REPORT

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Capitalising on the building sector's potential to lessen the costs of a broad based GHG emissions cut

Prepared for:

ASBEC Climate Change Task Group

EMBARGOED UNTIL
17 SEPTEMBER 2007

Centre for International Economics
Canberra & Sydney

September 2007

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Summary

The building sector can and should play a role in achieving the deep GHG reductions that science tells us are necessary to combat the threat of global warming. This study has examined the potential for additional GHG abatement from the buildings sector, in particular by examining the potential to invest in improved energy efficiency. It also reveals the difference that this would make to the economy-wide cost of achieving deep GHG emission cuts.

Building sector is responsible for a large proportion of Australia's GHG emissions and can make a major contribution to meeting a deep cuts target

- Without change, Australia's GHG emissions will continue to grow at a rapid rate. They are currently projected to reach an estimated 915 million tonnes by 2050. However, the Australian Business Roundtable on Climate Change (BRCC) reported that it is possible to achieve a 60 per cent reduction in GHG emissions by 2050 while maintaining strong economic growth, and that with early action, the economic impact by 2020 would be modest.
- Almost a quarter (23 per cent) of Australia's total greenhouse gas emissions are a result of energy demand in the building sector. The building sector, comprising residential and commercial buildings, houses a large proportion Australia's economic activity. This study extends the BRCC's analysis to include a more detailed analysis of the significant energy efficiency potential of the building sector.
- The building sector's contribution to GHG emissions is mainly driven by its end use of, or demand for, electricity. This is a key difference from many other sectors where the main issue is emissions from the supply of energy.
- The building sector as a whole could reduce its share of GHG emissions by 30-35 per cent whilst accommodating growth in the overall number of buildings by 2050. This can be achieved by using today's technology to significantly reduce the energy needed by residential and commercial buildings to perform the same services. For example, by replacing equipment with more energy efficient models, at the natural replacement rate, and upgrading the performance of the building shell.
- Detailed 'bottom up' analysis of energy efficiency opportunities suggests that net cost savings can be achievable in the medium to long term. Rather than a cost per tonne of GHG abatement, many energy efficiency options have a positive financial payback in addition to providing abatement benefits. The payback

period, can vary from a matter of months to many years. This finding is consistent with a large collection of case studies within Australia and overseas.

- The economy-wide analysis conducted in this study takes a conservative approach by using a cost neutral assumption rather than including any additional returns on energy efficiency investment that may be available.

A balanced strategy that tackles demand side energy use, as well as supply side emissions, would provide significant benefits to the entire economy

When coupled with a broad based GHG abatement target and a supporting policy environment, additional energy efficiency investments by the buildings sector would reduce the costs of change for the building sector and the economy at large.

Economy-wide modeling comparing the cost of deep cuts alone (the deep cuts scenario) compared to a situation with specific attention to energy efficiency and demand management in the building sector provides the following insights.

- Energy efficiency gains delivered by the building sector can reduce the costs of GHG abatement (cost per tonne of abatement) for all sectors by nearly 14 per cent by 2050.
- Loss to the overall level of economic activity in the economy would be minimized. By 2050, GDP is nearly 2 per cent higher (roughly equivalent to $38 billion per annum) with additional energy efficiency investments in the building sector.
- Adverse impacts on employment are minimized through building sector energy efficiency strategies. The reduction in job growth in the longer term is smaller, with a reduction in the period between 2030 and 2050 of around 0.1 to 0.4 per cent, compared with 0.2 to 0.6 per cent in the deep cuts scenario.
- Reducing the demand for electricity, coupled with an economy-wide carbon constraint, facilitates the growth of cleaner, more renewable sources of electricity (e.g. wind) and reduces the demand for coal-fired electricity. Wind-powered electricity experiences sizable growth, representing 23 per cent of electricity generation value added by 2050.

Investment and an effective policy framework are required to secure the practical and cost effective GHG abatement opportunities offered by the building sector

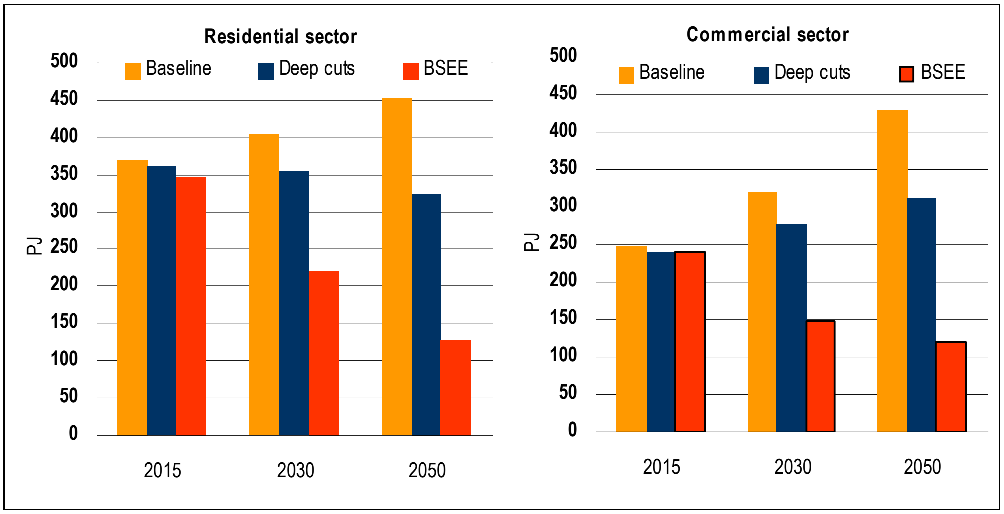
Despite being cost neutral in the medium to long term, achieving the additional GHG abatement action from the building sector faces challenges as well as opportunities.

- Adopting energy efficiency strategies requires upfront investment by businesses and households to become more energy efficient.
- The benefits, or payback of these investments, are gradual, accruing over the medium to long term, as savings on energy bills.
- The building sector will need some additional incentives to overcome the impediments to change. These need to address a range of issues, such as the need

to spur behavioural change, particularly to encourage adoption, and to offset the required upfront, direct capital expenditures.

- Essentially, there is a need to encourage the rebuilding of our current building stock to upgrade the energy efficiency of assets within buildings to deliver a more sustainable outcome.
- The pay-off from investing in the energy efficiency potential of the building sector would flow through the entire economy by reducing the cost that others would face to achieve their reduction in GHG emissions.

E.1 **Final energy demand reductions from the built environment**



[a] BSEE= with building sector energy efficiency enhancements.

Data source: MMRF-Green simulation results.

Contents

Boxes, charts and tables

1 Purpose of this report

Communities are increasingly aware of the urgency and importance of the need to reduce greenhouse gas (GHG) emissions. As the Stern Report (2007) writes:

> Climate change threatens the basic elements of life for people around the world — access to water, food production, health, and use of land and the environment.

At the same time, governments and societies are also acknowledging that the strategies that we choose to tackle GHG abatement have implications for our economy. The Australian Business Roundtable on Climate Change (BRCC) in the report, *The Business Case for Early Action* (released in 2006), suggests that taking action now could mean lower costs and greater benefits in the future.

Studies such as the BRCC's and others do not examine the roles specific sectors can play in contributing to deep cuts in GHG emissions. This study specifically examines the abatement potential and strategies that the building sector can offer in achieving a deep emissions cut. Its objectives are to provide better, more accurate, information that can help shape the policy debate and drive near term investment.

Defining the building sector

The building sector houses the majority of Australia's economy – nearly 60 per cent in terms of contribution to gross domestic product (GDP). This definition of the building sector captures both residential and commercial activity that takes place within our built environment.'[1]

The commercial sector, sometimes also called 'commercial and services' or 'commercial and institutional', comprises 11 major economic sectors. Largely following the approach used by ABARE (2006a) and the AGO, these sectors are (based on ANZSIC Division):

- wholesale trade (F);
- retail (G);
- accommodation, cafes and restaurants (H);
- communication services (J);

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1 It does not include building construction, manufacturing, transport or utilities sectors. This definition of the building sector is consistent with how the Australian Greenhouse Office defines the 'built environment. For more detail, see www.greenhouse.gov.au/buildings/ publications/emissions.html.

- finance and insurance (K);
- property and business services (L);
- government administration and defence (M);
- education (N);
- health and community services (O);
- cultural and recreational services (P); and
- personal and other services (Q).

The residential sector captures the dwellings in which households live and the daily activities that take place within these dwellings. It is viewed as being comprised of the following building classifications from the Building Code of Australia:

- Class 1a (i) — detached houses;
- Class 1a (ii) — attached dwellings; and
- Class 2 — buildings containing two or more sole occupancy units.

These building types constitute the vast majority of residential buildings in Australia (AGO 1999).

Accounting for the building sector's GHG emissions

Accounting for the building sector's GHG emissions requires a final demand framework. This framework allocates emissions based on how energy obtained from nature can be traced through to its end use in economic activities. Final demand equals total primary energy consumption minus the energy consumed or lost in conversion (that is, in electricity generation stations), transmission and distribution. In the residential sector this is the amount of energy that is used and purchased from sources such as an electrical power point on a wall or petrol from a service station.[2]

This framework recognises that demand for stationary energy, e.g. electricity, plays a central role in determining the allocation of GHG emissions to the building sector. This sector's abatement opportunities, therefore, necessarily must address energy efficiency. As such, the focus of attention for identifying abatement opportunities is upon the operational energy use of buildings. The analysis does not consider a building's 'embodied' energy, nor does it consider the GHG emissions associated with a building's construction.

