FINAL REGULATION IMPACT STATEMENT for DECISION
(Final RIS 2009-06)

Proposal to Revise the Energy Efficiency Requirements of the Building Code of Australia for Residential Buildings — Classes 1, 2, 4 and 10

December 2009

The Australian Building Codes Board (ABCB) has commissioned The Centre for International Economics to prepare this Final Regulation Impact Statement (RIS) in accordance with the requirements of *Best Practice Regulation: A Guide for Ministerial Councils and National Standard Setting Bodies,* endorsed by the Council of Australian Governments in 2007. Its purpose is to inform interested parties regarding a proposal to amend existing regulatory requirements for energy efficiency in residential buildings.

The RIS considers outcomes from public comment received in response to the consultation RIS 2009-05.

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Final Regulation Impact Statement for residential buildings (Class 1, 2, 4 and 10 buildings)

Proposal to revise energy efficiency requirements of the Building Code of Australia for residential buildings

Prepared for

Australian Building Codes Board

Centre for International Economics
Canberra & Sydney

December 2009

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TheCIE's professional staff arrange, undertake and publish commissioned economic research and analysis for industry, corporations, governments, international agencies and individuals.

TheCIE is based in Canberra and has an office in Sydney.

This report has been prepared by TheCIE on behalf of the Australian Building Codes Board.

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Disclaimer

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ABCB	Australian Building Codes Board
ABRB	Australian Building Regulation Bulletin
ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
AGGA	Australian Glass and Glazing Association
AIBS	Australian Institute of Building Surveyors
AIRAH	Australian Institute of Refrigeration, Air-conditioning and Heating
BAU	Business As Usual
BCA	Building Code of Australia
BCC	Building Codes Committee
BMT	BMT & ASSOC Pty Ltd
CBA	Commonwealth Bank of Australia
CIE	Centre for International Economics
COAG	Council of Australian Governments
CO2-e	Carbon Dioxide Equivalent
CPD	Continuing Professional Development
CPRS	Carbon Pollution Reduction Scheme
DEWHA	Department of the Environment, Water, Heritage and the Arts
DLC	Direct Load Control
DTS	Deemed-to-Satisfy
EER	Energy Efficiency Rating

(Continued on next page)

Glossary *(continued)*

ETS	Emissions Trading Scheme
FAQ	Frequently Asked Questions
GHG	Greenhouse Gas
GWh	Gigawatt Hour
HAI	Housing Affordability Index
HIA	Housing Industry Association
IEA	International Energy Agency
IGU	Insulated Glass Units
IPCC	Intergovernmental Panel on Climate Change
kVA	Kilo Volt Amperes
kW	KiloWatts
MJ	Megajoule
MEPS	Minimum Energy Performance Standards
MoU	Memorandum of Understanding
MRET	Mandatory Renewable Energy Target
Mt	Megatonnes or millions of tonnes
MW	Megawatt
NABERS	National Australian Built Environment Rating System
NaTHERS	Nationwide House Energy Rating Scheme
NPV	Net Present Value
NSEE	National Strategy on Energy Efficiency
OBPR	Office of Best Practice Regulation
O&M	Operation and maintenance

Glossary *(continued)*

PFC	Proposal for Change
PIA	Preliminary Impact Assessment
PJ	Petajoule
RBA	Reserve Bank of Australia
RET	Renewable Energy Target
RIS	Regulation Impact Statement
UNSW	University of New South Wales
USE	Unserved Energy

Summary

This report is a Final Regulation Impact Statement (RIS) that assesses the costs and benefits of proposed amendments to energy efficiency requirements in the Building Code of Australia (BCA) for residential buildings (equivalent to Class 1, 2, 4 and 10 buildings in the BCA).

Policy context of this RIS

The Australian Government, and more widely, the Australian community, has identified the objective of reducing greenhouse gas (GHG) emissions and improving energy efficiency as priorities. The primary instrument proposed by the Government to address this problem is through the Carbon Pollution Reduction Scheme (CPRS).

A range of technical reports have provided evidence that abatement of GHG emissions could be achieved at low or possibly negative cost in the building sector - relative to reductions available in other sectors of the economy. Moreover, this abatement could be achieved through the best-practice adoption of known energy efficiency technologies. Market failures and policy rigidities however, are thought to impede the take-up of these technologies and hence, addressing these barriers could require additional measures to complement the CPRS.

Scope of this RIS

The Council of Australian Governments (COAG) has already made an assessment of these market barriers in the context of the CPRS. The National Partnership Agreement on Energy Efficiency (COAG 2009d) states:

> A carbon price will provide an incentive for households and businesses to use energy more efficiently. *A carbon price alone, however, will not realise all the potential cost effective opportunities to improve energy efficiency across the Australian economy.* [emphasis added] Market barriers, such as split incentives, information failures, capital constraints, early mover disadvantage and transaction costs need to be addressed to remove impediments to investment in energy efficiency by households and business.

This RIS confines itself to considering the impacts of the amendments to the BCA as the only means of dealing with these barriers. This approach recognises that: a) COAG has already acknowledged the need to adopt a range of policies and tools so as to address the diversity of market barriers that exist, and b) the BCA is already in place and these amendments are only acting to increase its stringency.

The proposed amendments have been developed in accordance with an agreement between the Australian, State and Territory Governments to pursue a National Strategy on Energy Efficiency (COAG 2009a and 2009b). The amendments include provisions for outdoor areas and provisions to improve:

- a dwelling's thermal performance;
- the energy efficiency of water heating; and
- the energy efficiency of lighting.

It is proposed that the amendments be included in BCA 2010 and implemented by May 2011.

The scope of this report is strictly limited to quantifying the benefits and costs of the proposed amendments in a way that is consistent with COAG best practice regulation guidelines. It is worth noting that on this occasion, COAG has signed a National Partnership Agreement on Energy Efficiency (COAG 2009d) that supports the use of cost effective energy efficiency standards through the BCA.

Business as usual case

An important ingredient of the quantification of the benefits and costs of the proposed amendments is the establishment of a business as usual (BAU) scenario. The BAU represents what may happen 'without' the proposed amendments to the BCA. It accounts for:

- growth in the residential building stock and shifts in population location;
- baseline improvements in energy efficiency and changes in energy prices; and
- major policy initiatives and other factors.

The BAU uses current BCA requirements for new houses as the baseline, measuring estimated benefits and costs of meeting proposed BCA 2010 requirements as a stepped changed from meeting BCA 2006.

Importantly, the BAU also builds on the modelling undertaken by the Australian Government in its analysis of the CPRS and increases in mandatory renewable energy targets. It also excludes the implications of other policies such as financial incentives for energy efficiency investments and the national roll out of smart meters.

Consistent with the evaluation methodology recommended in CIE (2009a), the analysis only accounts for new buildings that are built within 10 years of the adoption of the new standards assumed to occur in 2011. It is assumed that compliance costs are fully passed on to the user of the asset (the owner-occupier). All new building work requiring approval from the relevant regulatory authority is assumed to comply with the amended BCA.

Expected net impacts to individual dwellings

Table 1 reports the estimated net impact on individual dwellings, estimated at a 7 per cent discount rate. From the thermal performance and lighting provisions alone, the impact on a typical house ranges between a net benefit of about $6400 and a net cost of about $2400 depending on the compliance pathway and location (both of these figures exclude the impact of water heating provisions). These estimates have been calculated using an economywide sample of dwellings and some caution should be taken when considering results at a local level. In particular, these estimates do not account for outdoor living credits that may apply in climate zones 1 and 2 (Darwin and Brisbane).

It should be noted that the *total* capital costs of building are typically lower for the simulation approach than for the elemental approach. Specifically, the results in the table represent the *increase* in required capital outlays between the 2010 BCA and 2009 BCA elemental provisions, and between the 2010 BCA and 2009 BCA simulation compliance. In other words, the two compliance pathways are compared against their *respective* baselines. Because the pathway reference points are different, the compliance costs cannot be compared between pathways.

Table 2 presents the estimated BCRs of the proposed changes at the dwelling level. BCRs follow the same pattern as the net impacts — with BCRs ranging from 0.27 to 6.47 depending on dwelling type, location and compliance pathway.

The impacts that the proposed BCA changes will have on housing affordability across Australia's capital cities have been analysed in this report using three affordability indicators.

1 Present value of net impact of thermal and lighting provisions on dwellings

	Darwin	*Brisbane*	*Longreach*	*Mildura*	*Adelaide*	*Perth*	*Sydney*	*Melbourne*	*Canberra*	*Hobart*	*Cabramurra*
Elemental											
House	1461	-2423	-450	65	62	-558	-1015	4	-1110	-1444	6294
Townhouse	871	-1095	-25	183	115	-320	-634	73	-690	-654	2933
Simulation											
House	1623	-750	-1327	-1683	-1269	-785	-1058	-109	512	-689	5437
Townhouse	128	-510	-1938	-1412	-910	-219	-771	-806	-814	-495	1460
Flat	4391	-454	1301	1323	-2047	-2355	-2192	-1364	-1024	-1254	-1488
Elemental-simulation average											
House	1576	-1235	-1073	-1176	-883	-719	-1045	-77	42	-908	5686
Townhouse	343	-680	-1384	-949	-612	-248	-731	-551	-779	-541	1887
Flat	4391	-454	1301	1323	-2047	-2355	-2192	-1364	-1024	-1254	-1488

Note: The elemental-simulation average is a weighted average of the impacts based on the expected market adoption of simulation (71 per cent) and elemental (29 per cent) compliance and a 7 per cent discount rate.
Source: CIE estimates based on data provided by ABCB (refer appendices).

2 Benefit cost ratio for thermal and lighting provisions — dwellings

	Darwin	*Brisbane*	*Longreach*	*Mildura*	*Adelaide*	*Perth*	*Sydney*	*Melbourne*	*Canberra*	*Hobart*	*Cabramurra*
Elemental											
House	1.84	0.27	0.83	1.03	1.04	0.65	0.45	1.00	0.61	0.53	5.72
Townhouse	2.22	0.32	0.98	1.22	1.14	0.65	0.42	1.10	0.54	0.58	6.47
Simulation											
House	2.04	0.54	0.63	0.54	0.54	0.57	0.44	0.94	1.42	0.71	3.48
Townhouse	1.09	0.50	0.38	0.42	0.50	0.73	0.38	0.50	0.50	0.64	1.73
Flat	3.31	0.62	1.81	1.78	0.50	0.43	0.47	0.51	0.59	0.50	0.52
Elemental-simulation average											
House	1.98	0.42	0.68	0.63	0.63	0.59	0.44	0.96	1.02	0.64	3.93
Townhouse	1.28	0.43	0.46	0.52	0.60	0.70	0.39	0.60	0.51	0.62	2.19
Flat	3.31	0.62	1.81	1.78	0.50	0.43	0.47	0.51	0.59	0.50	0.52

Note: The elemental-simulation average is a weighted average of the impacts based on the expected market adoption of simulation (71 per cent) and elemental (29 per cent) compliance and a 7 per cent discount rate.
Source: CIE estimates based on data provided by ABCB (refer appendices).

