projects compared with business-as-usual approaches.
2. **As Is**: Improved management and operation of energy-using equipment that will remain in operation at sites beyond the period of interest here, beyond business-as-usual approaches to energy management.
3. **Replace**: Replacement of existing technology / equipment with new, and designing and operating replacement equipment more efficiently than business-as-usual approaches.

The general approach to estimation of EEI potential in each of these areas is described below. We note that these are high level estimates based on our experience in many of these sectors, in particular over the last few 1-2 years with the advent of national programs such as Commonwealth's Energy Efficiency Opportunities (EEO), state-based programs such as the NSW Energy Savings Action Plans, and increasing focus on energy utilisation in a sustainability context by some large energy users. Where appropriate, we have drawn on, or made reference to, work done as input to the NFEE.

Growth

In a general sense, our experience is that, while substantial "technical" savings may be possible within the growth area of influence, the timeframe being assessed and the sectors within which significant growth is projected suggest that technologies to be employed in new projects are substantially "locked-in" and that the main influence will relate to the operation rather than design of new processes and technologies.

In the early years of operation of these processes we would expect that the level of EEI potential is generally low relative to other influence areas. An estimate of 0.5% pa improvement is estimated for the mining, chemicals, iron & steel and non-ferrous metals sectors, where this area of influence applies.

As Is

For the industrial sectors assessed, energy use is often characterised by a small items of equipment / plant consuming the vast majority of energy, with lesser quantities used by a larger number of relatively minor equipment.

While sizeable energy savings are often viable with improvements (e.g. via retrofit of controls such as VSD) to smaller equipment, more energy efficient management of major energy-using equipment is a function of both improved operation, maintenance, training and control (and in some cases retrofit) on the one hand, and control of non/indirect-energy factors such as productivity and planning processes on the other.

In general, based on our work with many companies in most of the industrial sectors reviewed here, we estimate a 1% pa improvement in energy use represents a realistic net assessment of EEI potential at up to 6-year payback. We have applied this to the mining, chemical, iron & steel (gas use only) and non-metallic minerals sectors.

For the non-ferrous metals sector (dominated by alumina) we have reduced this estimate of EEI potential to 0.25%, and for the iron & steel sector (coal only) we have halved this estimate of EEI potential to 0.5%, reflecting the fact that substantial new technologies have been implemented in these areas and, in the case of alumina, that energy use is so significant that an expectation of closer management of energy compared to other sectors is a reasonable assumption.

Replace

When equipment is replaced, there is generally an opportunity to go beyond business-as-usual in both the selection and operation of energy efficient technologies and processes. Whilst in many cases in recent years we have seen selection of energy efficient processes, it is not always the case that the maximum potential of this is employed to drive energy use reduction. In addition, where replacement relates to, say, large motor replacement, EEI potential will generally be small.

Consequently while, at the level of up to 6-year payback based on marginal implementation costs, EEI potential can be sizeable in some cases, we suggest an estimate of 2% pa EEI potential represents a realistic level where process and technology selection is allied to effective operation to realise this potential in practice. This EEI potential is estimated to apply for the mining, chemical, iron & steel (gas only) and non-metallic minerals sectors.

For the non-ferrous metals sector (dominated by alumina) we have reduced this estimate of EEI potential to 0.25%, and for the iron & steel sector (coal only) we have reduced this estimate of EEI potential to 0.5%, reflecting the fact that substantial new technologies have been implemented in these areas and, in the case of alumina, that energy use is so significant that an expectation of both efficient technology selection and closer management of energy compared to other sectors is a reasonable assumption for replacement equipment in a business-as-usual context.

GENERAL APPROACH – COMMERCIAL & RESIDENTIAL

The same areas of influence as used for the industrial sectors are employed here, however this is generally for illustrative purposes only. These sectors' energy use are much more analogous to the national context than are the large industrial sectors, and consequently we are of the view that studies used to estimate EEI potential for NFEE are generally applicable to WA.

For this reason, this study draws on studies by others as input to the NFEE to develop estimates of EEI potential in WA.

RESULTS SUMMARY

A basic output of estimated EEI potential at up to 2 and up to 6-year payback is shown below, both to 2014/15 and 2009/10.

Table 1.1: Aggregated 0-2 Year and 3-6-Year Payback EEI & CO_2 Saving Potential

Estimated Energy Efficiency Improvement (EEI) Potential to 2014/15						
Sector	**Fuel**	**PJ Savings up to 6-Year PB**	**CO_2 Savings up to 6-Year PB**	**PJ Savings up to 2-Year PB**	**CO_2 Savings up to 2-Year PB**	**CO_2 Factor (FFC)**
Mining	Coal	0.48 PJ	45,122 t CO2	0.17 PJ	15,793 t CO2	94.20 kt CO2/PJ
Mining	Gas	1.73 PJ	103,980 t CO2	0.61 PJ	36,393 t CO2	60.00 kt CO2/PJ
Mining	Electricity	2.46 PJ	679,236 t CO2	0.86 PJ	237,733 t CO2	276.00 kt CO2/PJ
Mining	Other Petroleum	6.50 PJ	503,750 t CO2	2.28 PJ	176,313 t CO2	77.50 kt CO2/PJ
Basic Chemicals	Gas	2.32 PJ	138,900 t CO2	1.85 PJ	111,120 t CO2	60.00 kt CO2/PJ
Iron & Steel	Coal	0.69 PJ	64,998 t CO2	0.35 PJ	32,499 t CO2	94.20 kt CO2/PJ
Iron & Steel	Gas	0.19 PJ	11,220 t CO2	0.09 PJ	5,610 t CO2	60.00 kt CO2/PJ
Non-Ferrous Metals	Coal	0.27 PJ	25,434 t CO2	0.22 PJ	20,347 t CO2	94.20 kt CO2/PJ
Non-Ferrous Metals	Gas	3.17 PJ	190,200 t CO2	2.54 PJ	152,160 t CO2	60.00 kt CO2/PJ
Non-Ferrous Metals	Electricity	0.46 PJ	126,960 t CO2	0.37 PJ	101,568 t CO2	276.00 kt CO2/PJ
Non-Metallic Minerals	Coal	0.76 PJ	71,121 t CO2	0.28 PJ	26,670 t CO2	94.20 kt CO2/PJ
Non-Metallic Minerals	Gas	1.93 PJ	115,500 t CO2	0.72 PJ	43,313 t CO2	60.00 kt CO2/PJ
Commercial	Gas	0.43 PJ	25,920 t CO2	0.34 PJ	20,218 t CO2	60.00 kt CO2/PJ
Commercial	Electricity	2.89 PJ	797,088 t CO2	2.25 PJ	621,729 t CO2	276.00 kt CO2/PJ
Residential	Gas	2.10 PJ	125,820 t CO2	0.52 PJ	31,455 t CO2	60.00 kt CO2/PJ
Residential	Electricity	1.93 PJ	533,508 t CO2	0.48 PJ	133,377 t CO2	276.00 kt CO2/PJ
Sub-Total	Coal	2.19 PJ	206,675 t CO2	1.01 PJ	95,309 t CO2	94.20 kt CO2/PJ
Sub-Total	Gas	11.86 PJ	711,540 t CO2	6.67 PJ	400,268 t CO2	60.00 kt CO2/PJ
Sub-Total	Electricity	7.74 PJ	2,136,792 t CO2	3.97 PJ	1,094,406 t CO2	276.00 kt CO2/PJ
Sub-Total	Other Petroleum	6.50 PJ	503,750 t CO2	2.28 PJ	176,313 t CO2	77.50 kt CO2/PJ
TOTAL	**All Fuel**	**28.30 PJ**	**3,558,757 t CO2**	**13.92 PJ**	**1,766,296 t CO2**	

Estimated Energy Efficiency Improvement (EEI) Potential to 2009/10						
Sector	**Fuel**	**PJ Savings up to 6-Year PB**	**CO_2 Savings up to 6-Year PB**	**PJ Savings up to 2-Year PB**	**CO_2 Savings up to 2-Year PB**	**CO_2 Factor (FFC)**
Mining	Coal	0.20 PJ	18,840 t CO2	0.07 PJ	6,594 t CO2	94.20 kt CO2/PJ
Mining	Gas	0.48 PJ	28,800 t CO2	0.17 PJ	10,080 t CO2	60.00 kt CO2/PJ
Mining	Electricity	0.72 PJ	198,720 t CO2	0.25 PJ	69,552 t CO2	276.00 kt CO2/PJ
Mining	Other Petroleum	1.60 PJ	124,000 t CO2	0.56 PJ	43,400 t CO2	77.50 kt CO2/PJ
Basic Chemicals	Gas	0.77 PJ	46,200 t CO2	0.62 PJ	36,960 t CO2	60.00 kt CO2/PJ
Iron & Steel	Coal	0.30 PJ	28,260 t CO2	0.15 PJ	14,130 t CO2	94.20 kt CO2/PJ
Iron & Steel	Gas	0.06 PJ	3,600 t CO2	0.03 PJ	1,800 t CO2	60.00 kt CO2/PJ
Non-Ferrous Metals	Coal	0.10 PJ	9,420 t CO2	0.08 PJ	7,536 t CO2	94.20 kt CO2/PJ
Non-Ferrous Metals	Gas	1.18 PJ	70,800 t CO2	0.94 PJ	56,640 t CO2	60.00 kt CO2/PJ
Non-Ferrous Metals	Electricity	0.19 PJ	52,440 t CO2	0.15 PJ	41,952 t CO2	276.00 kt CO2/PJ
Non-Metallic Minerals	Coal	0.26 PJ	24,492 t CO2	0.10 PJ	9,185 t CO2	94.20 kt CO2/PJ
Non-Metallic Minerals	Gas	0.60 PJ	36,000 t CO2	0.23 PJ	13,500 t CO2	60.00 kt CO2/PJ
Commercial	Gas	0.17 PJ	10,200 t CO2	0.13 PJ	7,956 t CO2	60.00 kt CO2/PJ
Commercial	Electricity	1.35 PJ	372,600 t CO2	1.05 PJ	290,628 t CO2	276.00 kt CO2/PJ
Residential	Gas	0.76 PJ	45,600 t CO2	0.19 PJ	11,400 t CO2	60.00 kt CO2/PJ
Residential	Electricity	0.79 PJ	218,040 t CO2	0.20 PJ	54,510 t CO2	276.00 kt CO2/PJ
Sub-Total	Coal	0.86 PJ	81,012 t CO2	0.40 PJ	37,445 t CO2	94.20 kt CO2/PJ
Sub-Total	Gas	4.02 PJ	241,200 t CO2	2.31 PJ	138,336 t CO2	60.00 kt CO2/PJ
Sub-Total	Electricity	3.05 PJ	841,800 t CO2	1.65 PJ	456,642 t CO2	276.00 kt CO2/PJ
Sub-Total	Other Petroleum	1.60 PJ	124,000 t CO2	0.56 PJ	43,400 t CO2	77.50 kt CO2/PJ
TOTAL	**All Fuel**	**9.53 PJ**	**1,288,012 t CO2**	**4.92 PJ**	**675,823 t CO2**	

Hence in our view, based on this and previous work (e.g. for NFEE) we estimate that a little over 50% of the identified EEI potential is available from activities with up to 2 year paybacks, while the remaining 50% (approx) is at 2-6 year payback. EEI potential at 2009/10 is approximately one third of that potentially available at 2014/15.

Energetics was requested to provide some specific outputs resulting from the imposition of carbon pricing to fossil fuel energy consumed in the sectors assessed here. These include:

- An indication of additional abatement that could be expected to occur at various carbon prices in 2010 and 2015 from a 2-year payback criterion perspective – i.e. abatement that is privately cost-effective,

- An indication of additional abatement that could be expected to occur at various carbon prices in 2010 and 2015 from a 6-year payback criterion perspective – i.e. abatement that is socially cost-effective

In order to develop reasonable estimates of this additional abatement, we have referenced work Energetics did for the NFEE to gauge the relative contribution to EEI potential (beyond-BAU) at paybacks ranging from 0.5 years up to 10 years, and applied these to EEI estimates for WA. Essentially this serves to split the "Up to 2 year simple payback" category of savings into 0.5 year, 1 year and 2 year paybacks, the "2-6 year payback" category into 2, 3, 4, 5 and 6 year payback, and enables WA EEI estimates to be extrapolated beyond 6 year payback to 7, 8 and 10 year payback levels.

With this additional disaggregation of EEI potential within each sector / fuel we then re-calculated the simple payback consequent on the imposition of a carbon price on each fuel type at $10, $20, $30 and $40 per tonne of carbon dioxide. This then allows us to see the additional savings that could be expected to result if a 2-year (private) or a 6-year (social) payback level is taken to be a trigger for implementation.

This analysis leads to the following estimate of energy and GHG savings that could result in 2010 and 2015 at carbon price levels of $10, $20, $30 and $40 per tonne of CO_2.

Table 1.2: EEI & CO_2 Potential in 2015 & 2010 at Various Carbon Price Levels

2 Year Payback Scenario (Privately Cost Effective)				
2015 Energy Saving @ <2 Year PB	**2010 Energy Saving @ <2 Year PB**	**2015 CO2 Saving @ < 2 Year PB**	**2010 CO2 Saving @ < 2 Year PB**	**Carbon Price**
16.59 PJ	5.91 PJ	2,104.00 kt CO2	796.00 kt CO2	$40.0 /t CO2
16.11 PJ	5.67 PJ	2,019.00 kt CO2	760.00 kt CO2	$30.0 /t CO2
14.65 PJ	5.20 PJ	1,835.00 kt CO2	703.00 kt CO2	$20.0 /t CO2
14.22 PJ	5.03 PJ	1,794.00 kt CO2	687.00 kt CO2	$10.0 /t CO2
13.92 PJ	4.92 PJ	1,766.00 kt CO2	676.00 kt CO2	$0.0 /t CO2

6 Year Payback Scenario (Socially Cost Effective)				
2015 Energy Saving @ <6 Year PB	**2010 Energy Saving @ <6 Year PB**	**2015 CO2 Saving @ < 6 Year PB**	**2010 CO2 Saving @ < 6 Year PB**	**Carbon Price**
36.37 PJ	12.44 PJ	4,660,658 kt CO2	1,700,027 kt CO2	$40.0 /t CO2
35.79 PJ	12.24 PJ	4,577,743 kt CO2	1,673,934 kt CO2	$30.0 /t CO2
33.16 PJ	11.30 PJ	4,127,872 kt CO2	1,502,451 kt CO2	$20.0 /t CO2
31.29 PJ	10.56 PJ	3,879,039 kt CO2	1,395,757 kt CO2	$10.0 /t CO2
28.30 PJ	9.53 PJ	3,558,757 kt CO2	1,288,012 kt CO2	$0.0 /t CO2

These results are illustrated graphically below.

Figure 1.1: GHG Savings in 2015 for Privately Cost-Effective Measures @ Various Carbon Price Levels

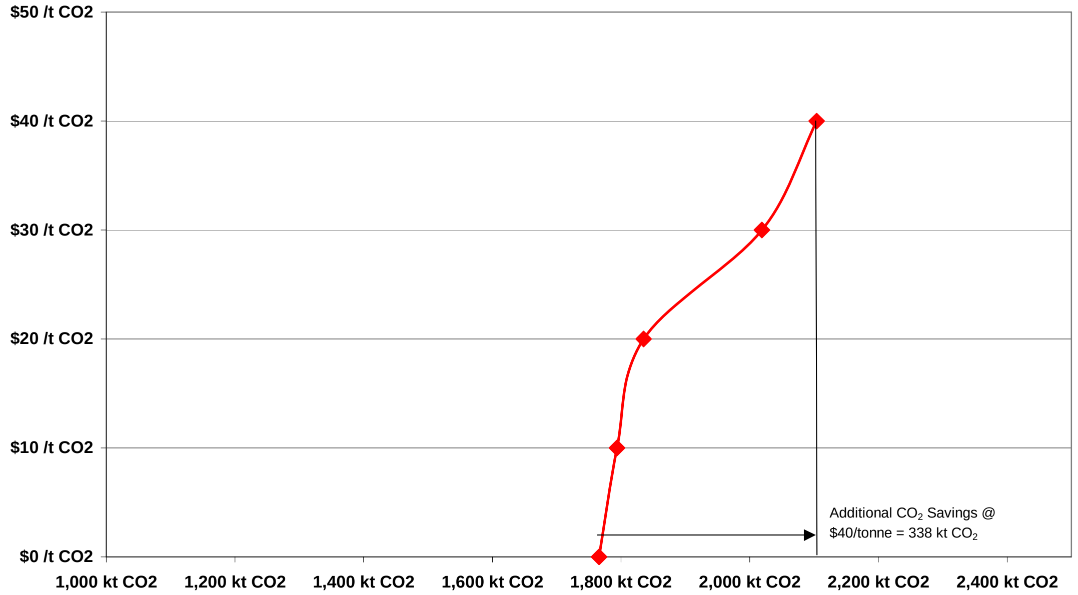


Figure 1.2: GHG Savings in 2010 for Privately Cost-Effective Measures @ Various Carbon Price Levels

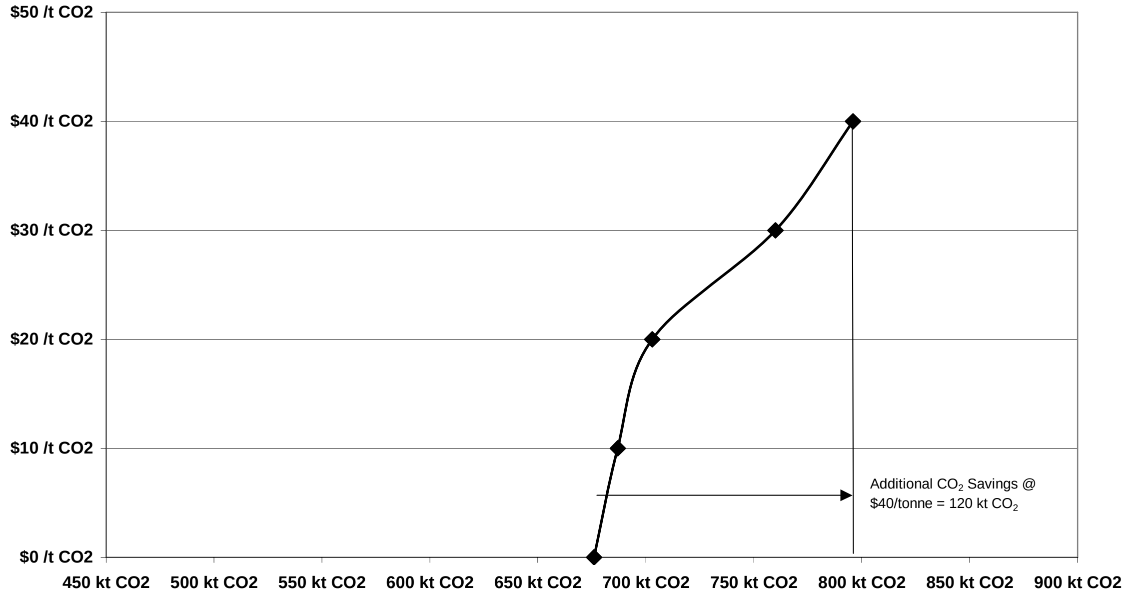


Figure 1.3: GHG Savings in 2015 for Socially Cost-Effective Measures @ Various Carbon Price Levels

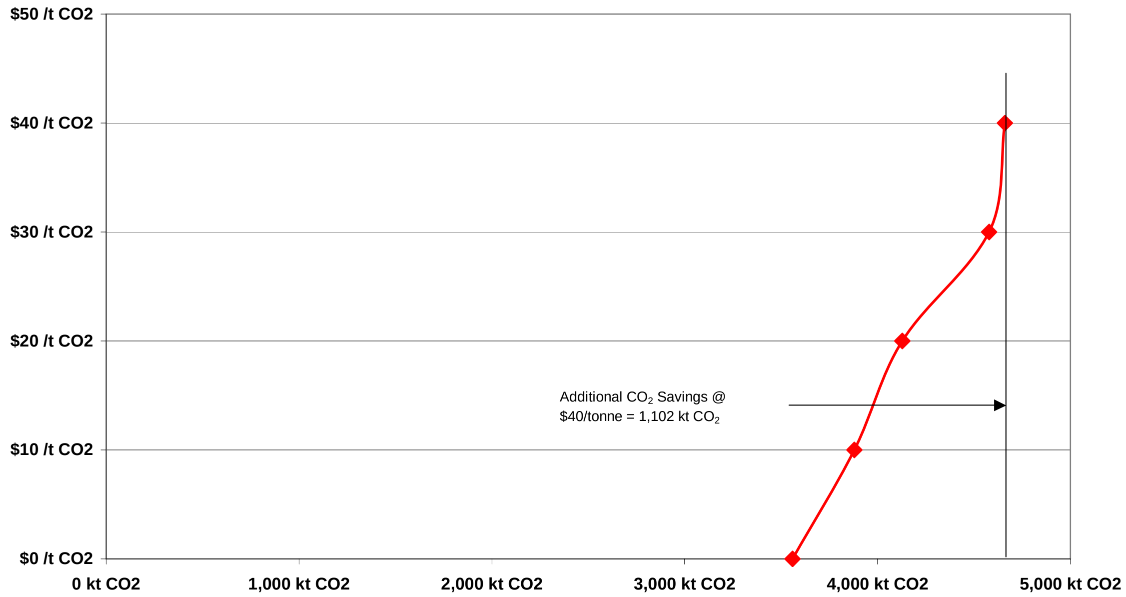
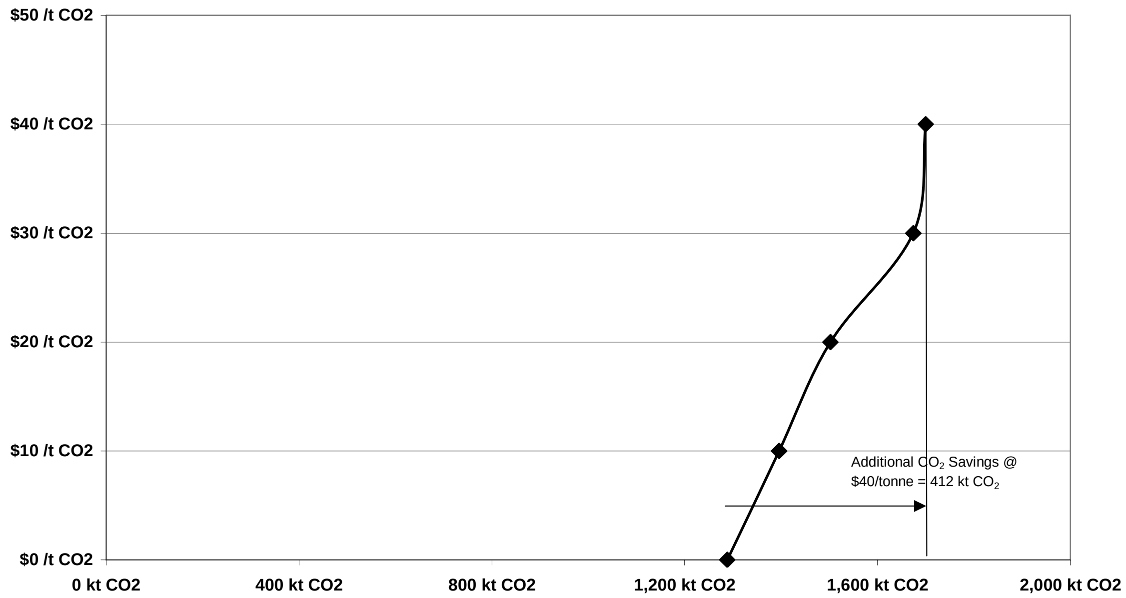


Figure 1.4: GHG Savings in 2010 for Socially Cost-Effective Measures @ Various Carbon Price Levels



DISCUSSION OF RESULTS

Overall v Sector Level EEI Estimates

The estimated year-2015 EEI potential in WA up to simple 6-year payback (beyond BAU) is determined here to be approximately 6.14% of assessed WA stationary energy (87% of total stationary energy & 63% of total WA final energy use in 2015 was assessed). On the face of it, this is a low potential, and advice during discussion with the Task Force suggests that other studies have derived much higher EEI estimates.

This overall estimate is made up of the following sectoral EEI estimates to 2015:

- Residential 12.6% EEI Beyond BAU (4.02 PJ)
- Commercial 11.3% EEI Beyond BAU (3.31 PJ)
- Non-Metallic Minerals 10.0% EEI Beyond BAU (2.68 PJ)
- Mining 9.3% EEI Beyond BAU (11.2 PJ)
- Chemicals 5.7% EEI Beyond BAU (2.37 PJ)
- Iron & Steel 5.1% EEI Beyond BAU (0.85 PJ)
- Non-Ferrous Metals 2.0% EEI Beyond BAU (3.88 PJ)

The most notable of these sectoral estimates is that for non-ferrous metals. This sector, which accounts for 42% of all WA energy assessed in this study and 37% of total WA stationary energy in 2015, is the single major factor that serves to pull the total state EEI potential down to the 6.14% overall estimate. Looking at the next level down, sectoral EEI estimates in many cases reflect substantial beyond-BAU potential over the 9-year period to 2015.

Assessment of EEI Potential within the "Growth" Area of Influence

Western Australia is in the midst of a significant economic growth cycle, primarily driven by resources. This is bringing with it a significant growth in demand for energy. Looking at ABARE forecast energy end-use in WA to 2015:

- For the period 2004 to 2015 the total forecast growth is 176 PJ. In 2015 the growth occurring from 2004 is 38% of the overall 2015 forecast.
- Of this 176 PJ in growth, 75% of it occurs by 2010.
- If we consider the period from 2007 to 2015 then total growth is 126 PJ & growth is 27% of the 2015 base energy forecast. Of this 66% will occur by 2010.

We conclude from this that "Growth" in energy demand is a material component of Western Australia's energy demand in 2015, and that the majority of this growth is related to activities that are committed, planned and in many cases in-development now.

Looking at the areas where growth is occurring, we see from ABARE data that 86% of all forecast growth from 2004 (or 81% of all growth from 2007) occurs in 4 sectors, namely Non-Ferrous, Mining, Chemicals and Iron & Steel.

- Within the Iron & Steel and Chemicals sectors, growth is from single projects that are built or in development. For these single-project sectors we have taken the view in this study that incremental, rather than step changes can be effected to achieve beyond-BAU energy efficiency within the “Growth” area of influence, on the basis that the projects’ technology is selected and/or built, and that given the fact the projects are new, the level of improvement would generally be modest relative to the “As Is” area of influence.

- Within Non-Ferrous Metals, the 2 material growth steps occur in 2004-05 and in 2008-09, which we have assumed are both largely related to expansion (e.g. Worsley), technology and cogeneration developments (e.g Pinjarra, Wagerup, Worsley expansion) in the alumina industry. These, allied to the generally strong energy focus of this industry, led to an assumption that additional efficiency improvement within the “Growth” area of influence is likely to be small.
- Growth in mining to 2015 is fairly linear, hence it could be expected that opportunities for beyond-BAU efficiency will be possible beyond projects that are already in development and committed. In respect of electricity consumption is very likely the case, although we are increasingly seeing some energy efficiency aspects, such as VSD control of electric motors, included in design considerations for materials handling equipment in mining. In relation to diesel-driven vehicles we have seen for a number of years life-cycle costing routinely applied to truck selection by some companies in the mining industry, specifically including consideration of energy costs since these are significant. Hence we would only expect further incremental improvement to occur in this area in the near future with the “Growth” area of influence, particularly given recent increases in fuel costs. We would expect similar incremental improvements to be possible in the generation of electricity from fuel in this sector rather than step changes. Future developments in R&D for the mining sector that can materially increase energy efficiency in the sector are not likely to be seen until after 2015.

From these factors outlined above, we concluded that within the terms of reference for this study, in particular the assessment of EEI potential to 2015, ABARE forecast trends reflect the majority of growth occurring before and up to 2010 and occurring in sectors / technologies that are not likely to be improved upon materially in the short term, other than via incremental control, retrofit or behavioural improvements. Many of the planned projects to 2010 will have fairly long lead times and the proportion of growth to this time that can be influenced by energy efficiency considerations will, in our view, be limited.

EEI Potential Beyond 2015

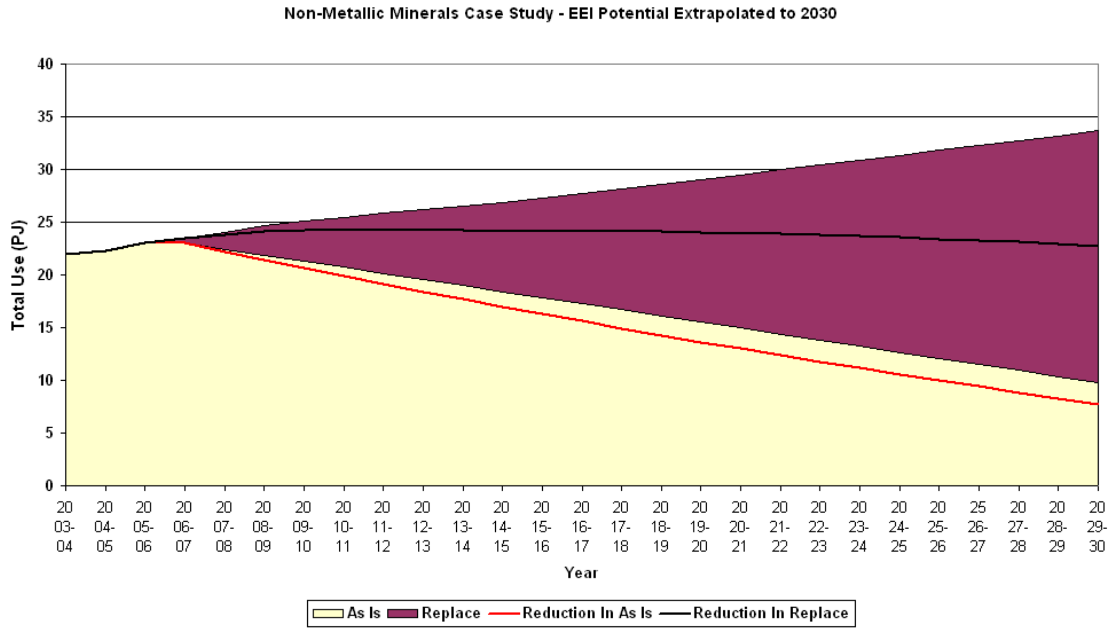
The timeframe of this assessment goes to 2015 per the requirements of the brief, and this is consistent with the NFEE assessment timeframe. As noted above, the high locked-in contribution to 2015 energy forecasts by Non-Ferrous Metals allied to the limited potential to influence the efficiency of much of the growth in WA in the short term are significant contributors to the apparent low overall EEI estimate developed in this study.

However, even a simple extrapolation of the EEI potential to say 2030 (a time mentioned in discussion with the Task Force) significantly increases this estimated EEI potential to, for example:

- 32% EEI in Non-Metallic Minerals,
- 19% EEI in Commercial, and

- 5.6% EEI in Non-Ferrous Metals

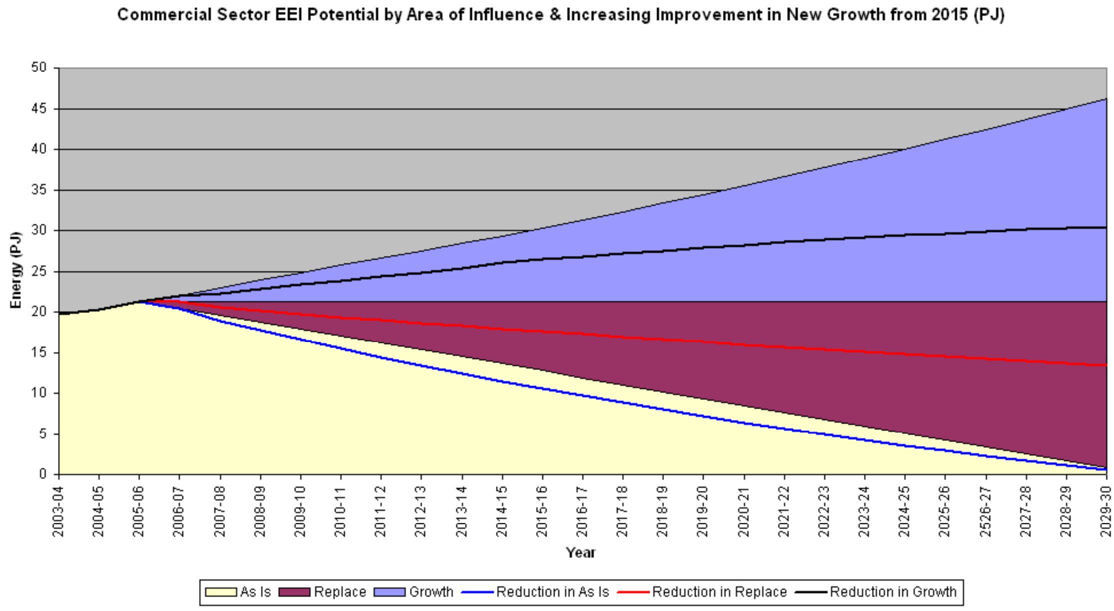
In non-metallic minerals, for example, the significant increase results from the greater relative contribution to EEI as old technology is replaced (“Replace”) compared with improving the efficiency of existing equipment (“As Is”). As the extrapolated chart below illustrates, the effect of a longer timeframe in this instance can be highly significant, even while retaining the same assumptions regarding improvement potential as were used to 2015.



Overall EEI would rise on this simple basis to around 15% across all sectors. As with our assessment to 2015, Non-Ferrous Metals at 5.6% EEI potential is the major factor bringing this figure down to this level.

However, over this longer timeframe we must also allow for the likelihood that this potential can be further strengthened by the achievement of beyond-BAU gains in new growth technology that is for the most part not likely to be achievable in the 2015 timeframe as described above. Looking out to 2030 we will see substantial turnover of technology in some sectors and will have the opportunity from a practical time perspective to see new energy efficiency policies take effect.

For example a simple extrapolation of the Commercial sector yields an EEI of about 19% by 2030. However if we assume that from 2015 onwards we start to see (say) a 2.5% beyond-BAU improvement in all new growth, then 2030 EEI potential increases to approximately 34% below the baseline forecast of energy consumption at this time. This is illustrated below.



While the Commercial sector may well have EEI potential in the order of magnitude illustrated above, we would not necessarily expect to see this level of potential in some sectors over even this longer timeframe without the introduction of new “break-through” technology. This may include sectors above such as Non-Ferrous Metals, Iron & Steel and Chemicals, which are characterised by single sites or single technologies that dominate the baseline energy forecast to 2030. Direct engagement with key participants in these sectors would be recommended if robust forecasts of future energy requirements and EEI potential to 2030 were to be made.

Large Energy Users in WA

As is indicated through the report, Western Australia’s energy profile is characterised by a very small number of participants – either companies or single sites – that are material in terms of energy consumption. This is the case in the Mining, Non-Ferrous Metals, Chemicals, Non-Metallic Minerals and Iron & Steel sectors, which together account for 78% of all stationary energy use forecast for 2015.

With this contribution to stationary energy use these individual sites and companies will have a significant direct influence on the true potential for EEI in Western Australia, through having significant “locked-in” assets, lumpy investments in new technology, and through company policies and practices in terms of energy efficiency – both at a technology selection level and at the operating & maintenance level. These factors, taken together and assessed through consultation with the relevant companies and / or sites, will best enable the true nature, level and timing of beyond-BAU EEI potential to be determined.

Accuracy of Estimates

In looking at the accuracy, or the potential for error, in the EEI potential estimates from this study all of the above factors need to be taken into account.

At the upper end of EEI estimates we understand other studies suggest that EEI potential of up to 50% is possible by 2030. Given the dominance of few sites, non-ferrous metals processing and the recent development of significant new projects in the Iron & Steel and Chemicals sectors in WA, as well as the use of significant quantities of fuel for remote on-site generation, we have doubts that this level is achievable in WA in this timeframe without some very significant breakthrough technology development and rapid adoption. Taking these factors into account (and noting factors such as technology roadmaps for say the alumina industry that suggest global industry targets of 20% by 2020), an EEI of 30% would be, in our view, a good case scenario in WA to 2030.

At a simple level extrapolation of the EEI estimates to 2015 from this study to 2030 yields an EEI potential of about 15% beyond BAU. Allowing for the potential to achieve significantly greater efficiencies in new growth in the medium to long term compared with the short term (which is substantially developed or committed) this EEI potential will increase, significantly in some sectors. We would expect an EEI estimate in the order of 20% to result from this assumption.

Summary

To summarise the above discussion:

1. The EEI potential estimated from this study to 2015, per the brief, does appear low,
2. However this estimate is heavily influenced by non-ferrous metals, which dominates WA energy use; at a sectoral level EEI potential ranges from 2% to over 12%,
3. Growth in WA is material over the analysis timeframe to 2015; however most of this growth occurs by 2010 and the vast majority of growth occurs in energy intensive industrial sectors, with generally long lead and planning times and relatively little scope for influence in the short to medium term,
4. EEI estimates, though appearing low, grow to 15% on a simple-extrapolation basis to 2030; and to an estimated 20% when the potential for EE policies to take effect and drive EE improvement in the growth segment in the medium to long term are taken into account,
5. Other studies suggesting EEI potential of 50% (generally) may be optimistic for WA (by 2030) given energy use is dominated by a small number of sites and companies, several of which have recently or are in the process of investing in significant new technology that does not represent breakthrough technology. Electricity generation in remote areas is also a sizeable energy user in WA and large-scale improvements would not be expected here. A more realistic “upper-level” EEI estimate, drawing on these studies, may be in the order of 30%,
6. The estimated 20% level forecast from this study, when extrapolated to 2030 per above discussion is not as divergent from other estimates as first appears,
7. Rather than look to refine this estimate or conduct detailed sensitivity analysis, we suggest that the dominance of a few sites / companies on energy use and the lumpy nature of investment calls for direct consultation with large users in the event more refined estimates of EEI potential are sought.

2. Baseline Data

ABARE data shows WA current and forecast energy use trends at a fuel level to be:

Fuel	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Black Coal	26.96 PJ	33.26 PJ	35.43 PJ	39.48 PJ	41.40 PJ	42.90 PJ	42.84 PJ	42.81 PJ	42.78 PJ	42.77 PJ	42.74 PJ	42.75 PJ
LPG	10.32 PJ	10.02 PJ	10.25 PJ	10.49 PJ	10.97 PJ	11.54 PJ	12.19 PJ	12.92 PJ	13.49 PJ	14.38 PJ	15.41 PJ	16.68 PJ
Other petroleum pro	208.78 PJ	212.86 PJ	220.59 PJ	226.41 PJ	234.19 PJ	242.43 PJ	249.60 PJ	256.84 PJ	264.30 PJ	272.10 PJ	280.31 PJ	288.88 PJ
Gas	161.62 PJ	179.53 PJ	195.74 PJ	217.00 PJ	223.96 PJ	245.79 PJ	249.10 PJ	251.52 PJ	254.60 PJ	257.61 PJ	260.63 PJ	263.80 PJ
Biomass	13.48 PJ	13.57 PJ	13.81 PJ	13.95 PJ	14.16 PJ	14.38 PJ	14.55 PJ	14.72 PJ	14.88 PJ	15.05 PJ	15.23 PJ	15.40 PJ
Electricity	77.06 PJ	78.35 PJ	81.74 PJ	84.38 PJ	87.49 PJ	91.75 PJ	94.30 PJ	96.85 PJ	99.46 PJ	102.12 PJ	104.87 PJ	107.68 PJ
Solar	1.09 PJ	1.11 PJ	1.15 PJ	1.18 PJ	1.23 PJ	1.27 PJ	1.30 PJ	1.34 PJ	1.38 PJ	1.41 PJ	1.45 PJ	1.49 PJ
Total	**499.30 PJ**	**528.72 PJ**	**558.71 PJ**	**592.88 PJ**	**613.40 PJ**	**650.05 PJ**	**663.87 PJ**	**676.99 PJ**	**690.89 PJ**	**705.44 PJ**	**720.62 PJ**	**736.68 PJ**

This represents growth in final energy use of 48% over the period shown, or 4.32% pa. This is taken to be a business-as-usual scenario, against which EEI potential estimates are made.

This work is concerned with stationary energy, hence we take it to be (generally) reasonable to assume that "Other Petroleum Products" and "LPG" are not of interest here. LPG is immaterial in terms of total energy use, and 67% of Other Petroleum is associated with transport. Of remaining "Other Petroleum" the mining sector is material, accounting for 54% of the sub-total, and rising unlike other sectors to over 65% by 2015. Consumption by the Chemicals industry is presumably mainly related to usage at the Kwinana refinery, at 9% of the remaining use; Agriculture is not included in this study.

Hence we include petroleum use by mining in this study, but have not included other LPG or petroleum use.

Other energy use accounts for just 5-6% of stationary energy use, spread across several sectors and fuel types. This is not included in the analysis.