The Australian Sustainable Built Environment Council (ASBEC) Climate Change Task Group commissioned the Centre for International Economics (CIE) to undertake this study. The study examines a range of questions relating to the role the building

2 Energy and GHG emissions accounting can follow one of two frameworks. They are: the use of primary fuels (such as coal) in conversion activities (making electricity) as well as transmission and distribution; and *end use,* formally titled final energy consumption but also called 'delivered energy'.

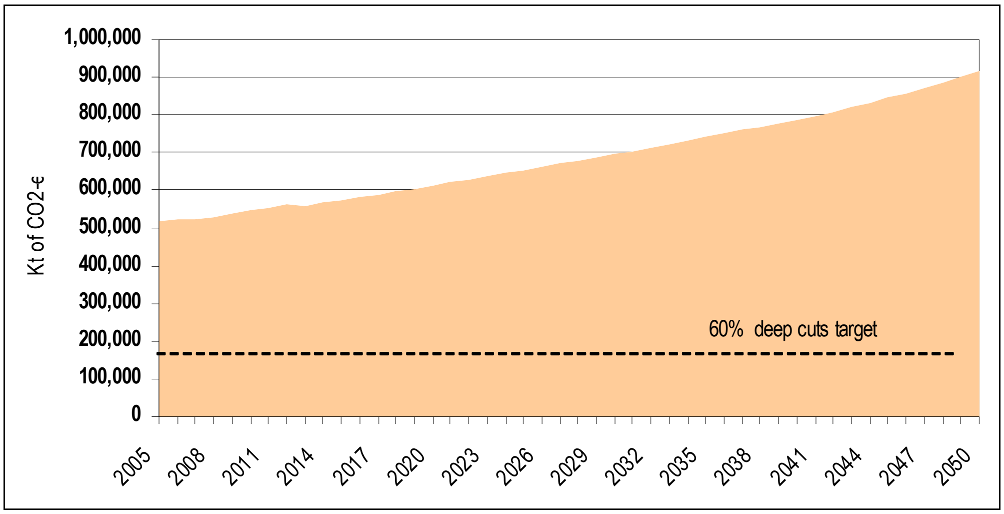
sector could play in reducing GHG emissions. It analyses the energy efficiency potential of the building sector from the ground up.

This study builds upon previous work commissioned by the BRCC (2006) analysing the effects of placing an economy-wide GHG emissions target of at least 60 per cent below 2000 levels by 2050. The BRCC study reported that achieving this target is possible while maintaining economic growth, and with early action, the economic impact by 2020 would be modest. Using this benchmark, the present study examines the implications to the economy if the building sector directly contributed to meeting this target through additional energy efficiency strategies.

2 Building sector's GHG abatement potential

GHG emissions (measured as tonnes of CO_2-e) are projected to grow if policy initiative and abatement strategies are not adopted. In order to stabilise emissions, it has been proposed that deep cuts are necessary. The chart below illustrates a deep cuts target of 60 per cent.

2.1 Baseline growth of GHG emission



[a] 60 per cent target based on 2000 levels.

Data source: MMRF-Green simulation results

Building sector is a significant source of GHG emissions

The building sector, comprising residential and commercial sectors, is a major contributor. It accounts for nearly one-quarter of national GHG emissions. This estimate is based on a final demand accounting framework reflecting direct and (estimated) indirect emissions for electricity consumption. It draws on ABARE energy end use data, analysis by Pears (2006 and 2007), and the AGO *Factors and Methods Workbook* (2006). The table below summarises the building sector's share and actual amount of GHG emissions.

2.2 Estimated GHG emissions by end use in the buildings sector (2005)

	CO_2-e Mt	*Share (%)*
Buildings sector		
Commercial and services	56	10
Residential	74	13
Sub-total	*130*	*23*
Other	429	77
Total	**559**	**100**

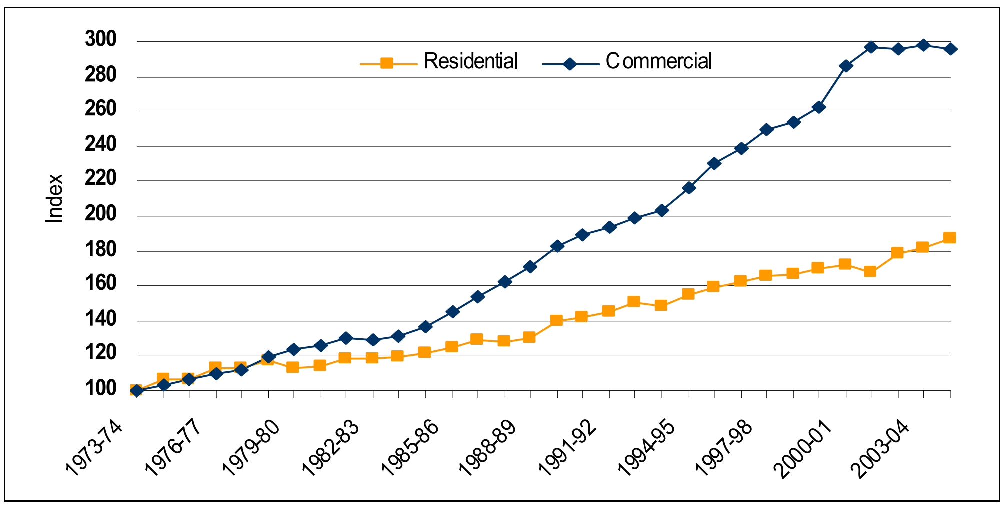
Source: Total and other from AGO (2007), building sector from Pears (2006 and 2007)

GHG emissions are driven by electricity consumption

The building sector's contribution to GHG emissions is mainly driven by its use of electricity. Electricity accounts for about 51 per cent of residential sector energy demand; a further 31 per cent of final energy consumption is sourced from gas (used largely in transport activities). The commercial sector is also electricity intensive accounting for almost a quarter of total electricity consumption in 2004-05 (ABARE 2006a).

The building sector's demand for energy has grown steadily since the 1970s. Residential sector energy end use is now nearly twice the level it was. Growth in the commercial sector is even stronger. Although the commercial sector's level of energy use is lower than the residential sector, its energy end use has nearly tripled since the 1970s.

2.3 Change in building sector energy end use: Index (1973-74 = 100)



[a] The chart of energy end use reflect total energy consumption across fuel sources. Fuel sources include fossil fuels and renewables. ABARE (2006a) estimates that of primary fuels consumed in Australia, around 45 per cent are used to generate electricity; roughly 24 per cent are used for transport; and 19 per cent for the manufacturing sector.

Data source: ABARE (2006a)

Electricity consumption activities in the building sector

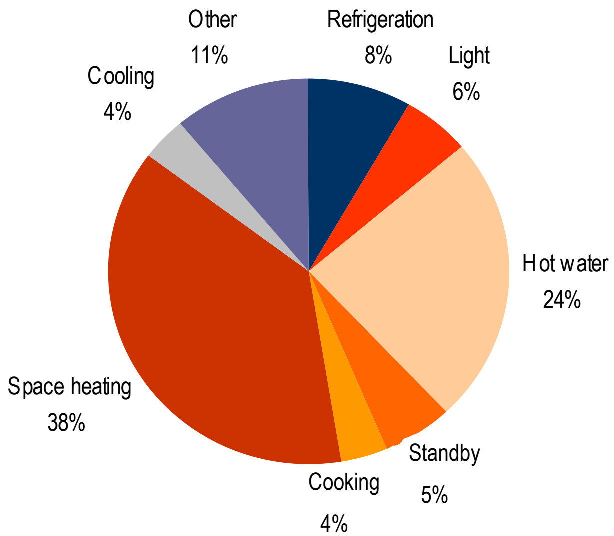
Understanding the exact sources of the building sector's electricity consumption is difficult. Limited information exists that specifically measures what activities and appliances consume electricity within a building, and the available information is better for the residential than the commercial sector.

The following draws on existing information to develop profiles for the residential and commercial sectors that capture the current level of understanding. These profiles form the basis for testing the extent to which the building sector could readily capitalise on existing solutions that enhance energy efficiency and contribute to GHG abatement.

Residential

Estimates of the composition of residential energy use are illustrated below. Space heating and hot water account for over 60 per cent of the average household's energy use in this framework.[3] It reflects a 'bottom up' model of household energy end use has been developed based largely upon analysis undertaken by Adjunct Professor Alan Pears from RMIT for the Business Council for Sustainable Energy (Pears 2007).

2.4 **Composition of residential energy use – 2007**



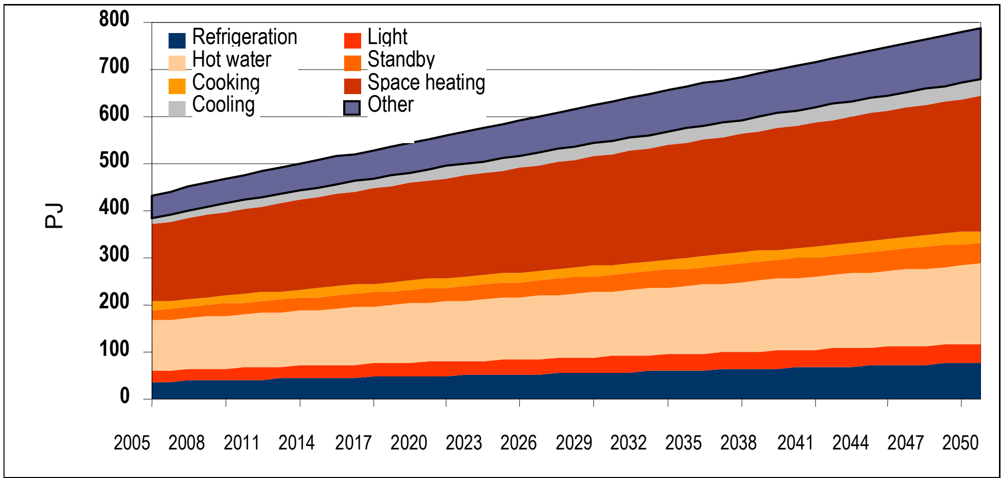
Data source: Pears (2007)

3 Is should be noted that low greenhouse intensity energy sources, such as gas and wood, provide much of the spaced heating and hot water. As a result, these categories of energy use have a much smaller share of residential GHG emissions.