Under initial estimates of benefits and costs, all three housing affordability measures showed only marginal impacts on housing affordability as a result of the amendments.

Expected net impacts for the economy

A high level analysis of the national impacts of the proposed BCA changes was undertaken through the aggregation of impacts from the dwelling sample to regional, state and national levels. The economywide results of the analysis under a 5 and 7 per cent discount rate are presented in table 3. This allows a comparison between results in the Consultation RIS, estimated utilising a 5 per cent discount rate, and the results in the Final RIS utilising a 7 per cent discount rate.

3 Present value of net impact, economywide, $million

Element	*5 per cent discount rate*	*7 per cent discount rate*
	$	**$**
Costs	**2.4 billion**	**2.2 billion**
Additional net capital outlays	2.4 billion	2.1 billion
Industry compliance costs	35 million	35 million
Additional administration	250,000	250,000
Benefits	**2.7 billion**	**1.9 billion**
Energy savings form improved thermal performance	2.1 billion	1.5 billion
Energy savings from lighting provisions	243 million	174 million
Hot water heating provisions	11 million	11 million
Installation of smaller appliances	107 million	97 million
Capital savings of electricity generation and transmission	259 million	186 million
Net benefits	**296 million**	**-259 million**

In net terms, under a 5 per cent discount rate, the community will gain a net estimated benefit from all the provisions of approximately $300 million in present value terms, with a benefit-cost ratio of 1.13. That is, the proposed amendments could be expected to generate $1.13 dollars of benefits to the community for every one dollar of costs incurred. Table 4 identifies the net impact and BCR of each of the provisions assessed for Class 1 and 2 buildings.

However, under a 7 per cent discount rate, as estimated in the Final RIS, net benefits are reduced to net costs of $259 million and a BCR of 0.88.

4 Present value of net impact, economywide, $million

	5 per cent discount rate		7 per cent discount rate	
	Net impact	Benefit Cost Ratio	Net impact	Benefit Cost Ratio
	$ million	BCR	$ million	BCR
Class 1				
Thermal performance	-4	1.00	-441	0.78
Lighting provisions	230	na	165	na
Water heating [a]	11	3.69	11	3.69
Total	237	1.11	-265	0.87
Class 2			0	
Thermal performance	46	1.25	-3	0.98
Lighting provisions	13	na	9	na
Total	59	1.32	6	1.03
Residential buildings			0	
Thermal performance	42	1.02	-444	0.8
Lighting provisions	243	na	174	na
Water heating	11	3.69	11	3.69
Total	296	1.13	-259	0.88

[a] Water heating benefits accrue only to those States that do not currently have water heating provisions.

Notes:

Thermal performance measures include the impact of requiring smaller appliances.

A BCR for lighting provisions cannot be estimated, as it has been estimated that the provision will involve zero costs.

Thermal performance net benefits include $259 million of net benefits accruing through electricity network sourced benefits.

Source: CIE estimates based on data provided by ABCB (refer appendices for details).

GHG abatement

The proposed changes can also be expected to reduce GHG emissions from the residential building sector. The analysis undertaken for this RIS shows that the thermal and lighting amendments will together reduce the sector's annual emissions by some 470 ktCO2-e by the year 2020. Water heating provisions could abate a further58 ktCO2-e; and together this represents about half of 1 per cent of the Government's abatement target of 138 MtCO2-e. Further, the abatement achieved is effectively 'locked in', irrespective of behavioural change, economic activity, price responses and shifting preferences created through the CPRS.

Stakeholder responses to initial estimates

Initial estimates of benefits and costs were presented to stakeholders in the Consultation RIS. Submissions responding to that RIS raised a wide variety of issues. Some of these have the potential to substantially change the initial results presented in the Consultation RIS, as is the case with OBPR advice on the discount rate.

Discount rate

The results in the Consultation RIS were estimated based on a 5 per cent discount rate. Arguments were presented that the discount rate should be both higher and lower. Arguments that it should be lower were centred on the fact that lower discount rates had been used in other climate change studies. The main arguments that it should be higher included the following:

- The evaluation of the 5 star BCA used a higher discount rate.
- The Office of Best Practice Regulation requires that a higher discount rate should be used, so as to be consistent and comparable with other Commonwealth benefit cost evaluations and decision making.
- Home owners who will incur the costs up front and the benefits much later are likely to have a higher discount rate and not taking account of this may mean ignoring a net cost being imposed on consumers (but possibly to the benefit of future generations).

The results are highly sensitive to the chosen discount rate. As shown in table 5, the effect of using a 7 per cent discount rate (instead of the 5 per cent used to generate the initial results) is to generate a net loss to the Australian economy from the proposed changes. There is projected to be a net loss of approximately $259 million and a BCR of 0.88.

Changes in the discount rate also affect the regional net benefits and BCR estimates. Tables 6 and 7 below outline these regional effects.

From table 5 it can be seen that an increase in the discount rate from 5 to 7 per cent reduces the value of thermal and lighting provisions on dwellings. For example, the value of thermal and lighting provisions in Melbourne under a 5 per cent discount rate is estimated at approximately $298 and under a 7 per cent discount rate, this is reduced to approximately -$29, that is, a net decrease in benefits.

The effect on the BCR from altering the discount rate follows the same pattern, where an increase in the discount rate lowers the value of future benefits, and reduces the estimated BCR. Following the results for a house in Melbourne again, under a 5 per cent discount rate, the BCR is approximately 1.17, and under a 7 per cent discount rate, the BCR reduces below 1 to 0.98.

5 Present value of net impact, economywide

	Net impact	*Benefit Cost Ratio*
	$ million	BCR
Total – 5 per cent discount rate	296	1.13
Total – 7 per cent discount rate	-259	0.88

6 Present value of net impact of thermal and lighting provisions on dwellings – 5 and 7 per cent discount rates

	Darwin	*Brisbane*	*Longreach*	*Mildura*	*Adelaide*	*Perth*	*Sydney*	*Melbourne*	*Canberra*	*Hobart*	*Cabramurra*
Elemental-simulation average 5 per cent discount rate											
House	2295	-1048	-576	-737	-553	-498	-871	298	431	-541	7415
Townhouse	691	-585	-1134	-735	-428	-136	-648	-382	-609	-356	2659
Flat	5805	299	1940	1986	-1599	-1972	-1779	-1058	-707	-991	-1131
Elemental-simulation average 7 per cent discount rate											
House	1624	-1187	-1025	-1128	-835	-671	-997	-29	90	-860	5734
Townhouse	364	-659	-1363	-929	-592	-227	-710	-531	-758	-520	1908
Flat	4419	-427	1328	1350	-2020	-2327	-2165	-1337	-996	-1227	-1461

Note: Simulation based compliance involves the introduction of a 6 star requirement based on thermal performance modelling software for all Classes of residential buildings (that is, Classes 1, 2, 4 and 10); and elemental compliance involves for satisfying a general increase in stringency of elemental Deemed to Satisfy (DTS) provisions for Class 1 and 10 buildings. The elemental-simulation average is a weighted average of the impacts based on the expected market adoption of simulation (71 per cent) and elemental (29 per cent) compliance.
Source: CIE estimates based on data provided by ABCB (refer appendices for details).

7 Benefit cost ratio for thermal and lighting provisions — dwellings, 5 and 7 per cent discount rates

	Darwin	*Brisbane*	*Longreach*	*Mildura*	*Adelaide*	*Perth*	*Sydney*	*Melbourne*	*Canberra*	*Hobart*	*Cabramurra*
Elemental-simulation average 5 per cent discount rate											
House	2.43	0.56	0.84	0.84	0.84	0.72	0.54	1.17	1.45	0.80	5.06

Townhouse	1.73	0.53	0.67	0.79	0.83	0.84	0.46	0.82	0.62	0.75	3.79
Flat	4.06	0.75	2.21	2.17	0.61	0.52	0.57	0.62	0.72	0.60	0.64
Elemental-simulation average 7 per cent discount rate											
House	2.01	0.44	0.69	0.64	0.65	0.61	0.47	0.98	1.05	0.66	3.95
Townhouse	1.29	0.44	0.47	0.53	0.61	0.73	0.41	0.61	0.52	0.64	2.21
Flat	3.33	0.64	1.83	1.79	0.51	0.43	0.47	0.52	0.60	0.51	0.53

Note: The elemental-simulation average is a weighted average of the impacts based on the expected market adoption of simulation (71 per cent) and elemental (29 per cent) compliance.
Source: CIE estimates based on data provided by ABCB (refer appendices).

There is no necessarily *correct* discount rate. What is clear from the analysis above is that the results are highly sensitive to the discount rate used. Over a plausible range of discount rates, the benefits change from positive to negative.

A key underlying factor in the choice of discount rate is whether the costs and benefits are being evaluated at a social or private level. Where a private evaluation is being undertaken, the appropriate discount rate is closely associated with the private decision making process of individuals. However, if the effects of the regulation are being evaluated at a social level, where there is the potential for benefits to be accumulating for a number of years, as well as to future generations, there is scope for these future benefits to hold a greater value, and hence attract a lower discount rate.

Regional aggregations

Another issue raised relates to the regional results. Three of the four main growth cities were found to have negative net benefits in the consultation RIS. Melbourne was the only significant growth centre with positive net benefits. The positive national net benefit was based on two critical assumptions used in the aggregation exercise. The first is that Melbourne is representative of the costs and benefits for climate zone 6 and that the alpine region, zone 8, a tiny zone with potentially large savings per house, will see around 1000 new homes a year. Both of these assumptions seem unreasonable. The effect of correcting for both of these is to halve the national net benefit, lowering the BCR from 0.88 to 0.82.

Building costs

A major issue of concern especially to stakeholders representing the building industry was that extra capital costs of building were grossly underestimated in the initial estimates. The claims were made that experience with the introduction of the 5 star ratings had been more costly than anticipated, and a variety of evidence was used to claim that extra building costs could be up to four times those used in the initial estimates. Three major submissions made similar claims but it has not been possible to verify the data and evidence submitted. The increased *build* cost underlying the initial estimates was based on capital costs rising by around 1.25 per cent on average. Claims from industry groups were that they would turn out to be more like 3 to 6 per cent and in some cases (for south facing flats) 20 per cent.

By contrast, some submissions suggested:

- lower additional building cost might eventually be achieved due to learning by doing;
- design changes could further reduce additional building costs; and
- the initial estimates presented in the Consultation RIS seemed to be consistent with experience of voluntarily introducing 5 and 6 star standards in Western Australia.