Sector	Fuel	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Mining	Gas	11.02	11.49	12.43	13.11	14.04	15.03	15.83	16.68	17.54	18.43	19.35	20.31
Mining	Electricity	18.50	18.98	19.99	20.73	21.73	22.77	23.65	24.56	25.49	26.45	27.45	28.48
Mining	Other Petroleum	33.36	34.65	37.48	39.56	42.51	45.69	48.46	51.44	54.56	57.87	61.44	65.22
Basic chemicals	Gas	13.26	13.65	20.11	33.07	34.43	35.81	36.84	37.87	38.86	39.80	40.73	41.66
Iron and steel	Coal	0.00	6.20	8.02	11.99	13.83	14.75	14.81	14.88	14.95	15.03	15.10	15.18
Iron and steel	Gas	31.95	0.12	0.79	1.17	1.35	1.44	1.45	1.47	1.49	1.52	1.54	1.56
Basic non-ferrous metals products (Other basic non ferrous metals)	Coal	12.50	12.51	12.73	12.83	12.90	13.38	13.35	13.33	13.33	13.34	13.35	13.38
Basic non-ferrous metals products (Other basic non ferrous metals)	Gas	74.81	122.86	129.64	135.94	139.31	157.38	158.08	157.83	158.32	158.80	159.27	159.84
Basic non-ferrous metals products (Other basic non ferrous metals)	Electricity	15.45	15.49	16.23	16.95	17.46	19.08	19.41	19.64	19.93	20.23	20.52	20.81
Nonmetallic minerals	Coal	7.49	7.54	7.62	7.67	7.74	7.81	7.85	7.89	7.92	7.95	7.97	8.00
Nonmetallic minerals	Gas	14.45	14.80	15.39	15.79	16.31	16.85	17.21	17.57	17.91	18.22	18.53	18.84
Commercial and services	Electricity	16.88	17.32	18.22	18.86	19.73	20.62	21.36	22.13	22.91	23.69	24.51	25.34
Commercial and services	Gas	2.83	2.90	3.04	3.13	3.26	3.38	3.48	3.59	3.68	3.78	3.88	3.98
Residential	Gas	8.70	8.95	9.38	9.64	9.98	10.39	10.61	10.84	11.05	11.25	11.45	11.65
Residential	Electricity	15.52	15.74	16.24	16.61	17.10	17.58	18.00	18.44	18.87	19.31	19.77	20.22
Sub Total		283.68	310.21	334.36	364.02	378.61	408.92	417.22	424.87	433.40	442.11	451.15	460.66
Total of all Stationary Energy		345.63	372.08	397.03	427.20	442.69	473.98	483.15	491.73	501.09	510.84	521.00	531.79
% Covered by Material Sources		82%	83%	84%	85%	86%	86%	86%	86%	86%	87%	87%	87%

The nature of trends in these sources over time serves to highlight where it is envisaged that major projects will either cease or come on line, as well as those sources / sectors that are expected to grow generally through increased throughput or services.

Biomass, solar and other energy sources have not been included in the study.

3. Case Study Selection & Approach

Based on the data shown above, we have selected the following case studies to develop high-level EEI potentials for WA:

1. Mining
2. Basic Chemicals
3. Iron & Steel
4. Basic Non-ferrous Metals
5. Non-metallic Minerals
6. Commercial
7. Residential

In general the approach taken to the assessment of EEI potential in these case studies involves:

- Preparation of a simple current and forecast energy use for each sector using ABARE data,
- Identification of sectors / case studies where there is a substantial growth pattern that evidences a new or several new major projects that will drive growth, using information such as Department of Industry and Resources data on committed and planned new projects; and estimation of "***Growth***" in energy use due to these activities,
- For remaining energy use in the forecasts, estimation of the likely average proportion of energy use that will be subject to equipment replacement ("***Replace***") on a year-to-year basis as equipment reaches the end of its useful life – typically this is 2.5% to 5% per year in manufacturing, mining and commercial sectors; and up to 10% per year in the residential sector. We note in these case studies that this is an assumed ***average*** rate of change, and there may be a wide range about this (eg up to 100% replacement per year for some residential lighting to say <10% annual change for residential hot water systems),
- This leaves an amount of energy use that, excepting any assumed behavioural improvements that may be forecast by ABARE, will remain "***As Is***" for the period of assessment – ie to 2015,
- Within each of these categories some level of improvement may be feasible – ie through improvement in design for growth areas where not yet committed or incremental improvement following commissioning of new plant; design efficiency into replacement plant and equipment; and improved behaviour or retrofits (or replacement before end-of-life) that can improve the efficiency with which the "As Is" category of energy use is managed

4. Mining

BASELINE ENERGY USAGE

The baseline information for all sectors assessed has been drawn from the ABARE WA Timeseries report data. This information is included in the table below as it relates to stationary energy in the Mining sector. The information included in this table is a projection of the energy requirements of the Mining sector to 2015.

Table 4.1: Baseline Energy Use for the Mining Sector

Fuel	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Fuel	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
Coal	7.0	7.0	7.1	7.0	6.9	7.0	6.8	6.7	6.6	6.5	6.3	6.2
Gas	11.0	11.5	12.4	13.1	14.0	15.0	15.8	16.7	17.5	18.4	19.3	20.3
Elec.	18.5	19.0	20.0	20.7	21.7	22.8	23.6	24.6	25.5	26.5	27.4	28.5
Other Pet.	33.4	34.6	37.5	39.6	42.5	45.7	48.5	51.4	54.6	57.9	61.4	65.2
Total	69.9	72.1	77	80.4	85.1	90.5	94.7	99.4	104.2	109.3	114.4	120.2

We have analysed each of these fuel types separately. In our analyses of the Mining sector in particular we pay attention to major new projects in the sector as presented by the Western Australian Department of Industry and Resources, which was updated in March 2006. Further, we use our expertise in the area of energy efficiency to present a baseline that is divided into three main areas of influence:

- **As Is** technology: which represents the technology in place in the industry that is expected to remain in place throughout the baseline period;
- **Replacement** technology: which is an indication of the technology in place in the industry which will be changed through routine replacement (maintenance, end of useful life etc); and
- **Growth**: which is represented by the major new projects as noted above. Note that this part of the baseline can be a function of "production creep" which results from increased throughput from existing infrastructure; this is not negligible, however, the potential to influence the energy efficiency of this sector lies in the "As Is" group.

The committed mining projects, sorted by completion date, are listed in the table below.

Table 4.2: Committed Major Projects in the Mining Industry

Project	First Production Date
Koolyanobbing - Iron Ore Project	2006-07
Pilbara - Rapid Growth Project 2: BHPB	2006-07
Cliff Head (Perth Offshore Basin) - Oil Field; Roc Oil; off shore unmanned platform with onshore processing plant	2006-07

Project	First Production Date
Nifty Copper Underground Mine; development of underground mine and associated ore processing facility	2007-08
Yandicoogina - Mine Expansion: Hammersley; new pit, new crushing and screening plant	2007-08
Ravensthorpe - Lateritic Nickel Mine and Hydrometallurgical Processing Plant	2007-08
North Eastern Goldfields - Jaguar - Base Metals Mine; copper zinc mine with concentrator	2007-08
Enfield (Carnarvon Offshore Basin) - Oil Field; Woodside; subsea well heads with floating production, storage and offloading vessel which produces crude oil	2007-08
Boddington - Gold Mine (Wandoo Expansion)	2008-09
Mid West Region - Koolanooka/Blue Hills Hematite Iron Ore Mine	2008-09
Pilbara - Rapid Growth Project 3: BHPB	2009-10
Angel (Carnarvon Offshore Basin) - Gas and Condensate Field: Woodside; fixed production platform; 50km subsea pipeline	2009-10
Stybarrow (Carnarvon Offshore Basin) - Oil Field; BHPB petroleum; Australia's deepest well, floating production, storage and offloading vessel which produces crude oil	2010-11

Note that while the baselines presented below show a significant increase in the area of Growth, this is a function of where we have implied that projects start; in reality these projects have started in the previous 18 months, the large increase is a result of grouping a large set of new projects together. We do not differentiate between committed and constructed projects in the models which follow. Rather we have used the indication of when first production is planned to start. We have applied heuristics to infer ramp ups in production from initial planned production start dates as projects are unlikely to deliver planned production in their first month, or even year, of operation.

ANALYSIS OF ELECTRICITY USE BY THE MINING SECTOR

The assumptions used in developing this model are:

- The total contribution to the baseline from the committed projects (included in the baseline figure as “Growth”) is:

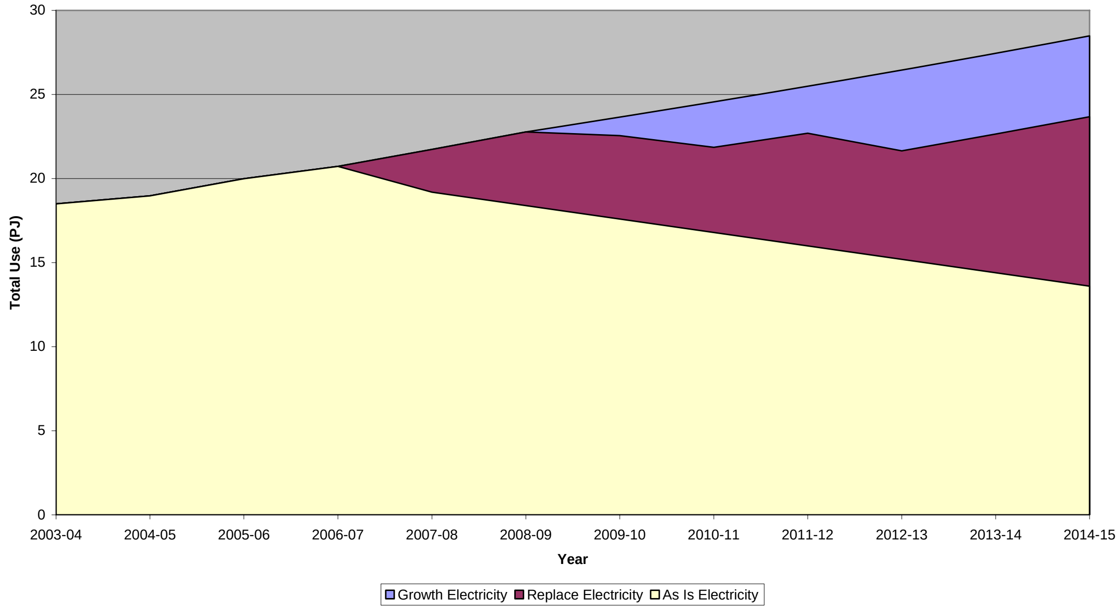
Table 4.3: Summary of Contribution of Major Projects (Growth) to Electricity Use

2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
2.4	2.6	3.7	5.3	5.4	7.4	7.4	7.4

- With respect to routine replacement of existing plant with new equipment, we have assumed a 25-year equipment life; while this assumption might appear trivial it is not, equipment life in the industry can range from 18 months in the case of small motors and pumps, to more than 40 years in the case of large capital plant. The selection of a 25-year life of equipment is representative of the spread of these various ages.

The resulting electricity baseline for the mining sector of the WA industry is illustrated in the figure below.

Figure 4.1: Mining Sector Baseline Electricity Use

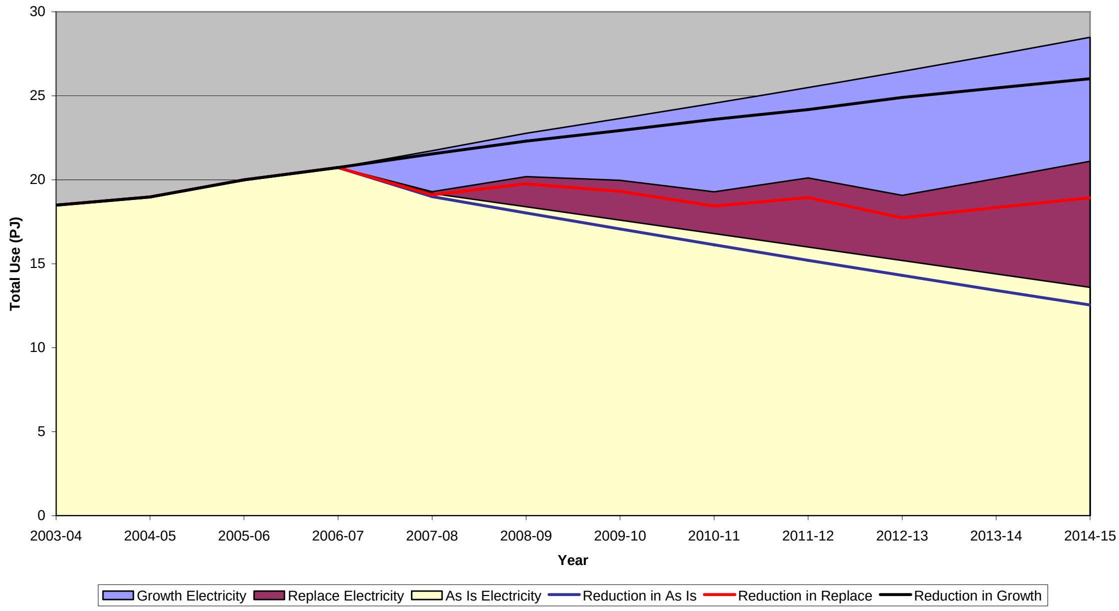


In this figure we illustrate the size of the various potential areas of influence. We then overlay on this knowledge-based assumptions of potential reductions in energy use that could result from policy initiatives in the three areas of influence. These assumptions are:

- **As Is**: has the potential to improve energy efficiency by 1% on a year on year basis
- **Replace**: has the potential to improve energy efficiency by 2% on a year on year basis
- **Growth** (new projects) have the potential to improve energy efficiency by 0.5% on a year on year basis with a one year delay as commission of plants for these projects has still to be completed and energy efficiency is unlikely to be a large driver in the initial year's of a project's implementation

This leads to the following scenario for future electricity use in this sector.

Figure 4.2: Mining Sector Baseline Electricity Use including consideration of Energy Efficiency Drives



The total electricity use by the sector as a result of these energy efficiency drives is detailed in the table below. In this table we illustrate the total percentage decrease in electricity use, relative to the projected growth rate for the industry, as a percentage decrease.

Table 4.4: Reduction in Electricity use by the Mining Industry given energy efficiency improvements

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	20.7	21.7	22.8	23.6	24.6	25.5	26.5	27.4	28.5
Energy Efficiency Scenario (PJ)	20.7	21.5	22.3	22.9	23.6	24.2	24.9	25.5	26.0
Percentage reduction (%)	0.0	0.9	2.0	3.0	3.9	5.2	5.9	7.2	8.6

ANALYSIS OF GAS USE BY THE MINING SECTOR

The assumptions used in developing this model are:

- The total contribution to the baseline from committed projects (included in the baseline figure as "Growth") is:

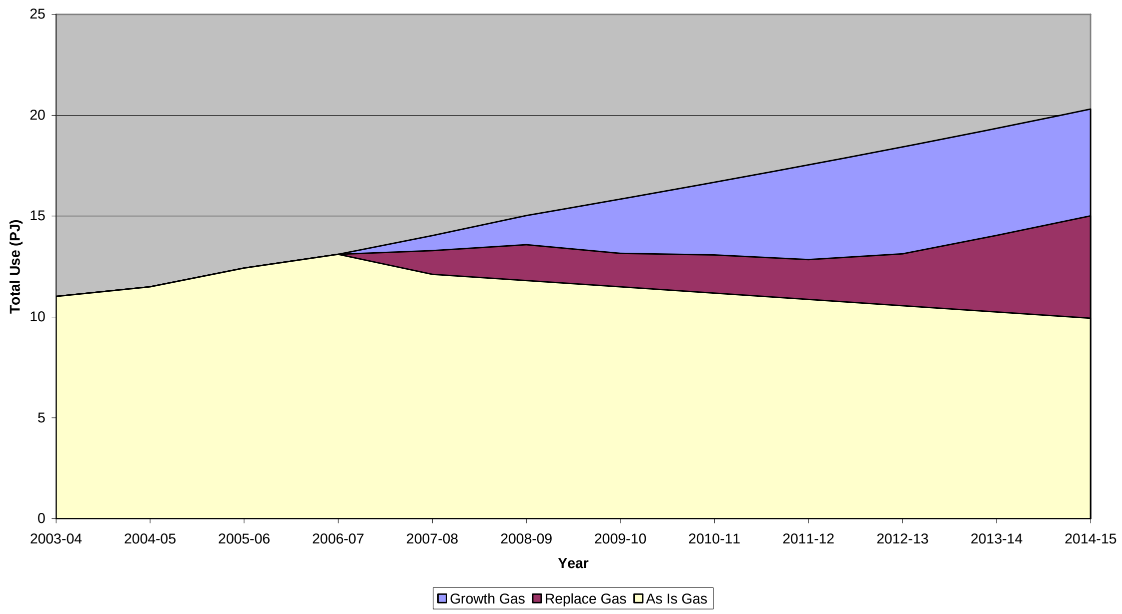
Table 4.5: Summary of Contribution of Major Projects (Growth) to Gas Use

2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
0.8	1.4	2.7	3.6	4.7	5.3	5.3	5.3

- With respect to routine replacement of existing plant with new equipment, we have assumed a 40 year equipment life; we have based this assumption on the fact that, in the main, in the mining sector gas will be used to generate electricity – the average life of this equipment is relatively long.

The resulting gas baseline for the mining sector of the WA industry is illustrated in the figure below.

Figure 4.3: Mining Sector Baseline Gas Use

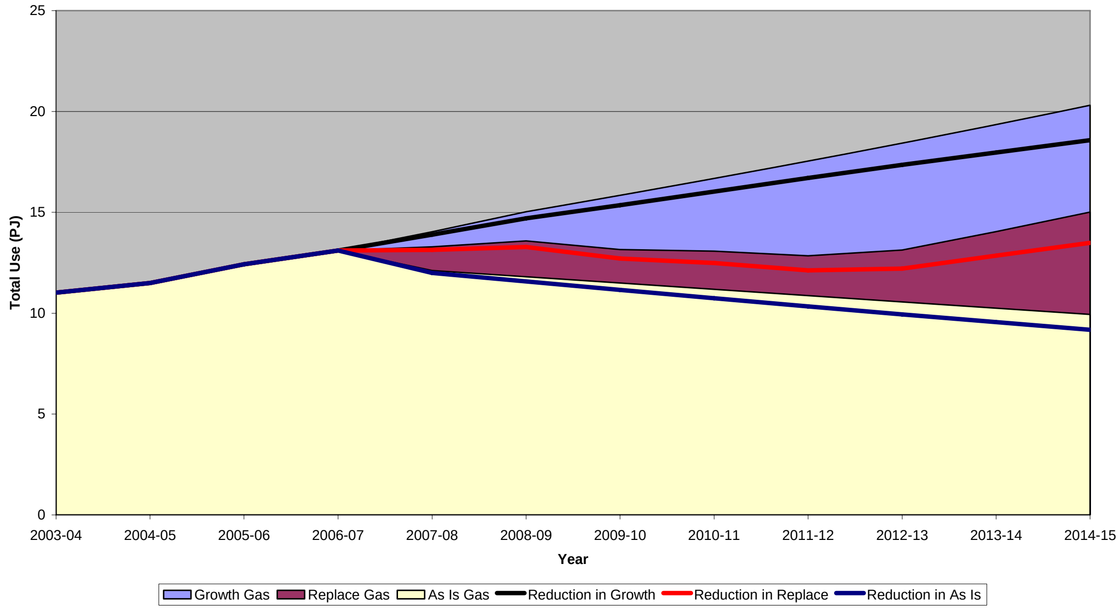


In this figure we illustrate the size of the various potential areas of influence. We then overlay on this knowledge-based assumptions of potential reductions in energy use that could result from policy initiatives in the three areas of influence. These assumptions are:

- **As Is**: has the potential to improve energy efficiency by 1% on a year on year basis
- **Replace**: has the potential to improve energy efficiency by 2% on a year on year basis
- **Growth** (new projects) have the potential to improve energy efficiency by 0.5% on a year on year basis with a one year delay as commission of plants for these projects has still to be completed and energy efficiency is unlikely to be a large driver in the initial year's of a project's implementation

This leads to the following scenario for future gas use in this sector.

Figure 4.4: Mining Sector Baseline Gas Use including consideration of Energy Efficiency Drives



The total gas use by the sector as a result of these energy efficiency drives is detailed in the table below. In this table we illustrate the total percentage decrease in gas use, relative to the projected growth rate for the industry, as a percentage decrease.

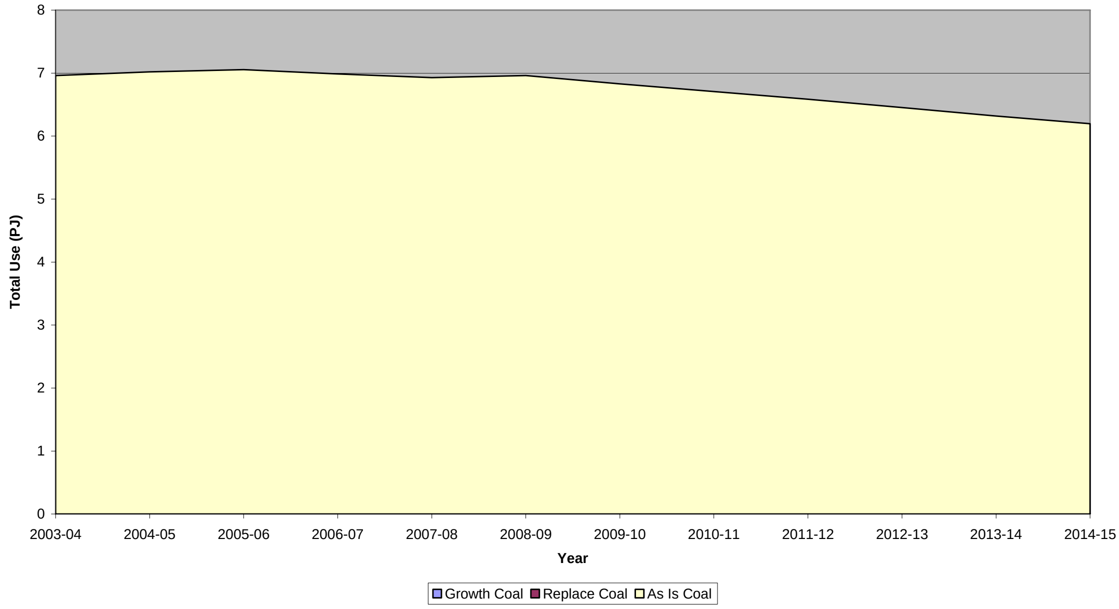
Table 4.6: Reduction in Gas use by the Mining Industry given energy efficiency improvements

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	13.1	14.0	15.0	15.8	16.7	17.5	18.4	19.3	20.3
Energy Efficiency Scenario (PJ)	13.1	13.9	14.7	15.4	16.0	16.7	17.4	18.0	18.6
Percentage reduction (%)	0.0	1.0	2.1	3.0	4.0	4.8	5.8	7.1	8.5

ANALYSIS OF COAL USE BY THE MINING SECTOR

This analysis is included for completeness. Examination of the data in Table 4.1 illustrates that coal is declining as an energy source for the mining industry. The coal baseline for the mining sector of the WA industry is illustrated in the figure below.

Figure 4.5: Mining Sector Baseline Coal Use

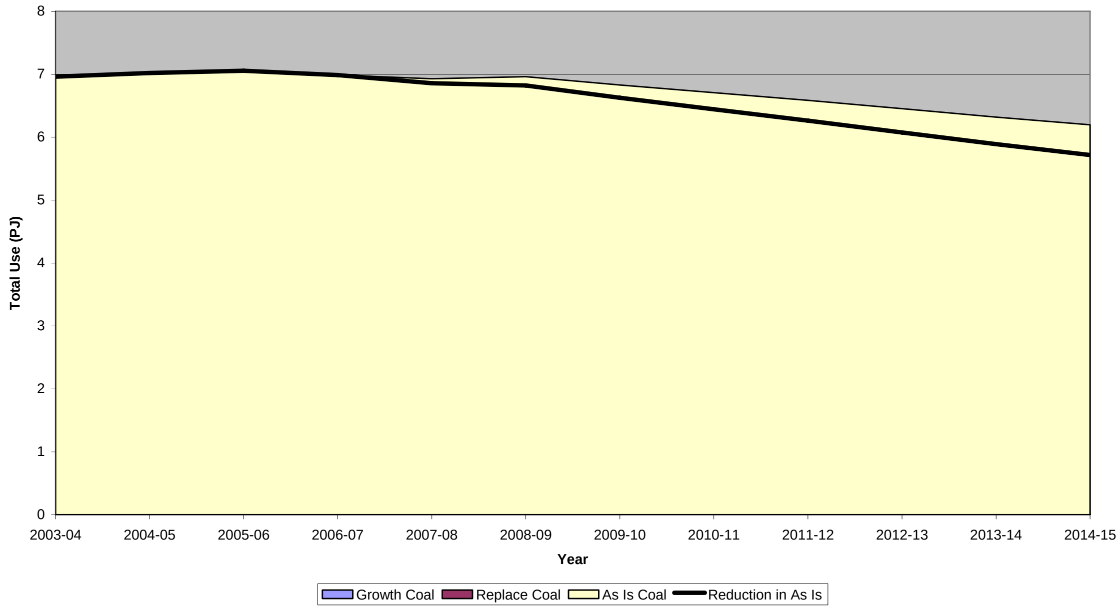


For this reason we have assumed that the only potential area of interest is the potential to improve the energy efficiency of technology in place. We assume that:

- **As Is**: has the potential to improve energy efficiency by 1% on a year on year basis

This leads to the following scenario for future coal use in this sector.

Figure 4.6: Mining Sector Baseline Coal Use including consideration of Energy Efficiency Drives



The total coal use by the sector as a result of these energy efficiency drives is detailed in the table below. In this table we illustrate the total percentage decrease in coal use, relative to the projected growth rate for the industry, as a percentage decrease.

Table 4.7: Reduction in Coal use by the Mining Industry given energy efficiency improvements

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	7.0	6.9	7.0	6.8	6.7	6.6	6.5	6.3	6.2
Energy Efficiency Scenario (PJ)	7.0	6.9	6.8	6.6	6.4	6.3	6.1	5.9	5.7
Percentage reduction (%)	0.0	1.0	2.0	3.0	3.9	4.9	5.9	6.8	7.7

ANALYSIS OF OTHER PETROLEUM PRODUCTS USE BY THE MINING SECTOR

In analysing this sector we have assumed that all of the petroleum products are diesel. We base this assumption on our understanding of the sector and the main energy sources used by the sector. In the main diesel is used in the mining industry to:

- Generate electricity at remote sites that do not have access to grid electricity or natural gas as a source to supply electricity, or
- Power haul trucks, these trucks are essentially electric trucks where the diesel is used to power an on-board generator on the truck.

Typical efficiency of both of these applications is in the region of 27% to 32%. For these reasons we have assumed that diesel use in the industry is essentially stationary use, even for the haul trucks as they essentially have stationary generators in place on mobile equipment. For this reason we have not attempted to disaggregate transport and stationary uses of diesel for the mining sector.

The assumptions used in developing this model are:

- The total contribution to the baseline from the committed projects (included in the baseline figure as “Growth”) is:

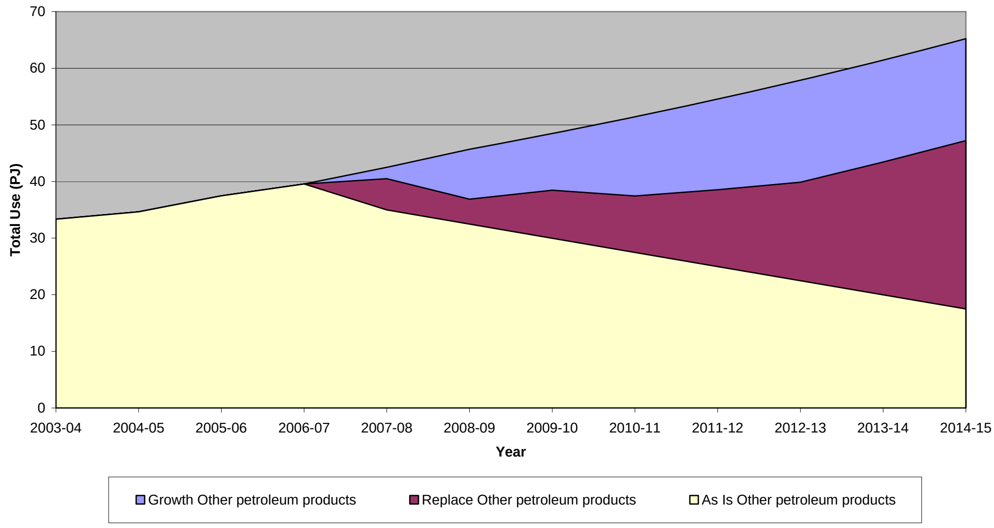
Table 4.8: Summary of Contribution of Major Projects (Growth) to Diesel Use

2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
2.0	8.8	10.0	14.0	16.0	18.0	18.0	18.0

- With respect to routine replacement or rebuilding of existing plant, we have assumed a 15-year equipment life; while this assumption might appear trivial it is not, equipment life in the industry can range from 15 years in the case of haul trucks, to 10 to 15 years in the case of electricity generation technology. At this time, while in many cases equipment will not necessarily be replaced, it would be common for engines / generators to be re-built

The resulting diesel baseline for the mining sector of the WA industry is illustrated in the figure below.

Figure 4.7: Mining Sector Baseline Diesel Use

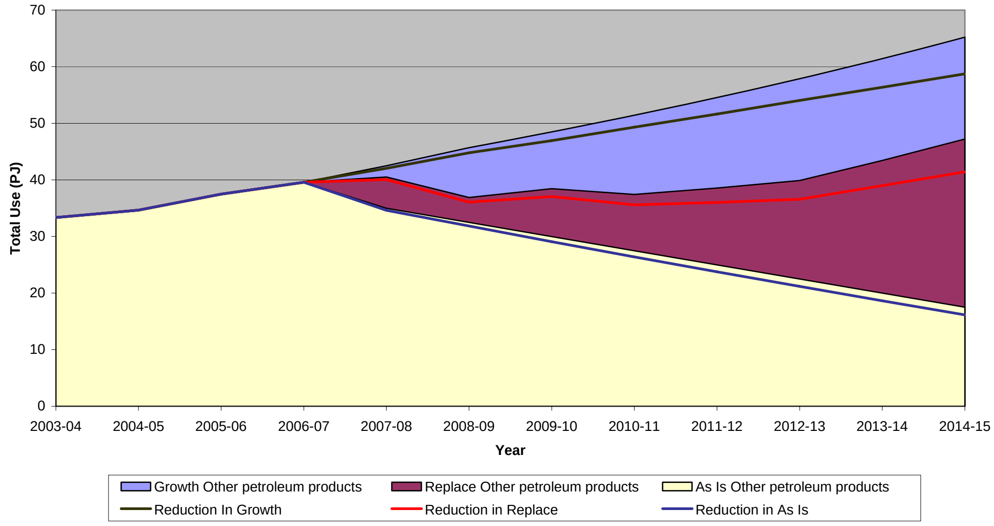


In this figure we illustrate the size of the various potential areas of influence. We then overlay on this knowledge-based assumptions of potential reductions in energy use that could result from policy initiatives in the three areas of influence. These assumptions are:

- **As Is**: has the potential to improve energy efficiency by 1% on a year on year basis
- **Replace (Rebuild)**: has the potential to improve energy efficiency by 2% on a year on year basis
- **Growth** (new projects) have the potential to improve energy efficiency by 0.5% on a year on year basis with a one year delay as commission of plants for these projects has still to be completed and energy efficiency is unlikely to be a large driver in the initial year's of a project's implementation

This leads to the following scenario for future diesel use in this sector.

Figure 4.8: Mining Sector Baseline Diesel Use including consideration of Energy Efficiency Drives



The total diesel use by the sector as a result of these energy efficiency drives is detailed in the table below. In this table we illustrate the total percentage decrease in diesel use, relative to the projected growth rate for the industry, as a percentage decrease.

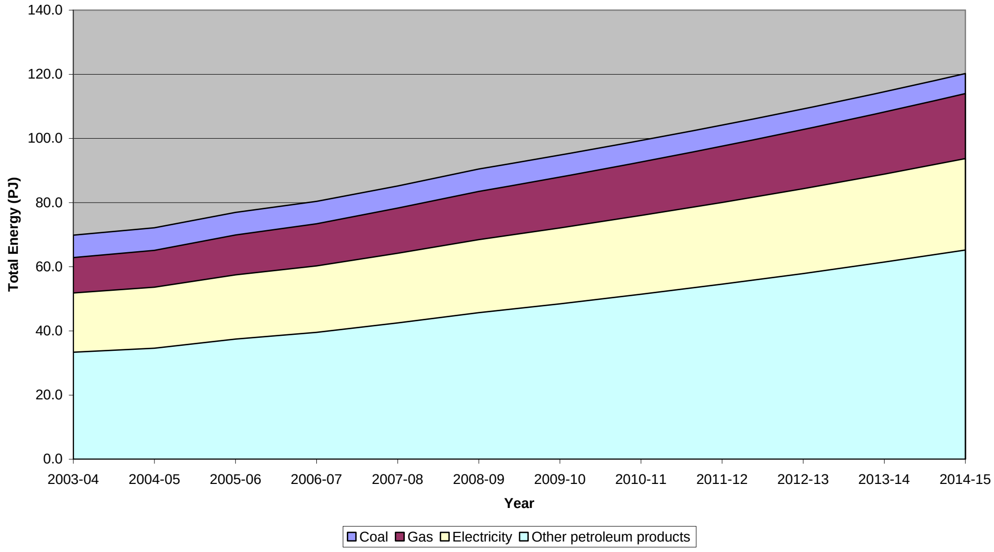
Table 4.9: Reduction in Diesel use by the Mining Industry given energy efficiency improvements

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	39.6	42.5	45.7	48.5	51.4	54.6	57.9	61.4	65.2
Energy Efficiency Scenario (PJ)	39.6	42.0	44.8	46.9	49.3	51.6	54.0	56.4	58.7
Percentage reduction (%)	0.0	1.1	2.0	3.2	4.1	5.4	6.6	8.3	10.0

OVERALL MINING INDUSTRY BASELINE & EEI POTENTIAL

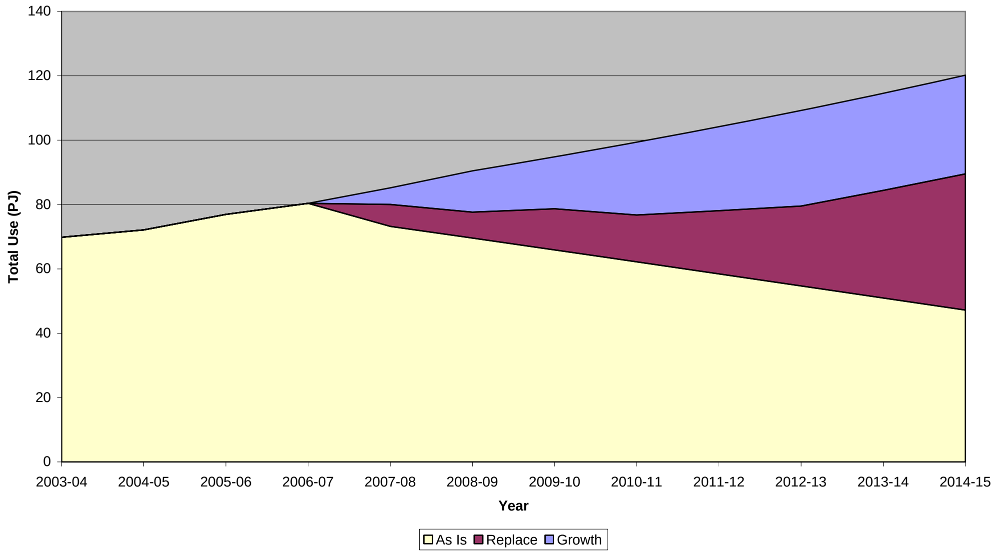
The total energy use by the mining industry is illustrated below.

Figure 4.9: Total Energy use by the Mining sector



Given that the majority of this energy will be used in the form of electricity, we chose to add all these values together[1]. This breakdown of energy use in the mining industry is illustrated below.

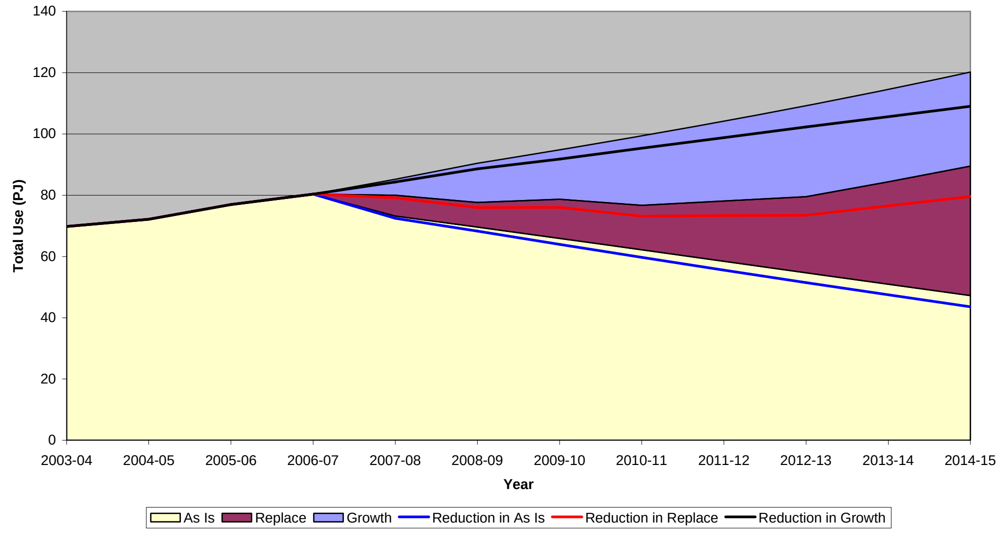
Figure 4.10: Breakdown of Energy Use in the Mining Sector by area of Influence



We overlay on this amount the potential energy efficiency initiatives we highlighted previously, to give an indication of the potential areas of greatest leverage.

[1] Note comments on how diesel is used in the mining industry included at the beginning of this section

Figure 4.11: Breakdown of Energy Use in the Mining Sector by area of Influence including Energy Efficiency Initiatives



A summary of the percentage change in the energy use of the sector that this represents is included in the table below.

Table 4.10: Reduction in Total Energy used by the Mining Industry given energy efficiency improvements

	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

DISCUSSION

Technology Trends

A different approach to reviewing this information is to determine the major processing units which are responsible for this energy consumption. The major areas that will use this energy are:

- Mining: 20%
- Materials Handling: 60%
- Initial Concentration: 20%

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 effect post 2015. In the time period used for this analysis (to end 2015) the following can be concluded about technology advances:

- Mining: improved blast management will play a role, as will improved digital control of mining machinery; these will result in incremental improvements; the step change technology most likely to be introduced into the industry will be the replacement of diesel stationary energy which will increase the mining industry's use of electrical stationary energy. These technologies include the pumping of ore and overburden, or the development of truck lifts. Improvements in the efficiency of diesel usage in mine haulage trucks are likely to be in the form of a shift to other energy sources, for example the replacement of diesel with compressed natural gas. At present the efficiency of these new technologies appear to be similar to those of existing technologies, though the greenhouse gas emission signatures will be different. This is particularly important in the coal industry which has the potential to generate its own gas (either from coal seam methane, or through the gasification of on site resources). Given the limited coal seam methane resources in WA this is unlikely to have a great effect. Recent advances in haul truck technology have focussed more on reducing air borne emissions (the Tier 2 and Tier 3 developments), these have, to an extent, limited total efficiency gains from the technology. There are a limited number of suppliers into this market, and it appears that their attention is not focussed on energy efficiency as yet, though pressure from the major companies in the mining industry might be able to affect this position.
- Materials handling: improved management of technology through enhanced management systems, as well as improvements in controllability of technologies in this sector will also result in incremental improvements in energy use; step change technologies will manifest in the longer term (more than 30 years probably) and will be linked to the changes in mining technology listed above. With respect to diesel usage, this stage uses electrical energy which is produced from diesel gensets at remote sites. Again technology developments in this area are likely to be incremental within the time horizon of 2015. However, a significant change would come about if gas were made available for electricity generation at remote sites. The challenge here is the potential for these remote sites to access gas reserves.
- Initial concentration: typically this is the production of metals in concentrate, the step change technology on the horizon in this area is improved management of material through mine to mill programs which have the potential to minimize energy used in crushing, grinding and milling. In the short to medium term covered by this assessment improvements in energy efficiency are likely to be incremental and linked to improved management and control of systems, similar to the case of materials handling listed above. With respect to diesel usage, the comments made above are the same.