The modelled pattern of energy use is broadly similar to that portrayed in published official estimates. The AGO (1999), for example, estimated that residential end use would be split as follows: water heating 26 per cent, cooking 5 per cent, space heating and cooling 40 per cent, and electrical appliances 30 per cent.

The chart below illustrates how the composition of residential energy use could grow over time in the absence of any significant drivers for change in household consumption patterns.

2.5 Residential sector projected energy use by activity – no action



Data source: Pears (2007) and CIE projections between 2030 and 2050

Commercial

As indicated earlier, how electricity is consumed by the commercial sector is less well understood. Published information is available for some parts of the sector. Very little of this information is 'bottom up'. In order to analyse the commercial sector's energy efficiency potential, the CIE constructed a model of sub-sectoral energy end use. The analysis identifies changes in energy use by the component parts of the commercial sector.

Reflecting the limited data, the commercial sector is divided into five groups. CIE reports for each group their energy use, relative shares of energy consumption and growth projections (see table 2.6). Wholesale and retail trade is the largest user of energy within the commercial sector. It also has a relatively high rate of growth. Office-orientated activities are also projected to grow relatively rapidly from a smaller base of energy end use (accounting for one-sixth of the total at present).

These figures are broadly in line with other analysts' views about the composition of energy end use within the commercial buildings sector. WWF (2006), for example, found that around 85 per cent of energy use (and GHG emissions) came from retail/wholesale and government and business sectors. It also viewed that around 15 per cent are from cultural, hospitality, recreational and community facilities.

2.6 **Commercial sector energy end use consumption**

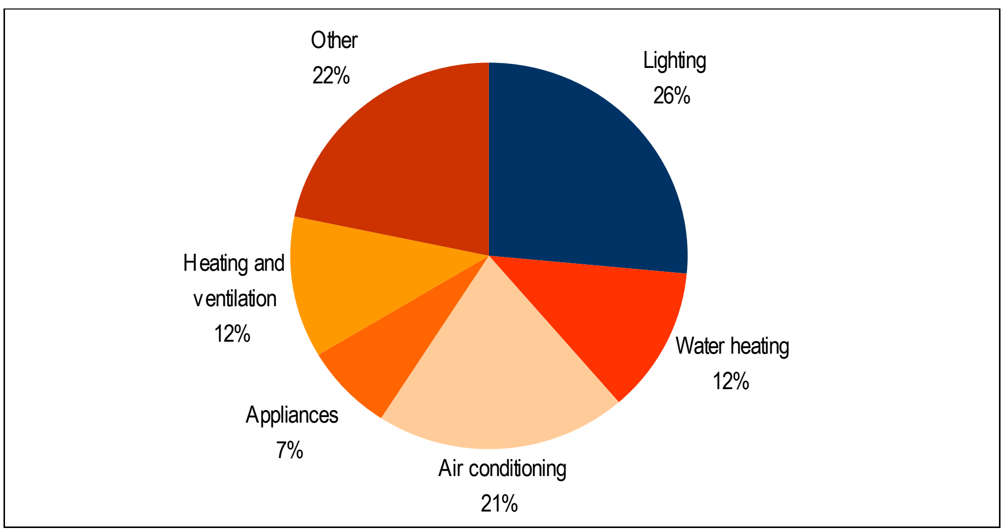
Commercial sub-group	*Energy use in 2005*	*Relative share of energy consumption*	*Average annual forecast growth*	*Base case in 2050*
	PJ	**%**	**%**	**PJ**
Wholesale and retail	101	43	2.2	269
Communications	6	3	2.0	16
Finance & insurance, plus property & business services	39	16	2.2	105
Government, education, health & community services	56	25	1.8	123
Accommodation, cafes & restaurants	32	14	2.1	83
Total for commercial sector	**234**	**100**	**2.1**	**596**

Source: ABARE 2006, Pears 2006, AGO 1999b and CIE analysis

Composition of commercial energy use

The composition of commercial energy end use by appliance type or activity is illustrated below. Lighting accounts for over one-quarter of commercial energy use in the sector. It is important to recall that the sector is comprised of a great many building types. Averages derived from just one type of building (particularly offices) are unlikely to form a reasonable basis of comparison or verification of these estimates.

2.7 **Composition of commercial energy use - 2005**



Data source: Pears (2006) and CIE analysis

The estimate of commercial energy use differs from official sources that have attempted to take a sector-wide view. A table 2.8 compares estimates of the composition of energy end use by application type. The AGO and GWA estimates place a higher proportion of energy use in heating, ventilation and cooling than the Pears/CIE figures. Overall, the table highlights the variation in estimates that have been calculated from available information about energy use in the commercial sector.

The chart 2.9 (below) illustrates how the composition of commercial energy use is anticipated to grow overtime in the absence of significant intervention.

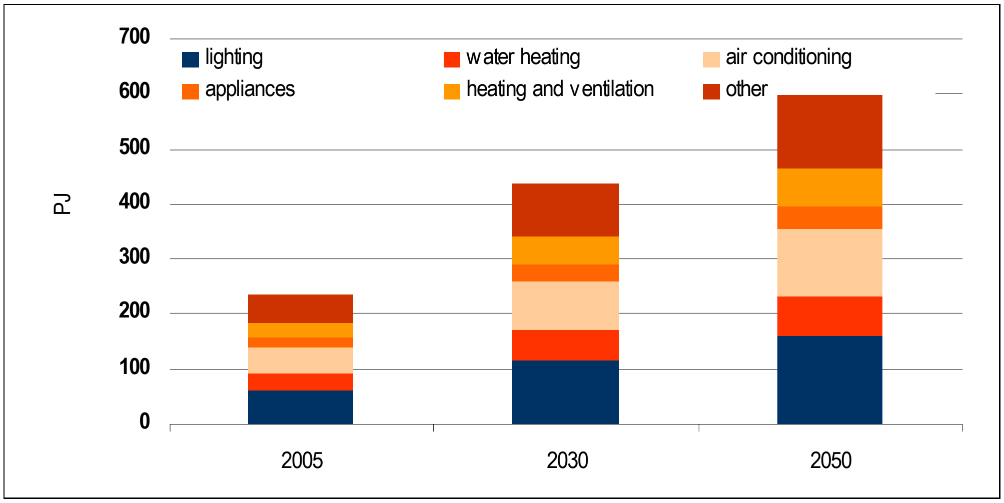
2.8 Commercial sector energy end use estimates

CIE/Pears category	***Share***	***AGO category***	***Share***	***GWA category***	***Share***	***WWF category***	***Share***
	%		**%**		**%**		**%**
Appliances	7	Office equipment & other	9	Refrigeration	12	Office equipment & other	7
Lighting	26	Lighting	15	Lighting	24	Lighting	27
HVAC	33	Heating ventilation & cooling	70	HVAC	56	Heating & cooling	32
Water heating	12	Cooking & hot water	6	Water heating	2	Hot water & other processes	34
Other	22	na	0	Other electricity	5	na	na
Total	**100**	**Total**	**100**	**Total**	**100**	**Total**	**100**

[a] HVAC=heating, ventilation and air conditioning.

Source: Pears (2006) and CIE analysis, AGO (1999b) and GWA (2005)

2.9 Commercial sector projected energy use by activity – no action



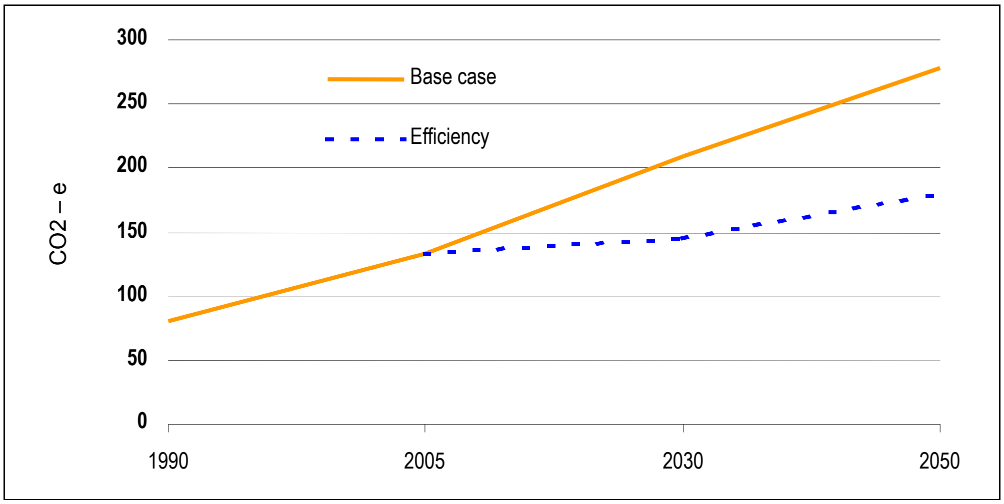
Data source: Pears (2007) and CIE analysis

Building sector's abatement potential

Studies within Australia and overseas point to the building sector's potential to raise energy efficiency and abate GHG.

By 2050, the assessed abatement options in this study are estimated to reduce the building sector's emissions (i.e. commercial and residential sectors) by 35 per cent from a base case of no significant policy changes. The chart highlights that through adoption of energy efficiency measures, the building sector could minimise future growth of its GHG emissions over the next three to four decades. That is, GHG emission from the building sector could potentially stay at current levels whilst accommodating growth in the overall number of buildings.