Although estimated by an independent quantity surveyor, the additional building costs estimated and reported in the Consultation RIS are, by their very nature, somewhat theoretical and untested. Moreover, because there has not been an independent ex post assessment of the costs incurred with the introduction of the 5 star BCA, considerable uncertainty (and suspicion) surrounds the estimates of increased building costs. Equally, the claims of considerably higher building costs from industry stakeholders have not been independently verified. Nonetheless, the claims are from those with practical experience of building costs.

What is clear from sensitivity testing is that if additional building costs are raised by 50 per cent from the 1.25 per cent of the initial estimates to 1.9 per cent, the net cost of the initial analysis would increase from $259 million to a net cost of $1333 million and the BCR would drop from 0.88 to 0.59. If additional building costs are assumed to be double those in the initial analysis (that is, 2.5 per cent of current build costs) the net cost to the economy would extend to $2407 million and the BCR would fall to 0.44. With extra building costs at 2.5 per cent, they would still be below those claimed by industry stakeholders.

Another indication of the sensitivity is that if additional building costs were 20 per cent lower than estimated in the consultation RIS, net benefits of approximately $171 million could be achieved and deliver a BCR of 1.10.

Clearly, the results and economic viability of the BCA 2010 energy efficiency proposal are highly sensitive to estimates of extra building costs and these are uncertain.

Energy prices

Some stakeholders have argued that energy prices used in the analysis may be underestimated. Accepting the most stringent climate change policy scenario modelled by either Treasury or Garnaut (Garnaut-25 rather than CPRS-5 used in the Consultation RIS), net national benefits increase by 50 per cent and the benefit to cost ratio climbs from 0.88 to 0.94 (using the 7 per cent discount rate). Under this scenario, wholesale electricity prices would be 250 per cent higher by 2050 than now. Although considerably more stringent, the biggest increase in electricity prices under the Garnaut-25 scenario come in later years and so they tend to be heavily affected by the discount rate. The higher is the discount rate, the lower is the effect of later increases in electricity prices.

Although it is often argued that domestic electricity demand is unresponsive to changes in electricity prices, this may not hold so tightly if electricity prices rise sharply. If higher electricity prices cause builders and consumers to adopt energy saving technologies (one of the reasons for the CPRS), the arguments relating to the need for stricter energy efficiency codes to address market failures are also diminished.

Overall consideration

The initial estimates provided in the Consultation RIS indicate small potential net economic gains nationally from the BCA 2010 energy efficiency proposal, although they also indicate net costs to some major growth regions. In general, the larger net benefits accrue to regions with more extreme temperature challenges where larger energy savings can be achieved. In more temperate climates (such as those in Sydney, Brisbane and Perth) it is more difficult to achieve large enough energy savings in both cold weather and hot weather, resulting in estimated net costs in these regions using contemporary house design approaches.

Following directions from OBPR on the methodology of the Consultation RIS, this Final RIS has utilised a 7 per cent discount rate instead of the 5 per cent discount rate utilised in the Consultation RIS. The impact of this change is to alter the final result from an estimated BCR of 1.13 to 0.88, indicating likely net costs to be imposed from the proposed changes.

Further evidence and claims made by stakeholders in submissions to the Consultation RIS raise several uncertainties about the net economic impacts of the proposed changes. They present cases for both positive and negative impacts on the assessment. On balance more, uncertainties appear to be raised increasing the likelihood of generating net costs from the proposal.

Major issues raised in submissions that highlight the sensitivity of the BCR include the choice of discount rate, estimation of additional build costs, regional weightings and projections of electricity and carbon prices.

Firstly, the results are highly sensitive to the discount rate. At the OBPR's preferred rate net costs are estimated. Secondly, while additional build costs are largely untested, industry groups have raised concern that they are more likely to be higher than estimated, resulting in a negative BCR. Changes to regional weightings also have a negative impact on the BCR. Finally, projected electricity and carbon prices are highly uncertain and heavily dependent on policy decisions yet to be made by governments, such as the stringency of a national carbon emissions policy.

While some of these uncertainties are difficult to resolve in the short term, it has been noted that closer scrutiny of the impacts that the BCA2006 had on delivered energy efficiency and extra building costs could assist in reducing the uncertainty surrounding the net benefit and cost estimates of the BCA2010 proposal.

Overall, based on the evidence as it now stands, the proposal outcomes point toward imposing net costs on major growth regions across Australia and to a strong possibility of imposing net costs nationally.

1 Introduction

The Building Code of Australia (BCA) provides nationally consistent, minimum necessary standards for the design and construction of buildings in Australia. The Australian Building Codes Board (ABCB) on behalf of the Australian Government and State and Territory Governments produces and maintains the BCA.

In addition to structural, fire protection and health and amenity provisions, Section J in BCA Volume One and Section 3.12 in the Volume Two (hereinafter referred to as Section J and Section 3.12) address minimum performance standards regarding residential buildings' energy performance.

The ABCB first introduced energy efficiency requirements for buildings in 2003. At that time, the requirements only addressed Classes 1 and 10. They were then expanded to apply to Classes 2, 3 and 4 in early 2005. In 2006, the BCA introduced energy efficiency requirements for nonresidential buildings (hereinafter referred to as commercial buildings) and increased energy efficiency requirements for Classes 1 and 10 to a 5-star standard. An overview of the regulatory impact analysis of the 2006 changes in energy efficiency requirements for Classes 1 and 10 buildings is provided in Box 1.1. Current energy efficiency requirements include building fabric, glazing and mechanical services. The extent of the requirements and the manner in which they are applied is dependent on the BCA Classification of the building and the climate zone in which the development falls.

At its meeting of 30 April 2009, the Council of Australian Governments (COAG) reaffirmed its commitment to introducing a comprehensive National Strategy for Energy Efficiency to help households and businesses reduce their energy costs, improve the productivity of the Australian economy and reduce the cost of greenhouse gas abatement under the Carbon Pollution Reduction Scheme (CPRS). As a first step, COAG agreed to five key measures to improve the energy efficiency of residential and commercial buildings across Australia (COAG 2009a):

- an increase in the stringency of energy efficiency requirements for all Classes of commercial buildings in the Building Code of Australia from 2010;

1.1 Impact analysis of increased energy efficiency requirements for Class 1 and 10 buildings to a 5-star standard (ABCB RIS 2006a)

In 2006, a RIS was produced to analyse the likely impact of changes proposed to the BCA that would increase the energy efficiency requirements for Class 1 and 10 buildings to a 5-star standard. The proposed changes affected the thermal performance of walls, ceilings, floors, glazing and shading to avoid or reduce the use of artificial heating and cooling but did not include changes to measures relating to the sealing of buildings, air movement and hot water systems.

The main findings of the analysis were that:

- The present value of the additional construction costs from the proposed measures over 10 years was about $429 million.
- The total benefits of the measures were $546 million in present value terms.
- The net effect of the provisions was to reduce the lifetime costs of houses by about $117 million.
- The effect of the measures was to reduce the emissions associated with the residential heating and cooling loads by about 1 per cent in 2010.
- The overall assessment was marginally positive, with the investment returning a benefit cost ratio of 1.27.
- The average net cost of expected reductions in greenhouse emissions was negative 3.6 cents/kg of CO2-e.

General features of the analysis underpinning the 2006 RIS include the following:

- Costs and benefits were discounted using a 6 per cent real pre-tax discount rate.
- The assumed life of the regulation is 10 years.
- Energy and appliance savings were valued over 40 years.
- The impact analysis assumes that 75 per cent of the building approvals will adopt performance based compliance (that is, the simulation approach), while 25 per cent will use DTS provisions.

It was assumed that the incremental costs are the same for DTS-based and performance compliance, but that energy savings are 40 per cent higher.

- The house stock was increased by 10 per cent to account for additions and alterations, with the implicit assumptions that the benefits and costs of the proposed measures were the same as for new houses.
- No allowance was made for additional repair and maintenance costs. A uniform figure of 5 per cent was applied to the estimates of additional construction costs to account for additional planning, design and compliance costs.

Notably, while many features of the methodology in this RIS are similar to those used for the 2006 RIS, the analysis necessarily differs. Any significant methodological differences between the two RISs have been highlighted in the body of the report.

Source: ABCB 2006a

- the phase-in of mandatory disclosure of the energy efficiency of commercial buildings and tenancies commencing in 2010;
- an increase in energy efficiency requirements for new residential buildings to six stars, or equivalent, nationally in the 2010 update of the Building Code of Australia, to be implemented by May 2011, as well as new efficiency requirements for hot-water systems and lighting;
- the phase-in of mandatory disclosure of residential building energy, greenhouse and water performance at the time of sale or lease, commencing with energy efficiency by May 2011; and
- an agreement to reform the current rating and assessment processes for building energy efficiency standards.

Following its meeting in April 2009, COAG requested the ABCB to implement the BCA proposals. At their meeting on 2 July 2009, COAG agreed to a National Strategy on Energy Efficiency and confirmed a full suite of measures to be included in the strategy, including the above measures.

Purpose of the report

Given the regulatory nature of the BCA and the fact that it is jointly produced by the Australian Government and State and Territory Governments, the increased energy efficiency provisions for residential buildings in the BCA are subject to a Regulation Impact Statement (RIS). Box 1.2 describes the process ABCB undertakes to determine when a RIS should be developed.

In light of this process, the ABCB commissioned the Centre for International Economics (CIE) to develop a Consultation RIS that assesses the costs and benefits of proposed changes to the energy efficiency provisions in the BCA with regards to residential buildings.

This final RIS report brings together the results and discussions from the Consultation RIS as well as issues raised throughout the public consultation period.

1.2 ABCB RIS undertaking

The ABCB undertakes a RIS process, only when:

- Proposal for Change (PFC) process justifies the BCA changes - A PFC requires that a proponent justify any proposed amendment to the BCA in alignment with COAG principles. This includes identifying the current problem and undertaking an assessment of the impacts of the proposed changes. The PFC process allows for consistency in consideration of all proposals;
- Preliminary Impact Assessment (PIA) process has noted material impacts - A PIA allows for early-stage impact analysis of proposed changes to the BCA. Although complementary to the PFC process, a PIA allows for a more thorough impact assessment to be carried out; and
- all non-regulatory solutions have been considered.

Source: ABCB 2008.

Scope of the RIS

The ABCB released a draft of the proposed technical changes in June 2009 for public comment. This document initially served as a Consultation RIS that assessed the costs and benefits of proposed changes to energy efficiency requirements for residential buildings (defined as Class 1, 2, 4 and 10 buildings in the BCA). It has now been updated to reflect that consultation.

A general summary of Classifications of buildings and structures used in the BCA is provided in table 1.3 below. The buildings defined as residential and addressed in this report have been shaded.