Summary of EEI Areas & Policy Implications

Incremental improvement in energy use in the mining sector is linked to the following areas:

- Improved management and enhanced management systems
- Improved and optimized process control
- Installation and optimal control of variable speed drives
- Installation of high efficiency motors

The implications for policy development are thus:

- Assist companies to develop and apply robust and proactive energy management systems
- Review policy on gas availability to remote areas of the state, potential for additional funding for the development of a gas reticulation system.
- Support a culture of proactive energy management in companies
- Develop generic design and procurement guidelines for typical energy efficiency applications of VSDs and HEMs

2-year & 6-Year Paybacks

Using background work conducted for NFEE, we are of the view that the potential savings in this sector are split between the 0-2 year payback period (linked to improved management and control of processes) and the 3-6 year payback period (which relates to the significant base of technology already in place in the industry which has a relatively long life span. We take 35% of EEI potential to be at 0-2 year payback, and 65% at the 3-6 year payback. Hence:

- EEI Potential estimate at 0-2 year payback = 3.98 PJ
- EEI Potential estimate at 2-6 year payback = 7.22 PJ

5. Basic Chemicals

BASELINE ENERGY USAGE

The baseline information for all sectors assessed has been drawn from the ABARE WA Timeseries report data. This information is included in the table below as it relates to stationary energy in the Basic Chemicals sector. The information included in this table is a projection of the energy requirements of the Basic Chemicals sector to 2015.

Table 5.1: Baseline Energy Use for the Basic Chemicals sector

Fuel	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Fuel	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
Gas	13.3	13.6	20.1	33.1	34.4	35.8	36.8	37.9	38.9	39.8	40.7	41.7
Total	13.3	13.6	20.1	33.1	34.4	35.8	36.8	37.9	38.9	39.8	40.7	41.7

In our analysis of the Basic Chemicals sector we pay particular attention to major new projects in the sector as presented by the Western Australian Department of Industry and Resources, which was updated in March 2006. This document notes only one project of significance in this sector, namely the Burrup Peninsula Ammonia Plant. The ABARE statistics have accounted for this project, which is the reason for the significant increase in energy use over the period 2005 to 2007. For this reason we have started our analyses from the 2005-2006 period, which is inconsistent with the other sectors analysed, but does make the information more accessible. In the analysis that follows we divide the baseline into three main areas of influence:

- **As Is** technology: which represents the technology in place in the industry that is expected to remain in place throughout the baseline period;
- **Replacement** technology: which is an indication of the technology in place in the industry which will be changed through routine replacement (maintenance, end of useful life etc); and
- **Growth**: which is represented by the major new projects as noted above. Note that this part of the baseline can be a function of "production creep" which results from increased throughput from existing infrastructure; this is not negligible, however, the potential to influence the energy efficiency of this sector lies in the "As Is" group. For this sector the only significant project is the Burrup Peninsula Ammonia Plant.

ANALYSIS OF GAS USE BY THE BASIC CHEMICALS SECTOR

The assumptions used in developing this model are:

- The total contribution to the baseline from Growth in the sector is:

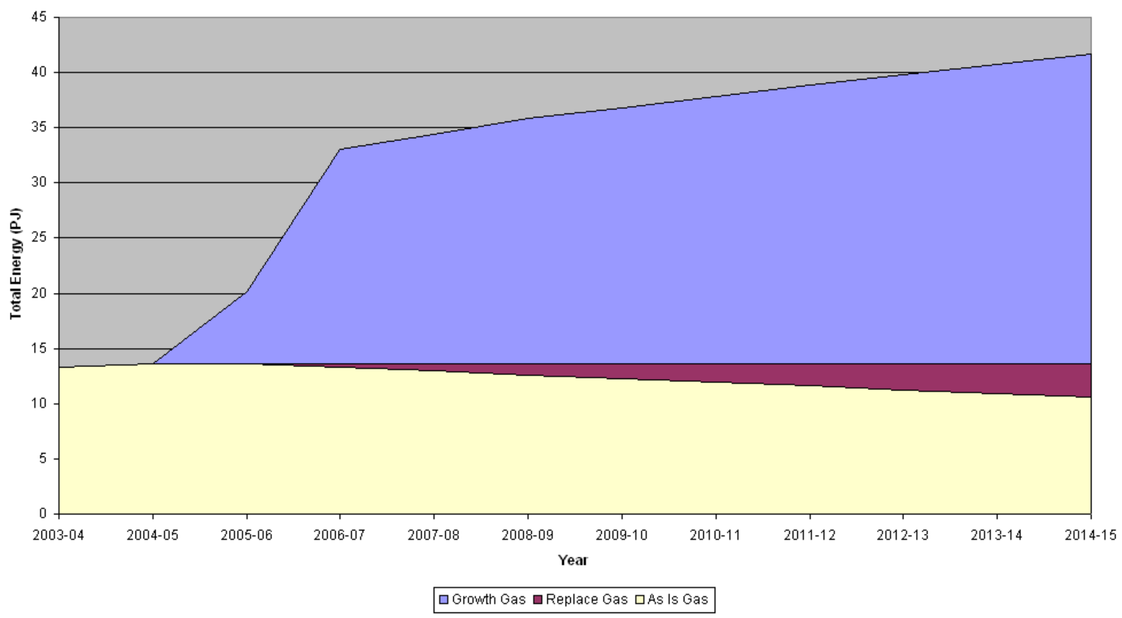
Table 5.2: Summary of Growth in Gas usage

2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
6.5	19.4	20.8	22.2	23.2	24.2	25.2	26.1	27.1

- With respect to routine replacement of existing plant with new equipment, we have assumed a 25-year equipment life; while this assumption might appear trivial it is not, equipment life in the industry can range from 18 months in the case of small motors and pumps, to more than 40 years in the case of large capital plant. The selection of a 25-year life of equipment is representative of the spread of these various ages.

The resulting gas baseline for the Basic Chemicals sector of the WA industry is illustrated in the figure below.

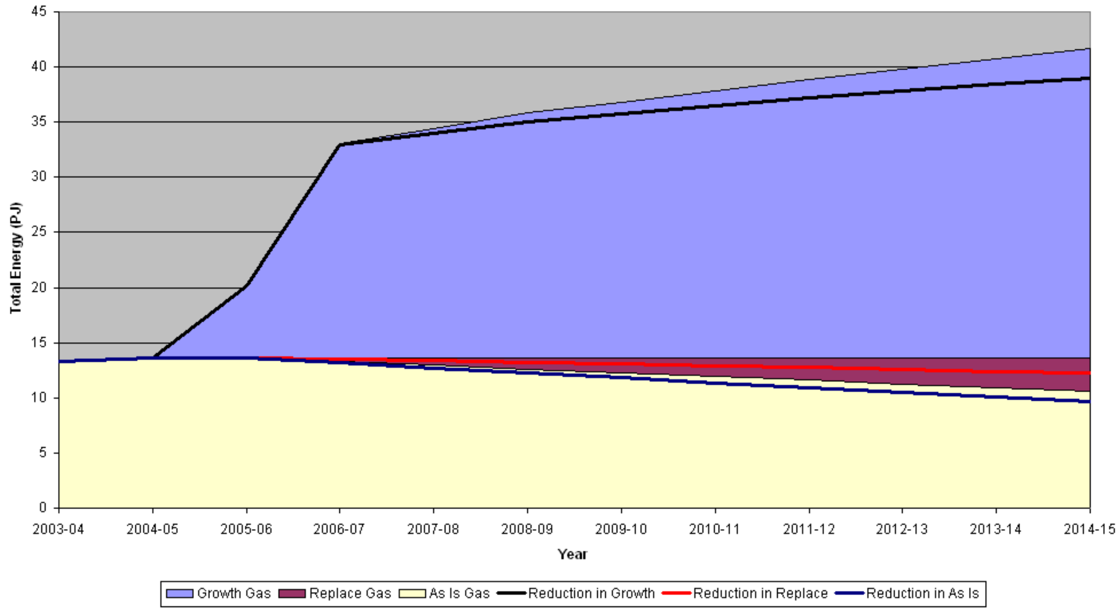
Figure 5.1: Basic Chemicals Sector Baseline Gas Use



In this figure we illustrate the size of the various potential areas of influence. We then overlay on this knowledge-based assumptions of potential reductions in energy use that could result from policy initiatives in the three areas of influence. These assumptions are:

- **As Is**: has the potential to improve energy efficiency by 1% on a year on year basis
- **Replace**: has the potential to improve energy efficiency by 2% on a year on year basis
- **Growth** (new projects) have the potential to improve energy efficiency by 0.5% on a year on year basis with a one year delay as commission of plants for these projects has still to be completed and energy efficiency is unlikely to be a large driver in the initial year's of a project's implementation

Figure 5.2: Basic Chemicals Sector Baseline Gas Use including consideration of Energy Efficiency Drives



The total gas use by the sector as a result of these energy efficiency drives is detailed in the table below. In this table we illustrate the total percentage decrease in gas use, relative to the projected growth rate for the industry, as a percentage decrease.

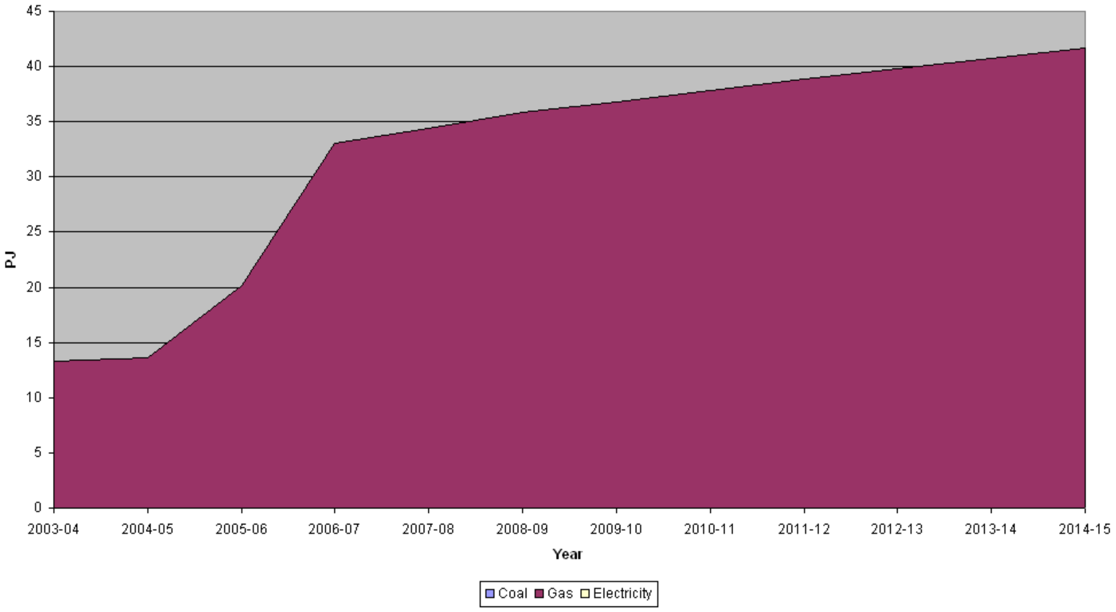
Table 5.3: Reduction in Gas use by the Basic Chemicals Sector given energy efficiency improvements

	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

OVERALL BASIC CHEMICALS INDUSTRY BASELINE & EEI POTENTIAL

The total energy use by the Basic Chemicals industry is illustrated below. The only energy source analysed for this sector is gas, thus the analysis included above contains the complete assessment for the Basic Chemicals sector.

Figure 5.3: Total Energy use by the Basic Chemicals sector



DISCUSSION

Technology Trends

Future technology trends in this sector are difficult to assess given the diverse nature of the sector. In the main "energy sources" are consumed in two ways by the sector:

- As reagents
- As true energy sources

Given the scale of projects in this industry there could be more value gained from improving extent of reaction by 1% than improving energy efficiency by 1%. This however would relate to energy sources which are consumed as reagents and have for this reason not been included in the baseline energy. These gains would be over and above any energy efficiency outcomes.

This argument aside, the energy efficiency gains to be made in the industry are a function of selection of operating regime within the thermodynamic bounds of the selected chemical system, there are trade-offs to be made between operability of the process, and capital costs. The more flexible a process is, the easier it is to operate; however the higher are the capital costs. In the main, processes in this sector are designed along the lines of existing processes, and processes with which the project proponent is familiar. Extending process design to incorporate consideration of flexibility and operability is complex and something that companies find difficult to engage with. It is unlikely that flexibility will be designed into processes in this sector in the near to medium term.

The other potential step change technology in this sector relates to reactor design. Given that the majority of chemicals produced in this sector are produced as a result of a sequence of chemical reactions, the potential does exist for the energy efficiency of the sector to improve significantly if different reactor sequences and regimes are introduced. The primary development in this area is most likely to be micro-reactors in which the temperature regimes under which reactions take place are controlled extremely tightly to ensure that reactions proceed as close to equilibrium as possible.

These reactors have the potential to increase the average yield of the industry significantly in the future. However, these reactors are only in place at laboratory scale at present and will not be commercial before 2015.

Given that the time horizon for this analysis extends only to 2015, and the fact that almost all the growth in the sector is accounted for by one project which is already in place, it is difficult to see anything other than incremental operational improvement in this sector.

Summary of EEI Areas & Policy Implications

Incremental improvement in energy use in the Basic Chemicals sector is linked to the following areas:

- Improved and optimized process control
- Improved management and enhanced management systems
- Installation and optimal control of variable speed drives
- Installation of high efficiency motors

The implications for policy development are thus:

- Assist companies to understand the positive implication of operating their technology using regimes that are atypical for their company.
- Assist companies to develop and apply robust and proactive energy management systems
- Support a culture of proactive energy management in companies
- Develop generic design and procurement guidelines for typical energy efficiency applications of VSDs and HEMs

2-year & 6-Year Paybacks

Using background work conducted for NFEE, we are of the view that the potential savings in this sector are more likely to be available at the 0-2 year payback linked to improved management and control of processes, and less available at 3-6 year paybacks given significant new technology installed or planned that is likely to be at or close to best practice. We take 80% of EEI potential to be at 0-2 year PB. Hence:

- EEI Potential estimate at 0-2 year payback = 1.84 PJ
- EEI Potential estimate at 2-6 year payback = 0.46 PJ

6. Iron & Steel

BASELINE ENERGY USAGE

The baseline information for all sectors assessed has been drawn from the ABARE WA Timeseries report data. This information is included in the table below as it relates to stationary energy in the Iron and Steel sector. The information included in this table is a projection of the energy requirements of the Iron and Steel sector to 2015.

Table 6.1: Baseline Energy Use for the Iron and Steel Sector

Fuel	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Fuel	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
Coal	0.0	6.2	8.0	12.0	13.8	14.8	14.8	14.9	15.0	15.0	15.1	15.2
Gas	32.0	0.1	0.8	1.2	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.6
Total	32.0	6.3	8.8	13.2	15.2	16.2	16.3	16.4	16.4	16.6	16.6	16.7

We have analysed these two fuel types separately. In our analysis of the Iron and Steel Sector in particular we pay attention to major new projects in the sector as presented by the Western Australian Department of Industry and Resources which was updated in March 2006. Further, we use our expertise in the area of energy efficiency to present a baseline, which is divided into three main areas of influence:

- **As Is** technology: which represents the technology in place in the industry that is expected to remain in place throughout the baseline period;
- **Replacement** technology: this grouping of technology has not been included in this model as the technology in place in the sector belongs to a single site which is extremely new, it has been decided that there will be limited technology replacement at this site in the time horizon of this study; and
- **Growth**: which is represented by the major new projects as noted above. Note that this part of the baseline can be a function of "production creep" which results from increased throughput from existing infrastructure; this is not negligible, however, the potential to influence the energy efficiency of this sector lies in the "As Is" group.

There was only one committed project in the iron and steel sector; this is the HISmelt commercial iron making plant located in Kwinana. The majority of the energy supply to this plant is coal in the form of coke.

ANALYSIS OF COAL USE BY THE IRON AND STEEL SECTOR

The assumptions used in developing this model are:

- The total contribution to the baseline from the committed projects (included in the baseline figure as "Growth") is:

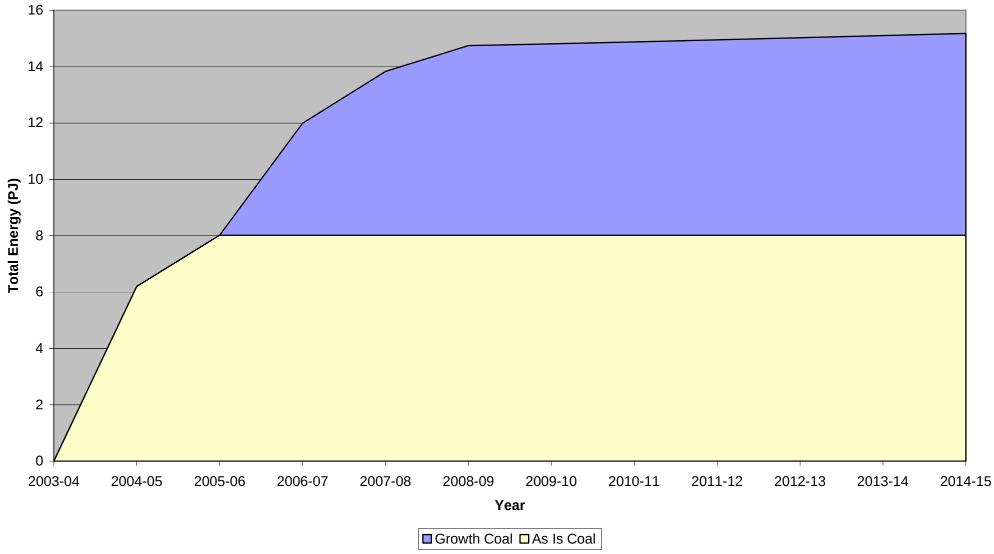
Table 6.2: Summary of Contribution of Major Projects to Coal Use

2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
4.0	5.8	6.7	6.8	6.9	6.9	7.0	7.1

- Given that the plant in place is new, we have assumed that there will be no replacement of equipment within the time horizon of this assessment

The resulting coal baseline for the Iron and Steel Sector of the WA industry is illustrated in the figure below.

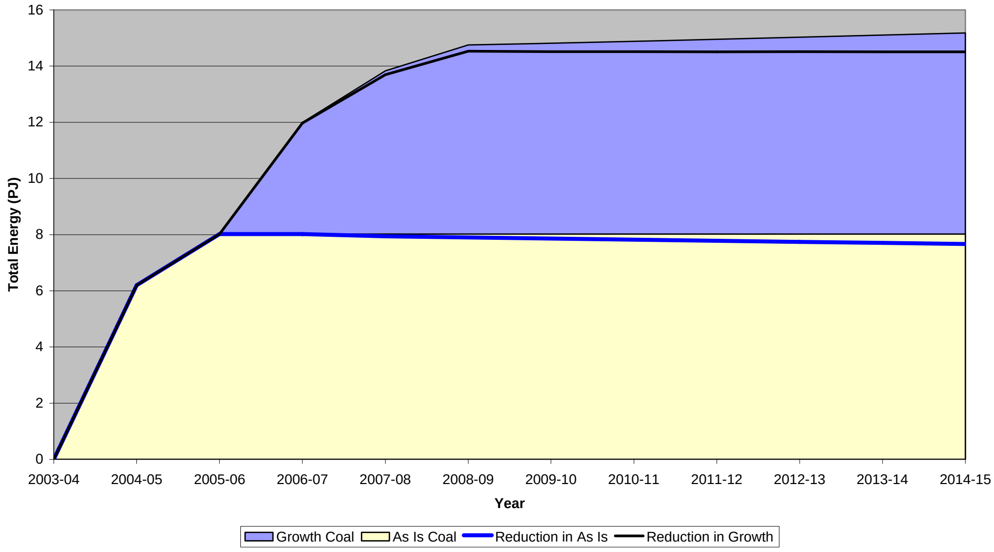
Figure 6.1: Iron and Steel Sector Baseline Coal Use



In this figure we illustrate the size of the various potential areas of influence. We then overlay on this knowledge-based assumptions of potential reductions in energy use that could result from policy initiatives in the three areas of influence. These assumptions are:

- **As Is**: has the potential to improve energy efficiency by 0.5% on a year on year basis given that the technology in place is extremely new.
- **Growth** (new projects) have the potential to improve energy efficiency by 0.5% on a year on year basis with a one year delay as commission of plants for these projects has still to be completed and energy efficiency is unlikely to be a large driver in the initial year's of a project's implementation

Figure 6.2: Iron and Steel Sector Baseline Coal Use including consideration of Energy Efficiency Drives



The total coal use by the sector as a result of these energy efficiency drives is detailed in the table below. In this table we illustrate the total percentage decrease in coal use, relative to the projected growth rate for the industry, as a percentage decrease.

Table 6.3: Reduction in Coal use by the Iron and Steel Industry given energy efficiency improvements

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	12.0	13.8	14.8	14.8	14.9	15.0	15.0	15.1	15.2
Energy Efficiency Scenario (PJ)	12.0	13.7	14.5	14.5	14.5	14.5	14.5	14.5	14.5
Percentage reduction (%)	0.2	1.0	1.5	2.0	2.5	3.0	3.4	3.9	4.4

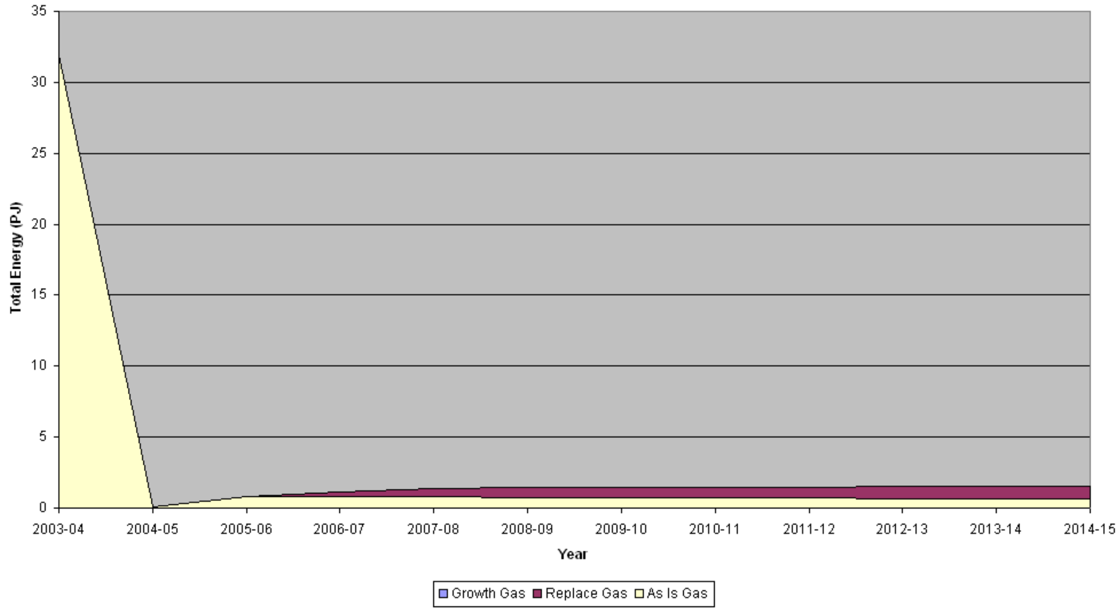
ANALYSIS OF GAS USE BY THE IRON AND STEEL SECTOR

The assumptions used in developing this model are:

- There is no growth in gas used by the sector that can be directly attributed to any project, rather there is a significant reduction in this use of gas which is associated with the closure of the DRI (direct reduced iron) plant at Port Hedland. Any increase in the baseline post the closure of the Port Hedland facility is ascribed to "production creep" as opposed to significant new projects.
- With respect to routine replacement of existing plant with new equipment, we have assumed a 40-year equipment life.

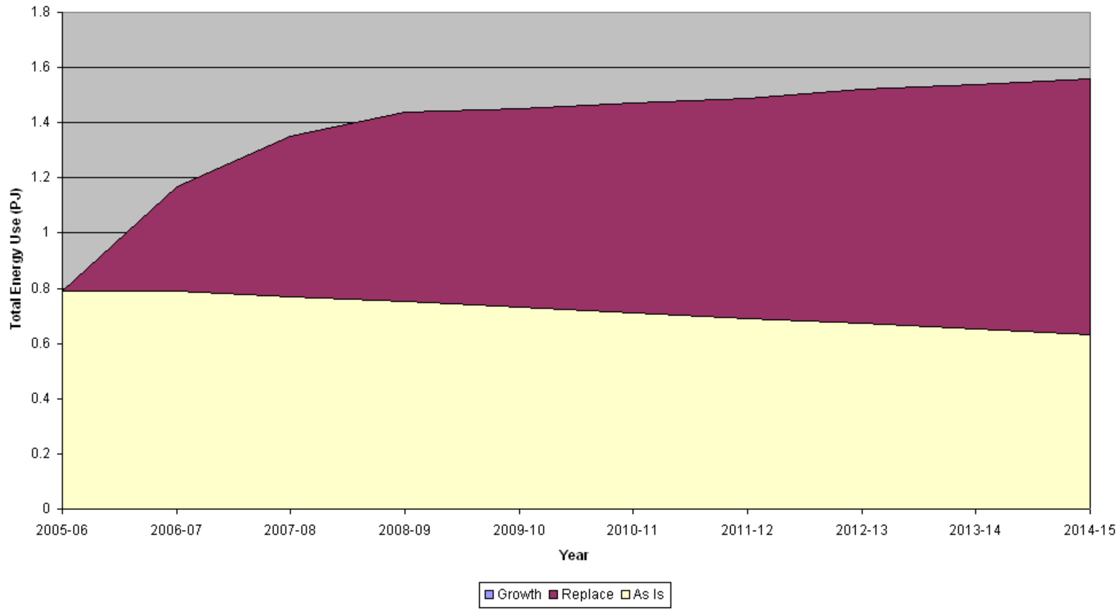
The resulting gas baseline for the Iron and Steel Sector of the WA industry is illustrated in the figure below.

Figure 6.3: Iron and Steel Sector Baseline Gas Use



This figure highlights the significant drop off in gas usage associated with the closure of the Port Hedland DRI plant. For ease of interpretation we have constructed this chart from 2005 onwards in order to make it possible to focus on the potential changes in the use of gas in this sector.

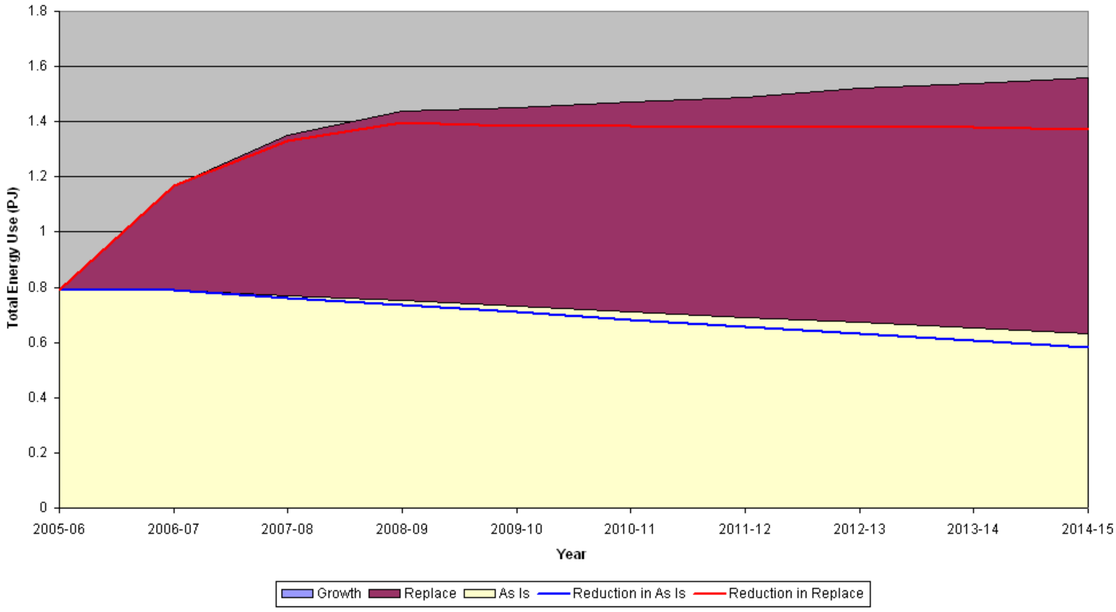
Figure 6.4: Iron and Steel Sector Baseline Gas Use post 2005



In this figure we illustrate the size of the various potential areas of influence. We then overlay on this knowledge-based assumptions of potential reductions in energy use that could result from policy initiatives in the three areas of influence. These assumptions are:

- **As Is**: has the potential to improve energy efficiency by 1% on a year on year basis
- **Replace**: has the potential to improve energy efficiency by 2% on a year on year basis

Figure 6.5: Iron and Steel Sector Baseline Gas Use including consideration of Energy Efficiency Drives



The total gas use by the sector as a result of these energy efficiency drives is detailed in the table below. In this table we illustrate the total percentage decrease in gas use, relative to the projected growth rate for the industry, as a percentage decrease.

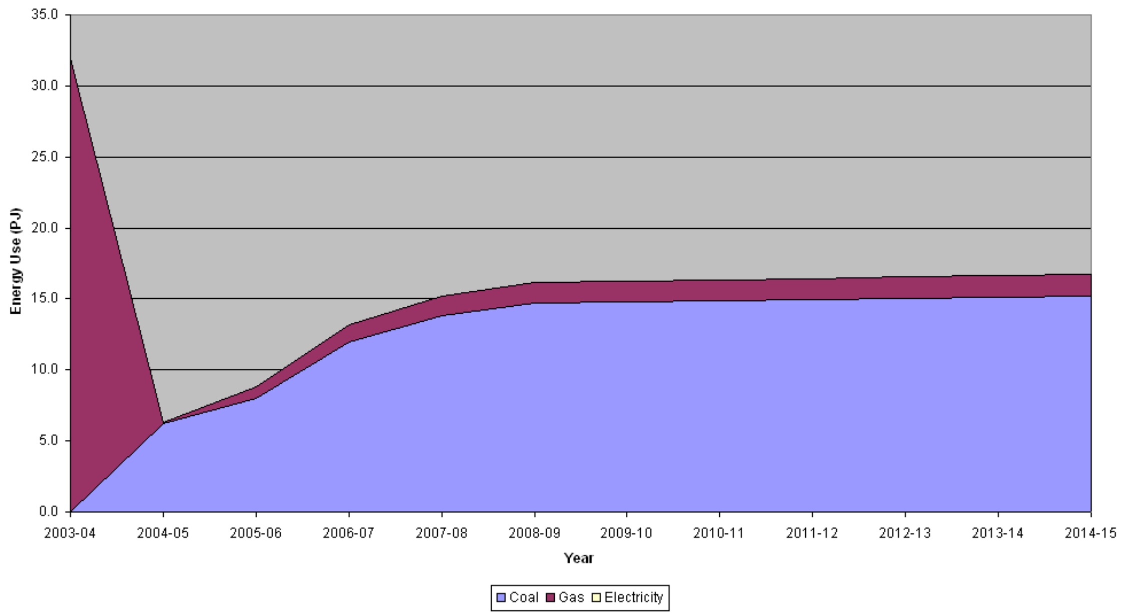
Table 6.4: Reduction in Gas use by the Iron and Steel Industry given energy efficiency improvements

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	1.2	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.6
Energy Efficiency Scenario (PJ)	1.2	1.3	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Percentage reduction (%)	0.0	1.4	2.9	4.4	5.9	7.4	9.0	10.5	12.0

OVERALL IRON AND STEEL INDUSTRY BASELINE & EEI POTENTIAL

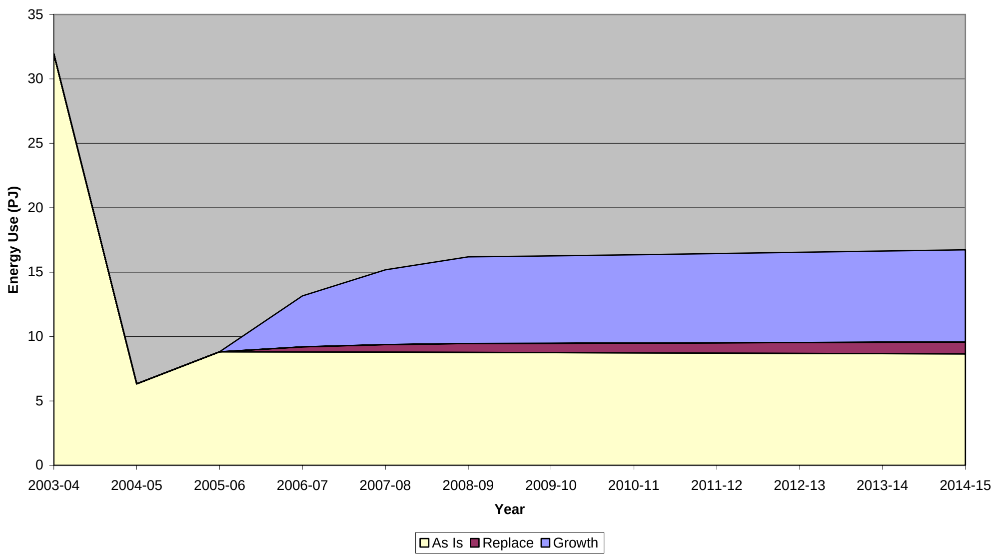
The total energy use by the Iron and Steel Industry is illustrated below.

Figure 6.6: Total Energy use by the Iron and Steel Sector



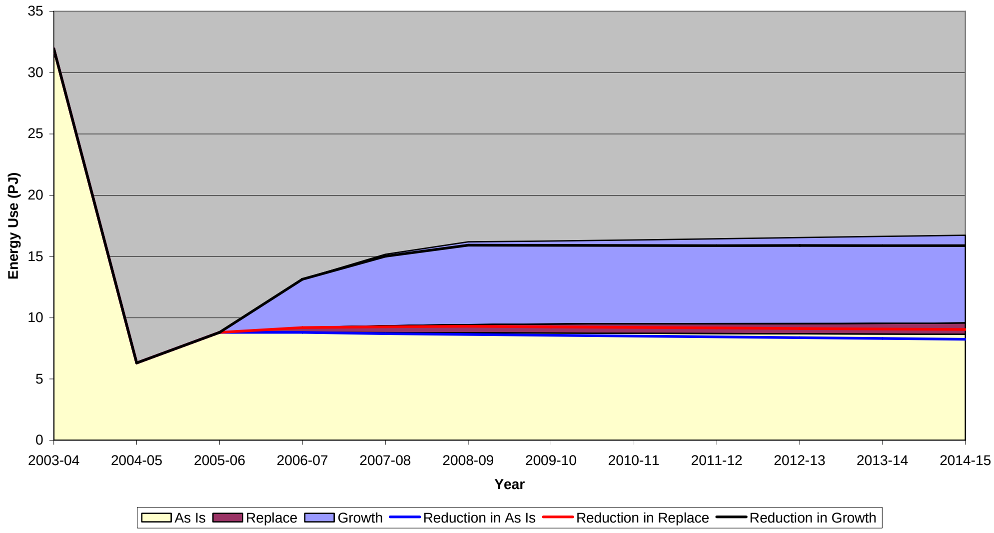
This baseline is aggregated and the areas of influence highlighted in the figure below.

Figure 6.7: Breakdown of Energy Use in the Iron and Steel Sector by area of Influence



We overlay on this amount the potential energy efficiency initiatives we highlighted previously, to give an indication of the potential areas of greatest leverage.

Figure 6.8: Breakdown of Energy Use in the Iron and Steel Sector by area of Influence including Energy Efficiency Initiatives



A summary of the percentage change in the energy use of the sector which this represents is included in the table below.

Table 6.5: Reduction in Total Energy used by the Iron and Steel Industry given energy efficiency improvements

	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

DISCUSSION

Technology Trends

A different approach to reviewing this information is to determine the major processing units that are responsible for this energy consumption. The major areas that will use this energy are:

- Production of pig iron (95%)
- Ancilliary services (5%)

Energy represents a significant cost to the iron and steel industry, they have focused on reducing energy use and improving their energy efficiency since the oil crisis of the late 1970s. Given this focus on energy the assumptions made about their potential to improve the energy efficiency of technology in place are potentially optimistic. At the same time, the Iron and Steel sector is more likely than the mining industry to adopt new technologies that save energy. This is evidenced by the technology in place in the WA sector. The two most recent advances in the production of iron and steel recently have been the evolution of DRI technologies, and the development and commercialisation of HISmelt (and similar technologies such as CSIROSmelt). Both of these technologies are, or were, present in this sector in WA. It is unlikely that any additional technology advance will take place in the iron and steel sector before the period of this analysis (to end 2015).

Summary of EEI Areas & Policy Implications

Incremental improvement in energy use in the Iron and Steel Sector is linked to the following areas:

- Improved management and enhanced management systems
- Improved and optimised process control

It should be noted that the iron and steel industry does not have a strictly linear correlation between energy use and greenhouse gas emissions.

The implications for policy development are thus:

- Assist companies to develop and apply robust and proactive energy and carbon management systems
- Support a culture of proactive energy management in companies

2-year & 6-Year Paybacks

Using background work conducted for NFEE, we are of the view that the potential savings in this sector are more likely to be available at the 0-2 year payback linked to improved management and control of processes, and less available at 3-6 year paybacks given significant new technology installed or planned that is likely to be at or close to best practice. This would suggest that 80% of EEI potential is at 0-2 year PB. However, given the single significant project being implemented in the sector over the relevant time horizon we would suggest that the 0-2 year payback proportion may be less. For this reason we assume a 50:50 split between the payback periods. Hence:

- EEI Potential estimate at 0-2 year payback = 0.44 PJ
- EEI Potential estimate at 2-6 year payback = 0.44 PJ

7. Non-Ferrous Metals

BASELINE ENERGY USAGE

The baseline information for all sectors assessed has been drawn from the ABARE WA Timeseries report data. This information is included in the table below as it relates to stationary energy in the Non-ferrous sector. The information included in this table is a projection of the energy requirements of the Non-ferrous sector to 2015.

Table 7.1: Baseline Energy Use for the Non-ferrous Sector

Fuel	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Fuel	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
Coal	12.5	12.5	12.7	12.8	12.9	13.4	13.4	13.3	13.3	13.3	13.3	13.4
Gas	74.8	122.9	129.6	135.9	139.3	157.4	158.1	157.8	158.3	158.8	159.3	159.8
Elec.	15.5	15.5	16.2	16.9	17.5	19.1	19.4	19.6	19.9	20.2	20.5	20.8
Total	102.8	150.9	158.6	165.7	169.7	189.8	190.8	190.8	191.6	192.4	193.1	194.0

We have analysed each of these fuel types separately. In our analyses of the Non-ferrous sector we pay attention to major new projects in the sector as presented by the Western Australian Department of Industry and Resources which was updated in March 2006. Further, we use our expertise in the area of energy efficiency to present a baseline that is divided into three main areas of influence:

- **As Is** technology: which represents the technology in place in the industry that is expected to remain in place throughout the baseline period;
- **Replacement** technology: which is an indication of the technology in place in the industry which will be changed through routine replacement (maintenance, end of useful life etc); and
- **Growth**: which is represented by the major new projects as noted above. Note that this part of the baseline can be a function of "production creep" which results from increased throughput from existing infrastructure; this is not negligible, however, the potential to influence the energy efficiency of this sector lies in the "As Is" group.

Two major committed projects are identified in the non-ferrous sector, being the Pinjarra/Huntly - Alumina Refinery Efficiency Upgrade to 4.2Mtpa and the Worsley Refinery Expansion to 3.5 and subsequently to 3.7 Mt/a. These two projects were considered further in the analysis. The other committed project in the non-ferrous sector were identified as part of the mining sector, these are:

- Nifty Copper Underground Mine: development of underground mine and associated ore processing facility
- Ravensthorpe: Lateritic Nickel Mine and Hydrometallurgical Processing Plant

- North Eastern Goldfields - Jaguar - Base Metals Mine: copper zinc mine with concentrator

These projects were included in the mining analysis as they have been classified as primarily mining projects, albeit with associated concentration (and, in the case of Ravensthorpe) refining processes.

To clarify the breakdown of energy use in this sector in WA; the following generic energy intensity values are used[2]:

- Bauxite to Alumina Processing: 2800 MJ/tonne alumina
- Copper/Zinc mining and concentration: 380 MJ/tonne concentrate
- Lateritic Nickel mining and refining: 194 MJ/kg metal product

Production from the WA minerals industry is dominated by iron ore, gold and alumina which provide 80% of the total value of this sector[3]. According to the WA Chamber of Minerals and Energy, in 2005 production from the Non-ferrous sector was:

- Alumina: 11.35 mt
- Copper (as metal): 83.95 kt
- Zinc (as metal): 59.51 kt
- Nickel: 188kt

Given that the production of alumina is an order of magnitude more energy intensive than the other products from this sector, and that alumina production represents 97% of the production from this sector we have chosen to analyse this sector from the point of view of alumina production only.