2.10 **Estimated change in total GHG emissions from built environment**



Data source: CIE

Overall, the efficiency gains proposed in this study seem to be within the range of estimates in other projects.

- Most studies about GHG abatement potential from energy efficiency gains in developed economies report potential reductions of between 20 and 40 per cent (CIE 2007b).
- The IPCC viewed that there is global potential to avoid about 30 per cent of the projected GHG emissions in the building sector by 2020 (Levine et al 2007). The data in this study is more cautious in proposing a reduction of around 30 per cent by 2050.

Technical costs of realising abatement potential

Understanding the potential technical costs and savings of adopting energy efficiency measures in the building sector is often addressed through case studies. Only a handful of comprehensive, sector-wide studies are readily available. As a result, the cost savings (that is, avoided or reduced expenditures on purchase of electricity) are less able to be benchmarked.

While there is less definitive information about costs and cost savings, broadly, the estimated cost savings in this study appear to be in line with, or larger than, the indications of costs from other sources. A wide range of estimates are available. For example, the sample of energy efficiency projects reviewed in the Energy Service Company (ESCO) industry data indicated a technical cost of between $23 per tonne to technical savings of $85 per tonne. Alternatively, the Stern Report cites studies with an average cost rather than cost savings. It estimates an average cost of US$25 per tonne of abatement from energy efficiency measures in the buildings sector at large. The IPCC viewed that 30 per cent emission reductions could be achieved with 'net economic benefit'.

Residential sector's abatement opportunities

The abatement opportunities look at technological substitution of less efficient energy appliances for more efficient ones. All of the technologies examined for the residential sector have been verified as being available today.

To assess the energy efficiency opportunities, the following projections are made. Australian households:

- make greater use of more greenhouse gas efficient appliances and assets over time;
- replace appliances on a like-with-like basis so that there is no change in service quality or live-ability[4]; and
- make replacements and changes when the previous assets wear out or become redundant (so that there is no loss of assets).

Changes begin in 2012-2013. Until that time energy use grows in line with projections that extend historical trends (i.e. base case). As a result, the actual average energy efficiency performance is variable through time, reflecting changing mixes of existing and new stock. At the same time, the overall energy efficiency should be improving through time as adoption occurs, increasing the penetration rate of energy efficient appliances and equipment.

4 Considering like-for-like implies that the replacement is of similar quality (i.e. an up-dated version) rather than an 'upgrade'.

Changes are projected in regard to energy use by appliance/activity area including[5]:

- *lighting* — substitution of energy inefficient with energy efficient light fittings;
- *refrigeration* — substitution of less efficient with more efficient fridges and freezers;
- *hot water* — adoption of more efficient appliances, improved fittings and reduced water use;
- *standby electricity* — adoption of devices that achieve low standby energy use;
- *space heating* — adoption of more efficient heating appliances and improvements in the thermal envelope, achieving 7-star energy rating; and
- *cooling* — adoption of more efficient appliances (as well as gains from thermal envelope improvements).

The following table summarises the estimated efficiency gains and impacts in residential energy use. The table indicates that the energy efficiency gains in some appliance categories are very deep. There are three areas where gains of more than 70 per cent are projected. They are refrigeration, lighting and hot water. The overall, the average across these categories of energy use, is a gain of around 48 per cent.

2.11 **Residential sector — estimated impact of abatement**

Category of energy use	*Efficiency gain*	*GHG savings in 2050*	*Technical cost/savings*
	%	Mt pa	\$/tonne CO_2-e
Refrigeration	70	13.2	87
Light	76	7.6	99
Hot water	61	12.0	133
Stand by	71	8.1	133
Cooking	0	0	na
Space heating	47	5.7	112
Cooling	70	5.9	120
Other	0	0	na
Total	**48**	**52.6**	**113**

Source: CIE

The energy efficiency/GHG efficiency measure, its cost and the value of energy savings are directly linked. All of the measures examined above result in technical cost savings. The average is a technical cost saving of $113 per tonne of GHG emissions abated.

The analysis does not examine what factors (or costs) may be involved in obtaining changes in behaviour that are generally required (that is changing brands or types of appliances). Further, the analysis only considers the direct out-of-pocket technical costs, such as the purchase costs of an appliance.

5 For more detail, see CIE 2007a.

Commercial sector's abatement opportunities

To quantify the commercial sector's abatement opportunity, estimated gains that can be made from using energy more efficiently combines data from overseas with data reflecting Australia's specific situation.

Vattenfall (2007) forms the basis for estimating the amount of energy end use that can be saved. Although overseas based, Vattenfall has several important strengths. It is among the most comprehensive and up-to-date studies available.[6] Specifically, Vattenfall (2007) provides information: (i) based on energy use/application categories (that is, air conditioning and appliances etc); and (ii) about the cost of change and the potential for abatement for each energy use/application category. Moreover, it is a publicly available study and takes into account the gains from continued background impacts in efficiency.

Consistent with the approach used for the residential sector, this analysis estimates the abatement potential based on a suite of technological change options regarding energy use within commercial buildings. Examined technologies are available now. The analysis is policy neutral. It examines what could happen. It does not examine how changes are brought about, or how impediments to change are overcome.

Specific changes are examined in the areas of:

- *air conditioning* — improved air conditioning systems;
- *appliances* — use of more efficient office appliances, and reducing standby losses;
- *heating and ventilation* — better insulation and improved heating and ventilation, including use of building energy management systems and adoption of other building shell measures;
- *lighting* — savings through use of efficient fixtures, timers and linear fluorescent lights (LFLs) for interior, exterior and parking lighting; and
- *water heating* — more efficient water heating systems and technologies, including solar heating.

The technical cost of abatement in each of these areas is also obtained from the Vattenfall analysis reflecting the average observed value in the many countries studied. These inputs are listed in the table below.

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6 Vattenfall estimates include estimates about the cost of nuclear powered electricity as well as renewable sources. Such scope is appropriate for overseas analyses, particularly where European and US markets are considered. The values regarding nuclear energy reported in the Vattenfall study form no part of the estimates that are used in this study.

2.12 **Commercial sector – estimated impact of abatement**

Category of energy end use	***Potential abatement (% of BAU energy consumption)***
Air conditioning	37
Appliances	38
Heating and ventilation	59
Lighting	12
Water heating	28

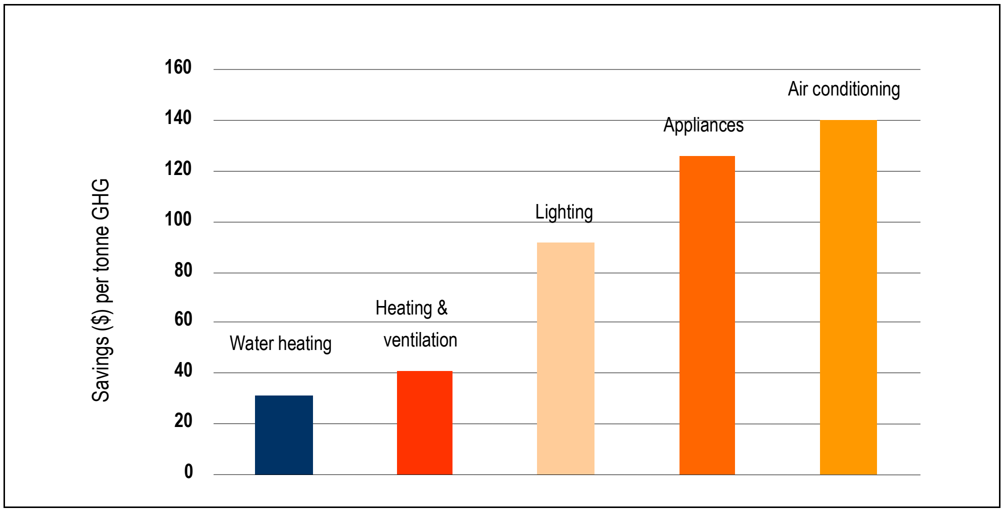
Source: Vattenfall (2007)

To tailor the Vattenfall study to the Australian context, international factors are combined with other factors such as:

- the amount of energy used by different appliance/functions types (taking into account, for example, the amount of energy use actually applied to heating and ventilation in Australia);
- the cost of electricity in Australia;
- the greenhouse gas intensity of energy use in Australia; and
- the pace of change (that is adoption rates of new technology).

CIE estimates of the Australian cost of abatement by activity/end use category are portrayed in the chart below. The differences in technical cost savings reflect differing capital costs as well as factors such as the different price of electricity for some activities (where some is available at an off peak price).