1.3 Classifications of buildings and structures used in the BCA

Class	*Description*
Class 1a	A single detached house or one or more attached dwellings, each being a building, separated by a fire-resisting wall, including a row house, terrace house, town house or villa unit.
Class 1b	A boarding house, guest house, hostel or the like with a total floor area not exceeding 300 m2 and in which not more than 12 persons would ordinarily be resident, which is not located above or below another dwelling or another Class of building other than a private garage.
Class 2	A building containing 2 or more sole-occupancy units each being a separate dwelling.
Class 3	A residential building, other than a Class 1 or 2 building, which is a common place of long term or transient living for a number of unrelated persons. Example: boarding house, hostel, backpacker’s accommodation or residential part of a hotel, motel, school or detention centre.

Class	***Description***
Class 4	A single dwelling in a Class 5, 6, 7, 8 or 9 building.
Class 5	An office building used for professional or commercial purposes, excluding buildings of Class 6, 7, 8 or 9.
Class 6	A shop or other building for the sale of goods by retail or the supply of services direct to the public, including: (a) an eating room, cafe, restaurant, milk or soft-drink bar; or (b) a dining room, bar, shop or kiosk part of a hotel or motel; or (c) a hairdresser's or barber's shop, public laundry, or undertaker's establishment; or (d) market or sale room, showroom, or service station.
Class 7a	A building which is a carpark.
Class 7b	A building which is for storage, or display of goods or produce for sale by wholesale.
Class 8	A laboratory, or a building in which a handicraft or process for the production, assembling, altering, repairing, packing, finishing, or cleaning of goods or produce is carried on for trade, sale, or gain.
Class 9a	A health-care building; including those parts of the building set aside as a laboratory; or
Class 9b	An assembly building, including a trade workshop, laboratory or the like in a primary or secondary school, but excluding any other parts of the building that are of another Class.
Class 9c	An aged care facility.
Class 10a	A non-habitable building being a private garage, carport, shed, or the like.
Class 10b	A structure being a fence, mast, antenna, retaining or free-standing wall, swimming pool, or the like.

Source: Building Code of Australia.

Compliance with COAG principles

This report acts as the Final RIS, documenting the changes under consideration and detailing their expected costs and benefits, as well as reviewing and responding to stakeholder submissions received throughout the consultation period.

The RIS has been developed in accordance with COAG regulatory principles set out in *Best Practice Regulation a Guide for Ministerial Councils and National Standard Setting Bodies* (referred to as the 'COAG Guidelines'). It follows a seven-stage process as depicted in chart 1.4.

The RIS process is aimed at ensuring that the preferred government action is 'warranted' and 'justified' (OBPR 2007). As such, a RIS should present any available evidence on benefits and costs. The process of developing a RIS is intended to enhance the transparency of the

1.4 **Stages of the ABCB RIS development process**

1. OBPR COLLABORATION

Consult OBPR and seek endorsement of RIS methodology

2. CONSULTATION RIS DEVELOPMENT

Prepare consultation RIS

3. OBPR COLLABRATION

Seek OBPR endorsement of consultation RIS for public release

4. PUBLIC CONSULTATION

Release consultation RIS

5. FINAL RIS DEVELOPMENT

Develop final RIS

6. OBPR COLLABORATION

Submit final RIS for OBPR for clearance for decision-making

7. BOARD DECISION

OBPR endorsed final RIS to Board for decision

Data source: ABCB (2008).

regulatory process (and thereby promote public scrutiny and debate) to provide comprehensive treatment of the anticipated (and unintended) consequences of the proposed changes.

The Council of Australian Governments (COAG 2009d) has signed a National Partnership Agreement which supports the inclusion of the proposed amendments in the 2010 update of the BCA with implementation by 2011, subject to a Regulatory Impact Assessment.

Structure of the report

This report is structured as follows.

- Chapter 2 presents evidence on the magnitude (scale and scope) of the problem being addressed by the proposed changes.
- Chapter 3 articulates the objectives of the government action and identifies a range of viable alternative policy approaches.
- Chapter 4 describes the framework for analysis.

- Chapter 5 presents the issues raised in the consultation period
- Chapter 6 presents the benefits analysis.
- Chapter 7 describes the costs analysis.
- Chapter 8 presents the net impact analysis.
- Chapter 9discusses other impacts and implementation issues.
- Chapter 10 articulates ABCB's proposed consultation process.
- Chapter 11 includes a scenario based sensitivity analysis and Monte Carlo analysis of the Final RIS results that consider submissions from the public consultation period.
- Chapter 12 concludes the report.

Submissions to the consultation process

Comments and submissions on the Consultation RIS were accepted over a 6-week period from 18 September 2009 to 30 October 2009.

2 Nature and size of the problem

Residential buildings are a key source of energy demand. Playing such an essential role in a modern economy, the energy efficiency of residential buildings can assist in achieving Greenhouse Gas (GHG) abatement objectives. Research shows that energy efficiency measures can be cost-effective on both a private and social level.[1] However, a range of barriers — informational and market-based — are recognised as the cause for the relatively low adoption of energy efficiency technology.

Energy demand in residential buildings

According to ABARE estimates of Australian energy consumption, in 2006-07 the residential sector accounted for 418 petajoules (PJ) or 12 per cent of Australia's total energy consumption of 3 593 PJ (ABARE 2007) (see chart 2.1). This represents an increase of around 35 per cent from the 1989-90 levels (309 PJ). This demand is projected to grow to around 593 PJ by 2029-30 under the current trends (ABARE 2007 p. 80).

In terms of fuel mix, a recent baseline study on residential energy use produced by DEWHA (2008b) predicts that the contribution of electricity (which is among the most GHG-intensive energy source) to total residential energy consumption will continue to increase, while the use of wood (with a low GHG intensity) will decrease.

In particular, DEWHA predicts that the contribution of electricity to total residential energy consumption will increase from 46 per cent in 1990 to 53 per cent in 2020, while wood is predicted to decrease from 21 per cent to 8 per cent over the same period (see chart 2.2). This trend towards an increased proportion of the total residential energy demand being met by electricity and a decrease in the use of wood indicates that growth in GHG emissions associated with the residential sector energy use will be at least as high as its growth in energy use. This highlights the role that the residential building sector can play in Australia's greenhouse and energy policies.

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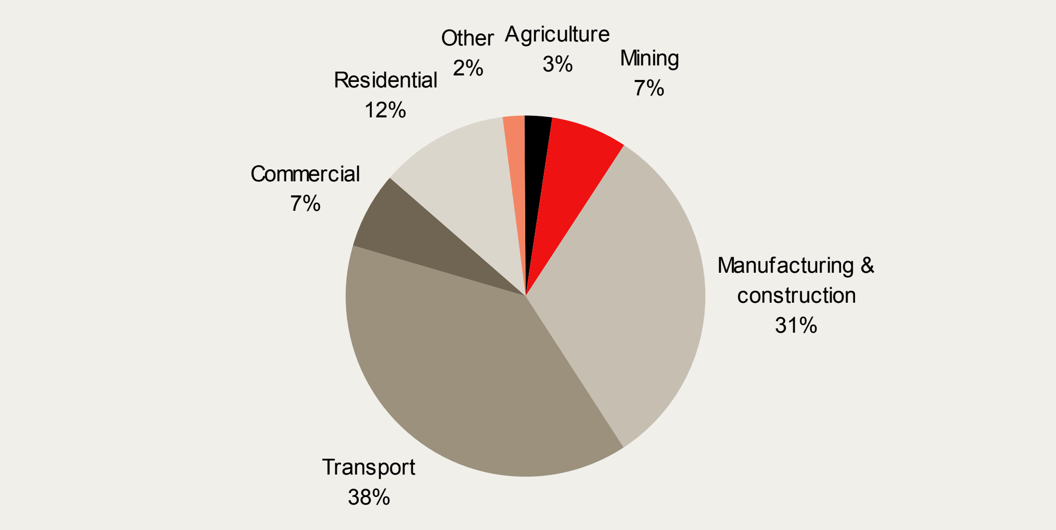
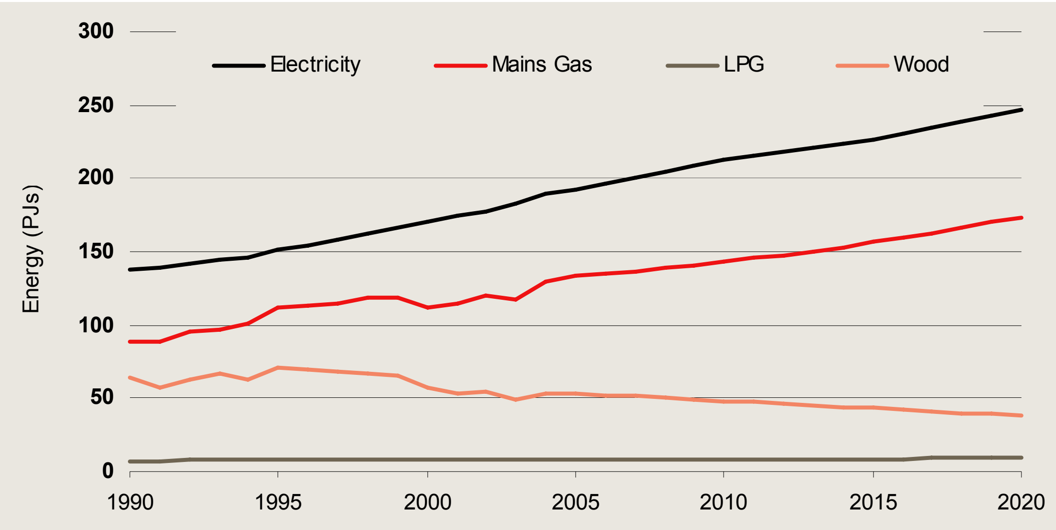
1 For instance Levine et al (2007), McKinsey & Company (2008), McLennan Magasanik Associates (2008) and Productivity Commission (2005).

2.1 Energy consumption in Australia, by industry, 2006-07



Data source: ABARE (2007).

2.2 Total energy consumption in the residential sector by fuel (PJ/year), Australia



Data source: DEWHA (2008b).

GHG emissions from the residential buildings sector

Rather than being a producer of *direct* GHG emissions (from, say, burning fossil fuels) the sector mostly drives emissions through the consumption of energy (mainly electricity).[2] Emissions from this sector are often accounted for against suppliers such as electricity producers (or generators) and those that transport or transmit electricity. Clearly producers would not supply energy unless there was demand for it. Emissions from the buildings sector are indirect, but as shown below, they are still substantial.

Buildings have other characteristics that raise issues for GHG emissions. Many have an effective lifespan that spans several decades — throughout which they house activities that consume energy. Much of the energy consumed in buildings is embedded in the systems used to support and operate that building. The design of buildings also has profound effects on the need for services such as lighting, heating and cooling. Decisions made *now* about buildings will shape energy demand for many years to *come* (CIE 2009b).