ANALYSIS OF ELECTRICITY USE BY THE NON-FERROUS SECTOR

The assumptions used in developing this model are:

- The total contribution to the baseline from the committed projects (included in the baseline figure as "Growth") is:

Table 7.2: Summary of Contribution of Major Projects to Electricity Use

2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
0.9	1.9	2.9	2.9	2.9	2.9	2.9	2.9

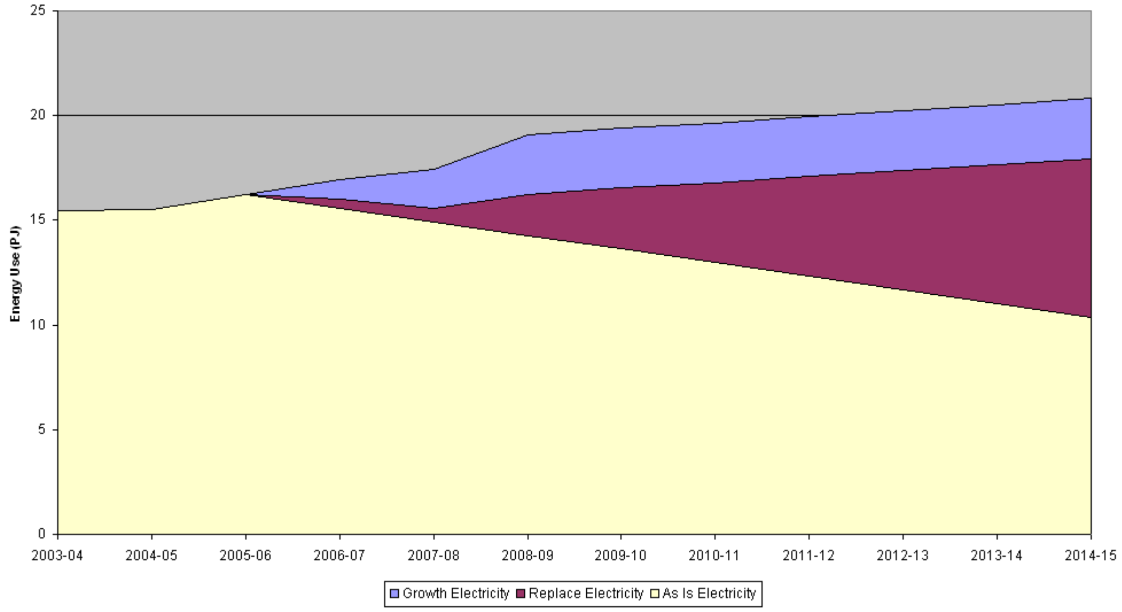
- With respect to routine replacement of existing plant with new equipment, we have assumed a 25-year equipment life; while this assumption might appear trivial it is not, equipment life in the industry can range from 18 months in the case of small motors and pumps, to more than 40 years in the case of large capital plant. The selection of a 25-year life of equipment is representative of the spread of these various ages.

[2] Stewart M and Petrie J G (2006) A Process Systems Approach to Life Cycle Inventories for Minerals: South African and Australian Case Studies, International Journal of Cleaner Production.

[3] DOIR

The resulting electricity baseline for the Non-ferrous sector of the WA industry is illustrated in the figure below.

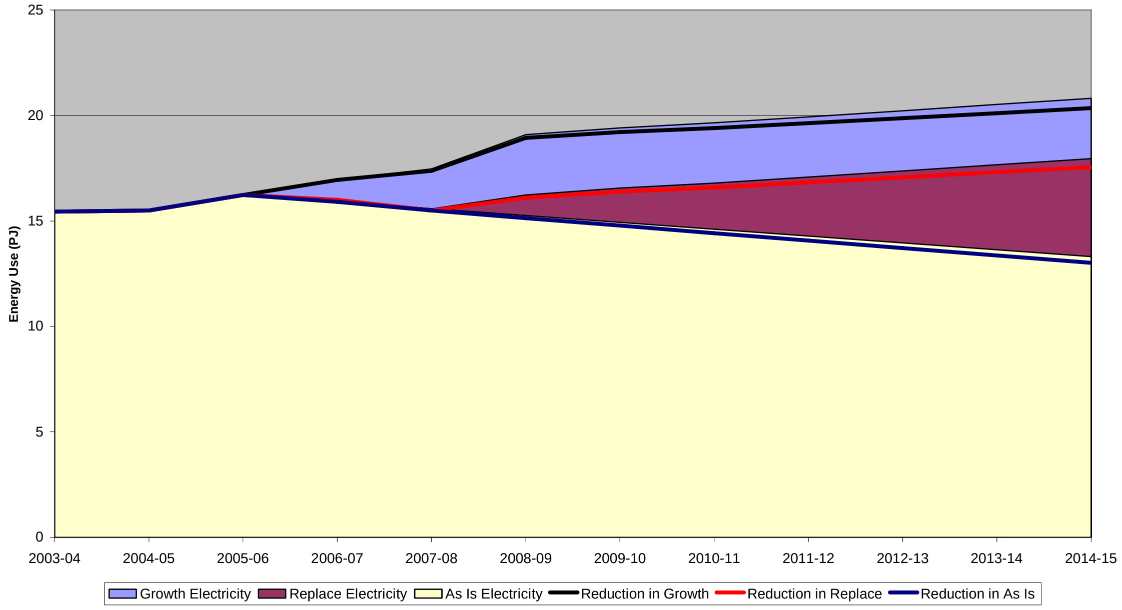
Figure 7.1: Non-ferrous Sector Baseline Electricity Use



In this figure we illustrate the size of the various potential areas of influence. We then overlay on this knowledge-based assumptions of potential reductions in energy use that could result from policy initiatives in the three areas of influence. These assumptions are:

- **As Is**: has the potential to improve energy efficiency by 0.25% on a year on year basis
- **Replace**: has the potential to improve energy efficiency by 0.25% on a year on year basis
- **Growth** (new projects) have the potential to improve energy efficiency by 0.25% on a year on year basis with a one year delay as commission of plants for these projects has still to be completed and energy efficiency is unlikely to be a large driver in the initial year's of a project's implementation

Figure 7.2: Non-ferrous Sector Baseline Electricity Use including consideration of Energy Efficiency Drives



The total electricity use by the sector as a result of these energy efficiency drives is detailed in the table below. In this table we illustrate the total percentage decrease in electricity use, relative to the projected growth rate for the industry, as a percentage decrease.

Table 7.3: Reduction in Electricity use by the Non-ferrous Industry given energy efficiency improvements

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	16.9	17.5	19.1	19.4	19.6	19.9	20.2	20.5	20.8
Energy Efficiency Scenario (PJ)	16.9	17.4	18.9	19.2	19.4	19.6	19.9	20.1	20.3
Percentage reduction (%)	0.0	0.5	0.7	1.0	1.2	1.5	1.7	2.0	2.2

ANALYSIS OF GAS USE BY THE NON-FERROUS SECTOR

The assumptions used in developing this model are:

- The total contribution to the baseline from committed projects (included in the baseline figure as "Growth") is:

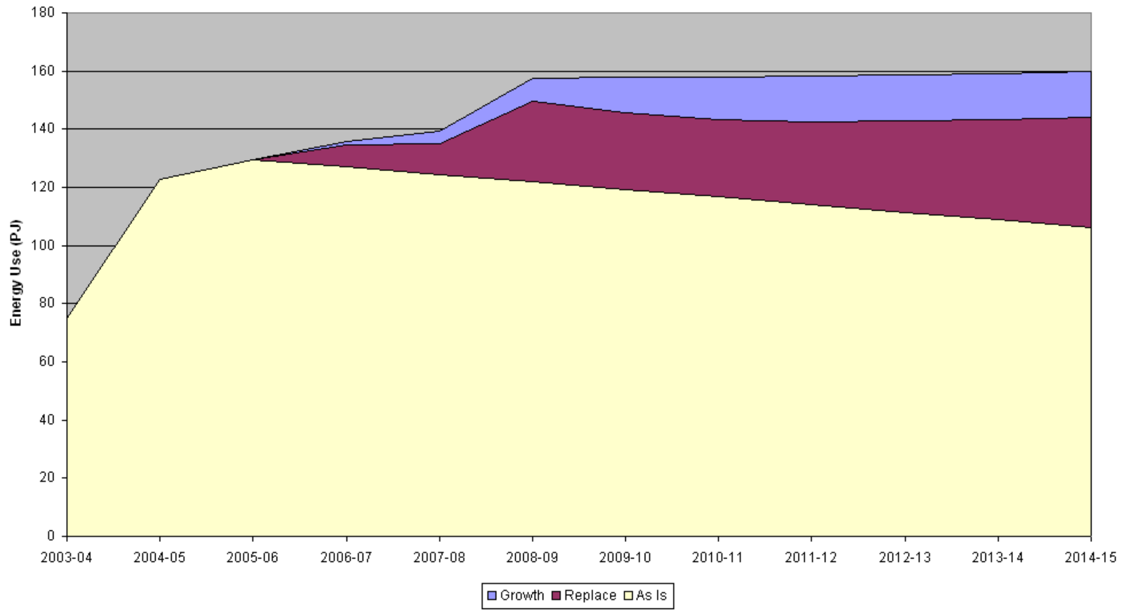
Table 7.4: Summary of Contribution of Major Projects to Gas Use

2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
1.5	4.4	7.8	12.5	14.4	15.8	15.8	15.8

- With respect to routine replacement of existing plant with new equipment, With respect to routine replacement of existing plant with new equipment, we have assumed a 40-year equipment life. We have based this assumption on the fact that, in the main, in the non-ferrous sector gas will be used to generate electricity – the average life of this equipment is relatively long.

The resulting gas baseline for the non-ferrous sector of the WA industry is illustrated in the figure below.

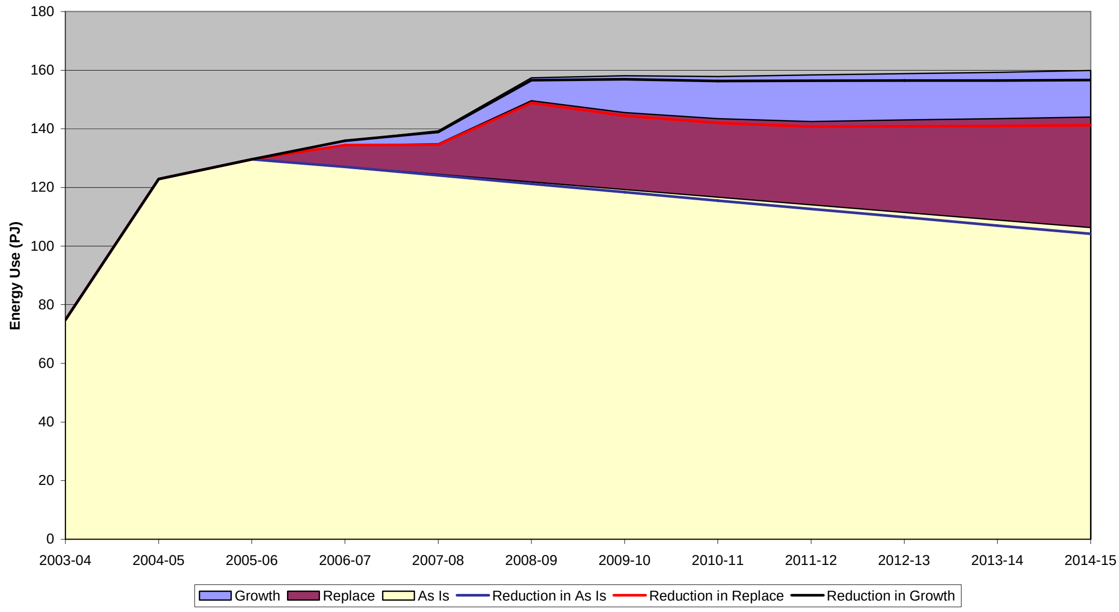
Figure 7.3: Non-ferrous Sector Baseline Gas Use



In this figure we illustrate the size of the various potential areas of influence. We then overlay on this knowledge-based assumptions of potential reductions in energy use which could result from policy initiatives in the three areas of influence. These assumptions are:

- **As Is**: has the potential to improve energy efficiency by 0.25% on a year on year basis
- **Replace**: has the potential to improve energy efficiency by 0.25% on a year on year basis
- **Growth** (new projects) have the potential to improve energy efficiency by 0.25% on a year on year basis with a one year delay as commission of plants for these projects has still to be completed and energy efficiency is unlikely to be a large driver in the initial year's of a project's implementation

Figure 7.4: Non-ferrous Sector Baseline Gas Use including consideration of Energy Efficiency Drives



The total gas use by the sector as a result of these energy efficiency drives is detailed in the table below. In this table we illustrate the total percentage decrease in gas use, relative to the projected growth rate for the industry, as a percentage decrease.

Table 7.5: Reduction in Gas use by the Non-ferrous Industry given energy efficiency improvements

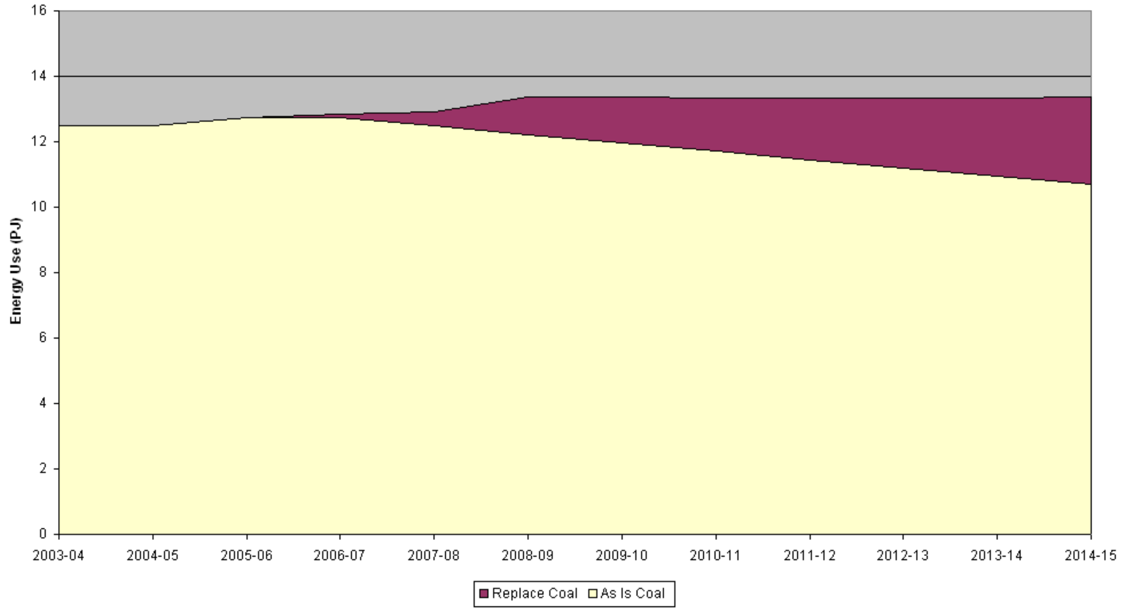
	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	135.9	139.3	157.4	158.1	157.8	158.3	158.8	159.3	159.8
Energy Efficiency Scenario (PJ)	135.9	139.0	156.6	156.9	156.3	156.4	156.4	156.5	156.7
Percentage reduction (%)	0.0	0.2	0.5	0.7	1.0	1.2	1.5	1.7	2.0

ANALYSIS OF COAL USE BY THE NON-FERROUS SECTOR

No use of coal in new growth projects was identified in the analysis. In the development of the model with respect to routine replacement of existing plant with new equipment, we have assumed a 40-year equipment life. This is typical of equipment used in this application.

The coal baseline for the Non-ferrous sector of the WA industry is illustrated in the figure below.

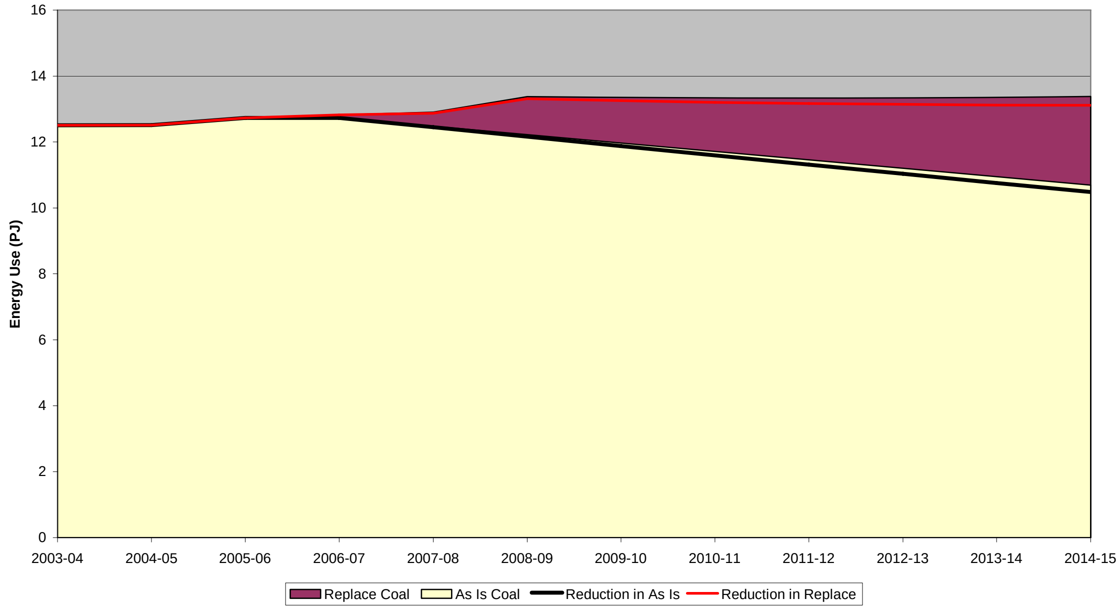
Figure 7.5: Non-ferrous Sector Baseline Coal Use



In this figure we illustrate the size of the various potential areas of influence. We then overlay on this knowledge-based assumptions of potential reductions in energy use that could result from policy initiatives in the two areas of influence. Assumptions are:

- **As Is**: has the potential to improve energy efficiency by 0.25% on a year on year basis
- **Replace**: has the potential to improve energy efficiency by 0.25% on a year on year basis

Figure 7.6: Non-ferrous Sector Baseline Coal Use including consideration of Energy Efficiency Drives



The total coal use by the sector as a result of these energy efficiency drives is detailed in the table below. In this table we illustrate the total percentage decrease in coal use, relative to the projected growth rate for the industry, as a percentage decrease.

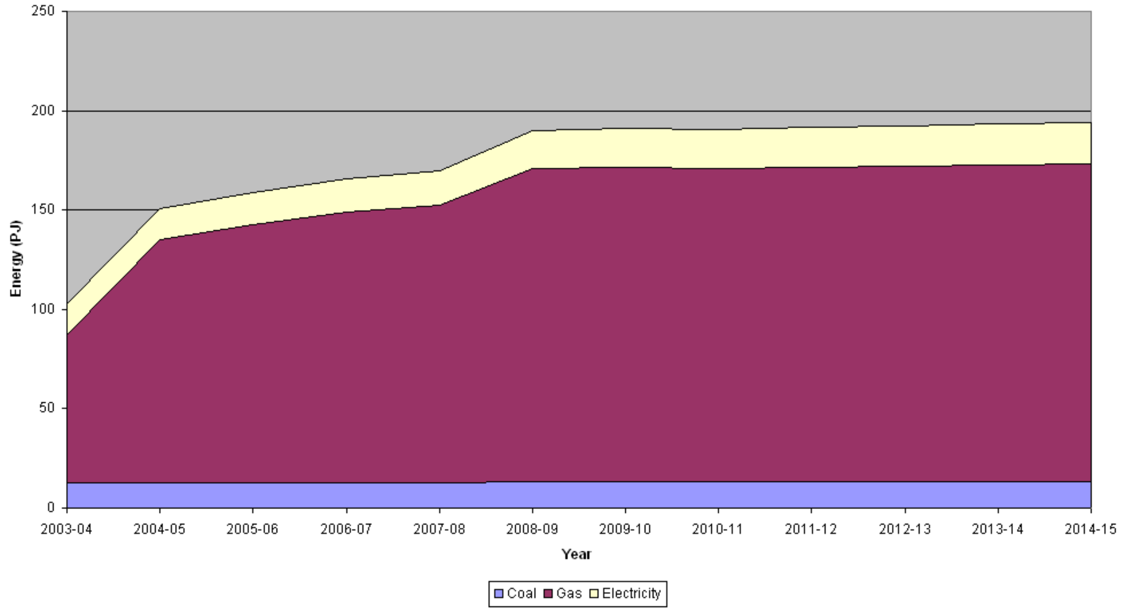
Table 7.6: Reduction in Coal use by the Non-ferrous Industry given energy efficiency improvements

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	12.8	12.9	13.4	13.4	13.3	13.3	13.3	13.3	13.4
Energy Efficiency Scenario (PJ)	12.8	12.9	13.3	13.3	13.2	13.2	13.1	13.1	13.1
Percentage reduction (%)	0.0	0.2	0.5	0.7	1.0	1.2	1.5	1.7	2.0

OVERALL NON-FERROUS INDUSTRY BASELINE

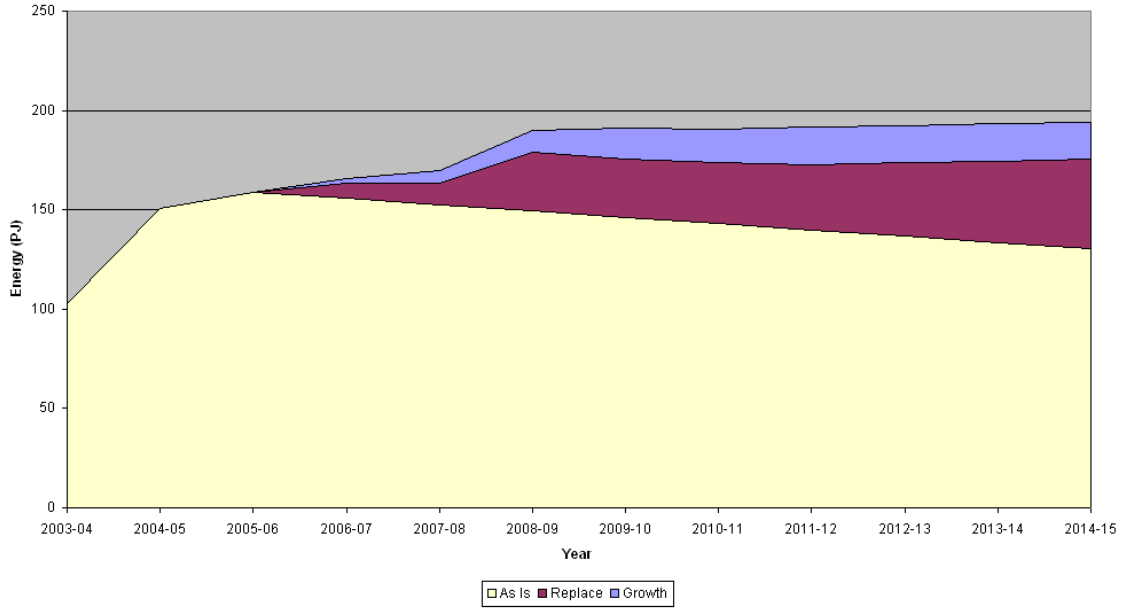
The total energy use by the Non-ferrous industry is illustrated below.

Figure 7.7 Total Energy use by the Non-ferrous sector



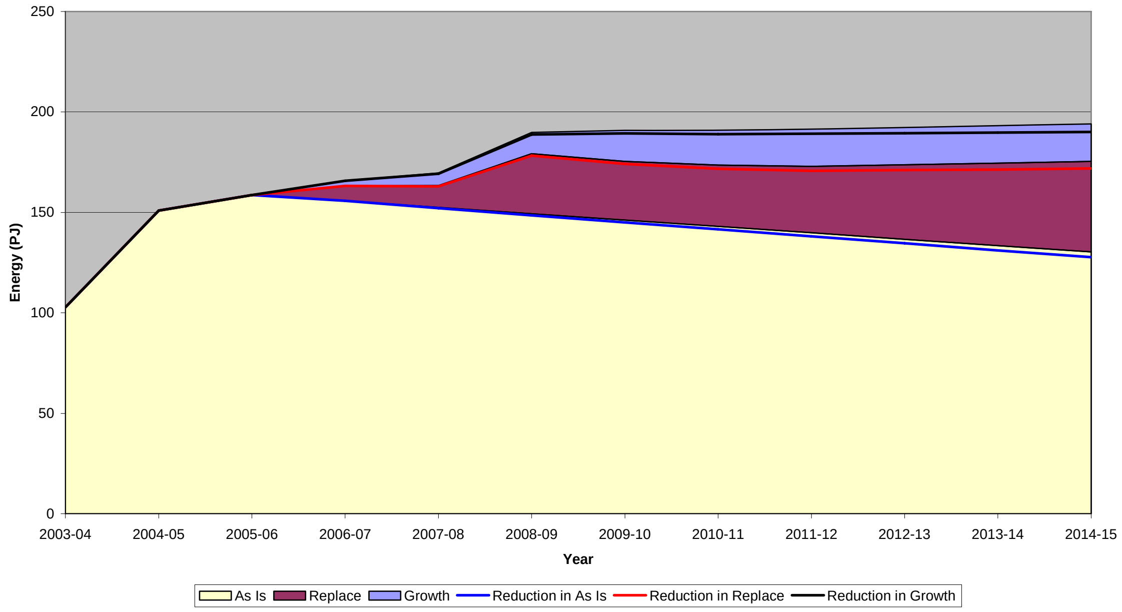
This baseline is aggregated and the areas of influence highlighted in the figure below.

Figure 7.8: Breakdown of Energy Use in the Non-ferrous Sector by area of Influence



We overlay on this amount the potential energy efficiency initiatives we highlighted previously, to give an indication of the potential areas of greatest leverage.

Figure 7.9: Breakdown of Energy Use in the Non-ferrous Sector by area of Influence including Energy Efficiency Initiatives



A summary of the percentage change in the energy use of the sector which this represents is included in the table below.

Table 7.7: Reduction in Total Energy used by the Non-ferrous Industry given energy efficiency improvements

	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

DISCUSSION

Technology Trends

The non-ferrous industry focuses on two main process types:

- Initial concentration (eg refining of bauxite to alumina),
- Final manufacturing (e.g. smelting from alumina to aluminium and fabricated products).

In the main the industry in WA is dominated by the former process type for various non-ferrous metals; limited fabricated metal products are produced by the industry, and do not include production of aluminium via smelting. The major energy users in initial concentration (for example to alumina) are:

- Materials Handling (30%)
- Process Energy (70%)

The review of potential future trend in this sector is similar to that included for the mining sector:

- Materials handling: improved management of technology through enhanced management systems, as well as improvements in controllability of technologies in this sector will also result in incremental improvements in energy use; step change technologies will manifest in the longer term (more than 30 years probably) and will be linked to the changes in mining technology listed above.
- Process energy: typically this is the production of metals in concentrate, the step change technology on the horizon in this area is improved management of material through mine to mill programs which have the potential to minimize energy used in crushing, grinding and milling. In the short to medium term covered by this assessment improvements in energy efficiency are likely to be incremental and linked to improved management and control of systems, similar to the case of materials handling listed above. With specific reference to the bauxite to alumina processes, improvements in these will be through improved crystallization processes – any changes in these are likely to be incremental in the near to medium term. Given that productivity of these processes is linked directly to these reactions companies in this industry are likely to pay adequate attention to developments in this area as part of good business practices.

Summary of EEI Areas & Policy Implications

Incremental improvement in energy use in this sector is linked to the following areas:

- Improved management and enhanced management systems
- Improved and optimised process control
- Installation and optimal control of variable speed drives
- Installation of high efficiency motors

The implications for policy development are thus:

- Assist companies to develop and apply robust and proactive energy management systems
- Support a culture of proactive energy management in companies
- Develop generic design and procurement guidelines for typical energy efficiency applications of VSDs and HEMs with specific reference to case studies for this sector.

2-year & 6-Year Paybacks

In general, we are of the view that the potential savings in this sector are more likely to be available at the 0-2 year payback linked to improved management and control of processes, and less available at 2-6 year paybacks given significant new technology installed or planned that is likely to be at or close to best practice. We take 80% of EEI potential to be at 0-2 year PB. Hence:

- EEI Potential estimate at 0-2 year payback = 3.12 PJ
- EEI Potential estimate at 2-6 year payback = 0.78 PJ

8. Non-Metallic Minerals

BASELINE ENERGY USAGE

The baseline information for all sectors assessed has been drawn from the ABARE WA Timeseries report data. This information is included in the table below as it relates to stationary energy in the non-metallic minerals sector. The information included in this table is a projection of the energy requirements of the Non-metallic minerals sector to 2015. No information was available in the Timeseries report data on growth in electricity demand in this sector, hence electricity is not considered further for this sector.

Table 8.1: Baseline Energy Use for the Non-metallic minerals Sector

Fuel	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Fuel	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
Coal	7.5	7.5	7.6	7.7	7.7	7.8	7.9	7.9	7.9	8.0	8.0	8.0
Gas	14.5	14.8	15.4	15.8	16.3	16.9	17.2	17.6	17.9	18.2	18.5	18.9
Total	22.0	22.3	23.0	23.5	24.0	24.7	25.1	25.5	25.8	26.2	26.5	26.9

We have analysed each of these fuel types separately. No new major new projects were identified in the sector by the Western Australian Department of Industry and Resources (updated in March 2006), so we use our expertise in the area of energy efficiency to present a baseline which is divided into two main areas of influence:

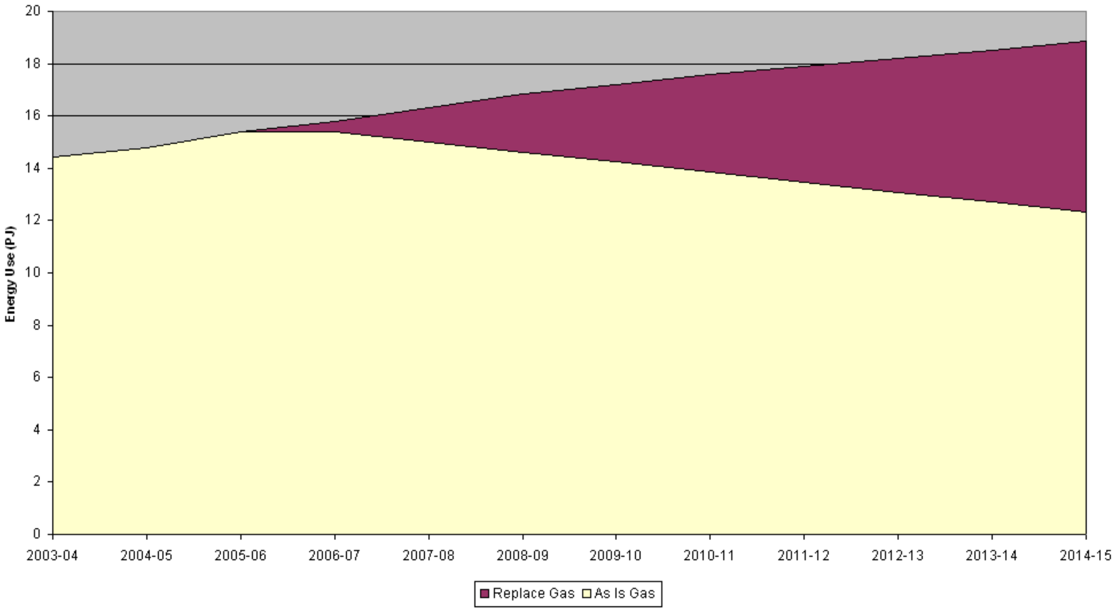
- **As Is** technology: which represents the technology in place in the industry that is expected to remain in place throughout the baseline period;
- **Replacement** technology: which is an indication of the technology in place in the industry which will be changed through routine replacement (maintenance, end of useful life etc); and

ANALYSIS OF GAS USE BY THE NON-METALLIC MINERALS SECTOR

With respect to routine replacement of existing plant with new equipment, we have assumed a 40 year equipment life. We have based this assumption on the fact that, in the main, in the non-metallic minerals sector gas will be used to fire kilns and dryers. The average life of this equipment is relatively long.

The resulting gas baseline for the non-metallic minerals sector of the WA industry is illustrated in the figure below.

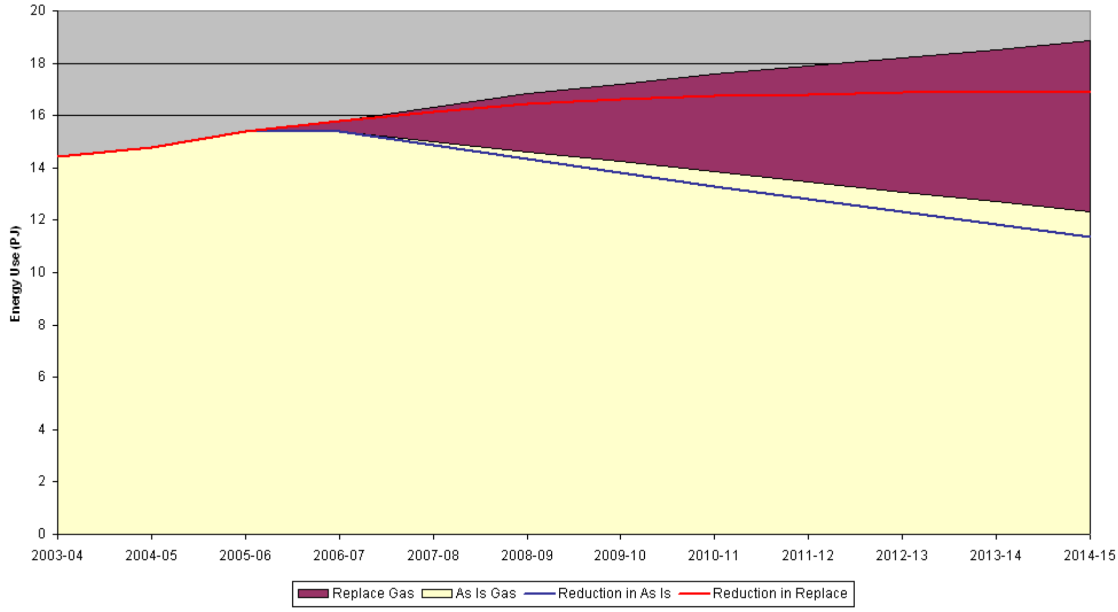
Figure 8.1: Non-metallic minerals Sector Baseline Gas Use



In this figure we illustrate the size of the various potential areas of influence. We then overlay on this knowledge-based assumptions of potential reductions in energy use that could result from policy initiatives in the three areas of influence. These assumptions are:

- **As Is**: has potential to improve energy efficiency 1% on a year on year basis
- **Replace**: has potential to improve energy efficiency 2% year on year

Figure 8.2: Non-metallic minerals Sector Baseline Gas Use including consideration of Energy Efficiency Drives



The total gas use by the sector as a result of these energy efficiency drives is detailed in the table below. In this table we illustrate the total percentage decrease in gas use, relative to the projected growth rate for the industry, as a percentage decrease.

Table 8.2: Reduction in Gas use by the Non-metallic minerals Industry given energy efficiency improvements

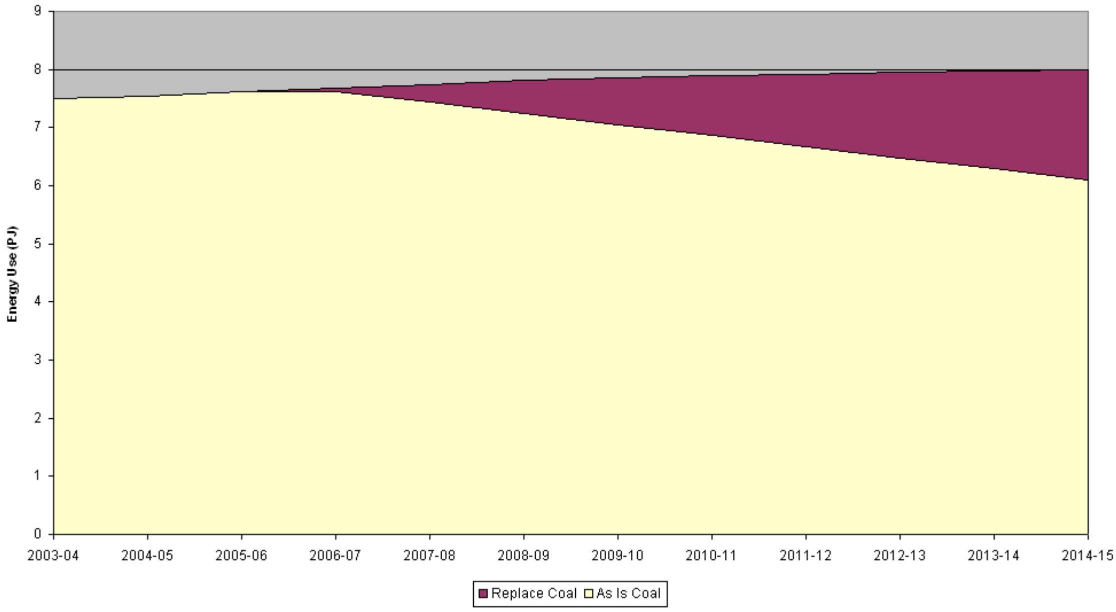
	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	15.8	16.3	16.8	17.2	17.6	17.9	18.2	18.5	18.8
Energy Efficiency Scenario (PJ)	15.8	16.1	16.5	16.6	16.7	16.8	16.9	16.9	16.9
Percentage reduction (%)	0.0	1.1	2.2	3.5	4.7	6.1	7.4	8.8	10.2

ANALYSIS OF COAL USE BY THE NON-METALLIC MINERALS SECTOR

In building the model, we have assumed a 40 year equipment life with respect to routine replacement of existing plant with new equipment for coal use. This is suggested to be typical of this industry.

The resulting coal baseline for the non-metallic minerals sector of the WA industry is illustrated in the figure below.

Figure 8.3: Non-metallic minerals Sector Baseline Coal Use

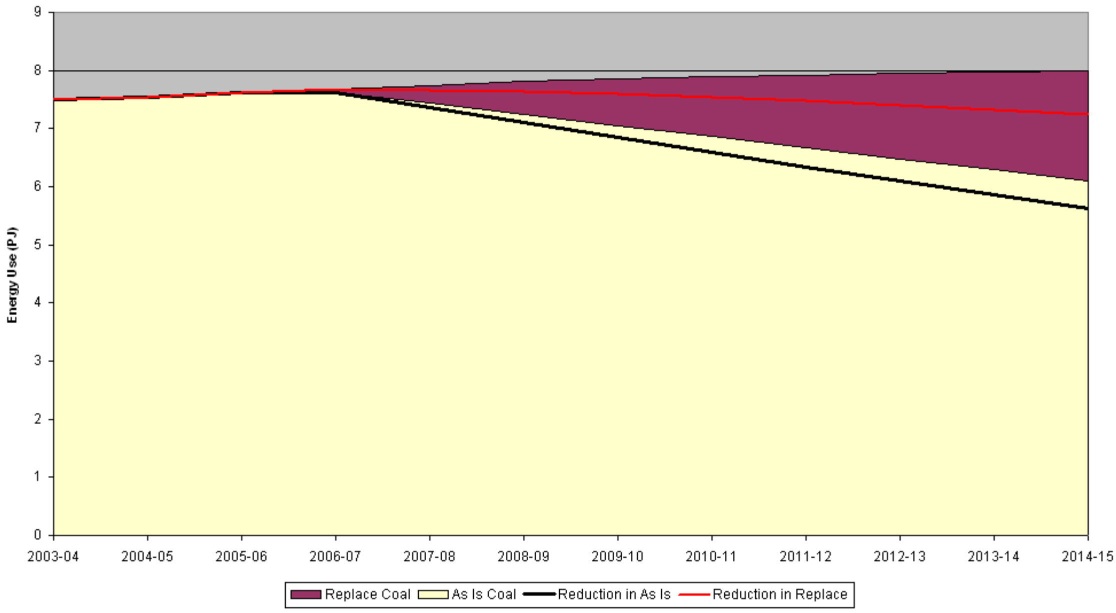


In this figure we illustrate the size of the various potential areas of influence. We then overlay on this knowledge-based assumptions of potential reductions in energy use that could result from policy initiatives in the three areas of influence. These assumptions are:

- **As Is**: has the potential to improve energy efficiency by 1% on a year on year basis
- **Replace**: has the potential to improve energy efficiency by 2% on a year on year basis

The resulting energy use projection is included in the figure below.

Figure 8.4: Non-metallic minerals Sector Baseline Coal Use including consideration of Energy Efficiency Drives



The total coal use by the sector as a result of these energy efficiency drives is detailed in the table below. In this table we illustrate the total percentage decrease in coal use, relative to the projected growth rate for the industry, as a percentage decrease.