2.13 **Commercial sector GHG abatement – technical savings ($) per tonne**



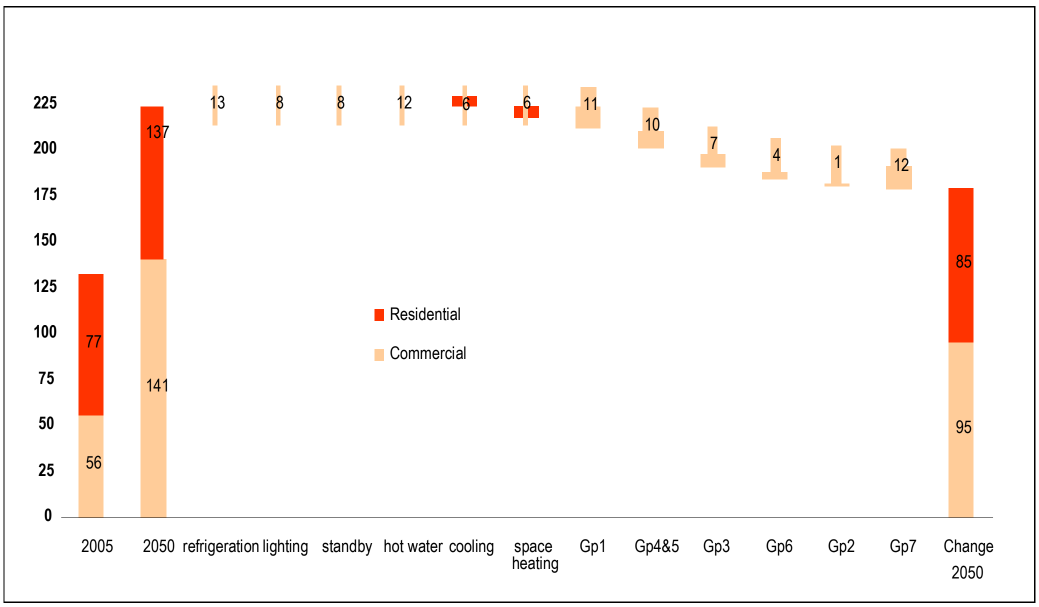
Data source: CIE

Modelling energy efficiency impacts on the economy

Chart 2.14 reflects how the analysed abatement opportunities contribute to an overall change in GHG emissions. It highlights that the costs and cost savings of the energy efficiency opportunities for the residential and commercial sectors have different profiles. All of the assessed abatement opportunities generate technical cost savings or break even (on a technical cost basis) while reducing GHG emissions.

The assessed range of energy efficiency opportunities currently exist or are plausible. A number of factors could result in even greater energy use savings (that is energy efficiency), as well as a wider range of potential options over the medium to long time horizon (that is, extending out to 2050). This future potential is not explicitly modelled or explored in this study.

2.14 **Building sector GHG emissions and abatement potential**



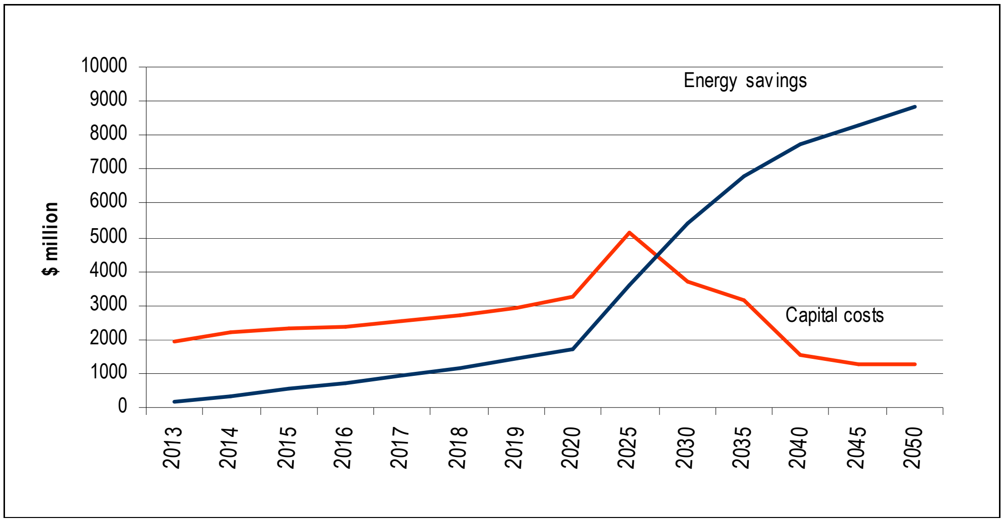
[a] Specified areas relate to abatement options for the residential sector. Categories beginning with “Gp” refer to the following groupings within the commercial sector: Gp 1=Wholesale and retail; Gp 2=Communications; Gp 3=Finance and insurance plus property and business services; Gp 4&5=Government, education, health and community services; Gp 6=Accommodation, cafes and restaurants.

Data source: CIE

While of the identified areas of energy efficiency have expected positive cost savings, the costs are incurred up-front. At the same time, the cost savings require a medium to long term payback period. Each area of energy use and its energy efficiency potential has a different profile in terms of when the benefits accrue to the point of offsetting their up-front costs.

The charts below illustrate the time profile of how, collectively across the suite of abatement opportunities, the costs and cost savings accrue from 2013 to 2050. Chart 2.15 represents the residential sector; chart 2.16 represents the commercial sector. The illustrated costs and costs savings reflect the collection of energy efficiency options. It models this time profile assuming costs and benefits, over the 37-year period are neutral, that is the cost savings offset the initial, upfront costs. This cost neutrality implies that the benefit cost ratio (BCR) of the suite of energy efficiency options is equal to one.

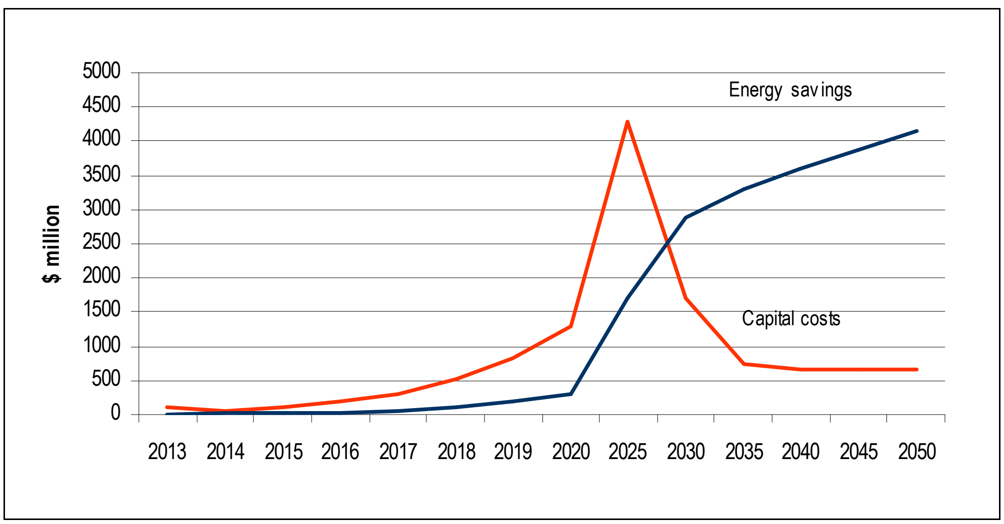
2.15 **Cost and cost savings time profile for residential sector**



[a] Profile of capital costs and energy savings equate to a benefit cost ratio of one over a 37-year period. They reflect a suite of energy efficiency options. Time profiles form the basis for an approximate 30 per cent improvement in energy efficiency that acts as the building sector's contribution to an economy-wide GHG abatement target.

Data source: CIE

2.16 **Cost and cost savings time profile for commercial sector**



[a] Profile of capital costs and energy savings equate to a benefit cost ratio of one over a 37-year period. They reflect a suite of energy efficiency options. Time profiles form the basis for an approximate 30 per cent improvement in energy efficiency that acts as the building sector's contribution to an economy-wide GHG abatement target.

Data source: CIE

3 Positive dividends through building sector strategies

The Australian Government, in its Climate Change policy report (July 2007) writes:

> The Australian economy depends more on fossil fuels for its wealth generation and power supply than most developed economies and we are a significant supplier of energy to the world. Adjusting to a carbon-constrained economy will entail costs. We cannot change the structure of our economy overnight and we need to manage the transition with care.

This study demonstrates how the building sector can assist in achieving GHG abatement through investments that reduce our demand for electricity in many of our economic activities. The previous chapter identified the existing options that could be adopted to facilitate the transition to a less carbon-intensive economy. This chapter places this potential in the context of national trends in GHG emissions and electricity demand under several future scenarios.

The future scenarios reflect a baseline and two change scenarios. The baseline assumes a future that is not carbon constrained. The two change scenarios are:

- Deep cuts — Australian economy reducing GHG emissions by 60 per cent from year 2000 levels by 2050; and
- With the building sector energy efficiency enhancements (BSEE) — the deep cuts scenario complemented by additional abatement action in the building sector.

The baseline and 'deep cuts' scenarios are consistent with that used in a report, *The Business Case for Early Action*, released by the Business Roundtable on Climate Change (BRCC) in April 2006. The deep cuts scenario analyses the effects of placing a GHG emissions constraint upon the entire economy. The constraint is sufficient to achieve a GHG reduction target of 60 per cent. This serves as the comparison or benchmark against which the building sector's contribution can be assessed. [7]

The 'with the building sector energy efficiency' (BSEE) scenario modifies the BRCC study in an important way. The BRCC report did not explicitly consider the range of abatement opportunities open to the built environment. This study explores what happens when building sector-specific opportunities are thrown into the mix of abatement options.

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[7] The BRCC report sets out how the analysis was undertaken and its key findings. Understanding of the BRCC report complements this study and provides useful background for gaining more comprehensive analytic details.