Despite the fact that the residential buildings sector is a major source of energy demand, there are few official statistics about the amount of GHG emissions that can be attributed to the sector. As such, it is necessary to approximate the likely amount of emissions based on some official indicators and a few informed estimates. Based on data from the most recent National Greenhouse Accounts (DCC 2009), data published by ABARE (2008) and CIE estimates, energy consumption in the residential buildings sector is estimated to be responsible for GHG emissions of around 60 Mt CO2-e in 2007 (measured including scope 1 and scope 2 emissions for electricity consumption). This estimate reflects the carbon intensity of fuels (for example, electricity and gas) consumed by building occupants (that is, households).

GHG emissions from the energy demand of the residential buildings sector are expected to rise at a relatively fast rate. Indeed, based on official parameters, the CIE estimates that emissions from the residential buildings sector would grow above 113 Mt CO2-e by 2050 *without the CPRS in place*. This reflects an average annual growth rate of 1.5 per cent (see chart 2.3).

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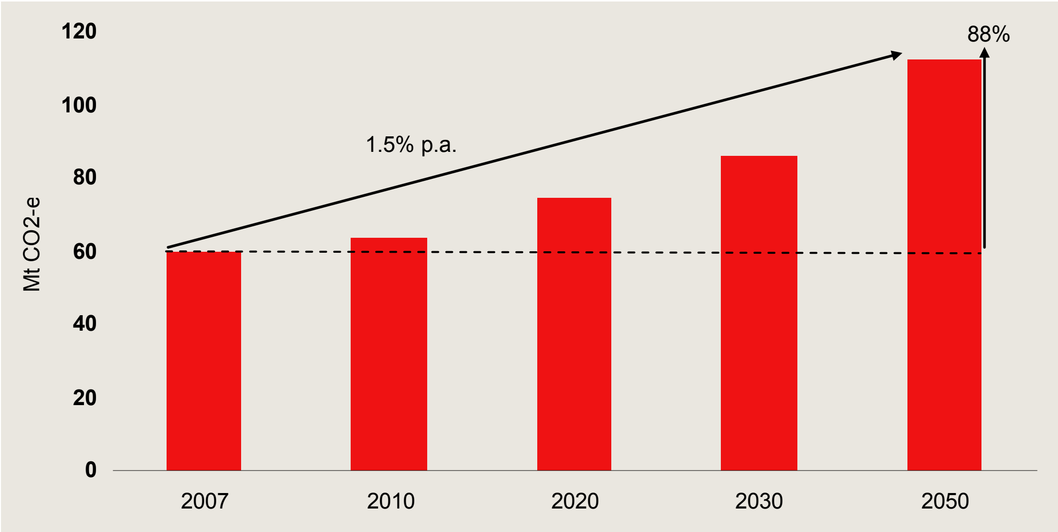
2 Approximately 61 per cent of the energy consumed by the buildings sector in 2009 was from electricity. Nonetheless, the sector also produces direct emissions through burning of natural gas, wood and other petroleum products.

2.3 **Residential building sector emissions projections**



a Estimates reflect the residential building sector's emissions in the absence of the CPRS.
Data source: CIE (2007), ABARE (2008) and Treasury (2008)

The CPRS will impact on the residential buildings sector emissions in two ways. First, and most significantly, the CPRS will reduce the emissions intensity of purchased electricity upon its introduction. From 2030 on — when renewable energy and carbon capture and storage technologies are expected to come online — this impact will be very dramatic. The Treasury's modelling of the CPRS[3] estimates that the intensity of electricity emissions will fall to less than one fifth of its 2006 level (Australian Government 2008).

Second, the price signal sent through the economy by the CPRS will encourage the residential buildings sector to consume less energy. Energy demand however, is relatively unresponsive to changes in price (NIEIR 2007). As a consequence, this will mean that the effects of any price signal will be relatively mute. The CPRS' price signal may be further suppressed by household assistance measures. The CIE has estimated that on average, the residential buildings sector will reduce energy consumption by just 10 per cent by 2050 as a result of this signal.

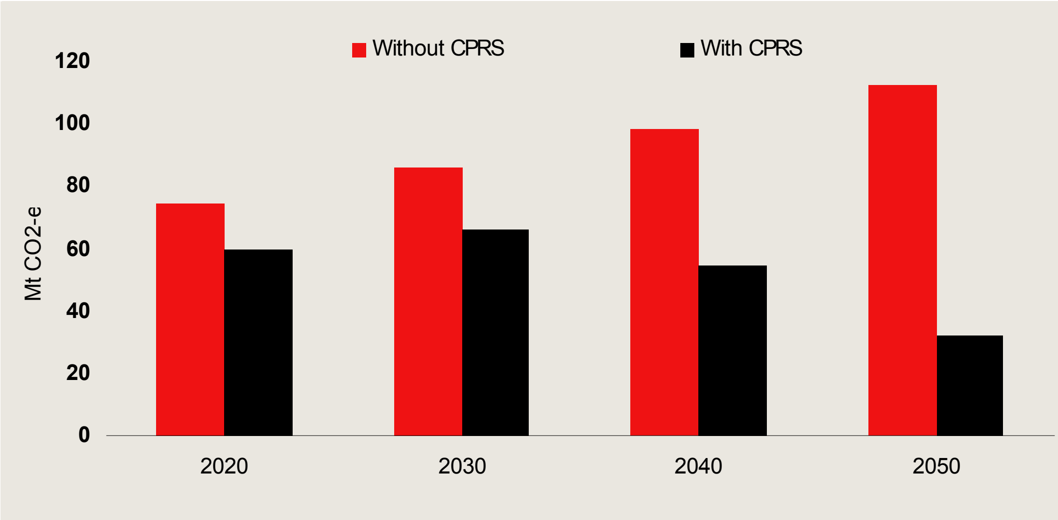
At best (that is, in the absence of any household assistance) these two effects can be expected to reduce the residential buildings sector's emissions by around 20 Mt CO2-e in 2030, and by approximately 80 Mt CO2-e in 2050 (see chart 2.4).

Notably, as chart 2.5 illustrates, the residential building sector's GHG abatement under CPRS rapidly accelerates after 2030. From 2020 to

[3] Specifically, the CPRS-5 scenario.

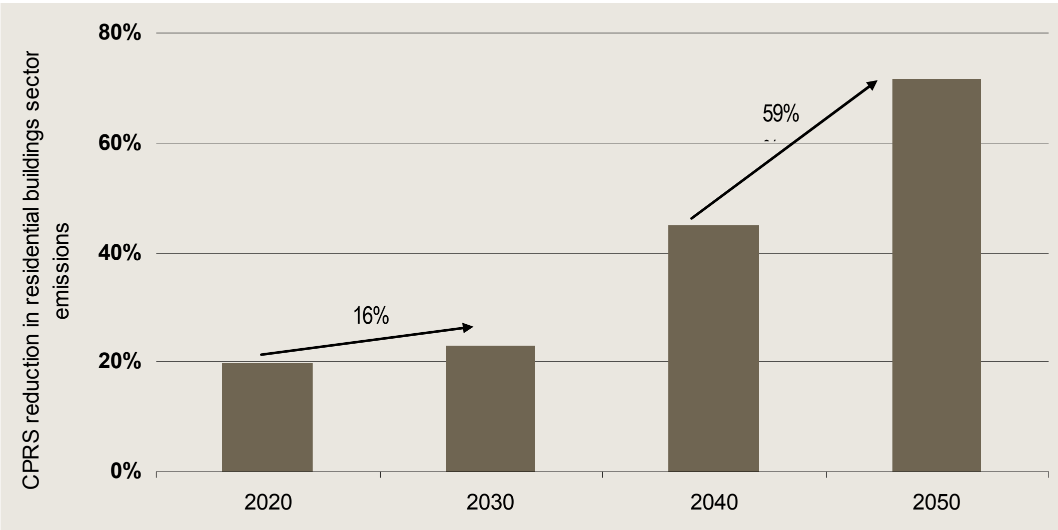
2030, abatement under CPRS increases by only around 16 per cent. In contrast, abatement increases by 59 per cent in the following two decades from 2030 to 2050. Under the CPRS, the residential buildings sector is expected to reduce its GHG emissions by nearly 71 per cent by 2050.

2.4 **Residential building sector emissions with and without the CPRS**



Data source: CIE (2007), ABARE (2008) and Treasury (2008)

2.5 **Residential buildings sector emissions abatement under the CPRS**



Data source: CIE estimates based on various sources, including ABARE (2008) and Australian Government (2008).

Policy response

While the CPRS' price signal may encourage some demand side abatement from the residential buildings sector, a substantial amount of abatement remains untapped. Studies undertaken in Australia to assess the potential for energy efficiency gains and related GHG emissions abatement report the existence of considerable untapped cost effective energy efficiency opportunities (CIE 2008). While there are aspects of these studies that draw comment and criticism (regarding assumptions about future energy prices, discount rates, investment costs necessary to achieve energy efficiency improvements, business as usual projections, adoption rates of best practice and administration costs) consistencies in the key results are significant. A summary of the estimated energy efficiency potential reported in selected Australian studies is provided in CIE (2008) and reproduced in table 2.6.

2.6 **Potential and scope for energy efficiency in Australia (selected sectors)**

	Energy efficiency potential (%)				
Sector	***SEAV-NFEE Phase 1 – low scenario***	***SEAV-NFEE Phase 1 – high scenario***	***SEAV-NFEE Phase 2***	***SEAV-NFEE general equilibrium study***	***Clean Energy Future Group***
Commercial	27	70	10.4	10.4	39
Residential	34	73	13	13	21

Note: SEAV = Sustainable Energy Authority Victoria. NFEE = National Framework for Energy Efficiency.
Source: McLennan Magasanik Associates Pty Ltd (2008) referred in CIE (2008).

International studies also highlight the significant potential to reduce energy demand in the building sector. Some examples are provided below.

- Stern (2007) notes that key reviews of global energy needs and options to combat climate change broadly agree that energy efficiency will make a very significant proportion of the GHG abatement needed and it will form the lower cost means of achieving that abatement.
- The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) examined the potential GHG abatement from the residential and commercial building sectors in considerable detail (Levine et al 2007). This study notes that a survey of 80 studies in the literature indicates that there is a global potential to cost-effectively reduce approximately 29 per cent of the projected baseline emissions in the residential and commercial sectors by 2020.

The International Energy Agency (IEA) reviewed the experience of developed countries and concluded that there was substantial scope for GHG abatement in the building sector and that unexploited energy efficiency offers the single largest opportunity for GHG emissions reductions (IEA 2003).