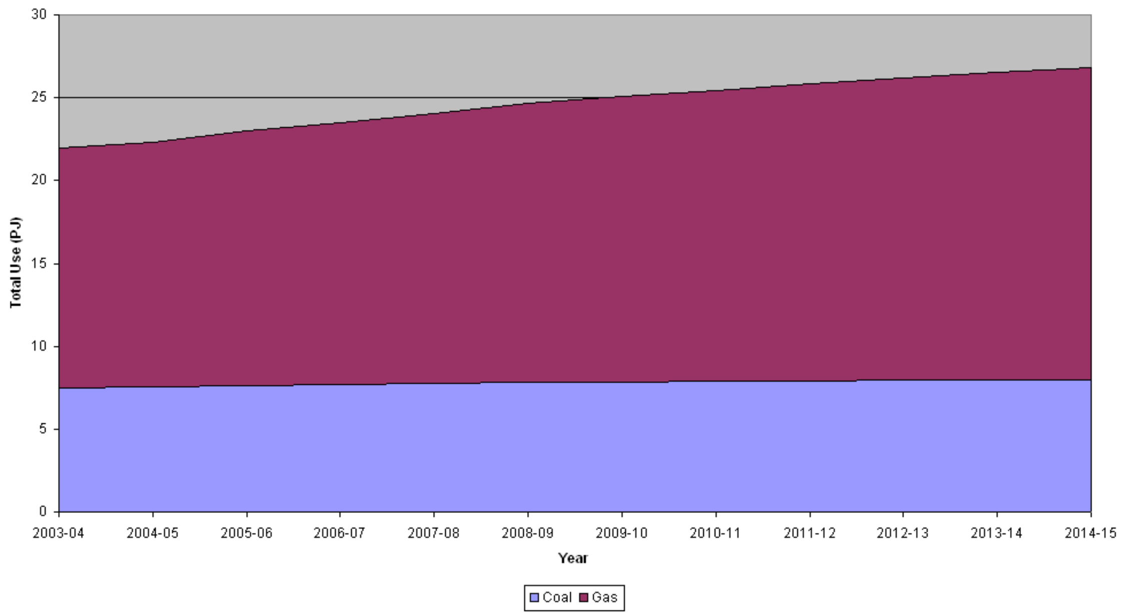
Table 8.3: Reduction in Coal use by the Non-metallic minerals Industry given energy efficiency improvements

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	7.7	7.7	7.8	7.8	7.9	7.9	7.9	8.0	8.0
Energy Efficiency Scenario (PJ)	7.7	7.7	7.6	7.6	7.5	7.5	7.4	7.3	7.2
Percentage reduction (%)	0.0	1.0	2.1	3.3	4.4	5.6	6.9	8.1	9.4

OVERALL NON-METALLIC MINERALS INDUSTRY BASELINE

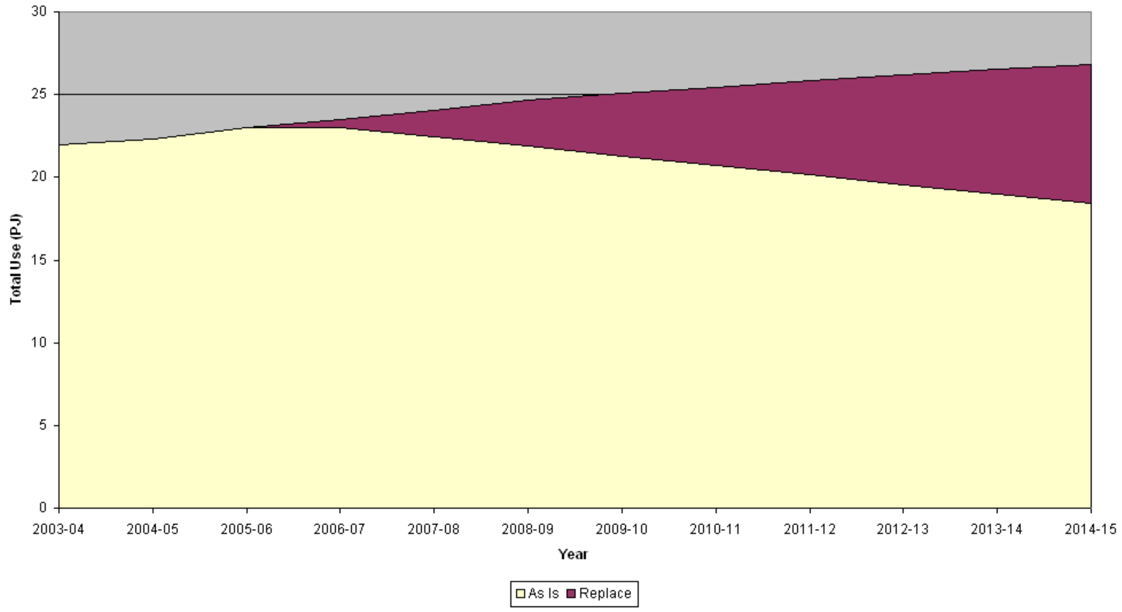
The total energy use by the non-metallic minerals industry is illustrated below.

Figure 8.5: Total Energy use by the Non-metallic minerals sector



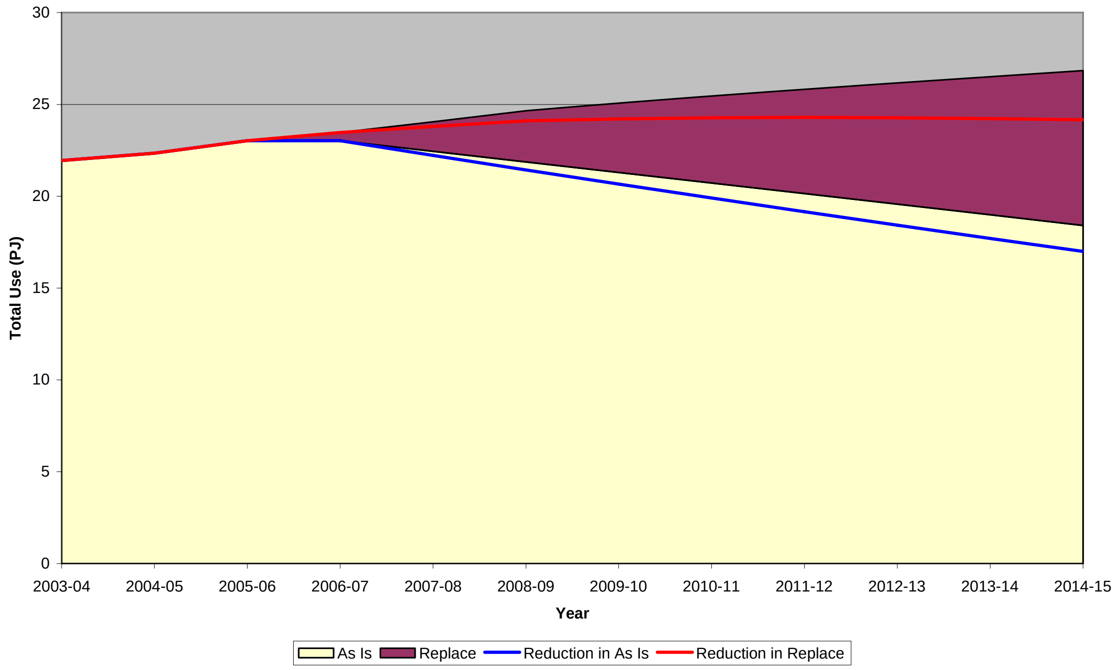
This baseline is aggregated and the areas of influence highlighted in the figure below.

Figure 8.6: Breakdown of Energy Use in the Non-metallic minerals Sector by area of Influence



We overlay on this amount the potential energy efficiency initiatives we highlighted previously, to give an indication of the potential areas of greatest leverage.

Figure 8.7: Breakdown of Energy Use in the Non-metallic minerals Sector by area of Influence including Energy Efficiency Initiatives



A summary of the percentage change in the energy use of the sector which this represents is included in the table below.

Table 8.4: Reduction in Total Energy used by the Non-metallic minerals Industry given energy efficiency improvements

	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

DISCUSSION

Technology Trends

Our assessment indicates that the non-metallic minerals sector in WA is dominated by a few sites involved in the manufacture of cement, lime, bricks and tiles. Cockburn Cement is by far the largest producer of cement and lime in the state with around 0.6 Mt cement & 0.9 Mt lime output per year, cement production in the state is augmented by a couple of clinker grinding sites using imported clinker; Midland Bricks (Boral) operates the largest brick manufacturing site in the world, and the Brickworks / Austral Bricks site is of a comparable size. Drawing on typical energy intensity figures for lime production, integrated cement production, clinker grinding, brick and tile manufacturing, we estimate that these few sites account for about two-thirds to three-quarters of the total energy use pa of the sector. Consequently it might reasonably be expected that EEI potential in the sector will be mainly influenced by potential energy management improvements, productivity enhancements and technology replacement at these sites. These may include, for example:

- Replacement of old kilns with newer technology, incorporating improved combustion technology, automated process controls, increased throughput, better heat distribution and recovery,
- Burner upgrade / replacement,
- Plant utilization / availability improvements,
- Enhancement of burner controls and heat recovery for existing kilns and dryers,
- Increased contribution of supplementary cementitious materials (SCM) in cement output,
- Conversion from wet to dry kiln process in cement manufacture if applicable,

With a few sites dominating energy usage and potential EEI, and with plant having a relatively long service life, it is likely that the true nature, timing and scope of improvement will be best identified through direct consultation with the major users. At this high level, a 2.5% pa plant replacement would result in some 8.4 PJ of the 2015 baseline being influenced by this category. A 2% pa improvement in efficiency would give a 1.3 PJ energy improvement by 2015, equal to 15% compared with the baseline. Of this we would expect roughly equal contribution by actions with under and over 2 year paybacks, and would assume that good or best practice is generally selected owing to the long life of equipment. A 7-8% overall improvement against the 2015 baseline is implied by a 1% pa improvement to the “As Is” area of influence. We expect that a significant amount – 75%+ - of this potential is available at paybacks exceeding 2 years, and that 3-6 years would be typical for many retrofit / replacement projects.

We believe these levels of improvement are reasonably conservative expectations where next-generation technologies and enhanced energy management focus are applied. The degree to which these savings potentials represent "beyond-BAU" levels will rely to a degree on current (and EEO-driven) internal approaches to energy management and best practice technology adoption, and the degree (if any) to which ABARE forecasts incorporate assumptions regarding energy efficiency improvement in the sector.

Summary of EEI Areas & Policy Implications

In summary, improvement in energy use in the non-metallic minerals sector are linked to the following areas:

- Improved management and enhanced management systems
- Improved and optimised process control
- Adoption of best practice technologies when replacing / augmenting major plant

The implications for policy development are thus:

- Support early adoption of best practice technology or BP technology on replacement of plant
- Assist companies to develop and apply robust and proactive energy management systems
- Support a culture of proactive energy management in companies

2-year & 6-Year Paybacks

As indicated above, of the total EEI potential of 2.68 PJ, approximately 50% is available in the "Replace" influence and 50% in the "As Is" area. Within the "Replace" area we expect that 50% is available at under 2 year payback and 50% at over 2 year payback. Within the "As Is" area we expect that 25% is available at under 2 year payback and 75% at over 2 year payback. Hence:

- EEI Potential estimate at 0-2 year payback = 1.005 PJ
- EEI Potential estimate at 2-6 year payback = 1.675 PJ

9. Commercial

BASELINE ENERGY USAGE

The baseline information for all sectors assessed has been drawn from the ABARE WA Timeseries report data. This information is included in the table below as it relates to stationary energy in the commercial sector. The information included in this table is a projection of the energy requirements of the commercial sector to 2015.

Table 9.1: Baseline Energy Use for the commercial Sector

Fuel	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Fuel	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
Gas	2.8	2.9	3.0	3.1	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0
Elec	16.9	17.3	18.2	18.9	19.7	20.6	21.4	22.1	22.9	23.7	24.5	25.3
Total	19.7	20.2	21.2	22	23	24	24.9	25.7	26.6	27.5	28.4	29.3

We have analysed each of these fuel types together. Drawing on work by EMET[4] consultants as input to the NFEE process, the commercial sector can be defined by:

- ANZSIC Div K & L – Finance & Insurance / Property & Business Services
- ANZSIC Div F & G – Wholesale Trade / Retail Trade
- ANZSIC Div M, N, O – Govt Admin / Education / Heath & Community
- ANZSIC Div H – Accommodation, Cafes & Restaurants
- ANZSIC Div P & Q – Culture & recreation / Personal & other services
- ANSZIC Div J – Communication services

This report suggests that it is reasonable to attribute growth in forecast energy use to new building / commercial space, and that current energy use will be replaced or refurbished at a rate of 4% pa.

Hence as per other sector analyses we can present a baseline that is divided into three main areas of influence:

- **As Is** technology: which represents the technology in place in the sector that is expected to remain in place throughout the baseline period;
- **Replacement** technology: which is an indication of the technology/facilities in place in the sector which will be refurbished or changed through routine replacement (end of useful life etc) – per the above note, we expect that this is a very significant area for influence over the period to 2015; and
- **Growth**: which is represented mainly by the new commercial space.

[4] 2004: SEAV - Energy Efficiency Improvement in the Commercial Sub-Sectors, EMET Consultants Pty Ltd, Version 1.3, February 2004

ANALYSIS OF ELECTRICITY & GAS USE BY THE COMMERCIAL SECTOR

With respect to routine replacement of existing appliances with new equipment, we have assumed a 25-year equipment life (i.e. 4% replacement per year). Commercial sector equipment will have a wide range of replacement frequency from less than 1 year for say incandescent or halogen lights in the retail sector, to well over 25 years for say some HVAC equipment or building facades.

The resulting baselines for the WA commercial sector are illustrated below.

Figure 9.1: Commercial Sector Baseline Electricity Use

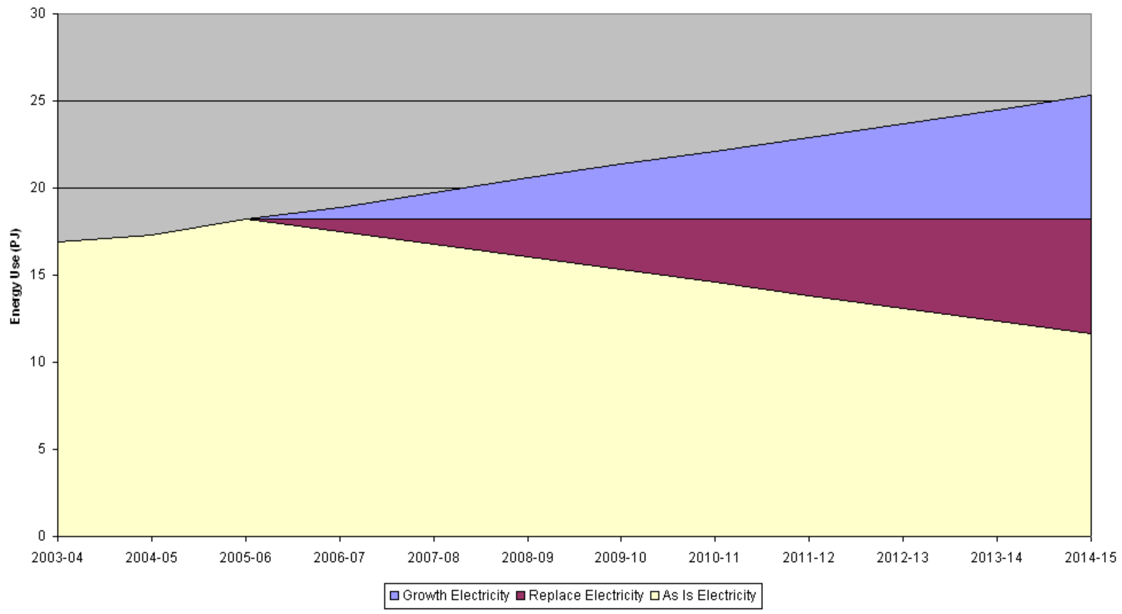
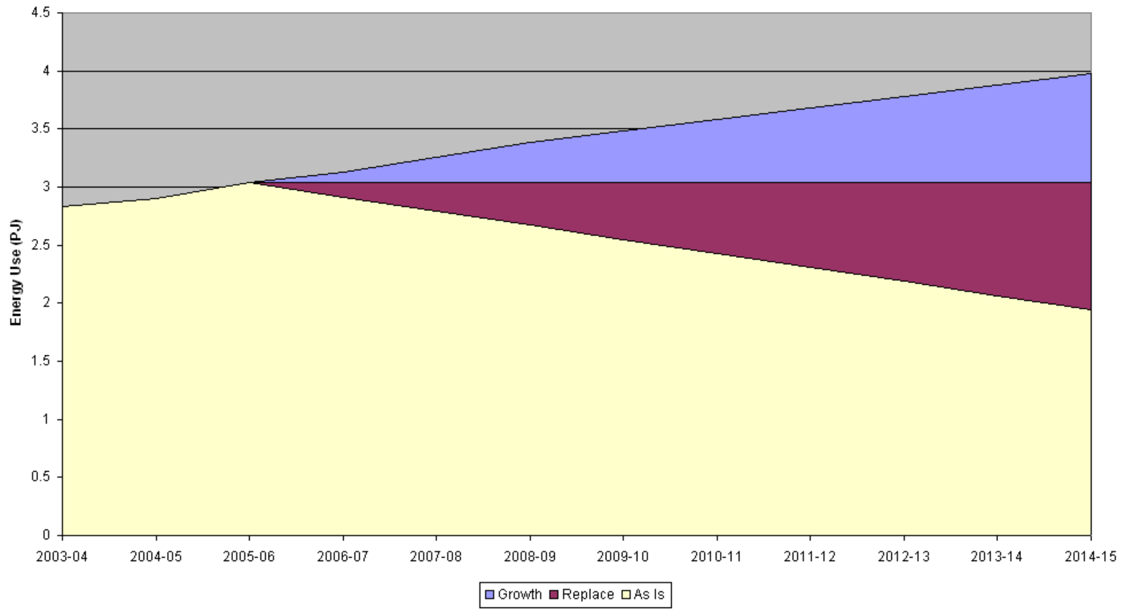


Figure 9.2: Commercial Sector Baseline Gas Use



This gives a total baseline as shown below.

Figure 9.3: Total Energy use by the Commercial sector

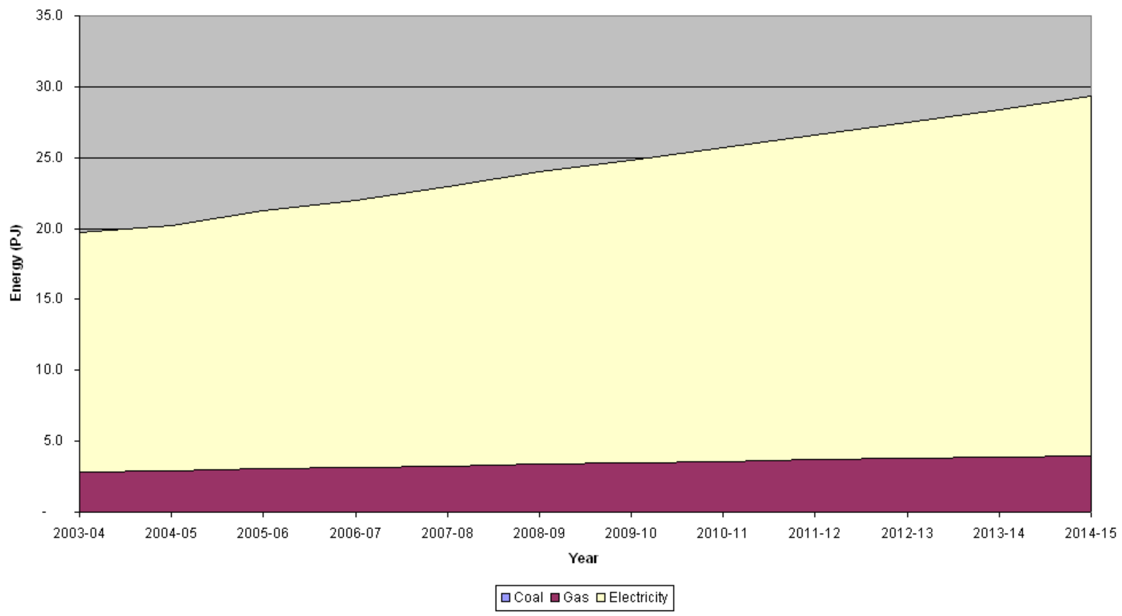
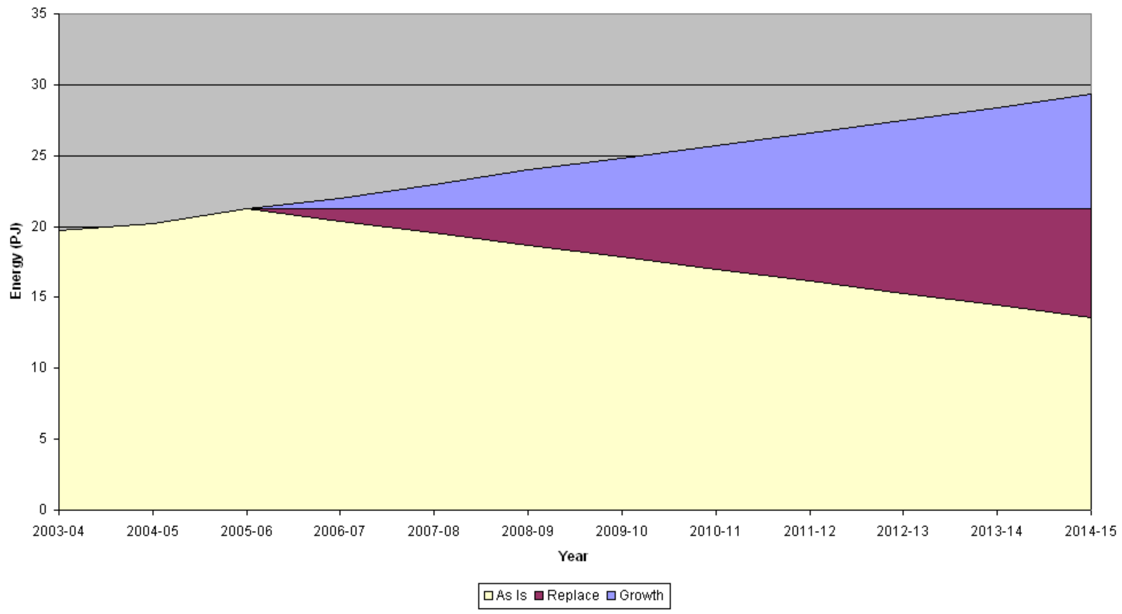


Figure 9.4: Breakdown of Energy Use in the Commercial Sector by area of Influence



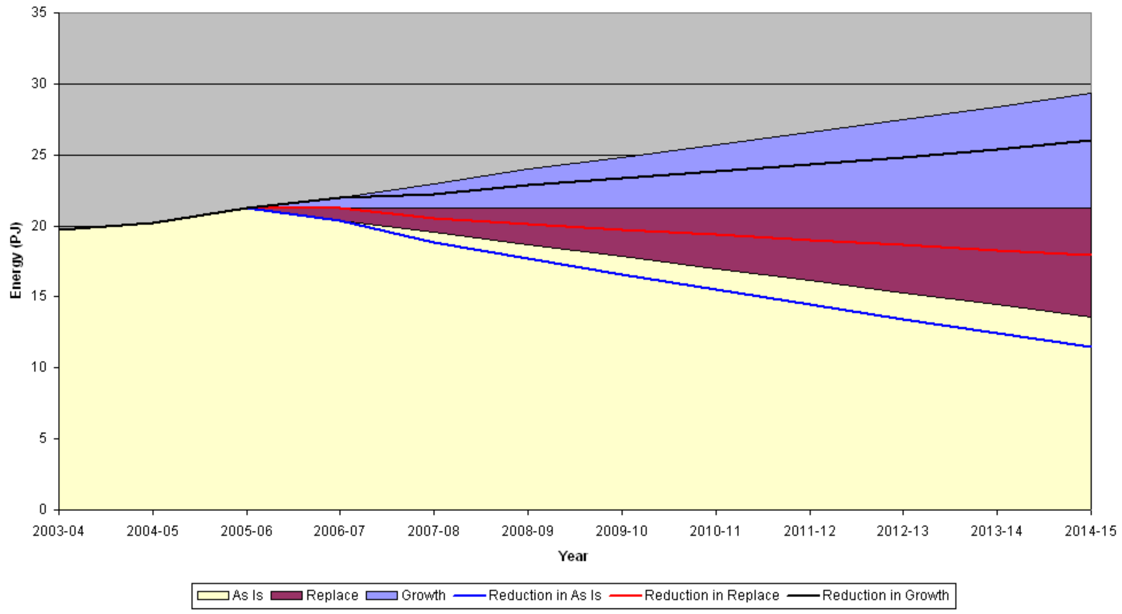
In the above figures we then illustrate the size of the potential influence of EEI measures. To do this we have drawn on the NFEE work by EMET. For simplicity we have assumed that in general the nature and impact of measures at the national level can be applied to the WA context. For the "Raw" EEI potential identified in this work, 94% is associated with non-HVAC systems, excepting as may be implied by their assumed potential improvements to new buildings. Almost 50% of their total EEI potential is identified to be associated with behavioural change, and 25% with improved lighting technology and control. There would be every reason to suggest that improvements of this nature have the same applicability in WA as in other states. In fact, with known significant improvements made by some retailers in Eastern states, government energy efficiency programs (including >$100 million in Energy Performance contracts) across NSW & QLD, a growing ABGR market in other states and other initiatives such as Building Tune-Up programs in Adelaide, there is anecdotal evidence at least to suggest that identified EEI potential may perhaps understate the potential in WA.

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 we assume they believe this will be implemented under a BAU scenario. This would suggest that all of the beyond-BAU potential will be realized via improvements as equipment is replaced, or via retrofit or behavioural improvement.

On this basis we assume that the total beyond-BAU EEI potential, applied to WA (electricity and gas combined) is equal to 3.31 PJ, or 11.3% of baseline energy usage. This is equivalent to about a 1.9% saving per year for both main fuel sources.

We illustrate below the total potential for gas and electricity.

Figure 9.5: Commercial Sector Baseline Energy Use including consideration of Energy Efficiency



The total energy use by the sector as a result of these energy efficiency drives is detailed in the tables below. In these tables we illustrate the total percentage decrease in electricity and gas use, relative to the projected growth rate for the sector, as a percentage decrease.

Table 9.2: Reduction in Electricity use by the Commercial sector given energy efficiency improvements

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	18.9	19.7	20.6	21.4	22.1	22.9	23.7	24.5	25.3
Energy Efficiency Scenario (PJ)	18.9	19.0	19.6	20.0	20.5	20.9	21.4	21.9	22.5
Percentage reduction (%)	0.0	3.5	4.9	6.3	7.5	8.6	9.7	10.6	11.4

Table 9.3; Reduction in Gas use by the Commercial sector given energy efficiency improvements

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	3.1	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0
Energy Efficiency Scenario (PJ)	3.1	3.2	3.3	3.3	3.4	3.4	3.4	3.5	3.5
Percentage reduction (%)	0.0	1.8	3.4	4.9	6.3	7.5	8.7	9.8	10.9

A summary of the percentage change in the energy use of the sector which this represents is included in the table below.

Table 9.4: Reduction in Total Energy used by the Commercial Sector given energy efficiency improvements

	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

DISCUSSION

Technology trends

According to the EMET study the following is identified to be achievable in terms of EEI potential across Australia:

Raw EEI potential at a combined 2-year payback is 80.5 PJ, while raw EEI potential at a combined 6-year payback is 102.9 PJ. Approximately three-quarters of this is available on a simple 2 and 6-year payback, while 70% of total raw potential is taken to be beyond-BAU. This suggests at a very simple level that beyond-BAU EEI potential of 42 PJ at 2-year payback and 54 PJ at 6-year payback is available. Based on simple extrapolation (i.e. assuming the take-up of BAU opportunities versus beyond-BAU opportunities is at the same relative level) this indicates 2.6 PJ savings beyond-BAU at 2-year payback in WA and 3.3 PJ savings beyond-BAU at 6-year payback in WA.

Summary of EEI Areas & Policy Implications

According to the EMET analysis the key sectors in terms of savings potential are Retail, Government and Office Accommodation, with over 80% of total EEI potential. According to their analysis, incremental improvements in energy use in the commercial sector are linked to the following areas:

- Behavioural change & better awareness
- Improved technology and control, particularly lighting systems
- Hot water systems loss reduction and technology
- To a lesser extent, HVAC improvements and new building design

The implications for policy development are thus:

- Information dissemination, particularly to Retail sector organisations
- Developing government energy efficiency response – eg through Energy Performance Contracting
- Building tune-up programs, ABGR / Green Star requirements for new buildings and government-occupied buildings / tenancies

2-year & 6-Year Paybacks

As indicated above, a very simple interpretation of the NFEE input data for the Commercial sector, applied to WA, could suggest that of the total 2015 EEI potential of 3.3 PJ at 6-year PB, some 2.6 PJ (78%) is available at paybacks of 2 years and under. This would of course imply that the significant contribution to overall savings from behavioural change and awareness practices are no more likely to be undertaken at a BAU level than other measures – i.e. retrofits or new technology. Based on our experience over the last several years, including facilitation of $50 million in Energy Performance Contracts in government, supporting commercial sector participants in SEDA's Energy Smart Business Program, supporting government agencies, and being the Energy Manager for a number of major commercial and retail sector participants, we believe that this is a reasonable assumption.

Hence:

- EEI Potential estimate at 0-2 year payback = 2.6 PJ
- EEI Potential estimate at 2-6 year payback = 0.7 PJ

10. Residential

BASELINE ENERGY USAGE

The baseline information for all sectors assessed has been drawn from the ABARE WA Timeseries report data. This information is included in the table below as it relates to stationary energy in the residential sector. The information included in this table is a projection of the energy requirements of the residential sector to 2015.

Table 10.1: Baseline Energy Use for the residential Sector

Fuel	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Fuel	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ	PJ
Gas	8.7	9.0	9.4	9.6	10.0	10.4	10.6	10.8	11.1	11.3	11.4	11.6
Elec	15.5	15.7	16.2	16.6	17.1	17.6	18.0	18.4	18.9	19.3	19.8	20.2
Total	24.2	24.7	25.6	26.2	27.1	28	28.6	29.2	30	30.6	31.2	31.8

We have analysed each of these fuel types together. The growth in energy use for both electricity and gas is assumed to be mainly the result of new housing starts at about 21,000 to 22,000 per year, or a little over 2.5% annual growth.

If we take it that new housing uses (on average across WA) 5,000 kWh of electricity and 10 GJ of gas per year, which is consistent with average energy use for existing housing stock, then the projected increase in energy use is fully accounted for by this activity. This would then imply that future energy use by existing stock would remain static, though this could reflect a combination of replacement of appliances with more efficient stock together with an overall increase in the number of energy using appliances.

We present a baseline which is divided into three main areas of influence:

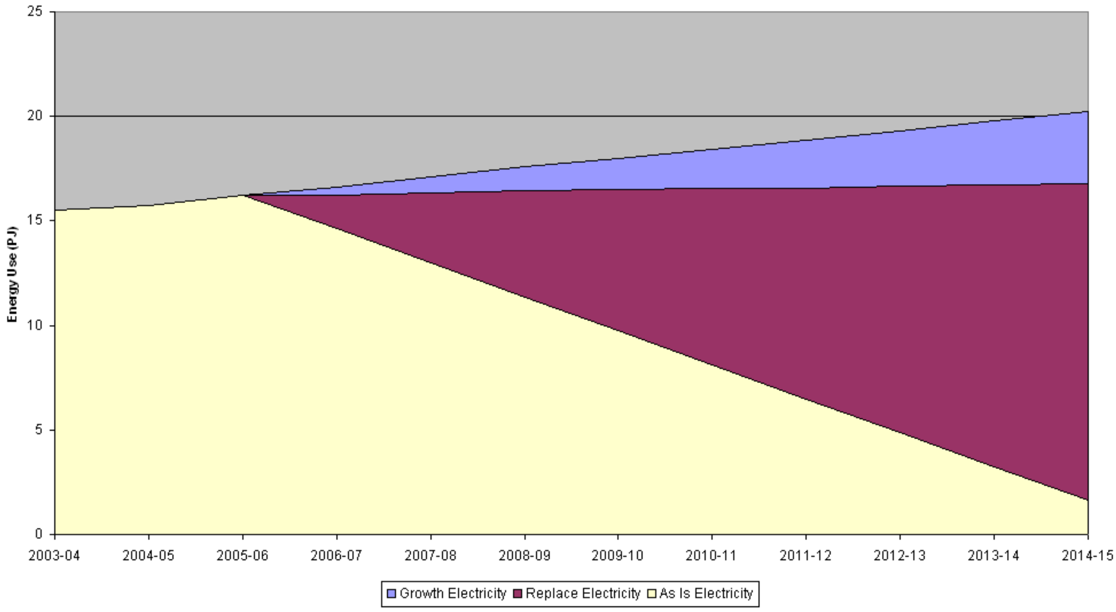
- **As Is** technology: which represents the technology in place in the sector that is expected to remain in place throughout the baseline period – in general we would expect that residential appliances has a shorter average replacement cycle than in the commercial and industrial sectors, so this area of influence will be small relative to other sectors;
- **Replacement** technology: which is an indication of the technology in place in the sector which will be changed through routine replacement (end of useful life etc) – per the above note, we expect that this is a very significant area for influence over the period to 2015; and
- **Growth**: which is represented mainly by the new housing starts as noted above.

ANALYSIS OF ELECTRICITY & GAS USE BY THE RESIDENTIAL SECTOR

With respect to routine replacement of existing appliances with new equipment, we have assumed a 10 year equipment life. Residential equipment will have a wide range of replacement frequency from less than 1 year for say incandescent lights, to well over 10 years for say some cookers or hot water systems *(we note that this figure is selected mainly to illustrate the potential magnitude of replacement over the assessment period – since overall EMET[5] and GWA[6] EEI findings are drawn on to estimate WA potential across all influence categories, the selection of this replacement rate does not have a bearing on the EEI potential. More detailed information regarding assumed replacement rates and opportunities from retrofit / replacement options for various residential end-uses are available from these reports)*. We note that the replacement of say shower heads or the retrofit of insulation could be in the "As Is" area of influence rather than the "Replace" area of influence, however for simplicity at this level of assessment (i.e. not splitting energy use by hot water or heating/cooling appliances into the 2 areas of influence) we will assume that all equipment / appliance related residential energy efficiency measures fall into the "Replace" area. Work by others such as EMET Consultants (EMET) and George Wilkenfeld & Associates (GWA) as input to the National Framework for Energy Efficiency (NFEE) can presumably be disaggregated to the level of Energy Efficiency Improvement (EEI) potential in WA and into more refined areas of influence, and the measures that potentially apply in the residential sector are sufficiently well defined to enable the correct distinction to be made.

The resulting baselines for the WA residential sector are illustrated below.

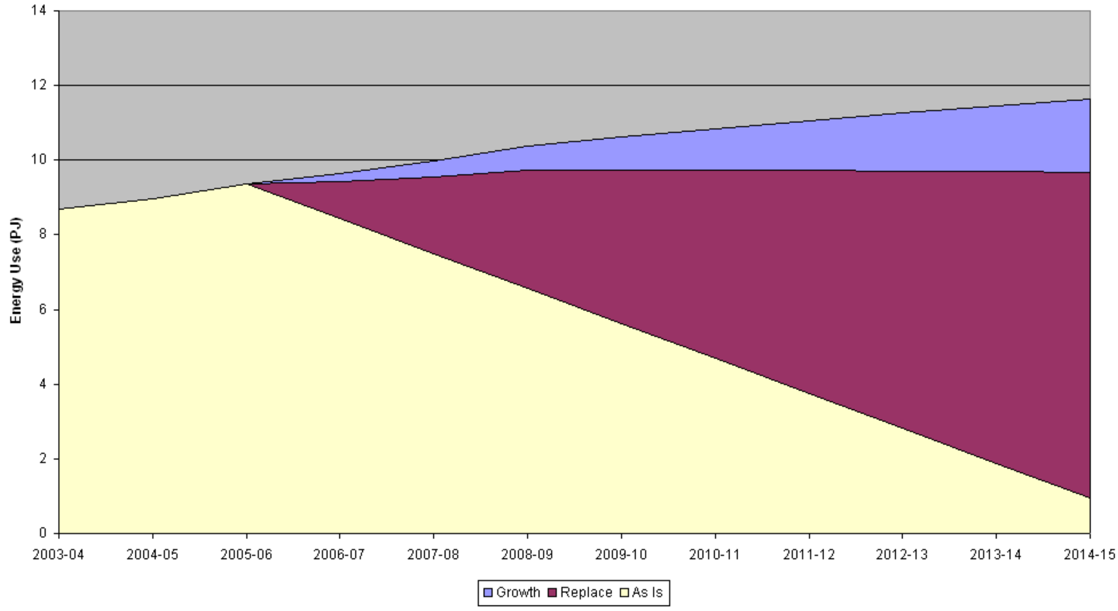
Figure 10.1: Residential Sector Baseline Electricity Use



[5] 2004: SEAV – Energy Efficiency Improvement in the Residential Sector, EMET Consultants Pty Ltd, Version 1.4, April 2004

[6] 2004: SEAV – NFEE: Energy efficiency improvement potential case studies, residential water heating. Report to the Sustainable Energy Authority Victoria by George Wilkenfeld and Associates Pty Ltd, February 2004

Figure 10.2: Residential Sector Baseline Gas Use



In the above figures we then illustrate the size of the potential influence of EEI measures. To do this we have mainly drawn on the NFEE work by EMET & GWA. For simplicity we have assumed that in general the nature and impact of measures at the national level can be applied to the WA context. For the estimated energy efficiency gains identified in these studies relating to more efficient water use (24%), and more efficient electrical appliances (20%), this is likely to be the case. The national potential estimates for gas heating and hot water technologies may be skewed somewhat towards EEI potential in Victoria given the much higher heating energy use per house there compared with other states – hence application to the WA context may tend to overstate the potential in these areas. We assume for the purpose of this study that this influence is not material to overall potential.

On this basis, we determine that the EEI potential in the residential sector is about 9% to 10% reduction in electricity use and 18% reduction in gas use compared with the 2015 baseline projection. We have not sought, in relation to each discrete measure identified by other studies, to disaggregate their identified potential into the three areas of influence here. Rather we illustrate below the total potential for gas and electricity, and note further below each of the identified measures together with the one or more areas of influence they could feasibly fall into.

Figure 10.3: Residential Sector Baseline Electricity Use including consideration of Energy Efficiency

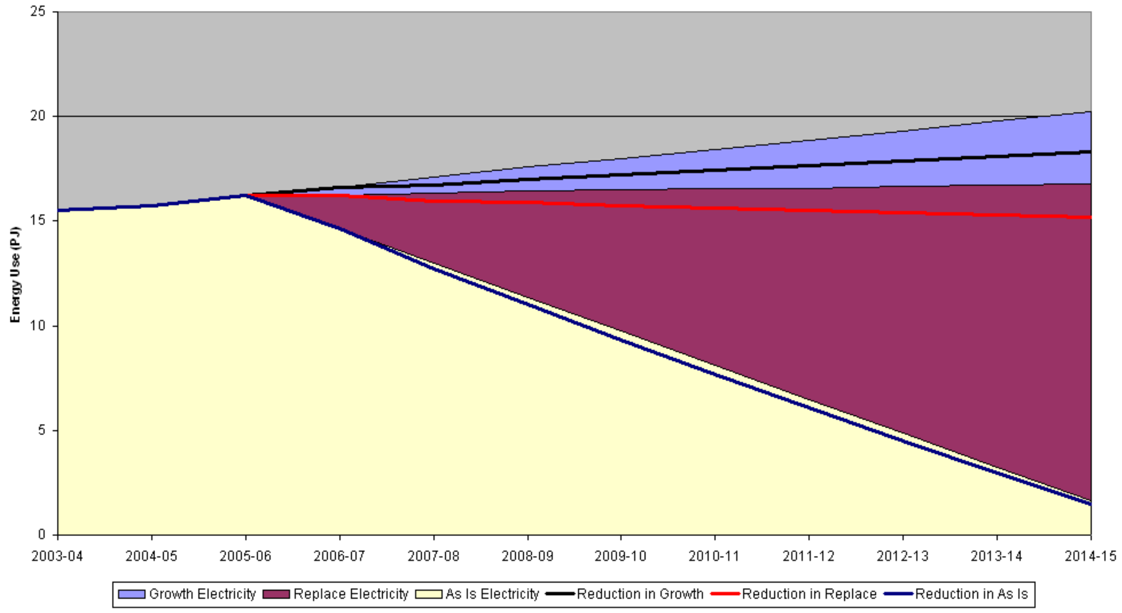
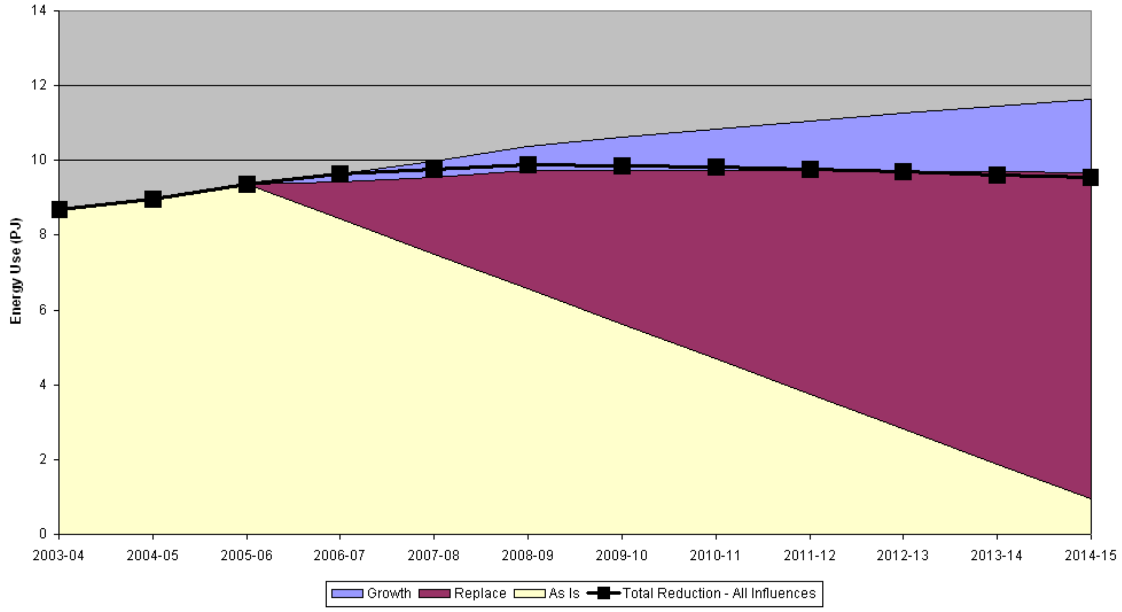


Figure 10.4: Residential Sector Baseline Gas Use including consideration of Energy Efficiency Drives



The total energy use by the sector as a result of these energy efficiency drives is detailed in the tables below. In these tables we illustrate the total percentage decrease in electricity and gas use, relative to the projected growth rate for the sector, as a percentage decrease.