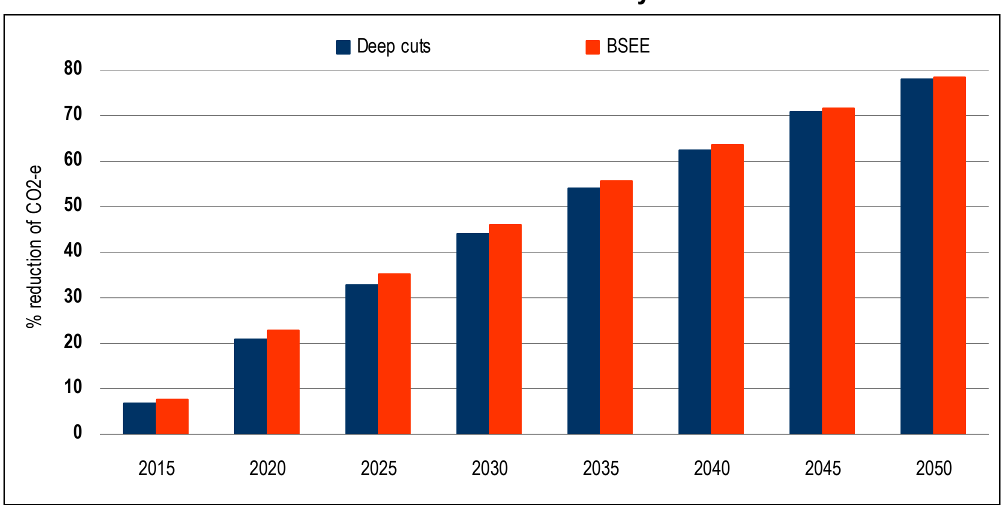
In the BSEE scenario, the buildings sector accommodates growth in the number of buildings while still being able to:

- employ a range of energy efficiency measures that have the potential to reduce GHG emissions in the sector by between 30 and 35 per cent by 2050;
- purchase less GHG intensive sources of energy including natural gas or natural gas fueled electricity;
- purchase low or zero emission sources of energy such as wind power, biomas, and biogas;
- sell (or purchase) emission abatement credits to others that have a deficit (or surplus); and
- contract or shrink activity to achieve the target.

Deep cuts in GHG emissions

Chart 3.1 shows that there is a slight increase in GHG emissions reductions in years prior to 2050 when coupling economy-wide deep emissions reductions with energy efficiency enhancements by the buildings sector (i.e. in the 'BSEE' scenario). The difference in abatement between the change scenarios is small. The overall level of abatement is shaped by the target. Essentially, within an economy-wide total, more abatement activity by the buildings sector offers the potential for reduced abatement effort in other sectors. The aspect that really matters is whether or not more or less abatement activity in the buildings sector raises or lowers the overall cost of achieving the abatement target.

3.1 **Annual reduction in GHG emissions — selected years**



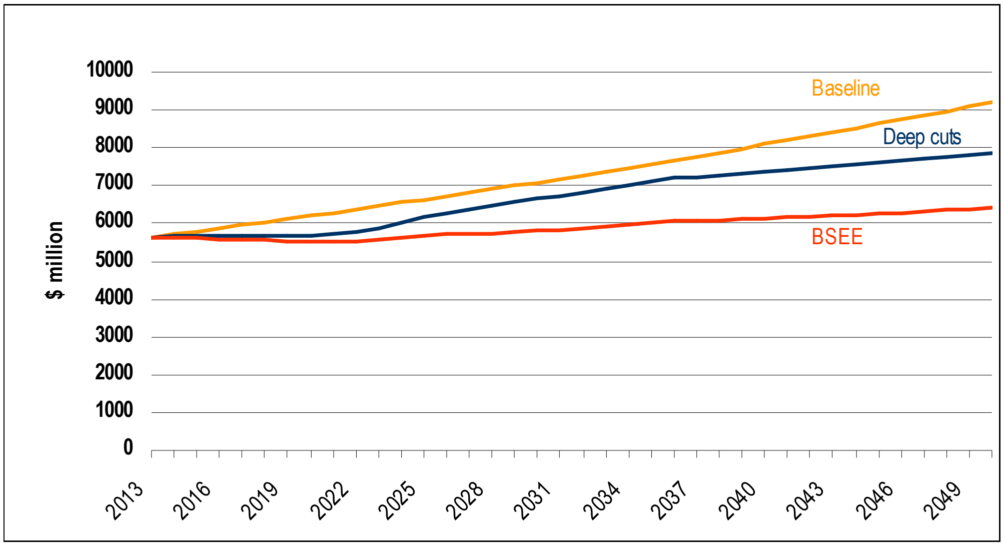
[a] BSEE= with building sector energy efficiency enhancements.

Data source: MMRF-Green simulation results

Final demand for electricity

The chart below shows how the total value added of electricity generation changes through time in the three scenarios analysed. This provides an indication of how the demand for electricity generation is suppressed with achievement of the GHG abatement target. When the building sector contributes to GHG abatement through additional energy efficiency achievements, electricity generation value added is projected to experience little growth. The sector's average annual growth rate is 0.43 per cent in this scenario. As a benchmark, this sector's average annual growth rate in the baseline scenario is three times higher (1.3 per cent).

3.2 **Annual real value added for electricity generation: 3 scenarios**



[a] 2005 prices; BSEE= with building sector energy efficiency enhancements.

Data source: MMRF-Green simulation results

Composition of electricity generation

The mix of technologies within the electricity generation sector would experience dramatic changes with the achievement of GHG abatement targets, highlighting the importance of renewable energies and cleaner fuel sources for electricity generation in meeting greenhouse gas abatement targets. Renewable sources, such as wind, play increasingly important roles, while coal-fired energy falls as a share of total value added. The share contributed by hydro-electricity remains relatively unaffected.

Table 3.3 provides estimates of how the real value added for the electricity generation sector is anticipated to deviate from the baseline scenario in selected years in the two change scenarios. It draws to attention the relative magnitude of changes within the electricity generation sector. Renewable sources of electricity generation, for example, essentially double their value added relative to the baseline from 2025 as a result of the abatement target.

3.3 **Deviation from baseline in real value added for electricity generation**

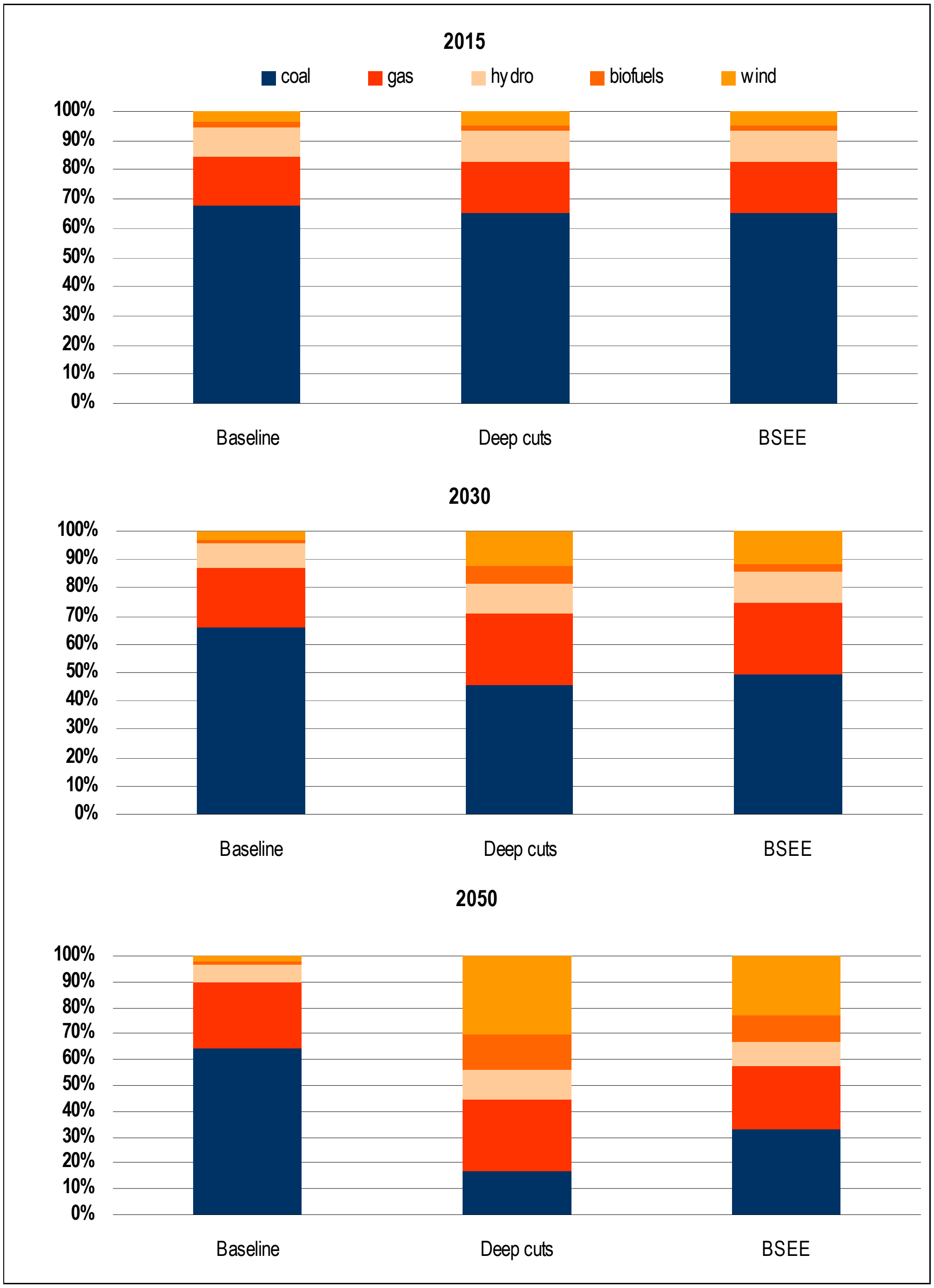
Electricity generation	*2015*	*2020*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
	%	%	%	%	%	%	%	%
Deep cuts								
Electricity – coal	-5.9	-22.0	-29.9	-34.9	-42.4	-48.5	-54.4	-60.7
Electricity – gas	-0.3	7.7	19.4	13.8	2.3	-6.8	-14.6	-21.0
Electricity – oil products[a]	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electricity – hydro	4.0	11.7	16.7	16.4	16.2	15.8	15.2	14.2
Electricity – biomas	24.2	87.6	173.9	298.1	503.0	609.7	720.6	860.7
Electricity – biogas	24.7	88.6	175.6	301.5	509.1	616.8	725.8	856.3
Electricity – wind	22.3	78.9	162.3	287.3	487.8	592.8	704.7	835.7
With building sector energy efficiency enhancements								
Electricity – coal	-6.7	-23.6	-33.9	-41.0	-48.3	-53.9	-58.8	-63.7
Electricity – gas	-1.0	3.8	7.7	-2.3	-13.7	-22.2	-28.9	-34.3
Electricity – oil products	-1.9	-8.9	-18.1	-25.8	-29.5	-31.6	-32.5	-33.2
Electricity – hydro	2.9	7.6	6.7	1.8	-1.2	-3.7	-5.7	-7.8
Electricity – biomas	21.9	75.9	135.0	215.9	358.0	425.9	500.1	593.2
Electricity – biogas	22.4	76.7	136.4	218.4	362.2	430.6	503.5	589.7
Electricity – wind	20.3	69.0	128.5	212.8	353.9	421.0	495.7	582.2

[a] Real value added for oil products is not affected in the deep cuts only scenario.