There are currently a suite of policy measures at national and State and Territory levels aimed at improving energy efficiency in the residential buildings sector, with these being at various stages of implementation. These initiatives include:

- the CPRS;
- the current energy efficiency requirements for new houses in the current BCA. In addition, a number of States also have State specific requirements (for instance, BASIX in NSW);
- mandatory disclosure of building energy, greenhouse and water performance;
- Minimum Energy Performance Standards (MEPS) and labelling for appliances and equipment;
- the phase-out of inefficient incandescent lighting;
- development of a national hot water strategy;
- audits and education programs to improve household adoption of energy efficient appliances, water heaters and insulation;
- rebates offered by a number of jurisdictions for energy efficiency and/or low-greenhouse gas emitting technologies, including solar water heaters and gas appliances;
- the Green Loans Program to assists households to install solar, water saving, and energy efficient products. This program provides detailed, quality Home Sustainability Assessments and access to interest free loans of up to $10 000 to make the changes recommended in the assessment; and
- funding assistance for ceiling installation in owner-occupier and rental properties.

Despite this range of measures focused on facilitating the adoption of energy efficient technologies, significant opportunities still exist for further improvements in the energy efficiency of residential buildings.

Need for further government intervention

Clearly, the Australian Government and leading international agencies have highlighted opportunities for GHG abatement through energy efficient buildings for a number of reasons. In addition to complementarity with multiple policy objectives, energy efficiency measures offer economically efficient and sizeable abatement potential. Achieving the abatement potential, however, requires government action to overcome market barriers.

The Australian Government has identified energy efficiency in buildings as a 'second plank' to its climate change policy. The Australian Government's white paper on the Carbon Pollution Reduction Scheme (DCC 2008) states:

> Together with the Carbon Pollution Reduction Scheme, an expanded Renewable Energy Target, investment in carbon capture and storage demonstration, and action on energy efficiency are the foundation elements of Australia's emissions reduction strategy. These policies will ensure that Australia has the tools and incentives to reduce its emissions and to develop technologies to help reduce greenhouse gas emissions globally.

Economic studies highlight the cost-effectiveness of energy efficiency measures as a GHG abatement strategy. Improving the energy efficiency of buildings is often viewed as cost neutral or even cost negative. In other words, on a financial basis, the direct expenditures associated with improving energy efficiency are fully offset by associated savings (i.e. measures lower than electricity-related expenditures). The Intergovernmental Panel on Climate Change (IPCC) in *Climate Change 2007: Mitigation* devotes a chapter to abating GHG emissions through policies that emphasise energy efficiency in residential and commercial buildings. The authors conclude that improving energy efficiency in buildings 'encompasses the most diverse, largest and most cost-effective mitigation opportunities in buildings.' Stern (2007) indicates that key reviews of options to address climate change generally agree energy efficiency will make a very significant proportion of the GHG abatement needed and form some of the lower cost means of abatement.

The GHG abatement opportunities in buildings are substantial. The presence of a significant 'energy efficiency gap', that is the difference between potential and actual energy efficiency in buildings, is widely recognised. The gap highlights abatement opportunities reliant on known technologies. IPCC (2007) concludes that 'substantial reductions in CO_2 emissions from energy use in buildings can be achieved over the coming years'. International Energy Agency (2007) writes, 'energy efficiency is also widely seen as the most important near term strategy to mitigate CO_2 emissions'.

Of course, the key issue here is whether government action, that is an amendment to the BCA, is warranted given the current suite of policy measures aimed at improving energy efficiency and the proposed implementation of the Australian Government's CPRS. In other words, will market barriers persist?

The above sections highlight that despite a range of measures focused on facilitating the adoption of energy efficient technologies in buildings, a substantial gap continues between the potential and actual energy efficiency performance of buildings. The above sections also highlight the importance residential buildings play in both energy demand and GHG emissions. Studies highlight that a gap exists between the current and potential level of cost-effective energy efficiency that could be achieved in buildings (see CIE 2007 and 2008, Levine et al 2007, McKinsey & Company 2008, McLennan Magasanik Associates 2008 and IEA 2008).

In the near term, the Australian Government's modelling suggests that CPRS will not have a strong impact on projected energy demand. This effect is attributed to several factors. First, energy demand is relatively inelastic (that is, relatively unresponsive to price changes). Second, a range of market barriers exist which are not addressed by the CPRS. In proposing amendments to the BCA, COAG noted several of these market barriers. The National Partnership Agreement (COAG 2009d) states:

> A carbon price will provide an incentive for households and businesses to use energy more efficiently. *A carbon price alone, however, will not realise all the potential cost effective opportunities to improve energy efficiency across the Australian economy.* [emphasis added] Market barriers, such as split incentives, information failures, capital constraints, early mover disadvantage and transaction costs need to be addressed to remove impediments to investment in energy efficiency by households and businesses.

COAG's view is consistent with leading international agencies. The IPCC (2007) concludes that the adoption of energy efficiency measures to abate GHG emissions faces 'substantial' market barriers. Among the noted market barriers is the 'high cost of gathering reliable information on energy efficiency measures'. The authors advocate for a 'faster pace of well-enforced policies and programs'.

The World Energy Council (2008) in a review of energy efficiency policies notes that regulatory measures are widely implemented where the market fails to give the right signals (buildings, appliances etc). It goes on to note that market measures fail because final users do not typically have to pay the heating or cooling bills and the lack of transparency in the market for overall energy service costs. It concludes, 'Energy efficiency policy and measures ('non-price measures') are therefore necessary to complement the role of prices.'

In addition, the ABCB, in its RIS for a 5-star standard (ABCB 2006a), noted several market barriers. They include:

- negative externalities associated with electricity consumption – that is, households could not make socially optimal choices regarding electricity consumption if the price of electricity excluded the cost of climate change and if they do not receive a clear price signal about the timing and quantum of their electricity consumption (for example, peak versus off peak, seasonal fluctuations);
- information asymmetry and limitations crucially affect decisions about investing in energy efficiency. That is, calculating the pay back to investing in energy efficiency requires knowledge about how long the household will occupy the house, future energy prices and amenity preferences. Collecting and understanding the information necessary to make fully informed decisions reflecting all of these factors is difficult and time consuming; and
- split incentives where the developer, home owner and occupier may not be the same entity, resulting in one party accruing the costs (that is, up-front capital investment), while the other party receives the benefits (for example, lower energy bills).

Some studies also note an additional barrier which is capital constraint (for example, Stern 2007, PC 2005, EEWG 2004, Australian Government 2008, Garnaut 2008). Energy efficiency investments require up-front capital (or financing) while the benefits of lower energy use accrue over time and often during a period that is not aligned with the financing period.

All but the negative externality associated with GHG emissions remain relevant to current and projected conditions. The Australian Government's proposed CPRS will address the carbon externality. It will place an economywide cap on GHG emissions. GHG abatement through the BCA's energy efficiency measures will effectively reduce the burden on other economic sectors in meeting their CPRS obligations without generating further reductions (beyond the aggregate, economywide emission cap).

3 Objectives of government action and policy options

This chapter outlines the objectives of government action, discusses the objectives of the proposed BCA amendments, provides a brief description of the regulatory proposal, and considers in brief alternative policy approaches.

Objectives of government action

All levels of government in Australia are committed to improving energy efficiency. In August 2004 the Ministerial Council on Energy (MCE), comprising the Energy Ministers of all Australian governments, agreed to support energy efficiency by agreeing to a comprehensive package of foundation measures under the National Framework for Energy Efficiency (NFEE).

The NFEE aims to ‘unlock the significant but un-tapped economic potential associated with the increased uptake of energy efficient technologies and processes across the Australian economy. It aims to achieve a major enhancement of Australia’s energy efficiency performance, reducing energy demand and lowering greenhouse gas emissions’ (DRET 2009).

The NFEE covers a range of policy measures designed to overcome the barriers and challenges that prevent the market delivering the actual economic potential of energy efficiency. In particular, the NFEE focuses on demand-side energy efficiency, primarily in the residential, commercial and industrial sectors. More details about the two stages of the NFEE are presented in Box 3.1.

While the NFEE is an important step towards improving energy efficiency, Governments recognised that additional efforts were needed to improve the uptake of energy efficient opportunities. Indeed, COAG (2009c, p. 2) states that:

> While Governments agree that existing initiatives such as the National Framework for Energy Efficiency…are making important contributions to improving energy efficiency, the need to transition to a low carbon future gives renewed impetus to deliver a step change in energy efficiency and to realise the benefits from cost-effective energy-saving initiatives.

3.1 Stage One and Two of the National Framework for Energy Efficiency (NFEE)

The NFEE Stage One ran from December 2004 through to the end of June 2008. The key measures within NFEE Stage One include (NFEE 2007):

- energy efficiency standards and mandatory disclosure for buildings;
- Minimum Energy Performance Standards (MEPS) and labelling for appliances and equipment;
- the Australian Government's Energy Efficiency Opportunities (EEO) scheme; and
- capacity building (including training, accreditation and information provision).

In December 2007, Stage Two of the NFEE was agreed by the Australian Government and State and Territory Energy Ministers. This stage comprises a package of five new energy efficiency measures:

- expanding and enhancing the MEPS program;
- Heating, ventilation and air conditioning (HVAC) high efficiency systems strategy;[4]
- phase-out of inefficient incandescent lighting;
- Government leadership though green leases; and
- development of measures for a national hot water strategy.[5]

In addition to the new measures above, a number of Stage One measures are continuing including the EEO program, the Energy Efficiency Exchange (EEX), and the National House Energy Rating Scheme (NatHERS).

Source: NFEE (2007).

In light of this, in October 2008 COAG agreed to develop a National Strategy on Energy Efficiency (NSEE) to accelerate energy efficiency efforts, streamline roles and responsibilities across levels of governments, and help households and businesses prepare for the introduction of the CPRS. The NSEE will complement the CPRS by addressing the barriers that are preventing the efficient uptake of energy efficient opportunities, such as split incentives and information failures.

On 30 April 2009, COAG reaffirmed its commitment to introducing the NSEE and agreed to the following five measures to improve the energy efficiency of residential and commercial buildings across Australia (COAG 2009a):

4 At the December 2008 meeting of the MCE, Australian Government and State and Territory Energy Ministers endorsed the National Hot Water Strategy and a revised HVAC high efficiency systems strategy. Both projects commenced on 1 January 2009.

5 Ibid.

- an increase in the stringency of energy efficiency requirements for all classes of commercial buildings in the BCA from 2010;
- an increase in energy efficiency requirements for new residential buildings to six stars, or equivalent, nationally in the 2010 update of the BCA, to be implemented by May 2011;
- new efficiency requirements for hot-water systems and lighting for new residential buildings;
- the phase-in of mandatory disclosure of the energy efficiency of commercial buildings and tenancies commencing in 2010; and
- the phase-in of mandatory disclosure of residential building energy, greenhouse and water performance at the time of sale or lease, commencing with energy efficiency by May 2011.