Table 10.2: Reduction in Electricity use by the Residential sector given energy efficiency improvements

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	16.6	17.1	17.6	18.0	18.4	18.9	19.3	19.8	20.2
Energy Efficiency Scenario (PJ)	16.6	16.7	17.0	17.2	17.4	17.6	17.9	18.1	18.3
Percentage reduction (%)	0.0	2.2	3.3	4.4	5.4	6.5	7.5	8.5	9.6

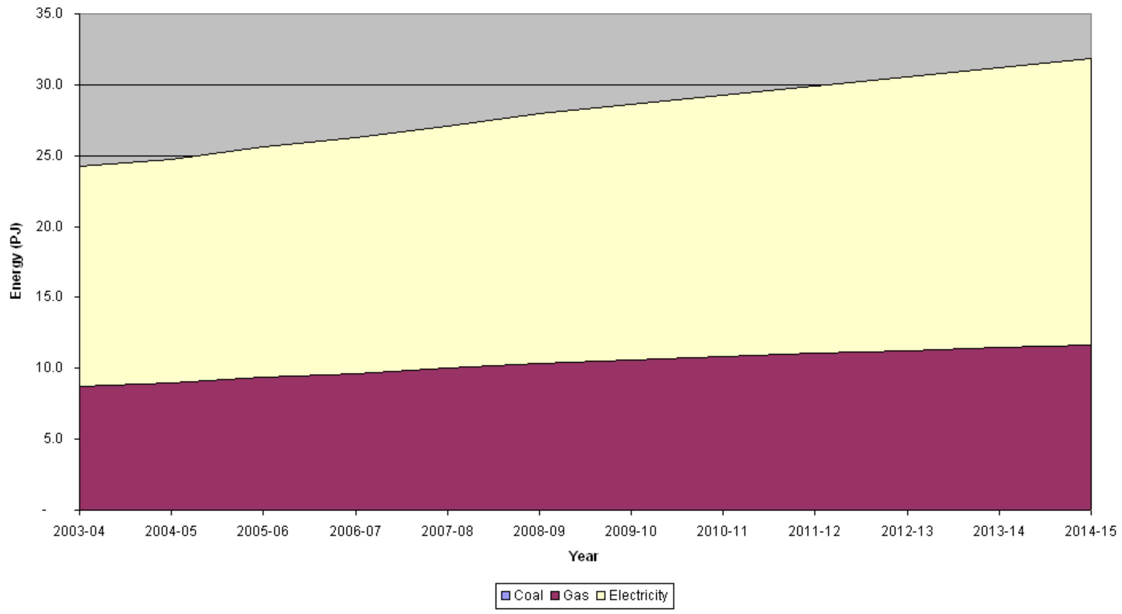
Table 10.3: Reduction in Gas use by the Residential sector given energy efficiency improvements

	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Baseline (PJ)	9.6	10.0	10.4	10.6	10.8	11.1	11.3	11.4	11.6
Energy Efficiency Scenario (PJ)	9.6	9.8	9.9	9.8	9.8	9.8	9.7	9.6	9.6
Percentage reduction (%)	0.0	2.3	4.8	7.2	9.4	11.7	13.8	15.9	18.0

OVERALL RESIDENTIAL SECTOR BASELINE

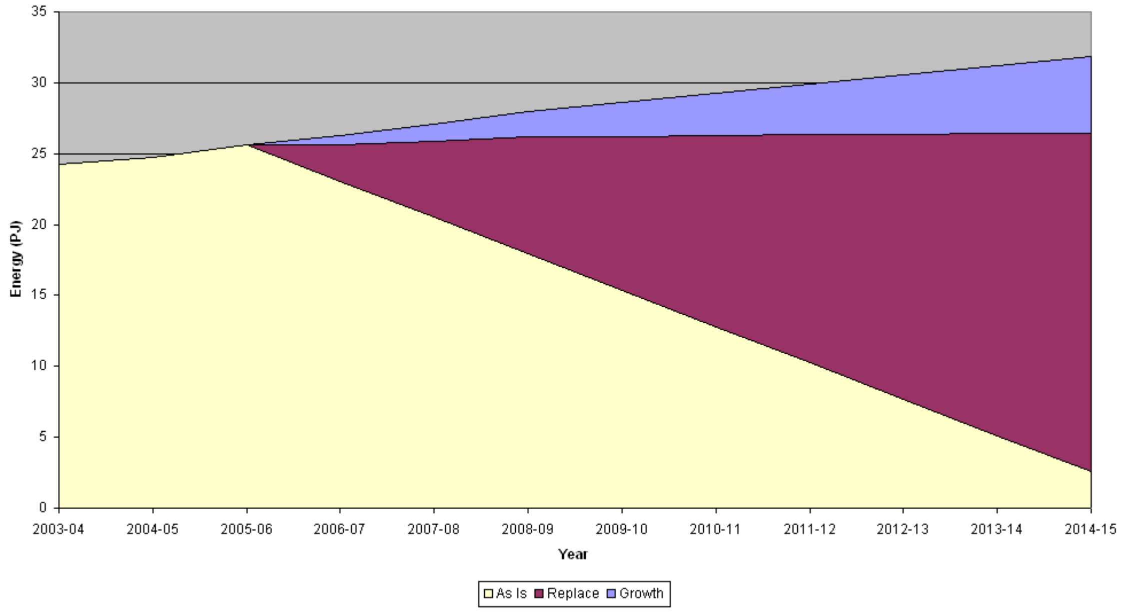
The total energy use by the residential sector is illustrated below.

Figure 10.5: Total Energy use by the Residential sector



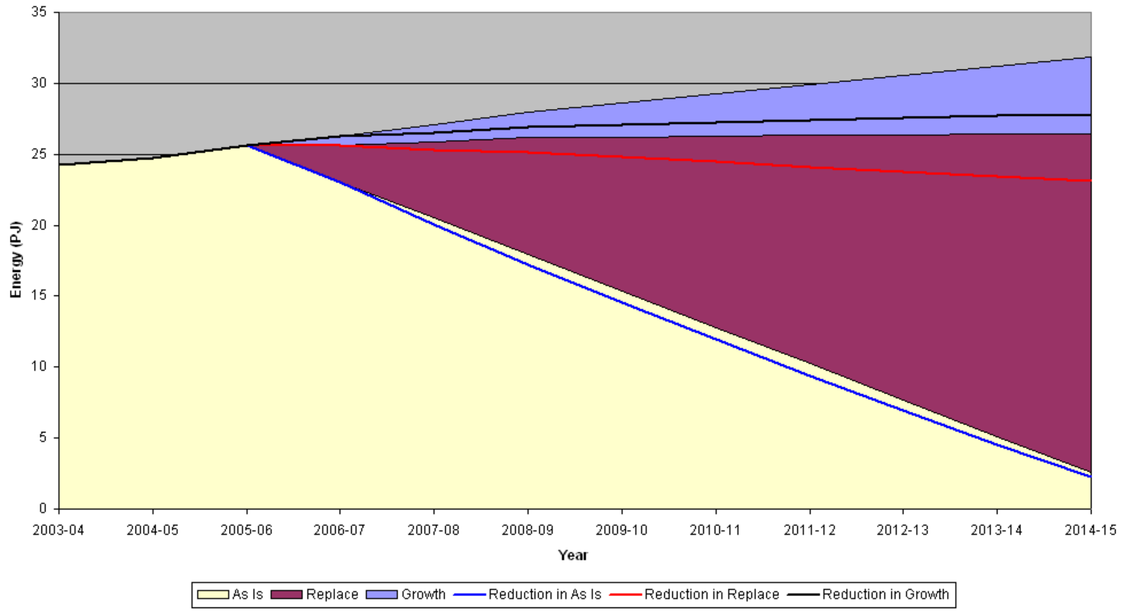
This baseline is aggregated and the areas of influence highlighted in the figure below.

Figure 10.6: Breakdown of Energy Use in the Residential Sector by area of Influence



We overlay on this amount the potential energy efficiency initiatives we highlighted previously, to give an indication of the total potential benefit.

Figure 10.7: Breakdown of Energy Use in the Residential Sector by area of Influence including Energy Efficiency Initiatives



A summary of the percentage change in the energy use of the sector which this represents is included in the table below.

Table 10.4: Reduction in Total Energy used by the Residential Sector given energy efficiency improvements

	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

DISCUSSION

Technology Trends

Studies by EMET & GWA in their analyses for the NFEE identified a range of measures in relation to residential energy use that could be implemented to deliver energy savings at about a 6-year payback. These are illustrated below.

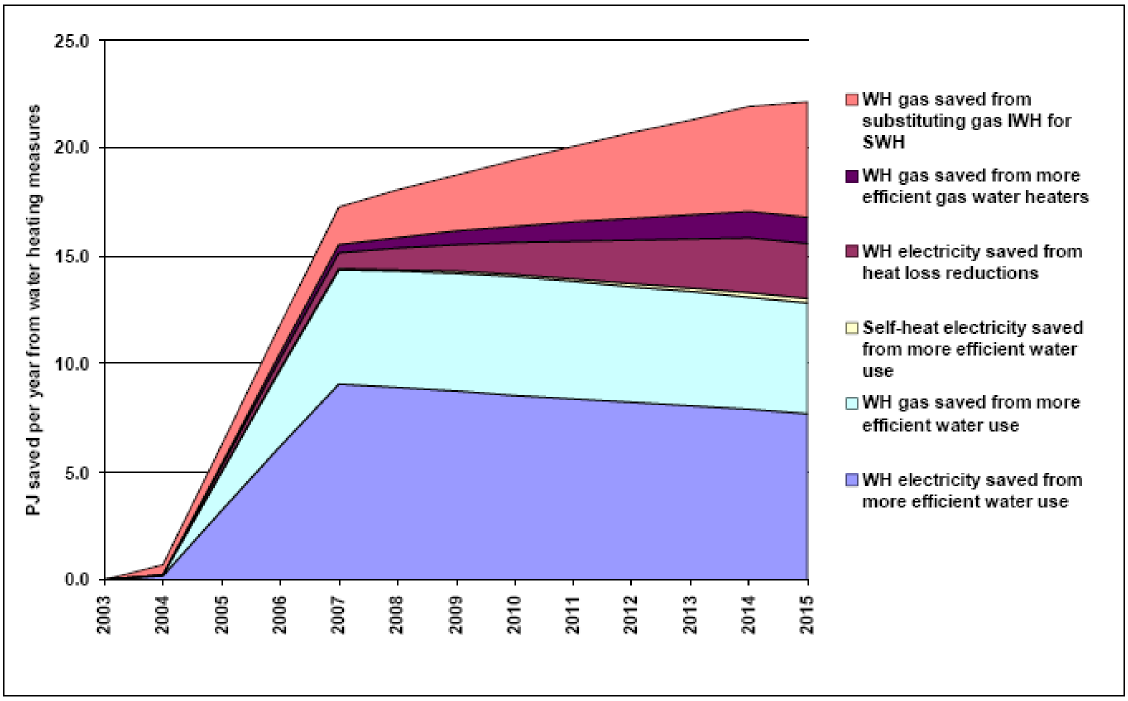
EMET

Note: The total EEI potential identified by EMET in the table is relative to total residential energy use, including biomass.

<=6.5 YEAR PAYBACK

Application	All fuels Total (PJ pa)	All fuels % of 2014 Total	Elec/Gas Total (PJ pa)	Elec (PJ pa)	Elec/ Gas % of 2014 Total
Building Shell	16.18	3.0%	10.34	3.83	1.9%
Heating/Cooling Appliances *	23.73	4.4%	10.34	0.10	1.9%
Lighting	2.71	0.5%	2.71	2.71	0.5%
Cooking	3.90	0.7%	3.90	2.16	0.7%
Refrigeration	3.51	0.7%	3.51	3.51	0.7%
Dishwasher	0.29	0.1%	0.29	0.29	0.1%
Clothes Washer	0.24	0.0%	0.24	0.24	0.0%
TOTALS	50.56	9.4%	31.33	12.83	5.8%

GWA



In relation to the EMET work, specific measures identified include:

- Heating & Cooling

  Building Shell Measures

  - Increase ratings of new homes in all States to 5 Stars, from 3.5 & 4 Stars, as appropriate (applicable to "Growth" area of influence).
  - Insulation of existing dwellings, and Weather stripping & Sealing of buildings (potentially in the "As Is" or "Replace" area of influence)

  Appliance Related Measures

  - Improvement in COP for reverse cycle heating and cooling (potentially in the "Growth" or "Replace" area of influence)
  - Improve the efficiency of larger gas and solid fuel burners (potentially in the "Growth" or "Replace" area of influence)
  - Replace the remainder of gas and solid fuel heaters with higher efficiency units (applicable to "Replace" area of influence)
  - Improve the efficiency of ducted heating & cooling (reduce losses) (applicable to "As Is" area of influence)
  - Replace electric heating with Heat Pumps (applicable to "Replace" area of influence)

- Lighting

  - Improvement in Lighting Efficiency (beyond BAU) (potentially in all areas of influence)
  - Improvement in Lighting Controls (potentially in all areas of influence)

- Cooking
    - Improved efficiency of burners & ovens (potentially in the "Growth" or "Replace" area of influence)
- Refrigeration
    - Selecting more efficient refrigeration equipment at the time of economic replacement (applicable to "Replace" area of influence)
    - Retrofitting/maintaining older refrigeration equipment for better efficiency (applicable to "As Is" area of influence)
- Dishwashers (excl HW)
    - Selecting more efficient Dishwashers at the time of economic replacement (applicable to "Replace" area of influence)
- Clothes washers (excl HW)
    - Selecting more efficient Clothes Washers at the time of economic replacement (applicable to "Replace" area of influence)

In relation to the GWA work, specific measures identified include:

- WH gas saved from substituting gas IWH for SWH (potentially in the "Growth" or "Replace" area of influence)
- WH gas saved from more efficient gas water heaters (potentially in the "Growth" or "Replace" area of influence)
- WH electricity saved from heat loss reductions (applicable to "As Is" area of influence)
- Self-heat electricity saved from more efficient water use (applicable to "As Is" or "Replace" areas of influence)
- WH gas saved from more efficient water use (applicable to "As Is" or "Replace" areas of influence)
- WH electricity saved from more efficient water use (applicable to "As Is" or "Replace" areas of influence)

Summary of EEI Areas & Policy Implications

In summary, incremental improvements in energy use in the residential sector are linked to the following areas:

- Improved technology,
- Improved end use of energy and control

The implications for policy development are thus:

- Design standards for new homes relating to energy efficiency
- Information dissemination and awareness raising relating to end use of energy
- Information and labelling and potentially incentives relating to user selection of new appliances

2-year & 6-Year Paybacks

The savings in the WA residential sector based on the work by EMET and GWA suggest a potential saving up to 6-year payback of 4.1 PJ or 12.6% of forecast energy use in 2014/15. A further assessment of these studies suggests that savings are generally concentrated in the 4-6 year payback range, with a relatively small contribution of approximately 25% from projects with 0-2 year paybacks. Interpreting these studies and applying to WA we get:

- EEI Potential estimate at 0-2 year payback = 1.025 PJ
- EEI Potential estimate at 2-6 year payback = 3.075 PJ

11. Effect on EEI from Carbon Pricing

SUMMARY

On the basis of discussions further to the submission of a draft report, Energetics was requested to provide some specific outputs resulting from the imposition of carbon pricing to fossil fuel energy consumed in the sectors assessed here. These include:

- A summary of EEI potential and associated GHG abatement potential in 2015,
- A summary of EEI potential and associated GHG abatement potential in 2010,
- An indication of additional abatement that could be expected to occur at various carbon prices in 2010 and 2015 from a 2-year payback criterion perspective – i.e. abatement that is privately cost-effective,
- An indication of additional abatement that could be expected to occur at various carbon prices in 2010 and 2015 from a 6-year payback criterion perspective – i.e. abatement that is socially cost-effective

Estimated EEI potential in 2010 and 2015 with associated GHG abatement potential is shown below. This is at $0/tonne CO2.

Table 11.1: Aggregated 0-2 Year and 6-Year Payback EEI & CO_2 Saving Potential

Estimated Energy Efficiency Improvement (EEI) Potential to 2014/15

Sector	Fuel	PJ Savings up to 6-Year PB	CO_2 Savings up to 6-Year PB	PJ Savings up to 2-Year PB	CO_2 Savings up to 2-Year PB	CO_2 Factor (FFC)
Mining	Coal	0.48 PJ	45,122 t CO2	0.17 PJ	15,793 t CO2	94.20 kt CO2/PJ
Mining	Gas	1.73 PJ	103,980 t CO2	0.61 PJ	36,393 t CO2	60.00 kt CO2/PJ
Mining	Electricity	2.46 PJ	679,236 t CO2	0.86 PJ	237,733 t CO2	276.00 kt CO2/PJ
Mining	Other Petroleum	6.50 PJ	503,750 t CO2	2.28 PJ	176,313 t CO2	77.50 kt CO2/PJ
Basic Chemicals	Gas	2.32 PJ	138,900 t CO2	1.85 PJ	111,120 t CO2	60.00 kt CO2/PJ
Iron & Steel	Coal	0.69 PJ	64,998 t CO2	0.35 PJ	32,499 t CO2	94.20 kt CO2/PJ
Iron & Steel	Gas	0.19 PJ	11,220 t CO2	0.09 PJ	5,610 t CO2	60.00 kt CO2/PJ
Non-Ferrous Metals	Coal	0.27 PJ	25,434 t CO2	0.22 PJ	20,347 t CO2	94.20 kt CO2/PJ
Non-Ferrous Metals	Gas	3.17 PJ	190,200 t CO2	2.54 PJ	152,160 t CO2	60.00 kt CO2/PJ
Non-Ferrous Metals	Electricity	0.46 PJ	126,960 t CO2	0.37 PJ	101,568 t CO2	276.00 kt CO2/PJ
Non-Metallic Minerals	Coal	0.76 PJ	71,121 t CO2	0.28 PJ	26,670 t CO2	94.20 kt CO2/PJ
Non-Metallic Minerals	Gas	1.93 PJ	115,500 t CO2	0.72 PJ	43,313 t CO2	60.00 kt CO2/PJ
Commercial	Gas	0.43 PJ	25,920 t CO2	0.34 PJ	20,218 t CO2	60.00 kt CO2/PJ
Commercial	Electricity	2.89 PJ	797,088 t CO2	2.25 PJ	621,729 t CO2	276.00 kt CO2/PJ
Residential	Gas	2.10 PJ	125,820 t CO2	0.52 PJ	31,455 t CO2	60.00 kt CO2/PJ
Residential	Electricity	1.93 PJ	533,508 t CO2	0.48 PJ	133,377 t CO2	276.00 kt CO2/PJ
Sub-Total	Coal	2.19 PJ	206,675 t CO2	1.01 PJ	95,309 t CO2	94.20 kt CO2/PJ
Sub-Total	Gas	11.86 PJ	711,540 t CO2	6.67 PJ	400,268 t CO2	60.00 kt CO2/PJ
Sub-Total	Electricity	7.74 PJ	2,136,792 t CO2	3.97 PJ	1,094,406 t CO2	276.00 kt CO2/PJ
Sub-Total	Other Petroleum	6.50 PJ	503,750 t CO2	2.28 PJ	176,313 t CO2	77.50 kt CO2/PJ
TOTAL	**All Fuel**	**28.30 PJ**	**3,558,757 t CO2**	**13.92 PJ**	**1,766,296 t CO2**	

Estimated Energy Efficiency Improvement (EEI) Potential to 2009/10

Sector	Fuel	PJ Savings up to 6-Year PB	CO_2 Savings up to 6-Year PB	PJ Savings up to 2-Year PB	CO_2 Savings up to 2-Year PB	CO_2 Factor (FFC)
Mining	Coal	0.20 PJ	18,840 t CO2	0.07 PJ	6,594 t CO2	94.20 kt CO2/PJ
Mining	Gas	0.48 PJ	28,800 t CO2	0.17 PJ	10,080 t CO2	60.00 kt CO2/PJ
Mining	Electricity	0.72 PJ	198,720 t CO2	0.25 PJ	69,552 t CO2	276.00 kt CO2/PJ
Mining	Other Petroleum	1.60 PJ	124,000 t CO2	0.56 PJ	43,400 t CO2	77.50 kt CO2/PJ
Basic Chemicals	Gas	0.77 PJ	46,200 t CO2	0.62 PJ	36,960 t CO2	60.00 kt CO2/PJ
Iron & Steel	Coal	0.30 PJ	28,260 t CO2	0.15 PJ	14,130 t CO2	94.20 kt CO2/PJ
Iron & Steel	Gas	0.06 PJ	3,600 t CO2	0.03 PJ	1,800 t CO2	60.00 kt CO2/PJ
Non-Ferrous Metals	Coal	0.10 PJ	9,420 t CO2	0.08 PJ	7,536 t CO2	94.20 kt CO2/PJ
Non-Ferrous Metals	Gas	1.18 PJ	70,800 t CO2	0.94 PJ	56,640 t CO2	60.00 kt CO2/PJ
Non-Ferrous Metals	Electricity	0.19 PJ	52,440 t CO2	0.15 PJ	41,952 t CO2	276.00 kt CO2/PJ
Non-Metallic Minerals	Coal	0.26 PJ	24,492 t CO2	0.10 PJ	9,185 t CO2	94.20 kt CO2/PJ
Non-Metallic Minerals	Gas	0.60 PJ	36,000 t CO2	0.23 PJ	13,500 t CO2	60.00 kt CO2/PJ
Commercial	Gas	0.17 PJ	10,200 t CO2	0.13 PJ	7,956 t CO2	60.00 kt CO2/PJ
Commercial	Electricity	1.35 PJ	372,600 t CO2	1.05 PJ	290,628 t CO2	276.00 kt CO2/PJ
Residential	Gas	0.76 PJ	45,600 t CO2	0.19 PJ	11,400 t CO2	60.00 kt CO2/PJ
Residential	Electricity	0.79 PJ	218,040 t CO2	0.20 PJ	54,510 t CO2	276.00 kt CO2/PJ
Sub-Total	Coal	0.86 PJ	81,012 t CO2	0.40 PJ	37,445 t CO2	94.20 kt CO2/PJ
Sub-Total	Gas	4.02 PJ	241,200 t CO2	2.31 PJ	138,336 t CO2	60.00 kt CO2/PJ
Sub-Total	Electricity	3.05 PJ	841,800 t CO2	1.65 PJ	456,642 t CO2	276.00 kt CO2/PJ
Sub-Total	Other Petroleum	1.60 PJ	124,000 t CO2	0.56 PJ	43,400 t CO2	77.50 kt CO2/PJ
TOTAL	**All Fuel**	**9.53 PJ**	**1,288,012 t CO2**	**4.92 PJ**	**675,823 t CO2**	

The analysis here, per the brief, has looked at simple payback EEI potential up to 2 and up to 6 years. In order to develop the analysis called for in relation to additional abatement potential via the application of carbon pricing, it is necessary to have knowledge of (ideally) the payback associated with each major energy efficiency opportunity, preferably from a bottom-up assessment. This is not the case here.

In order to develop reasonable estimates then, we have referenced work Energetics did for the NFEE to gauge the relative contribution to EEI potential (beyond-BAU) at paybacks ranging from 0.5 years up to 10 years, and applied these to EEI estimates for WA. Essentially this serves to split the "Up to 2 year simple payback" category of savings into 0.5 year, 1 year and 2 year paybacks, the "2-6 year payback" category into 2, 3, 4, 5 and 6 year payback, and enables WA EEI estimates to be extrapolated beyond 6 year payback to 7, 8 and 10 year payback levels.

With this additional disaggregation of EEI potential within each sector / fuel we can then re-calculate the simple payback consequent on the imposition of a carbon price on each fuel type at $10, $20, $30 and $40 per tonne of carbon dioxide. This then allows us to see the additional savings that could be expected to result if a 2-year (private) or a 6-year (social) payback level is taken to be a trigger for implementation.

This analysis leads to the following estimate of energy and GHG savings that could result in 2010 and 2015 at carbon price levels of $10, $20, $30 and $40 per tonne of CO_2.

Table 11.2: EEI & CO_2 Potential in 2015 & 2010 at Various Carbon Price Levels

2 Year Payback Scenario (Privately Cost Effective)				
2015 Energy Saving @ <2 Year PB	**2010 Energy Saving @ <2 Year PB**	**2015 CO2 Saving @ < 2 Year PB**	**2010 CO2 Saving @ < 2 Year PB**	**Carbon Price**
16.59 PJ	5.91 PJ	2,104.00 kt CO2	796.00 kt CO2	$40.0 /t CO2
16.11 PJ	5.67 PJ	2,019.00 kt CO2	760.00 kt CO2	$30.0 /t CO2
14.65 PJ	5.20 PJ	1,835.00 kt CO2	703.00 kt CO2	$20.0 /t CO2
14.22 PJ	5.03 PJ	1,794.00 kt CO2	687.00 kt CO2	$10.0 /t CO2
13.92 PJ	4.92 PJ	1,766.00 kt CO2	676.00 kt CO2	$0.0 /t CO2

6 Year Payback Scenario (Socially Cost Effective)				
2015 Energy Saving @ <6 Year PB	**2010 Energy Saving @ <6 Year PB**	**2015 CO2 Saving @ < 6 Year PB**	**2010 CO2 Saving @ < 6 Year PB**	**Carbon Price**
36.37 PJ	12.44 PJ	4,660,658 kt CO2	1,700,027 kt CO2	$40.0 /t CO2
35.79 PJ	12.24 PJ	4,577,743 kt CO2	1,673,934 kt CO2	$30.0 /t CO2
33.16 PJ	11.30 PJ	4,127,872 kt CO2	1,502,451 kt CO2	$20.0 /t CO2
31.29 PJ	10.56 PJ	3,879,039 kt CO2	1,395,757 kt CO2	$10.0 /t CO2
28.30 PJ	9.53 PJ	3,558,757 kt CO2	1,288,012 kt CO2	$0.0 /t CO2

These results are illustrated graphically below.

Figure 11.1: GHG Savings in 2015 for Privately Cost-Effective Measures @ Various Carbon Price Levels

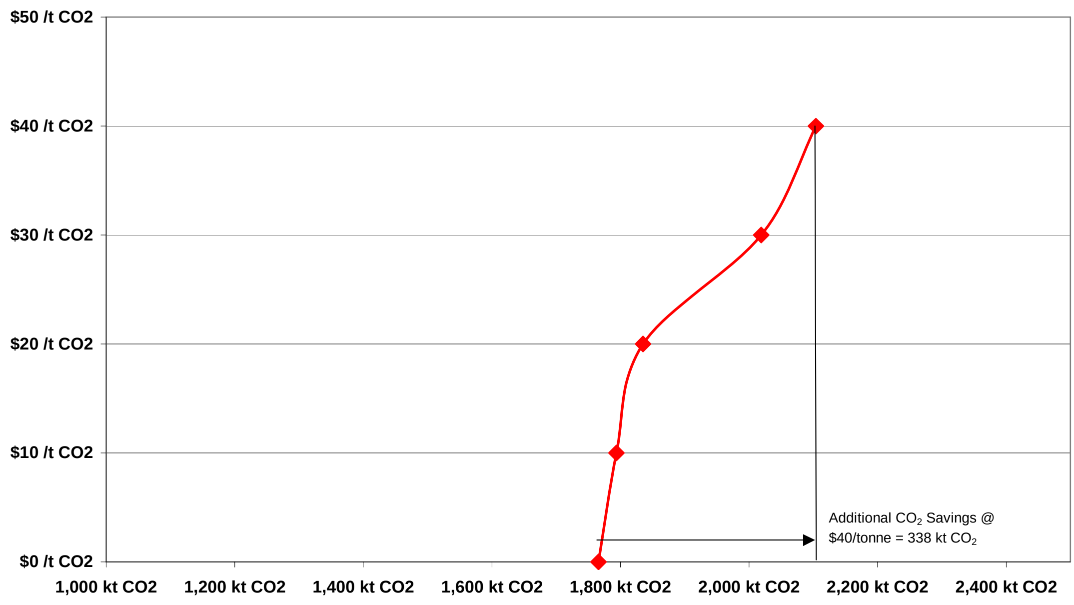


Figure 11.2: GHG Savings in 2010 for Privately Cost-Effective Measures @ Various Carbon Price Levels

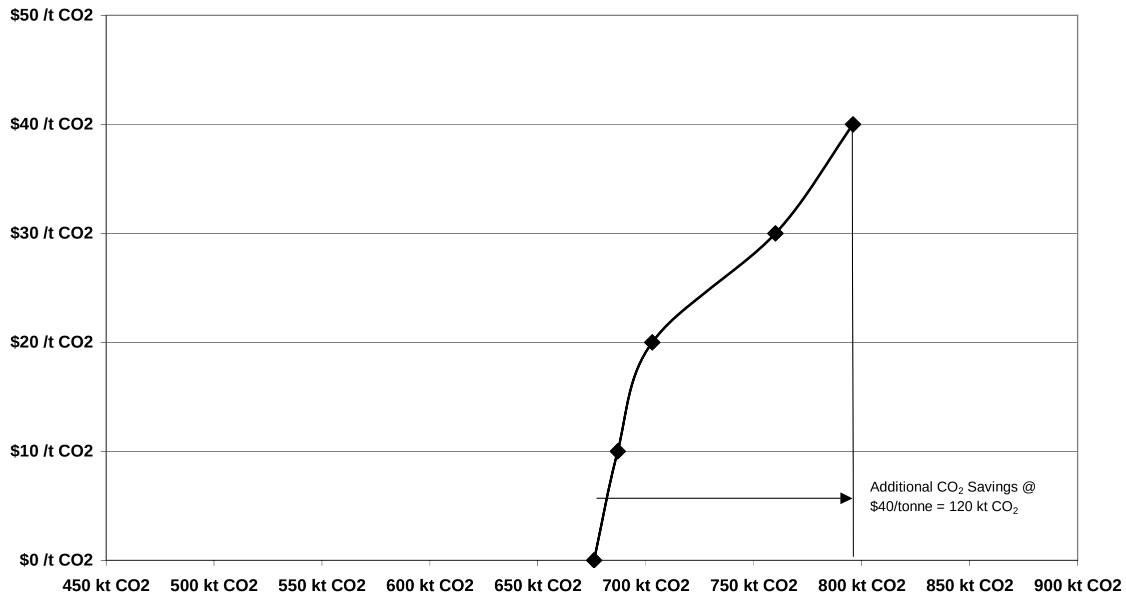


Figure 11.3: GHG Savings in 2015 for Socially Cost-Effective Measures @ Various Carbon Price Levels

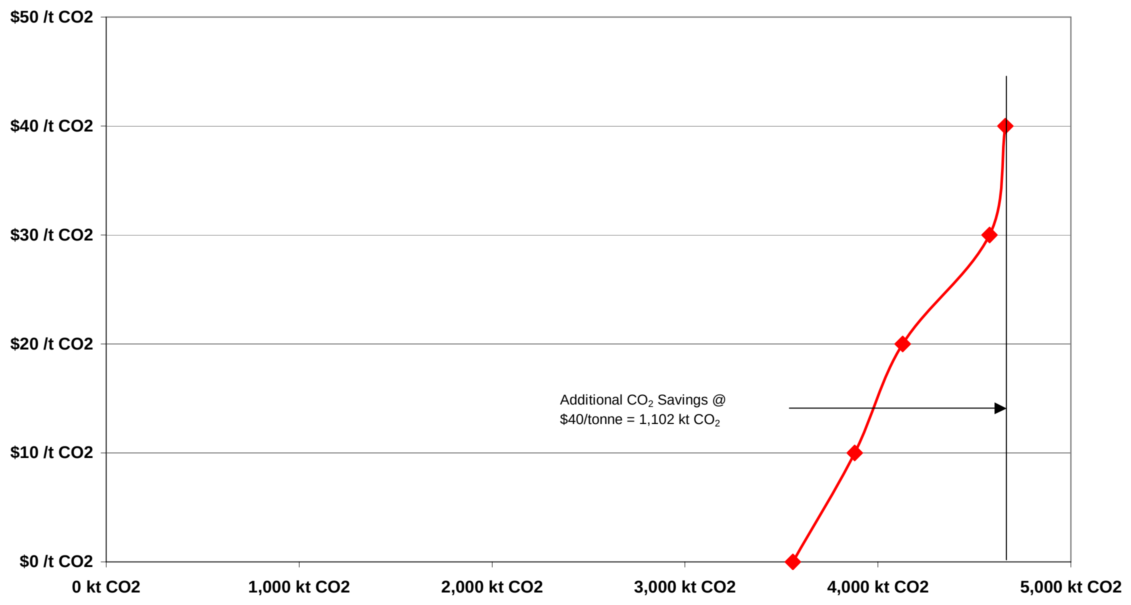
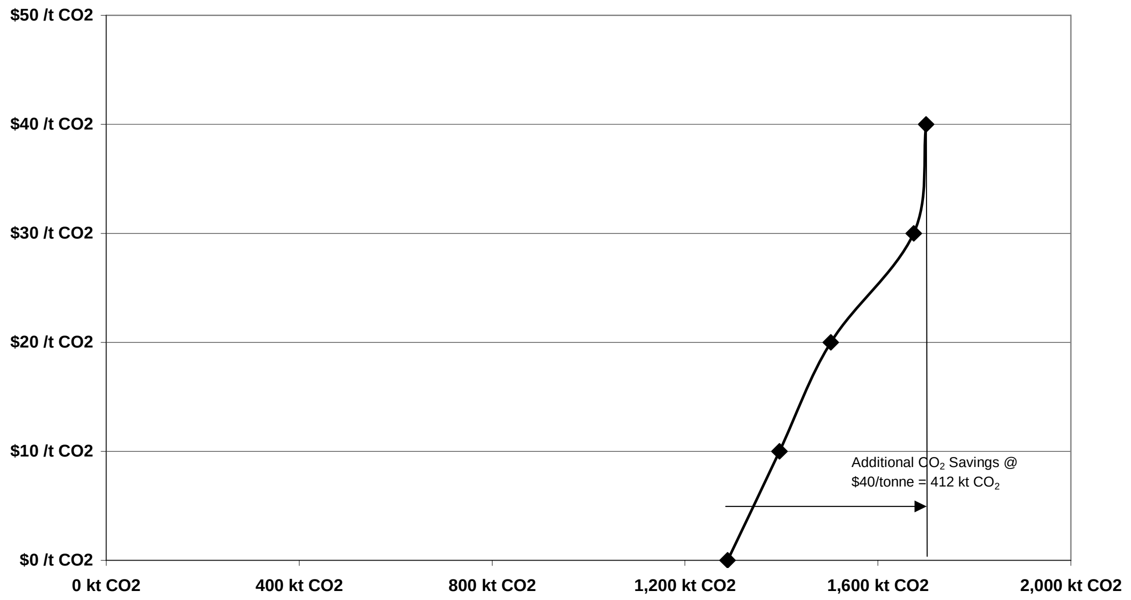


Figure 11.4: GHG Savings in 2010 for Socially Cost-Effective Measures @ Various Carbon Price Levels



PRIVATE COST-EFFECTIVENESS

For privately cost-effective measures we have taken data from Table 11.1, and utilised this plus our NFEE work to make an estimate of savings potential at a range of interim payback levels to inform this assessment. The EEI potential data set from which this analysis is conducted is therefore as shown below.