Source: MMRF-Green simulation results

Chart 3.4 provides snap shots of how the composition of electricity generation changes under three scenarios through time. In the deep cuts plus scenario, gas-fired electricity grows to 24 per cent in 2050 from 17 per cent in 2015. Wind-powered electricity experiences sizable growth, representing 23 per cent of value added by 2050. Coal-fired electricity falls from 65 per cent of the electricity generation's value added to 34 per cent over the period from 2015 to 2050.

3.4 **Change in composition of electricity by fuel source**



[a] Oil also provides a fuel source, however its share is less than 0.5 per cent; BSEE= with building sector energy efficiency enhancements.

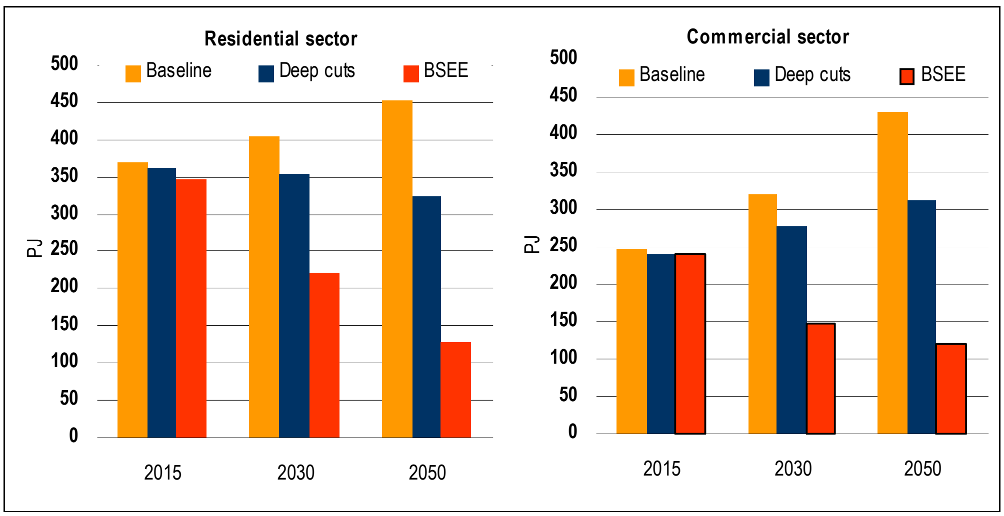
Data source: MMRF-Green simulation results

Building sector final demand for electricity

Chart 3.5 compares the building sector's changes in final electricity demand under the two change scenarios. In the baseline projections, energy use in the commercial sector grows faster than the residential sector. By 2050, the commercial sector has a similar level of energy use as the residential sector. The relative declines in electricity demand for the commercial and residential sectors in the deep cuts scenario are similar in scale.

Much deeper reductions in energy use are achieved in both sectors when energy efficiency is specifically adopted by the building sector. Relative to the baseline, the residential sector reduces final electricity demand by over 70 per cent in 2050 (or 326 PJ per year). The commercial sector's reductions are also around 70 per cent by 2050 (312 PJ per year).

3.5 **Final energy demand reductions from the built environment**



[a] BSEE= with building sector energy efficiency enhancements.

Data source: MMRF-Green simulation results

The reductions in building energy use in the change scenarios are much higher than previously projected. (See CIE 2007b for more detail.) This is because achievement of the full target is projected rather than reductions achievable through energy efficiency alone. The economy-wide analysis indicates that, as well as taking further action such as the purchase of electricity from lower emission energy technologies, the building sector also reduces underlying demand for energy.

The table below shows the annual percentage reductions, relative to the baseline, that are achieved in three years — 2015, 2030, and 2050. It is notable that by 2030, both the residential and commercial sectors roughly halve their final electricity demand.

3.6 Changes in final electricity demand by the building sector

Scenario	***2015***	***2030***	***2050***
	%	%	%
Residential sector			
Deep cuts only	2	12	28
With building sector energy efficiency enhancements	6	45	72
Commercial sector			
Deep cuts only	3	13	28
With building sector energy efficiency enhancements	3	54	72

[a] Annual percentage change relative to the baseline.

Source: MMRF-Green simulation results

4 Economy-wide impacts

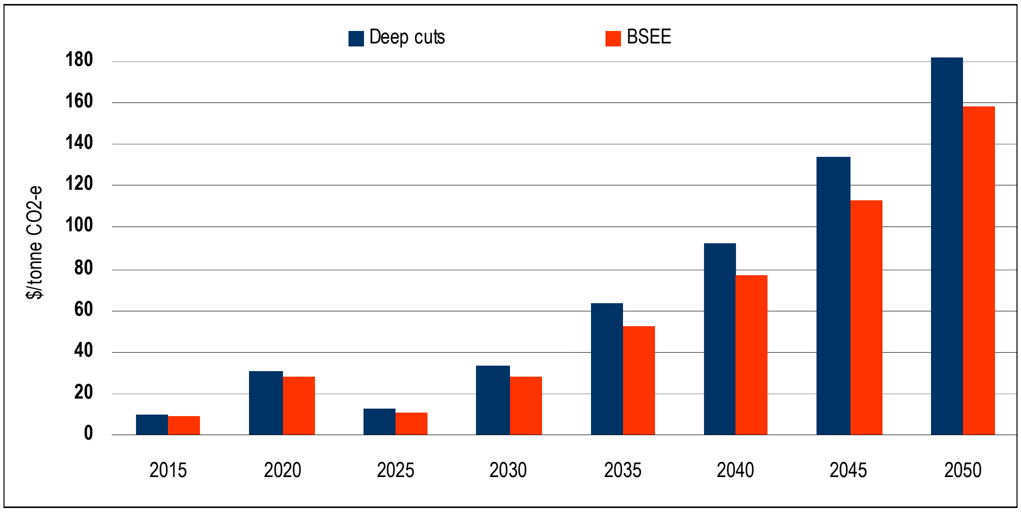
This study examines the economic implications of the economy achieving a 60 per cent reduction in GHG emissions by 2050. It builds upon the business case for early action on GHG abatement put forward by the Australian Business Roundtable on Climate Change (BRCC 2006) by specifically considering the implications of the building sector investing in energy efficiency enhancements.

The economic modelling takes into account the technical costs (and cost savings) of energy efficiency to illustrate the cumulative effects of resources as they are re-allocated to achieve GHG abatement. The following economic analysis does not include the social and environmental benefits from achieving abatement. That is, the analysis does not attempt to include the expected benefits from reduced global warming and climate change, as well as avoided externalities associated with pollution from GHG intensive sources of energy and its use.

Implied cost of GHG abatement

The implied cost of GHG abatement (measured in terms of a tonne of CO_2-e) generally increases over time in both change scenarios. One way of thinking about the implied cost is that it is the cost of investment that a business would make to achieve a reduction of a unit of GHG abatement. Another viewpoint is that it is the price that a business would pay someone else to avoid making a GHG emission. The implied cost reported is the highest cost faced by a firm to pay for the last tonne of GHG emission reduction needed to achieve the target in each year. The implied costs increase as deeper reductions are required to meet the target. The chart below shows the estimated implied cost of reducing a tonne of GHG emissions in selected years.

4.1 **Implied cost of GHG abatement — selected years**



[a] 2005 prices; BSEE= with building sector energy efficiency enhancements.

Data source: MMRF-Green simulation results

The chart also shows how growth trajectory of the implied costs of abatement's significant. In real terms, the implied cost of abatement under both change scenarios is approximately $9 per tonne in 2015. The cost of abatement in the deep cuts scenario is projected to climb to nearly $190 per tonne by 2050. In this same period, having the building sector directly involved could lead to slightly less dramatic growth in the implied cost of GHG abatement. By 2050, the price of GHG emissions is just under $160 per tonne or 14 per cent lower when the building sector contributes through energy efficiency.

The key point is that the implied abatement costs will be lower under a scenario where the building sector contributed through energy efficiency enhancements. Additional abatement activity by the buildings sector would substantially reduce the implied cost of each unit of GHG abatement across the economy as a whole. It will reduce the cost of change for everyone.