On 2 July 2009 COAG, signed the National Partnership Agreement on Energy Efficiency and confirmed a full suite of measures to be included in the strategy, including the above measures (COAG 2009d). This partnership agreement will deliver a nationally-consistent and cooperative approach to energy efficiency, encompassing (COAG 2009e):

- assistance to households to reduce energy use by providing information and advice, financial assistance and demonstration programs;
- assistance to business and industry to obtain the knowledge, skills and capacity to pursue cost-effective energy efficiency opportunities and therefore meet the challenges of a low carbon economy;
- higher energy efficiency standards to deliver substantial growth in the number of highly energy efficient homes and buildings, and provide a clear road map to assist Australia's residential and commercial building sector to adapt;
- nationally-consistent energy efficiency standards for appliances and equipment and a process to enable industry to adjust to increasingly stringent standards over time;
- introducing in 2010 new standards for the energy performance of air conditioners and increasing the standard by a further 10 per cent from 1 October 2011;
- addressing potential regulatory impediments to the take up of innovative demand side initiatives and smart grid technologies;
- governments working in partnership to improve the energy efficiency of their own buildings and operations; and
- a detailed assessment of possible vehicle efficiency measures, such as CO2 emission standards.

Specifically, the objectives of government action under the COAG National Partnership on Energy efficiency are as follows (COAG 2009d):

- Australia transitioning into a low carbon economy;
- Australian households and businesses reducing their energy consumption and costs;
- the development and adoption of new energy efficient technologies, and enhanced innovation in energy-using products and processes;
- an Australian workforce that is trained, skilled and qualified to assist with Australia's transformation into a low carbon economy; and
- Commonwealth, State and Territory Governments demonstrating clear leadership through the energy efficiency of their own operations.

Objective of the proposed amendments

The BCA sets out standards that address health, safety (structural and fire), amenity and sustainability objectives. It is intended to:

- be based upon a rigorously tested rationale for the regulation;
- generate benefits to society that are greater than the costs (that is, net benefits);
- be no more restrictive than necessary to protect the public interest; and
- be more economically efficient than other feasible regulatory or non-regulatory alternatives.

With the increased focus on combating climate change, the Australian Government, in agreement with State and Territory Governments, committed to increasing mandatory minimum building energy performance requirements through the BCA (see COAG MoU signed April 2009). The development of these energy efficiency provisions is a collaborative effort between the ABCB, other government agencies and industry. Furthering the broader, social role of energy efficiency standards in the BCA, the Commonwealth Government in setting out its vision of a CPRS noted the importance of complementary measures – particularly in the built environment through energy efficiency improvements.

To implement the energy efficiency measures, the ABCB proposes to amend the BCA to enhance energy efficiency requirements set out in Section J and Section 3.12. The amendments addressed in this RIS address residential buildings Class 1, 2, 4 and 10. Their objectives are to:

- abate greenhouse gas (GHG) emissions;
- reduce energy demand; and
- overcome market barriers to adoption of energy efficiency measures.

Description of the regulatory proposal

Box 3.2 provides an overview of the BCA's structure. This overview provides context to the proposed regulatory amendments.

3.2 **BCA structure**

The BCA is organised as a hierarchy of Objectives, Functional Statements, Performance Requirements and Building Solutions.

- Each objective is a broad societal goal, which in this case is to reduce greenhouse emissions.
- For each Objective, there are Functional Statements and Performance Requirements describing how a building meets the objectives. For example, the building's services need to be continually capable of using energy efficiently.
- The BCA is a performance-based code, in this case requiring the implementation of Building Solutions that deliver specified minimum levels of energy efficiency. For the BCA 2010 there are two broad types of compliance pathways that may be adopted:
  - **simulation based compliance** — which involves the introduction of a 6 star requirement based on thermal performance modelling software for all classes of residential buildings (that is, Classes 1, 2, 4 and 10); and
  - **elemental compliance** — which involves for satisfying a general increase in stringency of elemental Deemed to Satisfy (DTS) provisions for Class 1 and 10 buildings. The DTS provisions are detailed building requirements that are regarded as meeting the Performance Requirements.

Source: ABCB 2006b and CIE.

The proposed amendments address Section J and Section 3.12 of the BCA. (Appendix A provides a description of these amendments). The key features of the proposal are as follows:

- The Objective and Functional Statement in the BCA will be amended to specifically reference abatement of GHG emissions as well as energy use associated with operational energy.
- Houses will be required to obtain a 6-star rating which can be achieved either through compliance with a set of elemental provisions (that is, prescriptive conditions) or a simulation approach for thermal performance via computer modelling.
- Apartment blocks (Class 2 buildings) will be required to achieve an average of 6 stars, with individual units achieving a minimum of 5 stars.

- The scope of operational provisions will be broadened to include fixed lighting and water heaters (noting that electrical appliances and other plug-in equipment remain outside the BCA's scope).
- Verification Methods will also be affected by the proposed amendments. For example, Class 2 residential buildings require a NatHERS rating rather than detailed prescriptive solutions.
- Highlights of specific amendments to various parts of Section J are:
  - Part J0 affects glazing requirements for Class 2 buildings.
  - Part J6 addresses artificial lighting and involves introducing lighting power requirements for Class 2 buildings and Class 4 parts.
  - Part J7 extends the scope of energy efficiency requirements to include swimming pools and spa systems in addition to the currently affected reticulation systems of sanitary hot water and hot water for cooking.

DTS addresses both fabric and operational aspects of a house's design and construction. Building fabric considers insulation, roof colour and pitch, external walls, etc. Operational aspects (that is, services) take into consideration lighting, hot water services, etc and their associated energy source (for example, electricity, gas).

Alternative policy approaches

Improved energy efficiency in new houses could be achieved through alternative approaches. These include:

- non-regulatory strategies, such as information and financial incentives;
- quasi-regulatory approaches, such as codes of conduct; and
- direct regulation (such as the proposed approach).

It is worth noting that this RIS considers two options under the direct regulation approach in addition to the non-regulatory and quasi-regulatory options. They are:

- simulation based compliance; and
- elemental compliance.

This final RIS focuses on assessing the economic implications of alternative direct regulatory options against a 'business as usual' case which involves no further amendments to the BCA regarding energy efficiency, but the implementation of the CPRS.

The RIS does not formally analyse non-regulatory and quasi-regulatory approaches. This approach recognises that COAG has already acknowledged the need to adopt a range of policies and tools so as to address the diversity of market barriers that exist. The key point is that a suite of complementary measures to the CPRS are needed.

Non-regulatory approaches

Many of the non-regulatory approaches already exist in various forms at both the national and State level. For example, industry and government each offer a voluntary rating scheme. [6] Many jurisdictions offer subsidies and rebates for energy efficient technologies, such as solar hot water heaters.

The persistence of the energy efficiency gap highlights that voluntary approaches have had mixed results. Each of these options also tends to address a single market barrier while it may be the collective of market barriers that impede voluntary adoption of increased energy efficiency in houses.

The COAG agreement to a National Strategy on Energy Efficiency in July 2009 also highlights the government's move towards mixing regulatory strategies — among them are information and labelling approaches. For example, governments have committed to mandatory disclosure which imposes an obligation to disclose information about a building's energy performance.

Quasi-regulation

Quasi-regulation often involves industry-led approaches that are less formal than regulation, but are stronger than self-regulation. They often involve industry or a party other than government monitoring and enforcing a code of conduct.

The Australian Competition and Consumer Commission (ACCC) notes caution must be used when deciding if a code of conduct is appropriate. Ineffective (mandatory) codes may place compliance burdens on business without necessarily achieving any realisable benefits (ACCC 2005). Effective quasi-regulation codes require highly cohesive industries characterised by low rates of entry and exit.

The housing supply industry is recognised as being highly fragmented and disjointed. The supply of energy efficient houses requires cooperation up

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6 The National Australian Built Environment Rating System (NABERS) and the Green Building Council of Australia's Green Star rating tools are two examples of national schemes that 'score' building energy efficiency.

and down the supply chain. Effective codes of conduct require bridging the various suppliers — from the point of design to construction.

The proposed changes amend existing regulation. The infrastructure to support awareness and compliance with the BCA is already in place. A code (or similar) approach would make aspects of the existing infrastructure redundant without necessarily achieving greater compliance.

Elemental versus simulation requirements

The supporting commentary to the BCA amendments notes that the RIS will consider both elemental and simulation paths to compliance. As mentioned in box 3.2, the elemental path to compliance is a prescriptive approach. It involves establishing a set of minimum conditions that produce an equivalent energy efficiency outcome to the 6-star requirement. The simulation approach, although performance guided, also falls within the DTS (or Acceptable Construction Practice) category, but using software verification. It allows for creative design that takes into account the fundamental design of the house (for instance orientation, etc).

According to ABCB documentation (ABCB 2009c, p.7), the intention is to eventually move to solely a simulation approach rather than in combination with an elemental approach. The general rationale is that the simulation approach is more efficient and can facilitate innovation. That said the elemental approach is viewed by some as easier to comply with and enforce.

Alternative elemental and simulation requirements

This RIS only assesses the elemental and simulation requirements as proposed by the ABCB (ABCB 2009c). It is of course, feasible that the proposed changes could be implemented in variety of ways. For example, the changes could apply in only certain climate zones or jurisdictions. Further, it is plausible that an alternative implementation of the proposed amendments could produce a preferable net impact on the community.

Alternative approaches are not assessed here. Rather, this document provides a benchmark for industry and stakeholders to consider how alternative approaches could be devised, and if it would be appropriate to do so.

4 Framework for analysis

It is important that the impact analysis be conducted within the bounds of a consistent and coherent framework. This chapter outlines the framework of analysis, highlighting both its scope and the key methodological tacts employed.

Scope of analysis

At a broad level, the analysis contained in this RIS considers the impact of the proposed amendments to the BCA as they relate to:

- thermal performance;
- lighting; and
- provisions for outdoor areas.

This analysis has not evaluated the impact of the amendments on water heaters. Those provisions have been assessed in a separate study (W&A 2009a) (see box 4.1 and appendix B for further details). Further, this analysis has not attempted to replicate or review those findings.[7] The results of the water heater study are however, referred to in estimating the net impact.

The analysis here has been conducted at two levels:

- at the individual dwelling level — which assesses the impacts of the proposed amendments on houses, townhouses and flats, across major cities and climate zones; and
- at an economywide level — which assesses the impacts of the proposed amendments in different jurisdictions and climate zones.

Individual dwellings have been constructed using a sample of buildings provided by the ABCB, and aggregated to be consistent with ABS's

[7] The impact of the hot water systems proposal on the analysis conducted in this RIS is reported separately in this section of the report due to methodological differences (such as the treatment of tariff pricing and the discount rate used) that hinder the ability for the two analyses to be integrated extensively. As such, the impacts emerging from that analysis are treated as a discrete sum and used to assess the effect that the hot water systems proposal would have on the BCR calculated in this report.