Table 11.3: Estimate of Disaggregated 2015 EEI at Interim Payback Levels

Sector	Fuel	PJ Savings up to 6-Year PB	PJ Savings up to 2-Year PB	PJ Saving @ 0.5Y PB	PJ Saving @ 1Y PB	PJ Saving @ 2Y PB	PJ Saving @ 3Y PB	PJ Saving @ 4Y PB	PJ Saving @ 5Y PB	PJ Saving @ 6Y PB
Mining	Coal	0.48 PJ	0.17 PJ	0.03 PJ	0.08 PJ	0.05 PJ	0.08 PJ	0.08 PJ	0.08 PJ	0.08 PJ
Mining	Gas	1.73 PJ	0.61 PJ	0.12 PJ	0.30 PJ	0.18 PJ	0.28 PJ	0.28 PJ	0.28 PJ	0.28 PJ
Mining	Electricity	2.46 PJ	0.86 PJ	0.17 PJ	0.43 PJ	0.26 PJ	0.40 PJ	0.40 PJ	0.40 PJ	0.40 PJ
Mining	Other Petroleum	6.50 PJ	2.28 PJ	0.46 PJ	1.14 PJ	0.68 PJ	1.06 PJ	1.06 PJ	1.06 PJ	1.06 PJ
Basic Chemicals	Gas	2.32 PJ	1.85 PJ	0.37 PJ	0.93 PJ	0.56 PJ	0.12 PJ	0.12 PJ	0.12 PJ	0.12 PJ
Iron & Steel	Coal	0.69 PJ	0.35 PJ	0.07 PJ	0.17 PJ	0.10 PJ	0.09 PJ	0.09 PJ	0.09 PJ	0.09 PJ
Iron & Steel	Gas	0.19 PJ	0.09 PJ	0.02 PJ	0.05 PJ	0.03 PJ	0.02 PJ	0.02 PJ	0.02 PJ	0.02 PJ
Non-Ferrous Metals	Coal	0.27 PJ	0.22 PJ	0.04 PJ	0.11 PJ	0.06 PJ	0.01 PJ	0.01 PJ	0.01 PJ	0.01 PJ
Non-Ferrous Metals	Gas	3.17 PJ	2.54 PJ	0.51 PJ	1.27 PJ	0.76 PJ	0.16 PJ	0.16 PJ	0.16 PJ	0.16 PJ
Non-Ferrous Metals	Electricity	0.46 PJ	0.37 PJ	0.07 PJ	0.18 PJ	0.11 PJ	0.02 PJ	0.02 PJ	0.02 PJ	0.02 PJ
Non-Metallic Minerals	Coal	0.76 PJ	0.28 PJ	0.06 PJ	0.14 PJ	0.08 PJ	0.12 PJ	0.12 PJ	0.12 PJ	0.12 PJ
Non-Metallic Minerals	Gas	1.93 PJ	0.72 PJ	0.14 PJ	0.36 PJ	0.22 PJ	0.30 PJ	0.30 PJ	0.30 PJ	0.30 PJ
Commercial	Gas	0.43 PJ	0.34 PJ	0.07 PJ	0.17 PJ	0.10 PJ	0.02 PJ	0.02 PJ	0.02 PJ	0.02 PJ
Commercial	Electricity	2.89 PJ	2.25 PJ	0.45 PJ	1.13 PJ	0.68 PJ	0.16 PJ	0.16 PJ	0.16 PJ	0.16 PJ
Residential	Gas	2.10 PJ	0.52 PJ	0.10 PJ	0.26 PJ	0.16 PJ	0.39 PJ	0.39 PJ	0.39 PJ	0.39 PJ
Residential	Electricity	1.93 PJ	0.48 PJ	0.10 PJ	0.24 PJ	0.14 PJ	0.36 PJ	0.36 PJ	0.36 PJ	0.36 PJ
Sub-Total	Coal	2.19 PJ	1.01 PJ	0.20 PJ	0.51 PJ	0.30 PJ	0.30 PJ	0.30 PJ	0.30 PJ	0.30 PJ
Sub-Total	Gas	11.86 PJ	6.67 PJ	1.33 PJ	3.34 PJ	2.00 PJ	1.30 PJ	1.30 PJ	1.30 PJ	1.30 PJ
Sub-Total	Electricity	7.74 PJ	3.97 PJ	0.79 PJ	1.98 PJ	1.19 PJ	0.94 PJ	0.94 PJ	0.94 PJ	0.94 PJ
Sub-Total	Other Petroleum	6.50 PJ	2.28 PJ	0.46 PJ	1.14 PJ	0.68 PJ	1.06 PJ	1.06 PJ	1.06 PJ	1.06 PJ
TOTAL	**All Fuel**	**28.30 PJ**	**13.92 PJ**	**2.78 PJ**	**6.96 PJ**	**4.18 PJ**	**3.59 PJ**	**3.59 PJ**	**3.59 PJ**	**3.59 PJ**

Table 11.4: Estimate of Disaggregated 2010 EEI at Interim Payback Levels

Sector	Fuel	PJ Savings up to 6-Year PB	PJ Savings up to 2-Year PB	PJ Saving @ 0.5Y PB	PJ Saving @ 1Y PB	PJ Saving @ 2Y PB	PJ Saving @ 3Y PB	PJ Saving @ 4Y PB	PJ Saving @ 5Y PB	PJ Saving @ 6Y PB
Mining	Coal	0.20 PJ	0.07 PJ	0.01 PJ	0.04 PJ	0.02 PJ	0.03 PJ	0.03 PJ	0.03 PJ	0.03 PJ
Mining	Gas	0.48 PJ	0.17 PJ	0.03 PJ	0.08 PJ	0.05 PJ	0.08 PJ	0.08 PJ	0.08 PJ	0.08 PJ
Mining	Electricity	0.72 PJ	0.25 PJ	0.05 PJ	0.13 PJ	0.08 PJ	0.12 PJ	0.12 PJ	0.12 PJ	0.12 PJ
Mining	Other Petroleum	1.60 PJ	0.56 PJ	0.11 PJ	0.28 PJ	0.17 PJ	0.26 PJ	0.26 PJ	0.26 PJ	0.26 PJ
Basic Chemicals	Gas	0.77 PJ	0.62 PJ	0.12 PJ	0.31 PJ	0.18 PJ	0.04 PJ	0.04 PJ	0.04 PJ	0.04 PJ
Iron & Steel	Coal	0.30 PJ	0.15 PJ	0.03 PJ	0.08 PJ	0.05 PJ	0.04 PJ	0.04 PJ	0.04 PJ	0.04 PJ
Iron & Steel	Gas	0.06 PJ	0.03 PJ	0.01 PJ	0.02 PJ	0.01 PJ	0.01 PJ	0.01 PJ	0.01 PJ	0.01 PJ
Non-Ferrous Metals	Coal	0.10 PJ	0.08 PJ	0.02 PJ	0.04 PJ	0.02 PJ	0.01 PJ	0.01 PJ	0.01 PJ	0.01 PJ
Non-Ferrous Metals	Gas	1.18 PJ	0.94 PJ	0.19 PJ	0.47 PJ	0.28 PJ	0.06 PJ	0.06 PJ	0.06 PJ	0.06 PJ
Non-Ferrous Metals	Electricity	0.19 PJ	0.15 PJ	0.03 PJ	0.08 PJ	0.05 PJ	0.01 PJ	0.01 PJ	0.01 PJ	0.01 PJ
Non-Metallic Minerals	Coal	0.26 PJ	0.10 PJ	0.02 PJ	0.05 PJ	0.03 PJ	0.04 PJ	0.04 PJ	0.04 PJ	0.04 PJ
Non-Metallic Minerals	Gas	0.60 PJ	0.23 PJ	0.05 PJ	0.11 PJ	0.07 PJ	0.09 PJ	0.09 PJ	0.09 PJ	0.09 PJ
Commercial	Gas	0.17 PJ	0.13 PJ	0.03 PJ	0.07 PJ	0.04 PJ	0.01 PJ	0.01 PJ	0.01 PJ	0.01 PJ
Commercial	Electricity	1.35 PJ	1.05 PJ	0.21 PJ	0.53 PJ	0.32 PJ	0.07 PJ	0.07 PJ	0.07 PJ	0.07 PJ
Residential	Gas	0.76 PJ	0.19 PJ	0.04 PJ	0.10 PJ	0.06 PJ	0.14 PJ	0.14 PJ	0.14 PJ	0.14 PJ
Residential	Electricity	0.79 PJ	0.20 PJ	0.04 PJ	0.10 PJ	0.06 PJ	0.15 PJ	0.15 PJ	0.15 PJ	0.15 PJ
Sub-Total	Coal	0.86 PJ	0.40 PJ	0.08 PJ	0.20 PJ	0.12 PJ	0.12 PJ	0.12 PJ	0.12 PJ	0.12 PJ
Sub-Total	Gas	4.02 PJ	2.31 PJ	0.46 PJ	1.15 PJ	0.69 PJ	0.43 PJ	0.43 PJ	0.43 PJ	0.43 PJ
Sub-Total	Electricity	3.05 PJ	1.65 PJ	0.33 PJ	0.83 PJ	0.50 PJ	0.35 PJ	0.35 PJ	0.35 PJ	0.35 PJ
Sub-Total	Other Petroleum	1.60 PJ	0.56 PJ	0.11 PJ	0.28 PJ	0.17 PJ	0.26 PJ	0.26 PJ	0.26 PJ	0.26 PJ
TOTAL	**All Fuel**	**9.53 PJ**	**4.92 PJ**	**0.98 PJ**	**2.46 PJ**	**1.48 PJ**	**1.15 PJ**	**1.15 PJ**	**1.15 PJ**	**1.15 PJ**

By utilising estimated energy prices and applying various carbon prices we can re-calculate the simple payback, and by assuming that where this has the effect of reducing the simple payback to 2 years or less (in practice we have taken up to 2.1 year simple payback to effectively be a 2-year payback) implementation will occur, we can estimate potential GHG abatement at these carbon price levels. This is shown below (same impact on payback for 2010 and 2015).

Table 11.5: Illustration of Additional Measures meeting Private Payback Criterion at $10/tonne Carbon Price

Sector	Fuel	Effective PB @ $10/t CO2 for 0.5Y PB	Effective PB @ $10/t CO2 for 1 Y PB	Effective PB @ $10/t CO2 for 2 Y PB	Effective PB @ $10/t CO2 for 3 Y PB	Effective PB @ $10/t CO2 for 4 Y PB	Effective PB @ $10/t CO2 for 5 Y PB	Effective PB @ $10/t CO2 for 6 Y PB
Mining	Coal	0.34 Year PB	0.68 Year PB	1.36 Year PB	**2.04 Year PB**	2.72 Year PB	3.40 Year PB	4.08 Year PB
Mining	Gas	0.43 Year PB	0.87 Year PB	1.74 Year PB	2.61 Year PB	3.48 Year PB	4.35 Year PB	5.22 Year PB
Mining	Electricity	0.42 Year PB	0.84 Year PB	1.69 Year PB	2.53 Year PB	3.38 Year PB	4.22 Year PB	5.07 Year PB
Mining	Other Petroleum	0.48 Year PB	0.97 Year PB	1.94 Year PB	2.91 Year PB	3.88 Year PB	4.85 Year PB	5.82 Year PB
Basic Chemicals	Gas	0.40 Year PB	0.81 Year PB	1.61 Year PB	2.42 Year PB	3.23 Year PB	4.03 Year PB	4.84 Year PB
Iron & Steel	Coal	0.34 Year PB	0.68 Year PB	1.36 Year PB	**2.04 Year PB**	2.72 Year PB	3.40 Year PB	4.08 Year PB
Iron & Steel	Gas	0.43 Year PB	0.87 Year PB	1.74 Year PB	2.61 Year PB	3.48 Year PB	4.35 Year PB	5.22 Year PB
Non-Ferrous Metals	Coal	0.34 Year PB	0.68 Year PB	1.36 Year PB	**2.04 Year PB**	2.72 Year PB	3.40 Year PB	4.08 Year PB
Non-Ferrous Metals	Gas	0.42 Year PB	0.83 Year PB	1.67 Year PB	2.50 Year PB	3.33 Year PB	4.17 Year PB	5.00 Year PB
Non-Ferrous Metals	Electricity	0.41 Year PB	0.81 Year PB	1.63 Year PB	2.44 Year PB	3.25 Year PB	4.07 Year PB	4.88 Year PB
Non-Metallic Minerals	Coal	0.34 Year PB	0.68 Year PB	1.36 Year PB	**2.04 Year PB**	2.72 Year PB	3.40 Year PB	4.08 Year PB
Non-Metallic Minerals	Gas	0.43 Year PB	0.87 Year PB	1.74 Year PB	2.61 Year PB	3.48 Year PB	4.35 Year PB	5.22 Year PB
Commercial	Gas	0.45 Year PB	0.91 Year PB	1.82 Year PB	2.73 Year PB	3.64 Year PB	4.55 Year PB	5.45 Year PB
Commercial	Electricity	0.44 Year PB	0.88 Year PB	1.76 Year PB	2.64 Year PB	3.51 Year PB	4.39 Year PB	5.27 Year PB
Residential	Gas	0.48 Year PB	0.95 Year PB	1.90 Year PB	2.86 Year PB	3.81 Year PB	4.76 Year PB	5.71 Year PB
Residential	Electricity	0.47 Year PB	0.93 Year PB	1.86 Year PB	2.80 Year PB	3.73 Year PB	4.66 Year PB	5.59 Year PB

We see here that only coal-related measures are likely to reach a 2-year payback level with a $10/tonne carbon price, and then only measures with nominal payback of up to 3 years reach the 2-year payback level.

The level of additional GHG savings resulting from this is shown below.

Table 11.6: Illustration of Additional GHG Savings meeting Private Payback Criterion at $10/tonne Carbon Price

Sector	Fuel	CO2 Saving @ $10/t & 0.5 Y PB	CO2 Saving @ $10/t & 1 Y PB	CO2 Saving @ $10/t & 2 Y PB	CO2 Saving @ $10/t & 3 Y PB	CO2 Saving @ $10/t & 4 Y PB	CO2 Saving @ $10/t & 5 Y PB	CO2 Saving @ $10/t & 6 Y PB
Mining	Coal	3.16 kt CO2	7.90 kt CO2	4.74 kt CO2	7.33 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Mining	Gas	7.28 kt CO2	18.20 kt CO2	10.92 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Mining	Electricity	47.55 kt CO2	118.87 kt CO2	71.32 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Mining	Other Petroleum	35.26 kt CO2	88.16 kt CO2	52.89 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Basic Chemicals	Gas	22.22 kt CO2	55.56 kt CO2	33.34 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Iron & Steel	Coal	6.50 kt CO2	16.25 kt CO2	9.75 kt CO2	8.12 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Iron & Steel	Gas	1.12 kt CO2	2.81 kt CO2	1.68 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Ferrous Metals	Coal	4.07 kt CO2	10.17 kt CO2	6.10 kt CO2	1.27 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Ferrous Metals	Gas	30.43 kt CO2	76.08 kt CO2	45.65 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Ferrous Metals	Electricity	20.31 kt CO2	50.78 kt CO2	30.47 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Metallic Minerals	Coal	5.33 kt CO2	13.34 kt CO2	8.00 kt CO2	11.11 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Metallic Minerals	Gas	8.66 kt CO2	21.66 kt CO2	12.99 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Commercial	Gas	4.04 kt CO2	10.11 kt CO2	6.07 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Commercial	Electricity	124.35 kt CO2	310.86 kt CO2	186.52 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Residential	Gas	6.29 kt CO2	15.73 kt CO2	9.44 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Residential	Electricity	26.68 kt CO2	66.69 kt CO2	40.01 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Coal	19.06 kt CO2	47.65 kt CO2	28.59 kt CO2	27.84 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Gas	80.05 kt CO2	200.13 kt CO2	120.08 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Electricity	218.88 kt CO2	547.20 kt CO2	328.32 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Other Petroleum	35.26 kt CO2	88.16 kt CO2	52.89 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
TOTAL	**All Fuel**	**353.26 kt CO2**	**883.15 kt CO2**	**529.89 kt CO2**	**27.84 kt CO2**	**0.00 kt CO2**	**0.00 kt CO2**	**0.00 kt CO2**

Table 11.7: Illustration of Additional Measures meeting Private Payback Criterion at $20/tonne Carbon Price

Sector	Fuel	Effective PB @ $20/t CO2 for 0.5Y PB	Effective PB @ $20/t CO2 for 1 Y PB	Effective PB @ $20/t CO2 for 2 Y PB	Effective PB @ $20/t CO2 for 3 Y PB	Effective PB @ $20/t CO2 for 4 Y PB	Effective PB @ $20/t CO2 for 5 Y PB	Effective PB @ $20/t CO2 for 6 Y PB
Mining	Coal	0.26 Year PB	0.51 Year PB	1.03 Year PB	1.54 Year PB	2.06 Year PB	2.57 Year PB	3.09 Year PB
Mining	Gas	0.38 Year PB	0.77 Year PB	1.54 Year PB	2.31 Year PB	3.08 Year PB	3.85 Year PB	4.62 Year PB
Mining	Electricity	0.37 Year PB	0.73 Year PB	1.46 Year PB	2.19 Year PB	2.92 Year PB	3.65 Year PB	4.39 Year PB
Mining	Other Petroleum	0.47 Year PB	0.94 Year PB	1.88 Year PB	2.82 Year PB	3.77 Year PB	4.71 Year PB	5.65 Year PB
Basic Chemicals	Gas	0.34 Year PB	0.68 Year PB	1.35 Year PB	2.03 Year PB	2.70 Year PB	3.38 Year PB	4.05 Year PB
Iron & Steel	Coal	0.26 Year PB	0.51 Year PB	1.03 Year PB	1.54 Year PB	2.06 Year PB	2.57 Year PB	3.09 Year PB
Iron & Steel	Gas	0.38 Year PB	0.77 Year PB	1.54 Year PB	2.31 Year PB	3.08 Year PB	3.85 Year PB	4.62 Year PB
Non-Ferrous Metals	Coal	0.26 Year PB	0.51 Year PB	1.03 Year PB	1.54 Year PB	2.06 Year PB	2.57 Year PB	3.09 Year PB
Non-Ferrous Metals	Gas	0.36 Year PB	0.71 Year PB	1.43 Year PB	2.14 Year PB	2.86 Year PB	3.57 Year PB	4.29 Year PB
Non-Ferrous Metals	Electricity	0.34 Year PB	0.68 Year PB	1.37 Year PB	2.05 Year PB	2.74 Year PB	3.42 Year PB	4.11 Year PB
Non-Metallic Minerals	Coal	0.26 Year PB	0.51 Year PB	1.03 Year PB	1.54 Year PB	2.06 Year PB	2.57 Year PB	3.09 Year PB
Non-Metallic Minerals	Gas	0.38 Year PB	0.77 Year PB	1.54 Year PB	2.31 Year PB	3.08 Year PB	3.85 Year PB	4.62 Year PB
Commercial	Gas	0.42 Year PB	0.83 Year PB	1.67 Year PB	2.50 Year PB	3.33 Year PB	4.17 Year PB	5.00 Year PB
Commercial	Electricity	0.39 Year PB	0.78 Year PB	1.57 Year PB	2.35 Year PB	3.13 Year PB	3.92 Year PB	4.70 Year PB
Residential	Gas	0.45 Year PB	0.91 Year PB	1.82 Year PB	2.73 Year PB	3.64 Year PB	4.55 Year PB	5.45 Year PB
Residential	Electricity	0.44 Year PB	0.87 Year PB	1.75 Year PB	2.62 Year PB	3.49 Year PB	4.37 Year PB	5.24 Year PB

We see here that in addition to coal, some gas and electricity energy efficiency measures start to become cost effective, and coal measures at nominal 4-year payback drop to the 2-year level.

Table 11.8: Illustration of Additional GHG Savings meeting Private Payback Criterion at $20/tonne Carbon Price

Sector	Fuel	CO2 Saving @ $20/t & 0.5 Y PB	CO2 Saving @ $20/t & 1 Y PB	CO2 Saving @ $20/t & 2 Y PB	CO2 Saving @ $20/t & 3 Y PB	CO2 Saving @ $20/t & 4 Y PB	CO2 Saving @ $20/t & 5 Y PB	CO2 Saving @ $20/t & 6 Y PB
Mining	Coal	3.16 kt CO2	7.90 kt CO2	4.74 kt CO2	7.33 kt CO2	7.33 kt CO2	0.00 kt CO2	0.00 kt CO2
Mining	Gas	7.28 kt CO2	18.20 kt CO2	10.92 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Mining	Electricity	47.55 kt CO2	118.87 kt CO2	71.32 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Mining	Other Petroleum	35.26 kt CO2	88.16 kt CO2	52.89 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Basic Chemicals	Gas	22.22 kt CO2	55.56 kt CO2	33.34 kt CO2	6.95 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Iron & Steel	Coal	6.50 kt CO2	16.25 kt CO2	9.75 kt CO2	8.12 kt CO2	8.12 kt CO2	0.00 kt CO2	0.00 kt CO2
Iron & Steel	Gas	1.12 kt CO2	2.81 kt CO2	1.68 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Ferrous Metals	Coal	4.07 kt CO2	10.17 kt CO2	6.10 kt CO2	1.27 kt CO2	1.27 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Ferrous Metals	Gas	30.43 kt CO2	76.08 kt CO2	45.65 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Ferrous Metals	Electricity	20.31 kt CO2	50.78 kt CO2	30.47 kt CO2	6.35 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Metallic Minerals	Coal	5.33 kt CO2	13.34 kt CO2	8.00 kt CO2	11.11 kt CO2	11.11 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Metallic Minerals	Gas	8.66 kt CO2	21.66 kt CO2	12.99 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Commercial	Gas	4.04 kt CO2	10.11 kt CO2	6.07 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Commercial	Electricity	124.35 kt CO2	310.86 kt CO2	186.52 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Residential	Gas	6.29 kt CO2	15.73 kt CO2	9.44 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Residential	Electricity	26.68 kt CO2	66.69 kt CO2	40.01 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Coal	19.06 kt CO2	47.65 kt CO2	28.59 kt CO2	27.84 kt CO2	27.84 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Gas	80.05 kt CO2	200.13 kt CO2	120.08 kt CO2	6.95 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Electricity	218.88 kt CO2	547.20 kt CO2	328.32 kt CO2	6.35 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Other Petroleum	35.26 kt CO2	88.16 kt CO2	52.89 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
TOTAL	**All Fuel**	**353.26 kt CO2**	**883.15 kt CO2**	**529.89 kt CO2**	**41.13 kt CO2**	**27.84 kt CO2**	**0.00 kt CO2**	**0.00 kt CO2**

Table 11.9: Illustration of Additional Measures meeting Private Payback Criterion at $30/tonne Carbon Price

Sector	Fuel	Effective PB @ $30/t CO2 for 0.5Y PB	Effective PB @ $30/t CO2 for 1 Y PB	Effective PB @ $30/t CO2 for 2 Y PB	Effective PB @ $30/t CO2 for 3 Y PB	Effective PB @ $30/t CO2 for 4 Y PB	Effective PB @ $30/t CO2 for 5 Y PB	Effective PB @ $30/t CO2 for 6 Y PB
Mining	Coal	0.21 Year PB	0.41 Year PB	0.83 Year PB	1.24 Year PB	1.66 Year PB	2.07 Year PB	2.49 Year PB
Mining	Gas	0.34 Year PB	0.69 Year PB	1.38 Year PB	2.07 Year PB	2.76 Year PB	3.45 Year PB	4.14 Year PB
Mining	Electricity	0.32 Year PB	0.64 Year PB	1.29 Year PB	1.93 Year PB	2.58 Year PB	3.22 Year PB	3.87 Year PB
Mining	Other Petroleum	0.46 Year PB	0.91 Year PB	1.83 Year PB	2.74 Year PB	3.66 Year PB	4.57 Year PB	5.49 Year PB
Basic Chemicals	Gas	0.29 Year PB	0.58 Year PB	1.16 Year PB	1.74 Year PB	2.33 Year PB	2.91 Year PB	3.49 Year PB
Iron & Steel	Coal	0.21 Year PB	0.41 Year PB	0.83 Year PB	1.24 Year PB	1.66 Year PB	2.07 Year PB	2.49 Year PB
Iron & Steel	Gas	0.34 Year PB	0.69 Year PB	1.38 Year PB	2.07 Year PB	2.76 Year PB	3.45 Year PB	4.14 Year PB
Non-Ferrous Metals	Coal	0.21 Year PB	0.41 Year PB	0.83 Year PB	1.24 Year PB	1.66 Year PB	2.07 Year PB	2.49 Year PB
Non-Ferrous Metals	Gas	0.31 Year PB	0.63 Year PB	1.25 Year PB	1.88 Year PB	2.50 Year PB	3.13 Year PB	3.75 Year PB
Non-Ferrous Metals	Electricity	0.30 Year PB	0.59 Year PB	1.18 Year PB	1.78 Year PB	2.37 Year PB	2.96 Year PB	3.55 Year PB
Non-Metallic Minerals	Coal	0.21 Year PB	0.41 Year PB	0.83 Year PB	1.24 Year PB	1.66 Year PB	2.07 Year PB	2.49 Year PB
Non-Metallic Minerals	Gas	0.34 Year PB	0.69 Year PB	1.38 Year PB	2.07 Year PB	2.76 Year PB	3.45 Year PB	4.14 Year PB
Commercial	Gas	0.38 Year PB	0.77 Year PB	1.54 Year PB	2.31 Year PB	3.08 Year PB	3.85 Year PB	4.62 Year PB
Commercial	Electricity	0.35 Year PB	0.71 Year PB	1.41 Year PB	2.12 Year PB	2.83 Year PB	3.54 Year PB	4.24 Year PB
Residential	Gas	0.43 Year PB	0.87 Year PB	1.74 Year PB	2.61 Year PB	3.48 Year PB	4.35 Year PB	5.22 Year PB
Residential	Electricity	0.41 Year PB	0.82 Year PB	1.64 Year PB	2.46 Year PB	3.28 Year PB	4.11 Year PB	4.93 Year PB

At this level, coal projects at nominal 5-year payback become cost effective, while a greater number of gas and electricity measures become cost effective from a nominal 3-year payback level.

Table 11.10: Illustration of Additional GHG Savings meeting Private Payback Criterion at $30/tonne Carbon Price

Sector	Fuel	CO2 Saving @ $30/t & 0.5 Y PB	CO2 Saving @ $30/t & 1 Y PB	CO2 Saving @ $30/t & 2 Y PB	CO2 Saving @ $30/t & 3 Y PB	CO2 Saving @ $30/t & 4 Y PB	CO2 Saving @ $30/t & 5 Y PB	CO2 Saving @ $30/t & 6 Y PB
Mining	Coal	3.16 kt CO2	7.90 kt CO2	4.74 kt CO2	7.33 kt CO2	7.33 kt CO2	7.33 kt CO2	0.00 kt CO2
Mining	Gas	7.28 kt CO2	18.20 kt CO2	10.92 kt CO2	16.90 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Mining	Electricity	47.55 kt CO2	118.87 kt CO2	71.32 kt CO2	110.38 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Mining	Other Petroleum	35.26 kt CO2	88.16 kt CO2	52.89 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Basic Chemicals	Gas	22.22 kt CO2	55.56 kt CO2	33.34 kt CO2	6.95 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Iron & Steel	Coal	6.50 kt CO2	16.25 kt CO2	9.75 kt CO2	8.12 kt CO2	8.12 kt CO2	8.12 kt CO2	0.00 kt CO2
Iron & Steel	Gas	1.12 kt CO2	2.81 kt CO2	1.68 kt CO2	1.40 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Ferrous Metals	Coal	4.07 kt CO2	10.17 kt CO2	6.10 kt CO2	1.27 kt CO2	1.27 kt CO2	1.27 kt CO2	0.00 kt CO2
Non-Ferrous Metals	Gas	30.43 kt CO2	76.08 kt CO2	45.65 kt CO2	9.51 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Ferrous Metals	Electricity	20.31 kt CO2	50.78 kt CO2	30.47 kt CO2	6.35 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Metallic Minerals	Coal	5.33 kt CO2	13.34 kt CO2	8.00 kt CO2	11.11 kt CO2	11.11 kt CO2	11.11 kt CO2	0.00 kt CO2
Non-Metallic Minerals	Gas	8.66 kt CO2	21.66 kt CO2	12.99 kt CO2	18.05 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Commercial	Gas	4.04 kt CO2	10.11 kt CO2	6.07 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Commercial	Electricity	124.35 kt CO2	310.86 kt CO2	186.52 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Residential	Gas	6.29 kt CO2	15.73 kt CO2	9.44 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Residential	Electricity	26.68 kt CO2	66.69 kt CO2	40.01 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Coal	19.06 kt CO2	47.65 kt CO2	28.59 kt CO2	27.84 kt CO2	27.84 kt CO2	27.84 kt CO2	0.00 kt CO2
Sub-Total	Gas	80.05 kt CO2	200.13 kt CO2	120.08 kt CO2	52.80 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Electricity	218.88 kt CO2	547.20 kt CO2	328.32 kt CO2	116.72 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Other Petroleum	35.26 kt CO2	88.16 kt CO2	52.89 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
TOTAL	**All Fuel**	**353.26 kt CO2**	**883.15 kt CO2**	**529.89 kt CO2**	**197.37 kt CO2**	**27.84 kt CO2**	**27.84 kt CO2**	**0.00 kt CO2**

Table 11.11: Illustration of Additional Measures meeting Private Payback Criterion at $40/tonne Carbon Price

Sector	Fuel	Effective PB @ $40/t CO2 for 0.5Y PB	Effective PB @ $40/t CO2 for 1 Y PB	Effective PB @ $40/t CO2 for 2 Y PB	Effective PB @ $40/t CO2 for 3 Y PB	Effective PB @ $40/t CO2 for 4 Y PB	Effective PB @ $40/t CO2 for 5 Y PB	Effective PB @ $40/t CO2 for 6 Y PB
Mining	Coal	0.17 Year PB	0.35 Year PB	0.69 Year PB	1.04 Year PB	1.39 Year PB	1.73 Year PB	2.08 Year PB
Mining	Gas	0.31 Year PB	0.63 Year PB	1.25 Year PB	1.88 Year PB	2.50 Year PB	3.13 Year PB	3.75 Year PB
Mining	Electricity	0.29 Year PB	0.58 Year PB	1.15 Year PB	1.73 Year PB	2.30 Year PB	2.88 Year PB	3.46 Year PB
Mining	Other Petroleum	0.44 Year PB	0.89 Year PB	1.78 Year PB	2.67 Year PB	3.56 Year PB	4.45 Year PB	5.34 Year PB
Basic Chemicals	Gas	0.26 Year PB	0.51 Year PB	1.02 Year PB	1.53 Year PB	2.04 Year PB	2.55 Year PB	3.06 Year PB
Iron & Steel	Coal	0.17 Year PB	0.35 Year PB	0.69 Year PB	1.04 Year PB	1.39 Year PB	1.73 Year PB	2.08 Year PB
Iron & Steel	Gas	0.31 Year PB	0.63 Year PB	1.25 Year PB	1.88 Year PB	2.50 Year PB	3.13 Year PB	3.75 Year PB
Non-Ferrous Metals	Coal	0.17 Year PB	0.35 Year PB	0.69 Year PB	1.04 Year PB	1.39 Year PB	1.73 Year PB	2.08 Year PB
Non-Ferrous Metals	Gas	0.28 Year PB	0.56 Year PB	1.11 Year PB	1.67 Year PB	2.22 Year PB	2.78 Year PB	3.33 Year PB
Non-Ferrous Metals	Electricity	0.26 Year PB	0.52 Year PB	1.04 Year PB	1.56 Year PB	2.08 Year PB	2.60 Year PB	3.13 Year PB
Non-Metallic Minerals	Coal	0.17 Year PB	0.35 Year PB	0.69 Year PB	1.04 Year PB	1.39 Year PB	1.73 Year PB	2.08 Year PB
Non-Metallic Minerals	Gas	0.31 Year PB	0.63 Year PB	1.25 Year PB	1.88 Year PB	2.50 Year PB	3.13 Year PB	3.75 Year PB
Commercial	Gas	0.36 Year PB	0.71 Year PB	1.43 Year PB	2.14 Year PB	2.86 Year PB	3.57 Year PB	4.29 Year PB
Commercial	Electricity	0.32 Year PB	0.64 Year PB	1.29 Year PB	1.93 Year PB	2.58 Year PB	3.22 Year PB	3.87 Year PB
Residential	Gas	0.42 Year PB	0.83 Year PB	1.67 Year PB	2.50 Year PB	3.33 Year PB	4.17 Year PB	5.00 Year PB
Residential	Electricity	0.39 Year PB	0.77 Year PB	1.55 Year PB	2.32 Year PB	3.10 Year PB	3.87 Year PB	4.65 Year PB

We now see most 3-year payback measures becoming cost-effective, and an increasing number of 4-year payback measures, mainly in gas and coal. Only coal measures are cost-effective where nominal 5+ year paybacks apply.

Table 11.12: Illustration of Additional GHG Savings meeting Private Payback Criterion at $40/tonne Carbon Price

Sector	Fuel	CO2 Saving @ $40/t & 0.5 Y PB	CO2 Saving @ $40/t & 1 Y PB	CO2 Saving @ $40/t & 2 Y PB	CO2 Saving @ $40/t & 3 Y PB	CO2 Saving @ $40/t & 4 Y PB	CO2 Saving @ $40/t & 5 Y PB	CO2 Saving @ $40/t & 6 Y PB
Mining	Coal	3.16 kt CO2	7.90 kt CO2	4.74 kt CO2	7.33 kt CO2	7.33 kt CO2	7.33 kt CO2	7.33 kt CO2
Mining	Gas	7.28 kt CO2	18.20 kt CO2	10.92 kt CO2	16.90 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Mining	Electricity	47.55 kt CO2	118.87 kt CO2	71.32 kt CO2	110.38 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Mining	Other Petroleum	35.26 kt CO2	88.16 kt CO2	52.89 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Basic Chemicals	Gas	22.22 kt CO2	55.56 kt CO2	33.34 kt CO2	6.95 kt CO2	6.95 kt CO2	0.00 kt CO2	0.00 kt CO2
Iron & Steel	Coal	6.50 kt CO2	16.25 kt CO2	9.75 kt CO2	8.12 kt CO2	8.12 kt CO2	8.12 kt CO2	8.12 kt CO2
Iron & Steel	Gas	1.12 kt CO2	2.81 kt CO2	1.68 kt CO2	1.40 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Ferrous Metals	Coal	4.07 kt CO2	10.17 kt CO2	6.10 kt CO2	1.27 kt CO2	1.27 kt CO2	1.27 kt CO2	1.27 kt CO2
Non-Ferrous Metals	Gas	30.43 kt CO2	76.08 kt CO2	45.65 kt CO2	9.51 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Ferrous Metals	Electricity	20.31 kt CO2	50.78 kt CO2	30.47 kt CO2	6.35 kt CO2	6.35 kt CO2	0.00 kt CO2	0.00 kt CO2
Non-Metallic Minerals	Coal	5.33 kt CO2	13.34 kt CO2	8.00 kt CO2	11.11 kt CO2	11.11 kt CO2	11.11 kt CO2	11.11 kt CO2
Non-Metallic Minerals	Gas	8.66 kt CO2	21.66 kt CO2	12.99 kt CO2	18.05 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Commercial	Gas	4.04 kt CO2	10.11 kt CO2	6.07 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Commercial	Electricity	124.35 kt CO2	310.86 kt CO2	186.52 kt CO2	43.84 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Residential	Gas	6.29 kt CO2	15.73 kt CO2	9.44 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Residential	Electricity	26.68 kt CO2	66.69 kt CO2	40.01 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Coal	19.06 kt CO2	47.65 kt CO2	28.59 kt CO2	27.84 kt CO2	27.84 kt CO2	27.84 kt CO2	27.84 kt CO2
Sub-Total	Gas	80.05 kt CO2	200.13 kt CO2	120.08 kt CO2	52.80 kt CO2	6.95 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Electricity	218.88 kt CO2	547.20 kt CO2	328.32 kt CO2	160.56 kt CO2	6.35 kt CO2	0.00 kt CO2	0.00 kt CO2
Sub-Total	Other Petroleum	35.26 kt CO2	88.16 kt CO2	52.89 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2	0.00 kt CO2
TOTAL	**All Fuel**	**353.26 kt CO2**	**883.15 kt CO2**	**529.89 kt CO2**	**241.21 kt CO2**	**41.13 kt CO2**	**27.84 kt CO2**	**27.84 kt CO2**

SOCIAL COST-EFFECTIVENESS

For socially cost-effective measures we have taken data from Table 11.1, and utilised this plus our NFEE work to make an estimate of savings potential at a range of interim payback levels to inform this assessment, including extrapolation of WA EEI estimates beyond 6-year payback levels (which indicates an additional 4.29 PJ EEI potential to 2010, and 12.73 PJ additional EEI potential to 2015). The EEI potential data set from which this analysis is conducted is therefore as shown below.

Table 11.13: Estimate of Disaggregated 2015 EEI at Interim Payback Levels

Sector	Fuel	PJ Savings up to 6-Year PB	PJ Savings up to 2-Year PB	PJ Saving @ 7Y PB	PJ Saving @ 8.5Y PB	PJ Saving @ 10Y PB
Mining	Coal	0.48 PJ	0.17 PJ	0.09 PJ	0.09 PJ	0.04 PJ
Mining	Gas	1.73 PJ	0.61 PJ	0.31 PJ	0.31 PJ	0.16 PJ
Mining	Electricity	2.46 PJ	0.86 PJ	0.44 PJ	0.44 PJ	0.22 PJ
Mining	Other Petroleum	6.50 PJ	2.28 PJ	1.17 PJ	1.17 PJ	0.59 PJ
Basic Chemicals	Gas	2.32 PJ	1.85 PJ	0.42 PJ	0.42 PJ	0.21 PJ
Iron & Steel	Coal	0.69 PJ	0.35 PJ	0.12 PJ	0.12 PJ	0.06 PJ
Iron & Steel	Gas	0.19 PJ	0.09 PJ	0.03 PJ	0.03 PJ	0.02 PJ
Non-Ferrous Metals	Coal	0.27 PJ	0.22 PJ	0.05 PJ	0.05 PJ	0.02 PJ
Non-Ferrous Metals	Gas	3.17 PJ	2.54 PJ	0.57 PJ	0.57 PJ	0.29 PJ
Non-Ferrous Metals	Electricity	0.46 PJ	0.37 PJ	0.08 PJ	0.08 PJ	0.04 PJ
Non-Metallic Minerals	Coal	0.76 PJ	0.28 PJ	0.14 PJ	0.14 PJ	0.07 PJ
Non-Metallic Minerals	Gas	1.93 PJ	0.72 PJ	0.35 PJ	0.35 PJ	0.17 PJ
Commercial	Gas	0.43 PJ	0.34 PJ	0.08 PJ	0.08 PJ	0.04 PJ
Commercial	Electricity	2.89 PJ	2.25 PJ	0.52 PJ	0.52 PJ	0.26 PJ
Residential	Gas	2.10 PJ	0.52 PJ	0.38 PJ	0.38 PJ	0.19 PJ
Residential	Electricity	1.93 PJ	0.48 PJ	0.35 PJ	0.35 PJ	0.17 PJ
Sub-Total	Coal	2.19 PJ	1.01 PJ	0.39 PJ	0.39 PJ	0.20 PJ
Sub-Total	Gas	11.86 PJ	6.67 PJ	2.13 PJ	2.13 PJ	1.07 PJ
Sub-Total	Electricity	7.74 PJ	3.97 PJ	1.39 PJ	1.39 PJ	0.70 PJ
Sub-Total	Other Petroleum	6.50 PJ	2.28 PJ	1.17 PJ	1.17 PJ	0.59 PJ
TOTAL	**All Fuel**	**28.30 PJ**	**13.92 PJ**	**5.09 PJ**	**5.09 PJ**	**2.55 PJ**

Table 11.13: Estimate of Disaggregated 2010 EEI at Interim Payback Levels

Sector	Fuel	PJ Savings up to 6-Year PB	PJ Savings up to 2-Year PB	PJ Saving @ 7Y PB	PJ Saving @ 8.5Y PB	PJ Saving @ 10Y PB
Mining	Coal	0.20 PJ	0.07 PJ	0.04 PJ	0.04 PJ	0.02 PJ
Mining	Gas	0.48 PJ	0.17 PJ	0.09 PJ	0.09 PJ	0.04 PJ
Mining	Electricity	0.72 PJ	0.25 PJ	0.13 PJ	0.13 PJ	0.06 PJ
Mining	Other Petroleum	1.60 PJ	0.56 PJ	0.29 PJ	0.29 PJ	0.14 PJ
Basic Chemicals	Gas	0.77 PJ	0.62 PJ	0.14 PJ	0.14 PJ	0.07 PJ
Iron & Steel	Coal	0.30 PJ	0.15 PJ	0.05 PJ	0.05 PJ	0.03 PJ
Iron & Steel	Gas	0.06 PJ	0.03 PJ	0.01 PJ	0.01 PJ	0.01 PJ
Non-Ferrous Metals	Coal	0.10 PJ	0.08 PJ	0.02 PJ	0.02 PJ	0.01 PJ
Non-Ferrous Metals	Gas	1.18 PJ	0.94 PJ	0.21 PJ	0.21 PJ	0.11 PJ
Non-Ferrous Metals	Electricity	0.19 PJ	0.15 PJ	0.03 PJ	0.03 PJ	0.02 PJ
Non-Metallic Minerals	Coal	0.26 PJ	0.10 PJ	0.05 PJ	0.05 PJ	0.02 PJ
Non-Metallic Minerals	Gas	0.60 PJ	0.23 PJ	0.11 PJ	0.11 PJ	0.05 PJ
Commercial	Gas	0.17 PJ	0.13 PJ	0.03 PJ	0.03 PJ	0.02 PJ
Commercial	Electricity	1.35 PJ	1.05 PJ	0.24 PJ	0.24 PJ	0.12 PJ
Residential	Gas	0.76 PJ	0.19 PJ	0.14 PJ	0.14 PJ	0.07 PJ
Residential	Electricity	0.79 PJ	0.20 PJ	0.14 PJ	0.14 PJ	0.07 PJ
Sub-Total	Coal	0.86 PJ	0.40 PJ	0.15 PJ	0.15 PJ	0.08 PJ
Sub-Total	Gas	4.02 PJ	2.31 PJ	0.72 PJ	0.72 PJ	0.36 PJ
Sub-Total	Electricity	3.05 PJ	1.65 PJ	0.55 PJ	0.55 PJ	0.27 PJ
Sub-Total	Other Petroleum	1.60 PJ	0.56 PJ	0.29 PJ	0.29 PJ	0.14 PJ
TOTAL	**All Fuel**	**9.53 PJ**	**4.92 PJ**	**1.72 PJ**	**1.72 PJ**	**0.86 PJ**

By utilising estimated energy prices and applying various carbon prices we can re-calculate the simple payback, and by assuming that where this has the effect of reducing the simple payback to 6 years or less (in practice we have taken up to 6.1 year simple payback to effectively be a 6-year payback) implementation will occur, we can estimate potential GHG abatement at these carbon price levels. This is shown below (same impact on payback for 2010 and 2015).