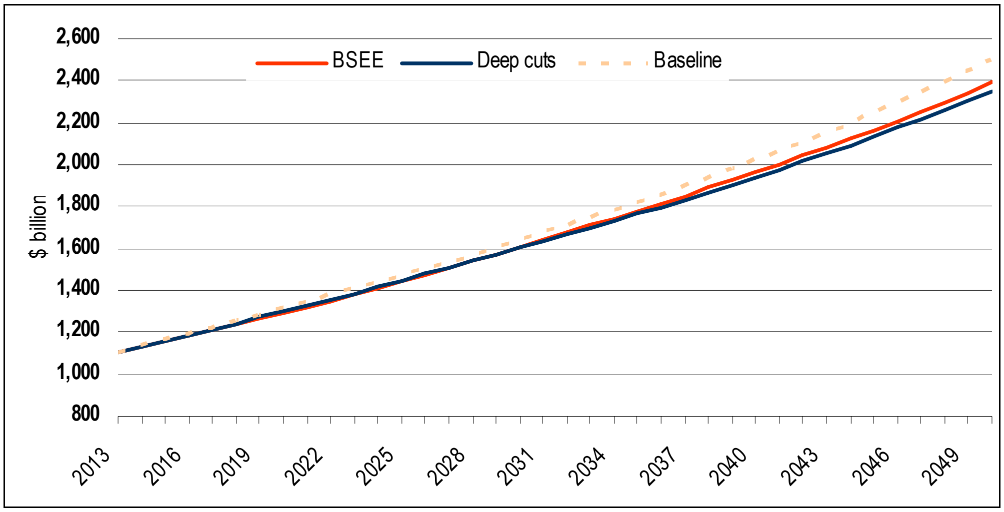
Gross domestic product

Chart 4.2 illustrates the projected level of gross domestic product (GDP) through time under three scenarios — the baseline, deep cuts and BSEE. The average annual rate of growth in the baseline projection over the forecast period is almost 2.2 per cent.

The deep cuts scenario reveals that significant reductions in GHG emissions would have a relatively minor impact on GDP over time. The average rate of economic growth over the project period was foreshadowed to fall to 2.0 per cent. This cost was described in the BRCC report as being 'modest' and 'affordable '.

The results suggest that the building sector's contribution to abatement helps achieve the targeted reduction in GHG abatement at a lower cost. This is reflected in terms of a smaller reduction in the average growth rate over the forecast period with an average annual growth rate over the whole period of 2.1 per cent.

4.2 **GDP in three scenarios from 2013 to 2050**



[a] 2005 prices; BSEE= with building sector energy efficiency enhancements.

Data source: MMRF-Green simulation results

It should be noted that comparing changes in growth rates over a long period of time may smooth over a great many particular issues and problems. It is useful to drill a little deeper.

The slightly slower GDP growth rate means that the level of economic activity is slightly lower (in every year) when achieving progressively deeper reductions in GHG emissions. As the chart above illustrates, the gap between GDP in the baseline and where deep reductions in GHG emissions are achieved grows through time. By 2050, the deep cuts scenario results in annual GDP more than doubling (from 2013). It grows to $2.35 trillion, which is nearly $145 billion lower than baseline projections.

The building sector, through energy efficiency enhancements, can help close this gap. It delivers, relative to the deep cuts scenario, an additional $38 billion annually GDP by 2050.

While GDP provides a measure of the economy's productivity or level of activity, private household consumption is a better measure of welfare or economic wellbeing. Private consumption is projected to experience an average annual growth rate that is similar to that of GDP growth in all scenarios (baseline and the two change scenarios).

Employment

Overall, employment continues to grow even when deep cuts in GHG emissions are achieved. However, the rate of job growth slows relative to the baseline. Consequently, the economy, relative to the baseline, misses some employment growth opportunities. With the building sector contributing to GHG abatement, the magnitude of this loss is mitigated. Additionally, the variations from baseline employment levels are dampened.

Table 4.3 summarises the impact on economy-wide employment in selected years under the three scenarios. Of particular significance is the relatively higher level of total employment (relative to the deep cuts scenario) post 2030.

4.3 **Change in national employment – selected years**

Scenario	*2015*	*2020*	*2030*	*2040*	*2050*
Baseline total employment (1000 people)	10 700	11 200	12 035	12 820	13 695
Deep cuts					
total employment (1000 people)	10 690	11 190	12 025	12 805	13 690
% deviation from the baseline	-0.4	-0.6	-0.3	-0.6	-0.2
Deep cuts with building sector energy efficiency					
total employment (1000 people)	10 690	11 190	12 030	12 807	13 690
% deviation from the baseline	-0.4	-0.6	-0.1	-0.4	-0.1

Source: MMRF-Green simulation results

Present value of the cumulative impact

A key aim of this study is to assess the effect that GHG abatement action taken up by the building sector has to the economy. A key indicator of this impact is the present value loss of GDP over the 37-year analytic period under the two change scenarios.

As the charts illustrated earlier, GDP continues to grow through time when deep emission cuts are achieved. However, this growth is slower. Its cost, measured as the present value of the cumulative difference (between baseline and deep cuts) in annual GDP (from 2013 to 2050) is around $970 billion (using a 3 per cent discount rate). When the building sector contributes through energy efficiency investments to an economy-wide emissions abatement target, the overall loss to GDP, in present value terms, is around $810 billion. In other words, the cumulative difference, from 2013 to 2050, is a gain of $160 billion dollars due to the building sector's energy efficiency enhancements. This equates to the economy being better off by nearly 17 per cent relative to deep cuts only scenario as a results of the building sector energy efficiency strategies.

Table 4.4 summarises the present value of the GDP loss due to achieving GHG reductions using three different discount rates (3, 5 and 7 per cent). These discount rates are commonly used in government analyses. The lowest discount rate of 3 per cent is probably more appropriate than the higher discount rates commonly used for project evaluation because the changes examined here are economy-wide and reflect a risk profile that is as diversified as the economy at large.

4.4 Present value of GHG reductions — 2013 to 2050

	Discount rate		
Change scenario	***3%***	***5%***	***7%***
Deep cuts ($ billion)	-$974	-$609	-$398
With the building sector energy efficiency enhancements ($ billion)	-$812	-$529	-$362
Gain from building sector's contribution ($ billion)	$162	$80	$36

[a] All prices in 2005 real dollars.
Source: MMRF-Green simulation results

The estimated costs to the economy (in table 4.4) reflect the cumulative effect as resources are re-allocated to achieve GHG abatement. It does not include the benefits from achieving abatement (including expected benefits from reduced global warming and climate change as well as avoided externalities associated with pollution from GHG intensive sources of energy and its use).

How sensitive are the results of the analysis to changes in key assumptions?

Table 4.5 presents information on how GDP changed in the two change scenarios as well as how it would change in variants of how the building sector could contribute to the deep emissions abatement target. The first sensitivity scenario considers what may happen if the building sector's GHG abatement increased to 35 per cent (from 30 per cent). This scenario reflects, for example, the possibility of achieving deeper energy efficiency gains in the commercial sector through additional efficiencies in offices. With an economy-wide achievement of the GHG target, the main difference would be in the cost of achieving the target. The simulation results indicate that this change would have a slight impact on GDP in 2050. An additional 5 per cent reduction of GHG emissions from the building sector (i.e. overall building sector reduction of 35 per cent rather than 30 per cent) could lift GDP by $7 billion. In other words, GDP would be reduced by $100 billion rather than $107 billion per annum by 2050.

The other scenarios vary the benefit cost ratio (BCR) of energy efficiency in the built environment that is an input to assessing the economy-wide impacts. It shows that what could happen if the BCR of energy efficiency improvements by the building sector were different. If efficiency gains resulted in $2 of benefits for every dollar of cost, the deviation in GDP (from the baseline) would be smaller. By 2050, the reduction in annual GDP is estimated to be around $68 billion (a loss of about 2.8 per cent of baseline GDP). Assuming linear relationships, if the BCR is halved (that is, energy efficiency only returns half the benefits), the reduction in baseline GDP is $126 billion in 2050 (5 per cent of the baseline GDP).

4.5 **Sensitivity analysis of deep cuts plus**

	Change in GDP ($ billion)	***Change in GDP (%)***
Change scenarios		
Deep cuts	-145	-5.8
With building sector energy efficiency enhancements	-107	-4.3
Sensitivity scenarios		
Building sector achieves 35% GHG reductions	-100	-4.0
BCR of energy efficiency – 2:1	-68	-2.7
BCR of energy efficiency – 0.5:1	-126	-5.0

[a] All values in $ billion and 2005 prices. Change in GDP estimated as the deviation from baseline scenario

Source: CIE and MMRF-Green results

5 *Implications of capitalising on the building sector's potential*

This study adds to our current understanding by addressing how the building sector can specifically contribute to achieving a given GHG reduction target of 60 per cent below 2000 levels by 2050.

This study highlights that energy efficiency strategies in the building sector can positively contribute to overall economic activity — when measured in terms of GDP and employment. Based on previous work by the BRCC, a carbon-constrained economy continues to grow, however at a slightly slower rate. When the building sector's energy efficiency opportunities are explicitly considered in this deep cuts scenario (that is, 60 per cent economy-wide deep emissions abatement target), the GDP growth rate picks up slightly.

Capitalizing on abatement opportunities in the building sector also reduces the cost of placing energy use on a more sustainable platform. The building sector houses a significant share of the economy's activity and accounts for nearly one-quarter of the nation's GHG emissions under a final demand accounting framework. It offers readily available opportunities and strategies that complement initiatives that aim to reduce GHG emission at the source. In other words, it facilitates a balanced GHG abatement strategy for the nation by tackling both the demand and supply side.

This study characterizes the economy-wide benefits of the building sector achieving a 30 per cent improvement in energy efficiency. This contribution raises GDP growth (relative to the deep cuts scenario). By 2050, GDP could be nearly $38 billion higher per year. Importantly, these investments in energy efficiency by the building sector also help to reduce the costs of GHG abatement for all sectors. Implicit price of GHG abatement is 14 per cent lower when energy efficiency opportunities are taken up in the building sector.

These opportunities however, require an effective policy framework to promote their uptake in the building sector. As shown in chapter 2, the energy efficiency opportunities for households and businesses can be cost neutral or even cost savings. However, the investments in energy efficiency require upfront costs. The benefits, however, accrue over the medium to long term. That is, they require the building sector to overcome this upfront cost to benefit the entire economy.

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