Table 11.14: Illustration of Additional Measures meeting Social Payback Criterion at $10/tonne Carbon Price, with Additional Energy & GHG Savings

Sector	Fuel	Effective PB @ $10/t CO_2 for 7Y PB	Effective PB @ $10/t CO_2 for 8.5Y PB	Effective PB @ $10/t CO_2 for 10Y PB	PJ Saving @ $10/t for 7 Y PB	PJ Saving @ $10/t for 8.5 Y PB	PJ Saving @ $10/t for 10 Y PB	Additional CO_2 Saving
Mining	Coal	4.76 Year PB	5.78 Year PB	6.80 Year PB	0.09 PJ	0.09 PJ	0.00 PJ	16.2 kt CO_2
Mining	Gas	6.09 Year PB	7.39 Year PB	8.70 Year PB	0.31 PJ	0.00 PJ	0.00 PJ	18.7 kt CO_2
Mining	Electricity	5.91 Year PB	7.18 Year PB	8.45 Year PB	0.44 PJ	0.00 PJ	0.00 PJ	122.3 kt CO_2
Mining	Other Petroleum	6.79 Year PB	8.24 Year PB	9.70 Year PB	0.00 PJ	0.00 PJ	0.00 PJ	0.0 kt CO_2
Basic Chemicals	Gas	5.65 Year PB	6.85 Year PB	8.06 Year PB	0.42 PJ	0.00 PJ	0.00 PJ	25.0 kt CO_2
Iron & Steel	Coal	4.76 Year PB	5.78 Year PB	6.80 Year PB	0.12 PJ	0.12 PJ	0.00 PJ	23.4 kt CO_2
Iron & Steel	Gas	6.09 Year PB	7.39 Year PB	8.70 Year PB	0.03 PJ	0.00 PJ	0.00 PJ	2.0 kt CO_2
Non-Ferrous Metals	Coal	4.76 Year PB	5.78 Year PB	6.80 Year PB	0.05 PJ	0.05 PJ	0.00 PJ	9.2 kt CO_2
Non-Ferrous Metals	Gas	5.83 Year PB	7.08 Year PB	8.33 Year PB	0.57 PJ	0.00 PJ	0.00 PJ	34.2 kt CO_2
Non-Ferrous Metals	Electricity	5.69 Year PB	6.91 Year PB	8.13 Year PB	0.08 PJ	0.00 PJ	0.00 PJ	22.9 kt CO_2
Non-Metallic Minerals	Coal	4.76 Year PB	5.78 Year PB	6.80 Year PB	0.14 PJ	0.14 PJ	0.00 PJ	25.6 kt CO_2
Non-Metallic Minerals	Gas	6.09 Year PB	7.39 Year PB	8.70 Year PB	0.35 PJ	0.00 PJ	0.00 PJ	20.8 kt CO_2
Commercial	Gas	6.36 Year PB	7.73 Year PB	9.09 Year PB	0.00 PJ	0.00 PJ	0.00 PJ	0.0 kt CO_2
Commercial	Electricity	6.15 Year PB	7.47 Year PB	8.79 Year PB	0.00 PJ	0.00 PJ	0.00 PJ	0.0 kt CO_2
Residential	Gas	6.67 Year PB	8.10 Year PB	9.52 Year PB	0.00 PJ	0.00 PJ	0.00 PJ	0.0 kt CO_2
Residential	Electricity	6.53 Year PB	7.92 Year PB	9.32 Year PB	0.00 PJ	0.00 PJ	0.00 PJ	0.0 kt CO_2

This shows that a number of coal, gas and electricity measures become cost effective where a nominal 7-year payback applies without a carbon price, as well as coal measures up to 8.5 year payback.

Table 11.15: Illustration of Additional Measures meeting Social Payback Criterion at $20/tonne Carbon Price, with Additional Energy & GHG Savings

Sector	Fuel	Effective PB @ $20/t CO_2 for 7Y PB	Effective PB @ $20/t CO_2 for 8.5Y PB	Effective PB @ $20/t CO_2 for 10Y PB	PJ Saving @ $20/t for 7 Y PB	PJ Saving @ $20/t for 8.5 Y PB	PJ Saving @ $20/t for 10 Y PB	Additional CO_2 Saving
Mining	Coal	3.60 Year PB	4.38 Year PB	5.15 Year PB	0.09 PJ	0.09 PJ	0.04 PJ	20.3 kt CO_2
Mining	Gas	5.38 Year PB	6.54 Year PB	7.69 Year PB	0.31 PJ	0.00 PJ	0.00 PJ	18.7 kt CO_2
Mining	Electricity	5.12 Year PB	6.21 Year PB	7.31 Year PB	0.44 PJ	0.00 PJ	0.00 PJ	122.3 kt CO_2
Mining	Other Petroleum	6.59 Year PB	8.00 Year PB	9.42 Year PB	0.00 PJ	0.00 PJ	0.00 PJ	0.0 kt CO_2
Basic Chemicals	Gas	4.73 Year PB	5.74 Year PB	6.76 Year PB	0.42 PJ	0.42 PJ	0.00 PJ	50.0 kt CO_2
Iron & Steel	Coal	3.60 Year PB	4.38 Year PB	5.15 Year PB	0.12 PJ	0.12 PJ	0.06 PJ	29.2 kt CO_2
Iron & Steel	Gas	5.38 Year PB	6.54 Year PB	7.69 Year PB	0.03 PJ	0.00 PJ	0.00 PJ	2.0 kt CO_2
Non-Ferrous Metals	Coal	3.60 Year PB	4.38 Year PB	5.15 Year PB	0.05 PJ	0.05 PJ	0.02 PJ	11.4 kt CO_2
Non-Ferrous Metals	Gas	5.00 Year PB	6.07 Year PB	7.14 Year PB	0.57 PJ	0.57 PJ	0.00 PJ	68.5 kt CO_2
Non-Ferrous Metals	Electricity	4.79 Year PB	5.82 Year PB	6.85 Year PB	0.08 PJ	0.08 PJ	0.00 PJ	45.7 kt CO_2
Non-Metallic Minerals	Coal	3.60 Year PB	4.38 Year PB	5.15 Year PB	0.14 PJ	0.14 PJ	0.07 PJ	32.0 kt CO_2
Non-Metallic Minerals	Gas	5.38 Year PB	6.54 Year PB	7.69 Year PB	0.35 PJ	0.00 PJ	0.00 PJ	20.8 kt CO_2
Commercial	Gas	5.83 Year PB	7.08 Year PB	8.33 Year PB	0.08 PJ	0.00 PJ	0.00 PJ	4.7 kt CO_2
Commercial	Electricity	5.49 Year PB	6.66 Year PB	7.84 Year PB	0.52 PJ	0.00 PJ	0.00 PJ	143.5 kt CO_2
Residential	Gas	6.36 Year PB	7.73 Year PB	9.09 Year PB	0.00 PJ	0.00 PJ	0.00 PJ	0.0 kt CO_2
Residential	Electricity	6.11 Year PB	7.42 Year PB	8.73 Year PB	0.00 PJ	0.00 PJ	0.00 PJ	0.0 kt CO_2

At this carbon price ($20/t) most measures at nominal 7-year payback become cost effective, as well as several coal and gas and some electricity measures at 8.5 year payback. Only coal measures at 10 year payback become cost effective.

Table 11.16: Illustration of Additional Measures meeting Social Payback Criterion at $30/tonne Carbon Price, with Additional Energy & GHG Savings

Sector	Fuel	Effective PB @ $30/t CO2 for 7Y PB	Effective PB @ $30/t CO2 for 8.5Y PB	Effective PB @ $30/t CO2 for 10Y PB	PJ Saving @ $30/t for 7 Y PB	PJ Saving @ $30/t for 8.5 Y PB	PJ Saving @ $30/t for 10 Y PB	Additional CO2 Saving
Mining	Coal	2.90 Year PB	3.52 Year PB	4.14 Year PB	0.09 PJ	0.09 PJ	0.04 PJ	20.3 kt CO2
Mining	Gas	4.83 Year PB	5.86 Year PB	6.90 Year PB	0.31 PJ	0.31 PJ	0.00 PJ	37.4 kt CO2
Mining	Electricity	4.51 Year PB	5.48 Year PB	6.44 Year PB	0.44 PJ	0.44 PJ	0.00 PJ	244.5 kt CO2
Mining	Other Petroleum	6.40 Year PB	7.78 Year PB	9.15 Year PB	0.00 PJ	0.00 PJ	0.00 PJ	0.0 kt CO2
Basic Chemicals	Gas	4.07 Year PB	4.94 Year PB	5.81 Year PB	0.42 PJ	0.42 PJ	0.21 PJ	62.5 kt CO2
Iron & Steel	Coal	2.90 Year PB	3.52 Year PB	4.14 Year PB	0.12 PJ	0.12 PJ	0.06 PJ	29.2 kt CO2
Iron & Steel	Gas	4.83 Year PB	5.86 Year PB	6.90 Year PB	0.03 PJ	0.03 PJ	0.00 PJ	4.0 kt CO2
Non-Ferrous Metals	Coal	2.90 Year PB	3.52 Year PB	4.14 Year PB	0.05 PJ	0.05 PJ	0.02 PJ	11.4 kt CO2
Non-Ferrous Metals	Gas	4.38 Year PB	5.31 Year PB	6.25 Year PB	0.57 PJ	0.57 PJ	0.00 PJ	68.5 kt CO2
Non-Ferrous Metals	Electricity	4.14 Year PB	5.03 Year PB	5.92 Year PB	0.08 PJ	0.08 PJ	0.04 PJ	57.1 kt CO2
Non-Metallic Minerals	Coal	2.90 Year PB	3.52 Year PB	4.14 Year PB	0.14 PJ	0.14 PJ	0.07 PJ	32.0 kt CO2
Non-Metallic Minerals	Gas	4.83 Year PB	5.86 Year PB	6.90 Year PB	0.35 PJ	0.35 PJ	0.00 PJ	41.6 kt CO2
Commercial	Gas	5.38 Year PB	6.54 Year PB	7.69 Year PB	0.08 PJ	0.00 PJ	0.00 PJ	4.7 kt CO2
Commercial	Electricity	4.95 Year PB	6.01 Year PB	7.07 Year PB	0.52 PJ	0.52 PJ	0.00 PJ	287.0 kt CO2
Residential	Gas	6.09 Year PB	7.39 Year PB	8.70 Year PB	0.38 PJ	0.00 PJ	0.00 PJ	22.6 kt CO2
Residential	Electricity	5.75 Year PB	6.98 Year PB	8.21 Year PB	0.35 PJ	0.00 PJ	0.00 PJ	96.0 kt CO2

At this carbon price ($30/t) nearly all measures at nominal 7-year payback become cost effective, as well as most measures at 8.5 year payback. Coal and some gas and electricity measures become cost effective at 10 year nominal payback.

Table 11.17: Illustration of Additional Measures meeting Social Payback Criterion at $40/tonne Carbon Price, with Additional Energy & GHG Savings

Sector	Fuel	Effective PB @ $40/t CO2 for 7Y PB	Effective PB @ $40/t CO2 for 8.5Y PB	Effective PB @ $40/t CO2 for 10Y PB	PJ Saving @ $40/t for 7 Y PB	PJ Saving @ $40/t for 8.5 Y PB	PJ Saving @ $40/t for 10 Y PB	Additional CO2 Saving
Mining	Coal	2.43 Year PB	2.95 Year PB	3.47 Year PB	0.09 PJ	0.09 PJ	0.04 PJ	20.3 kt CO2
Mining	Gas	4.38 Year PB	5.31 Year PB	6.25 Year PB	0.31 PJ	0.31 PJ	0.00 PJ	37.4 kt CO2
Mining	Electricity	4.03 Year PB	4.90 Year PB	5.76 Year PB	0.44 PJ	0.44 PJ	0.22 PJ	305.7 kt CO2
Mining	Other Petroleum	6.23 Year PB	7.56 Year PB	8.90 Year PB	0.00 PJ	0.00 PJ	0.00 PJ	0.0 kt CO2
Basic Chemicals	Gas	3.57 Year PB	4.34 Year PB	5.10 Year PB	0.42 PJ	0.42 PJ	0.21 PJ	62.5 kt CO2
Iron & Steel	Coal	2.43 Year PB	2.95 Year PB	3.47 Year PB	0.12 PJ	0.12 PJ	0.06 PJ	29.2 kt CO2
Iron & Steel	Gas	4.38 Year PB	5.31 Year PB	6.25 Year PB	0.03 PJ	0.03 PJ	0.00 PJ	4.0 kt CO2
Non-Ferrous Metals	Coal	2.43 Year PB	2.95 Year PB	3.47 Year PB	0.05 PJ	0.05 PJ	0.02 PJ	11.4 kt CO2
Non-Ferrous Metals	Gas	3.89 Year PB	4.72 Year PB	5.56 Year PB	0.57 PJ	0.57 PJ	0.29 PJ	85.6 kt CO2
Non-Ferrous Metals	Electricity	3.65 Year PB	4.43 Year PB	5.21 Year PB	0.08 PJ	0.08 PJ	0.04 PJ	57.1 kt CO2
Non-Metallic Minerals	Coal	2.43 Year PB	2.95 Year PB	3.47 Year PB	0.14 PJ	0.14 PJ	0.07 PJ	32.0 kt CO2
Non-Metallic Minerals	Gas	4.38 Year PB	5.31 Year PB	6.25 Year PB	0.35 PJ	0.35 PJ	0.00 PJ	41.6 kt CO2
Commercial	Gas	5.00 Year PB	6.07 Year PB	7.14 Year PB	0.08 PJ	0.08 PJ	0.00 PJ	9.3 kt CO2
Commercial	Electricity	4.51 Year PB	5.48 Year PB	6.44 Year PB	0.52 PJ	0.52 PJ	0.00 PJ	287.0 kt CO2
Residential	Gas	5.83 Year PB	7.08 Year PB	8.33 Year PB	0.38 PJ	0.00 PJ	0.00 PJ	22.6 kt CO2
Residential	Electricity	5.42 Year PB	6.59 Year PB	7.75 Year PB	0.35 PJ	0.00 PJ	0.00 PJ	96.0 kt CO2

At this level just a few additional measures appear to become cost effective. We note that in all scenarios above, improvements to diesel consumption measures in the mining industry do not reach the 6-year payback level.

12. Carbon Pricing – General Review

For the purpose of illustrating possible impacts of carbon pricing applied to purchased stationary energy use we have simply taken energy use for the material energy forms / sectors in 2006-07, calculated greenhouse gas emissions using standard factors, and calculated cost impacts at $10/t, $20/t, $30/t and $40/t. In addition for each sector we have made assumptions regarding current energy rates (e.g. coal = $2/GJ; Gas = $2.50/GJ in Chemicals up to $12/GJ in residential; Electricity = $12/GJ in Non-Ferrous metals up to $38/GJ in Residential), to calculate the percent increase in total energy cost consequent on these carbon prices. This is shown below.

Table 12.1: Estimated Cost & % Impact of Various Carbon Prices – 2006-07

Sector	Fuel	Assumed Energy Price $/GJ	Energy Use in 2006-07 PJ	GHG Emissions in 2006-07	Estimated Energy Spend in 2006-07 $M	Cost & % Increase @ $10/t CO2		Cost & % Increase @ $20/t CO2		Cost & % Increase @ $30/t CO2		Cost & % Increase @ $40/t CO2	
Mining	Coal	$2.00/GJ	7.00 PJ	659 kt CO2	$14m	$7m	47%	$13m	94%	$20m	141%	$26m	188%
Iron & Steel	Coal	$2.00/GJ	12.00 PJ	1,130 kt CO2	$24m	$11m	47%	$23m	94%	$34m	141%	$45m	188%
Non-Ferrous Metals	Coal	$2.00/GJ	12.80 PJ	1,206 kt CO2	$26m	$12m	47%	$24m	94%	$36m	141%	$48m	188%
Non-Metallic Minerals	Coal	$2.00/GJ	7.70 PJ	725 kt CO2	$15m	$7m	47%	$15m	94%	$22m	141%	$29m	188%
Non-Ferrous Metals	Electricity	$12.00/GJ	16.90 PJ	4,664 kt CO2	$203m	$47m	23%	$93m	46%	$140m	69%	$187m	92%
Mining	Electricity	$15.00/GJ	18.50 PJ	5,106 kt CO2	$278m	$51m	18%	$102m	37%	$153m	55%	$204m	74%
Commercial	Electricity	$20.00/GJ	18.90 PJ	5,216 kt CO2	$378m	$52m	14%	$104m	28%	$156m	41%	$209m	55%
Residential	Electricity	$38.00/GJ	16.60 PJ	4,582 kt CO2	$631m	$46m	7%	$92m	15%	$137m	22%	$183m	29%
Basic Chemicals	Gas	$2.50/GJ	33.10 PJ	1,986 kt CO2	$83m	$20m	24%	$40m	48%	$60m	72%	$79m	96%
Non-Ferrous Metals	Gas	$3.00/GJ	135.90 PJ	8,154 kt CO2	$408m	$82m	20%	$163m	40%	$245m	60%	$326m	80%
Mining	Gas	$4.00/GJ	11.00 PJ	660 kt CO2	$44m	$7m	15%	$13m	30%	$20m	45%	$26m	60%
Iron & Steel	Gas	$4.00/GJ	1.20 PJ	72 kt CO2	$5m	$1m	15%	$1m	30%	$2m	45%	$3m	60%
Non-Metallic Minerals	Gas	$4.00/GJ	15.80 PJ	948 kt CO2	$63m	$9m	15%	$19m	30%	$28m	45%	$38m	60%
Commercial	Gas	$6.00/GJ	3.10 PJ	186 kt CO2	$19m	$2m	10%	$4m	20%	$6m	30%	$7m	40%
Residential	Gas	$12.00/GJ	9.60 PJ	576 kt CO2	$115m	$6m	5%	$12m	10%	$17m	15%	$23m	20%
Mining	Diesel	$25.00/GJ	39.60 PJ	3,069 kt CO2	$990m	$31m	3%	$61m	6%	$92m	9%	$123m	12%

From an energy efficiency perspective we can estimate the potential impact on the payback of 6-year, 4-year and 2-year payback projects with the application of these carbon prices. For simplicity we take a 1 GJ saving for each sector / fuel per the above table, available at 2-, 4- and 6-year payback.

Table 12.2: Estimated Impact on 6-Year PB Projects with Various Carbon Prices

Sector	Fuel	Cost to Achieve a 1GJ Saving @ 6-Year	Revised Payback @ $10/t	Revised Payback @ $20/t	Revised Payback @ $30/t	Revised Payback @ $40/t
Mining	Coal	$ 12.00	4.08 Years	3.09 Years	2.49 Years	2.08 Years
Iron & Steel	Coal	$ 12.00	4.08 Years	3.09 Years	2.49 Years	2.08 Years
Non-Ferrous Metals	Coal	$ 12.00	4.08 Years	3.09 Years	2.49 Years	2.08 Years
Non-Metallic Minerals	Coal	$ 12.00	4.08 Years	3.09 Years	2.49 Years	2.08 Years
Non-Ferrous Metals	Electricity	$ 72.00	4.88 Years	4.11 Years	3.55 Years	3.13 Years
Mining	Electricity	$ 90.00	5.07 Years	4.39 Years	3.87 Years	3.46 Years
Commercial	Electricity	$ 120.00	5.27 Years	4.70 Years	4.24 Years	3.87 Years
Residential	Electricity	$ 228.00	5.59 Years	5.24 Years	4.93 Years	4.65 Years
Basic Chemicals	Gas	$ 15.00	4.84 Years	4.05 Years	3.49 Years	3.06 Years
Non-Ferrous Metals	Gas	$ 18.00	5.00 Years	4.29 Years	3.75 Years	3.33 Years
Mining	Gas	$ 24.00	5.22 Years	4.62 Years	4.14 Years	3.75 Years
Iron & Steel	Gas	$ 24.00	5.22 Years	4.62 Years	4.14 Years	3.75 Years
Non-Metallic Minerals	Gas	$ 24.00	5.22 Years	4.62 Years	4.14 Years	3.75 Years
Commercial	Gas	$ 36.00	5.45 Years	5.00 Years	4.62 Years	4.29 Years
Residential	Gas	$ 72.00	5.71 Years	5.45 Years	5.22 Years	5.00 Years
Mining	Diesel	$ 150.00	5.82 Years	5.65 Years	5.49 Years	5.34 Years

Table 12.3: Estimated Impact on 4-Year PB Projects with Various Carbon Prices

Sector	Fuel	Cost to Achieve a 1GJ Saving @ 4-Year Payback	Revised Payback @ $10/t	Revised Payback @ $20/t	Revised Payback @ $30/t	Revised Payback @ $40/t
Mining	Coal	$ 8.00	2.72 Years	2.06 Years	1.66 Years	1.39 Years
Iron & Steel	Coal	$ 8.00	2.72 Years	2.06 Years	1.66 Years	1.39 Years
Non-Ferrous Metals	Coal	$ 8.00	2.72 Years	2.06 Years	1.66 Years	1.39 Years
Non-Metallic Minerals	Coal	$ 8.00	2.72 Years	2.06 Years	1.66 Years	1.39 Years
Non-Ferrous Metals	Electricity	$ 48.00	3.25 Years	2.74 Years	2.37 Years	2.08 Years
Mining	Electricity	$ 60.00	3.38 Years	2.92 Years	2.58 Years	2.30 Years
Commercial	Electricity	$ 80.00	3.51 Years	3.13 Years	2.83 Years	2.58 Years
Residential	Electricity	$ 152.00	3.73 Years	3.49 Years	3.28 Years	3.10 Years
Basic Chemicals	Gas	$ 10.00	3.23 Years	2.70 Years	2.33 Years	2.04 Years
Non-Ferrous Metals	Gas	$ 12.00	3.33 Years	2.86 Years	2.50 Years	2.22 Years
Mining	Gas	$ 16.00	3.48 Years	3.08 Years	2.76 Years	2.50 Years
Iron & Steel	Gas	$ 16.00	3.48 Years	3.08 Years	2.76 Years	2.50 Years
Non-Metallic Minerals	Gas	$ 16.00	3.48 Years	3.08 Years	2.76 Years	2.50 Years
Commercial	Gas	$ 24.00	3.64 Years	3.33 Years	3.08 Years	2.86 Years
Residential	Gas	$ 48.00	3.81 Years	3.64 Years	3.48 Years	3.33 Years
Mining	Diesel	$ 100.00	3.88 Years	3.77 Years	3.66 Years	3.56 Years

Table 12.4: Estimated Impact on 2-Year PB Projects with Various Carbon Prices

Sector	Fuel	Cost to Achieve a 1GJ Saving @ 2-Year Payback	Revised Payback @ $10/t	Revised Payback @ $20/t	Revised Payback @ $30/t	Revised Payback @ $40/t
Mining	Coal	$ 4.00	1.36 Years	1.03 Years	0.83 Years	0.69 Years
Iron & Steel	Coal	$ 4.00	1.36 Years	1.03 Years	0.83 Years	0.69 Years
Non-Ferrous Metals	Coal	$ 4.00	1.36 Years	1.03 Years	0.83 Years	0.69 Years
Non-Metallic Minerals	Coal	$ 4.00	1.36 Years	1.03 Years	0.83 Years	0.69 Years
Non-Ferrous Metals	Electricity	$ 24.00	1.63 Years	1.37 Years	1.18 Years	1.04 Years
Mining	Electricity	$ 30.00	1.69 Years	1.46 Years	1.29 Years	1.15 Years
Commercial	Electricity	$ 40.00	1.76 Years	1.57 Years	1.41 Years	1.29 Years
Residential	Electricity	$ 76.00	1.86 Years	1.75 Years	1.64 Years	1.55 Years
Basic Chemicals	Gas	$ 5.00	1.61 Years	1.35 Years	1.16 Years	1.02 Years
Non-Ferrous Metals	Gas	$ 6.00	1.67 Years	1.43 Years	1.25 Years	1.11 Years
Mining	Gas	$ 8.00	1.74 Years	1.54 Years	1.38 Years	1.25 Years
Iron & Steel	Gas	$ 8.00	1.74 Years	1.54 Years	1.38 Years	1.25 Years
Non-Metallic Minerals	Gas	$ 8.00	1.74 Years	1.54 Years	1.38 Years	1.25 Years
Commercial	Gas	$ 12.00	1.82 Years	1.67 Years	1.54 Years	1.43 Years
Residential	Gas	$ 24.00	1.90 Years	1.82 Years	1.74 Years	1.67 Years
Mining	Diesel	$ 50.00	1.94 Years	1.88 Years	1.83 Years	1.78 Years

At this high level, the analysis suggests that projects with simple paybacks of 6 years are likely to remain uneconomic under most carbon tax scenarios, where economic is taken to generally mean a payback in 2 to 3 years. Only projects relating to coal energy efficiency at carbon tax greater than $20/tonne are likely to switch to being economic.

Whilst the impact on projects that have a 2-year payback will be to reduce this to under 1 year in some cases and generally to about 1-1.7 years, it might be argued that these projects are cost-effective in any event, frequently relate to better operating methods and practices, and could be better achieved via improved information provision and support.

With projects that may have a simple payback of 4 years now, it appears from this high-level analysis that carbon pricing at $10/tonne would have little impact if a 2-3 year payback is acceptable, at $20/tonne many projects would be on the threshold of a

3-year payback, and it is only at $30/tonne and higher that many projects generally look cost effective.

CURRENT GHG ABATEMENT SCHEMES

At this stage there has been some limited experience gained in Australia with valuing greenhouse gas emissions reductions. Examples include NGGAS & Energy Savings Fund in NSW and the Commonwealth's GGAP. To the extent information from these initiatives permit we can see the following in terms of types of activities implemented.

Energy Savings Fund

Approximately $19 million was granted in the first round of ESF in early 2006. This money was allocated across the following project types:

Table 12.5: Project Types funded in ESF Round 1

Sector / Type	Alternative power generation	Demand Management	Energy Efficiency	Power factor correction	Grand Total
C&I DSM		$ 2,500,000			$ 2,500,000
Commercial EE			$ 926,050		$ 926,050
Generation	$ 5,562,498				$ 5,562,498
Industrial EE			$ 1,182,045		$ 1,182,045
Local government			$ 4,180,880		$ 4,180,880
PFC				$ 606,450	$ 606,450
Residential			$ 4,093,689		$ 4,093,689
Grand Total	$ 5,562,498	$ 2,500,000	$ 10,382,664	$ 606,450	$19,051,612

Approximately 55% of funds went to energy efficiency, 29% to cogeneration, and 13% to demand management. Of the energy efficiency funds 40% went to Residential, 40% to Local Government (Street Lighting), with just 20% to commercial and industrial energy efficiency.

NGACs

We show below the summary of abatement type up to 2005 for the NSW Greenhouse Gas Abatement Scheme. We assume that in general NGACs are worth $13/tonne excluding transaction costs.

Table 12.6: NGAC Project Types over 3 Years to 2005

Type	2003	2004	2005	% Contribution 2005
DSA	345,141 NGAC	742,233 NGAC	1,509,199 NGAC	15%
Generation	6,317,835 NGAC	6,744,229 NGAC	7,936,816 NGAC	79%
Carbon Sequestration	0 NGAC	166,005 NGAC	538,471 NGAC	5%
Large User	0 NGAC	0 NGAC	94,277 NGAC	1%
Totals	**6,662,976 NGAC**	**7,652,467 NGAC**	**10,078,763 NGAC**	**100%**

As this indicates, approximately 15% of all NGACs surrendered in 2005 (est value $131 million @$13/NGAC) are from Demand Side Abatement (DSA) activities. Of this a sizeable proportion, and certainly the majority of the growth in DSA between 2004 and 2005, has resulted from initiatives targeting the Residential sector. The overall contribution by the Commercial and Industrial sectors is modest both in terms of DSA and total NGAC activity.

Greenhouse Gas Abatement Program – GGAP

The types of activities implemented under this program are highlighted below.

Table 12.7: GGAP Project Types and Funding Levels

GGAP Projects	Description	Type	GGAP Funding $M	CO2 Savings/Year
Industrial processing	Destruction of Synthetic Gases from Refrigeration	Non-Energy	$ 0.28	0.23
Industrial processing	Energy Efficient Drying of Alumina	Energy Efficiency	$ 11.00	0.36
Industrial processing	Reducing HFC Emissions from the Refrigeration and A/C Industry	Non-Energy	$ 3.70	1.68
Mining	Burning CH4 Contained in Waste Coal Mine Gas to Produce Electricity	CSM	$ 13.00	0.56
Mining	Burning CH4 Contained in Waste Coal Mine Gas to Produce Electricity	CSM	$ 9.00	0.43
Mining	Recovering Thermal Energy from Combustion of Waste Coal Mine Gas	CSM	$ 6.00	0.26
Mining	Waste Coal Mine Gas to Generate Electricity	CSM	$ 15.50	1.52
Power generation	Equipment Upgrade for Power Station Efficiency	Generation EE	$ 5.00	0.42
Power generation	Waste Heat Power Generation	Generation EE	$ 2.08	0.06
Travel Behaviour Change	National Travel Behaviour Change	Transport	$ 6.40	0.31
Travel Behaviour Change	Western Australia TravelSmart Households	Transport	$ 3.00	0.09

Of the projects highlighted here, just one relates to end use energy efficiency, accounting for 15% of funding for these projects and 6% of estimated abatement.

Hence, the whole, it has been the experience (to date) that the contribution by energy efficiency to the total (forecast) abatement achieved by these initiatives is relatively low, and that the participation of the commercial and industrial sectors is also low, accounting for less than 10% of all incentives.

In relation to each of these programs / initiatives, we can look at the implied carbon value ($/tonne) from the end-users perspective if we consider their assessment (at a very simple level) of projects uses a 3, 5 or 10-year life, and then show the total incentive provided / derived. This shows:

Table 12.8: ESF, NGAC & GGAP End-User Valuation for 3, 5 & 10-Year Project Assessment Timeframes, compared with various Carbon Prices

Measure	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Carbon Tax @ $10/t	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00	$ 10.00
Carbon Tax @ $20/t	$ 20.00	$ 20.00	$ 20.00	$ 20.00	$ 20.00	$ 20.00	$ 20.00	$ 20.00	$ 20.00
Carbon Tax @ $30/t	$ 30.00	$ 30.00	$ 30.00	$ 30.00	$ 30.00	$ 30.00	$ 30.00	$ 30.00	$ 30.00
Carbon Tax @ $40/t	$ 40.00	$ 40.00	$ 40.00	$ 40.00	$ 40.00	$ 40.00	$ 40.00	$ 40.00	$ 40.00
ESF Value pa if a 10-Year Project	$ 14.61	$ 14.61	$ 14.61	$ 14.61	$ 14.61	$ 14.61	$ 14.61	$ 14.61	$ 14.61
ESF Value pa if a 5-Year Project	$ 29.23	$ 29.23	$ 29.23	$ 29.23	$ 29.23				
ESF Value pa if a 3-Year Project	$ 48.71	$ 48.71	$ 48.71						
NGAC Value	$ 13.00	$ 13.00	$ 13.00	$ 13.00	$ 13.00	$ 13.00	$ 13.00	$ 13.00	$ 13.00
GGAP Value pa if a 10-Year Project	$ 1.27	$ 1.27	$ 1.27	$ 1.27	$ 1.27	$ 1.27	$ 1.27	$ 1.27	$ 1.27
GGAP Value pa if a 5-Year Project	$ 2.54	$ 2.54	$ 2.54	$ 2.54	$ 2.54				
GGAP Value pa if a 3-Year Project	$ 4.23	$ 4.23	$ 4.23						

As indicated in Tables 12.2 & 12.3 above, it may be the case that a carbon tax of $10 to $20 per tonne of abatement will not materially improve the business case for projects that have simple paybacks of 4 to 6 years, and that higher tax levels may only facilitate the uptake of projects with a nominal 4 year payback or better. This perhaps is a factor underlying the relatively low uptake of energy efficiency within the current Australian schemes, and by the commercial and industrial sectors in particular. As the table above suggests, an end-user who looks at a 5-year life for the purpose of assessing the viability of an energy efficiency proposal may, on average, value an ESF incentive at about $29/tonne (noting this is derived from a fairly small dataset); notwithstanding this the contribution by commercial and industrial energy efficiency projects in the successful first round of ESF funding is low.

On the whole, we do not feel that we can draw any firm conclusions from this analysis, as it is conducted at a high level and draws on a small available data set. The analysis does suggest that the levels of carbon pricing assessed may have a generally limited impact on the cost-effectiveness of many actions, excepting those that may be cost-effective anyway and are not implemented, often through lack of information or behavioural factors. Current schemes in Australia present a limited data set, from which a very preliminary finding might be that the case for energy efficiency is not greatly advanced by the level of incentives available, however more experience with these schemes and knowledge of some of the barriers to participation would be needed in order to derive more robust conclusions.

OVERSEAS EXPERIENCE – UK CLIMATE CHANGE LEVY

The UK's Climate Change Levy (CCL) is a levy on energy use by business (domestic sector is exempt), and corresponds to an average increase in energy costs of about 7-11%. As part of the scheme, large users can reduce their levy rate by 80% through signing a Negotiated Agreement with Government whereby they agree to reduce GHG emissions to a specified level. Emissions reductions under the Negotiated Agreements may be met through trading within the framework of the Emissions Trading Scheme.

This "carrot and stick" approach is perhaps worth looking at in the context of this analysis here. We consider 3 cases:

- In all cases we assume that a 15% energy saving can be made at an average 6-year payback,
- We look at a "low" case where a tax of $10/tonne is applied and a 25% reduction in this tax is available subject to achieving this level of saving,
- We then look at a "medium" case where a tax of $20/tonne is applied and a 50% reduction in this tax is available subject to achieving this level of saving,
- We then look at a "high" case where a tax of $30/tonne is applied and a 75% reduction in this tax is available subject to achieving this level of saving

Table 12.9: Low Case - $10/tonne Tax & 25% Reduction Available for EE Implementation of 15% Savings

Sector	Fuel	Energy Use in 2006-07 PJ	Estimated Energy Spend in 2006-07 $M	Cost & % Increase @ $10/t CO2		15% Saving @ 6-Year PB	Cost	Annual Avoided Tax - 25%	Net Annual "Saving"	Effective PB
Mining	Coal	7.00 PJ	$14m	$7m	47%	$2.1m	$12.6m	$1.6m	$3.7m	3.36 Years
Iron & Steel	Coal	12.00 PJ	$24m	$11m	47%	$3.6m	$21.6m	$2.8m	$6.4m	3.36 Years
Non-Ferrous Metals	Coal	12.80 PJ	$26m	$12m	47%	$3.8m	$23.0m	$3.0m	$6.9m	3.36 Years
Non-Metallic Minerals	Coal	7.70 PJ	$15m	$7m	47%	$2.3m	$13.9m	$1.8m	$4.1m	3.36 Years
Non-Ferrous Metals	Electricity	16.90 PJ	$203m	$47m	23%	$30.4m	$182.5m	$11.7m	$42.1m	4.34 Years
Mining	Electricity	18.50 PJ	$278m	$51m	18%	$41.6m	$249.8m	$12.8m	$54.4m	4.59 Years
Commercial	Electricity	18.90 PJ	$378m	$52m	14%	$56.7m	$340.2m	$13.0m	$69.7m	4.88 Years
Residential	Electricity	16.60 PJ	$631m	$46m	7%	$94.6m	$567.7m	$11.5m	$106.1m	5.35 Years
Basic Chemicals	Gas	33.10 PJ	$83m	$20m	24%	$12.4m	$74.5m	$5.0m	$17.4m	4.29 Years
Non-Ferrous Metals	Gas	135.90 PJ	$408m	$82m	20%	$61.2m	$366.9m	$20.4m	$81.5m	4.50 Years
Mining	Gas	11.00 PJ	$44m	$7m	15%	$6.6m	$39.6m	$1.7m	$8.3m	4.80 Years
Iron & Steel	Gas	1.20 PJ	$5m	$1m	15%	$0.7m	$4.3m	$0.2m	$0.9m	4.80 Years
Non-Metallic Minerals	Gas	15.80 PJ	$63m	$9m	15%	$9.5m	$56.9m	$2.4m	$11.9m	4.80 Years
Commercial	Gas	3.10 PJ	$19m	$2m	10%	$2.8m	$16.7m	$0.5m	$3.3m	5.14 Years
Residential	Gas	9.60 PJ	$115m	$6m	5%	$17.3m	$103.7m	$1.4m	$18.7m	5.54 Years

Table 12.9: Medium Case - $20/tonne Tax & 50% Reduction Available for EE Implementation of 15% Savings

Sector	Fuel	Energy Use in 2006-07 PJ	Estimated Energy Spend in 2006-07 $M	Cost & % Increase @ $20/t CO2		15% Saving @ 6-Year PB	Cost	Annual Avoided Tax - 50%	Net Annual "Saving"	Effective PB
Mining	Coal	7.00 PJ	$14m	$13m	94%	$2.1m	$12.6m	$6.6m	$8.7m	1.45 Years
Iron & Steel	Coal	12.00 PJ	$24m	$23m	94%	$3.6m	$21.6m	$11.3m	$14.9m	1.45 Years
Non-Ferrous Metals	Coal	12.80 PJ	$26m	$24m	94%	$3.8m	$23.0m	$12.1m	$15.9m	1.45 Years
Non-Metallic Minerals	Coal	7.70 PJ	$15m	$15m	94%	$2.3m	$13.9m	$7.3m	$9.6m	1.45 Years
Non-Ferrous Metals	Electricity	16.90 PJ	$203m	$93m	46%	$30.4m	$182.5m	$46.6m	$77.1m	2.37 Years
Mining	Electricity	18.50 PJ	$278m	$102m	37%	$41.6m	$249.8m	$51.1m	$92.7m	2.69 Years
Commercial	Electricity	18.90 PJ	$378m	$104m	28%	$56.7m	$340.2m	$52.2m	$108.9m	3.13 Years
Residential	Electricity	16.60 PJ	$631m	$92m	15%	$94.6m	$567.7m	$45.8m	$140.4m	4.04 Years
Basic Chemicals	Gas	33.10 PJ	$83m	$40m	48%	$12.4m	$74.5m	$19.9m	$32.3m	2.31 Years
Non-Ferrous Metals	Gas	135.90 PJ	$408m	$163m	40%	$61.2m	$366.9m	$81.5m	$142.7m	2.57 Years
Mining	Gas	11.00 PJ	$44m	$13m	30%	$6.6m	$39.6m	$6.6m	$13.2m	3.00 Years
Iron & Steel	Gas	1.20 PJ	$5m	$1m	30%	$0.7m	$4.3m	$0.7m	$1.4m	3.00 Years
Non-Metallic Minerals	Gas	15.80 PJ	$63m	$19m	30%	$9.5m	$56.9m	$9.5m	$19.0m	3.00 Years
Commercial	Gas	3.10 PJ	$19m	$4m	20%	$2.8m	$16.7m	$1.9m	$4.7m	3.60 Years
Residential	Gas	9.60 PJ	$115m	$12m	10%	$17.3m	$103.7m	$5.8m	$23.0m	4.50 Years

Table 12.10: High Case - $30/tonne Tax & 75% Reduction Available for EE Implementation of 15% Savings

Sector	Fuel	Energy Use in 2006-07 PJ	Estimated Energy Spend in 2006-07 $M	Cost & % Increase @ $30/t CO2		15% Saving @ 6-Year PB	Cost	Annual Avoided Tax - 75%	Net Annual "Saving"	Effective PB
Mining	Coal	7.00 PJ	$14m	$20m	141%	$2.1m	$12.6m	$14.8m	$16.9m	0.74 Years
Iron & Steel	Coal	12.00 PJ	$24m	$34m	141%	$3.6m	$21.6m	$25.4m	$29.0m	0.74 Years
Non-Ferrous Metals	Coal	12.80 PJ	$26m	$36m	141%	$3.8m	$23.0m	$27.1m	$31.0m	0.74 Years
Non-Metallic Minerals	Coal	7.70 PJ	$15m	$22m	141%	$2.3m	$13.9m	$16.3m	$18.6m	0.74 Years
Non-Ferrous Metals	Electricity	16.90 PJ	$203m	$140m	69%	$30.4m	$182.5m	$104.9m	$135.4m	1.35 Years
Mining	Electricity	18.50 PJ	$278m	$153m	55%	$41.6m	$249.8m	$114.9m	$156.5m	1.60 Years
Commercial	Electricity	18.90 PJ	$378m	$156m	41%	$56.7m	$340.2m	$117.4m	$174.1m	1.95 Years
Residential	Electricity	16.60 PJ	$631m	$137m	22%	$94.6m	$567.7m	$103.1m	$197.7m	2.87 Years
Basic Chemicals	Gas	33.10 PJ	$83m	$60m	72%	$12.4m	$74.5m	$44.7m	$57.1m	1.30 Years
Non-Ferrous Metals	Gas	135.90 PJ	$408m	$245m	60%	$61.2m	$366.9m	$183.5m	$244.6m	1.50 Years
Mining	Gas	11.00 PJ	$44m	$20m	45%	$6.6m	$39.6m	$14.9m	$21.5m	1.85 Years
Iron & Steel	Gas	1.20 PJ	$5m	$2m	45%	$0.7m	$4.3m	$1.6m	$2.3m	1.85 Years
Non-Metallic Minerals	Gas	15.80 PJ	$63m	$28m	45%	$9.5m	$56.9m	$21.3m	$30.8m	1.85 Years
Commercial	Gas	3.10 PJ	$19m	$6m	30%	$2.8m	$16.7m	$4.2m	$7.0m	2.40 Years
Residential	Gas	9.60 PJ	$115m	$17m	15%	$17.3m	$103.7m	$13.0m	$30.2m	3.43 Years

- The “low” case indicates that with a relatively low carbon tax and a modest reduction available for delivery of energy efficiency savings, there is unlikely to be sufficient incentive for end-users to participate, with net paybacks often likely to be outside a 2-3 year criterion.
- The “high” case, with a relatively high tax and high reduction for achievement of agreed energy savings, could make energy efficiency projects highly cost effective across many sectors.
- The “medium’ case would have an intermediate effect, and there is potential that a significant amount of EE projects would fall to around the 3-year payback level for many sectors.

As with the analysis of current experience with Australian programs, we do not seek to draw firm conclusions from this type of analysis, but seek mainly to highlight the potential impacts and responses from end users to an initiative of this nature.