4.1 Proposed regulations for hot water systems

As part of the agreement to improve energy efficiency of buildings across Australia, the COAG agreed to add new efficiency requirements for hot water systems for new residential buildings in their meeting of 30 April 2009.

A Consultation and Final RIS on the costs and benefits of introducing the proposed regulations for hot water systems were developed by George Wilkenfeld and Associates (W&A 2009a) on behalf of the Department of Environment, Water, Heritage and the Arts (DEWHA).

The Final RIS analysis is provided in full in appendix B.

dwelling structures. Estimating the amendments' impact on the economy at large is underpinned by the analysis conducted at the individual dwelling level.

Building sample

A sample of representative houses has been provided by the ABCB, and provides the 'building blocks' of this analysis. The sample includes examples of one and two storey houses, a townhouse and an apartment selected by the ABCB.[8] House H12 has suspended timber flooring and is the ABCB's representation of a 'transportable home.' All housing structures (except the flat and H12) are modelled with both concrete and timber flooring. Table 4.2 provides a brief description, and further details of the sample are provided in appendix C.

4.2 ABCB sample houses

House name	*Type*	*Class*	*Storeys*	*Floor type*
H01	Separate house	Class 1	Single	Concrete and timber
H04	Separate house	Class 1	Single	Concrete and timber
H08	Separate house	Class 1	Double	Concrete and timber
H09	Townhouse	Class 1	Double	Concrete and timber
H12	Separate house	Class 1	Single	Timber
H13	Separate house	Class 1	Single	Concrete and timber
FLAT	Flat	Class 2	Single	Concrete

Note: House H12 in the sample is considered a transportable home.
Source: ABCB (refer appendices for details).

[8] The houses were not selected specifically as representative of a particular climate zone or regional building style, but as representative of national style and as they contained sufficient known features to assess the rating change, having been used in previous ratings analysis — such as Constructive Concepts (2009).

Buildings are analysed in a sample of population centres representing each of the capital cities and climate zones. Note that while the sample may be representative of the economy as a whole, it may not be representative of all locations. While the assessment has taken into consideration regional impacts, an assessment of the BCA's impact on a particular location would require further analysis.

The locations analysed are presented in table 4.3, and a map showing the ABCB's eight climate zones is provided in chart 4.4.

4.3 **Representative locations**

BCA Climate Zone	*Population centre*	*State*	*NatHERS Climate Zone*
Climate zone 1	Darwin	NT	1
Climate zone 2	Brisbane	Qld	10
Climate zone 3	Longreach	Qld	3
Climate zone 4	Mildura	NSW	27
Climate zone 5	Adelaide	SA	16
	Perth	WA	13
	Sydney	NSW	17
Climate zone 6	Melbourne	Vic	21
Climate zone 7	Canberra	ACT	24
	Hobart	Tas	26
Climate zone 8	Cabramurra	NSW	25

Source: Building Code of Australia & NatHERS.

Aggregation and the BAU

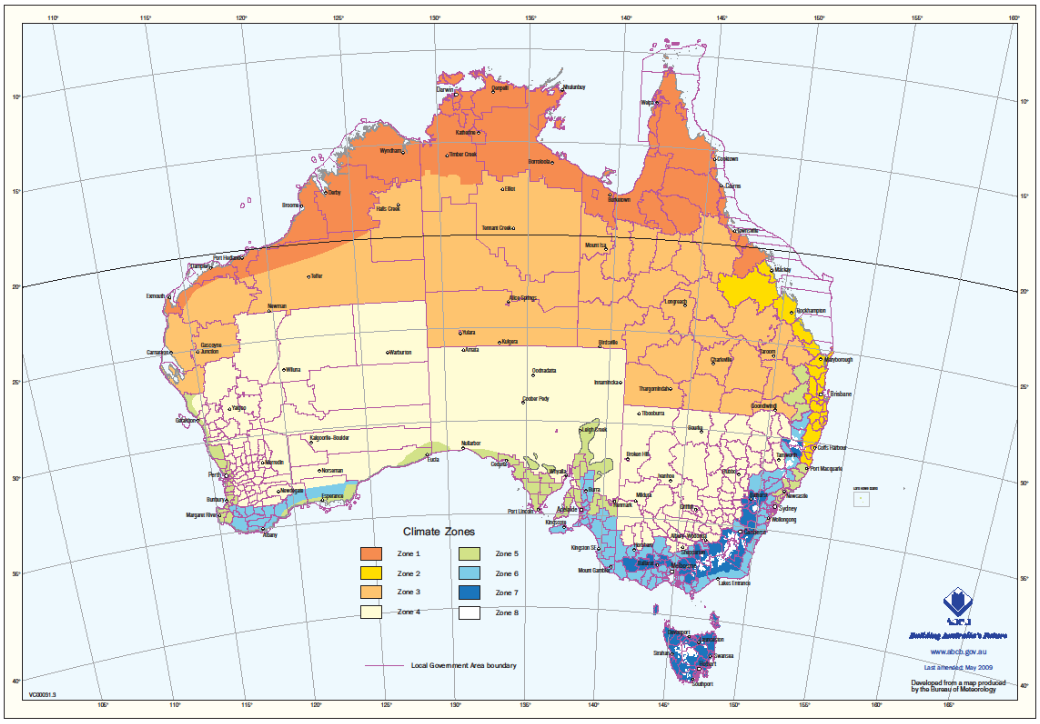
To estimate impacts at an economywide level requires the dwelling sample be aggregated to regional, State and national levels. How this task has been undertaken is described in appendix D.

The aggregation of the dwelling sample accounts for:

- growth in the building stock;
- population shifts;
- the distribution of sample houses;
- changes in energy consumption;
- changes in energy prices;
- major policy initiatives (such as the CPRS and RET expansion); and
- other factors.

This aggregation provides the business-as-usual case at the economywide level, to which the impacts of the amendments will be assessed. This BAU scenario is based on new houses meeting existing requirements in the BCA.

4.4 **ABCB climate zones**



Data source: Building Code of Australia.

Thermal performance compliance pathways

For each house in the ABCB sample, the direct costs and benefits associated with thermal performance compliance are estimated based on ABCB-defined ‘compliance pathways.’ Specifically, these compliance pathways reflect:

- **simulation based compliance** — which involves the introduction of a 6 star requirement based on thermal performance modelling software for all Classes of residential buildings (that is, Classes 1, 2, 4 and 10); and
- **elemental compliance** — which involves satisfying a general increase in stringency of elemental DTS provisions for Class 1 and 10 buildings.

A survey of HIA members — provided as part of a submission for this RIS — suggested that it is likely that the market will show a preference for simulation based compliance over elemental compliance. The results suggest that the proportion of the market that would opt for the simulation compliance pathway would be in the order of 71 per cent. Previous studies have found that simulation compliance is generally preferred by the market. For example, a Victorian study found that as many as three quarters of new residential buildings opted for simulation compliance over elemental (ABCB 2006a). A Brisbane study of new residential construction found similar results (60 per cent of new residential constructions opting for simulation compliance).[9] The sensitivity analysis nonetheless, tests the impact of this assumption on the central case of the impact analysis.

Cost pass through

In many cases, the costs of complying with the amended BCA will be incurred by different entities. For example, capital costs will be initially incurred by the builder. A building occupier (not necessarily the owner) may be responsible for operating costs, while the asset owner will incur maintenance and disposal costs.

Following the recommendation in CIE (2009 p. 32), this report models compliance costs as being incurred by the user of the asset (that is, the owner-occupier).

Market adaptation

Although the proposed BCA amendments are indeed likely to induce a market response — in say the design, orientation and construction of new dwellings — the impact analysis in this report has deliberately assessed the amendments as if there is no market response whatsoever. The intent of the assessment is to reflect on the change in the cost and benefits of current choices and practices.

Interactions with State and Territory legislation

The interaction between the proposed BCA amendments and planned and existing State and Territory policies has not been addressed in the RIS. Explicitly, the analysis undertaken is in reference to the national 2009 BCA.

The exception to this being the treatment of water heating provisions. For a number of jurisdictions, water heating provisions in the 2010 BCA simply replace existing requirements — and will result in little material change. Only Tasmania and the Northern Territory do not have any current (or planned) requirements for water heating.

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9 In ABCB (2006a, pg 18) the analysis assumed that 75 per cent of residential buildings would opt for simulation based compliance — following the findings of the Victorian study.

Refurbishments

Recognising the difficulty of accurately estimating the impacts of the proposed BCA amendments on existing buildings, this analysis has been excluded from this RIS. The key practical difficulties for analysing the issue of refurbishment of existing buildings are summarised below.

- *Variability in the application of the BCA across jurisdictions.* The application of the BCA to existing buildings being altered, extended or undergoing a change of use or Classification is covered in the relevant building legislation in each State and Territory (ABCB 2007). As such, individual jurisdictions or approval authorities can apply the BCA to existing buildings undergoing refurbishment as rigorously as they see fit.
- *Variability in the scale and scope of the refurbishments.* Each refurbishment project is unique. This in turn means that the extent of BCA compliance associated with the new building work will vary by project.
- *Not all existing buildings have the ability to comply with the BCA provisions.* When carrying out new building work associated with an existing building, there are a number of factors that may compromise the ability of the new building work to fully comply with the BCA provisions. These factors are generally related to the location of the existing building on the site, which may, for example, prevent the practicality of replacing major building elements, the internal configuration of existing spaces and/or the services being reused (ABCB 2007).

These factors make it difficult to reasonably estimate the amount of refurbishments that would need to comply with the new measures each year and the extent of BCA compliance that will be required for new building work associated with existing buildings. Omitting refurbishments from the impact analysis, however, will understate both costs and benefits. Moreover, the directional bias — that is, to bias the net impact assessment — is unclear.

Consistent with ABCB (2006a) then, the analysis here has scaled new residential building stock by 10 per cent to account for refurbishments. The sensitivity of the central case of the impact analysis to this assumption is tested explicitly in the sensitivity analysis.

Analytical timeframe

The analytic timeframe used to model the costs and benefits of the proposed changes to the BCA reflects the effective life of the amendments and their associated impact. The amendments' effective lifespan affects the period of time over which asset owners incur costs of compliance and government incurs enforcement and monitoring costs (that is, the effective life of the amendments affects the start and duration of its associated impacts).

As recommended by CIE (2009a), the analytic timeframe in this RIS begins in the year that the amendments are anticipated to take effect (2011) and compliance and enforcement actions are modelled to extend for ten years (until 2021). As noted in CIE (2009a), there are a number of simplifying assumptions behind this recommendation:

- compliance starts from the point that the regulation comes into effect. In reality, a lag is likely to occur between when the regulation takes effect and the affected buildings are occupied. However, all else equal, to account for the lag in the analytic time period simply shifts costs and benefits out by a set period of time; and
- the analysis models full compliance. In reality not all new constructions are likely to fully comply with the requirement. However, little information exists to support an alternative approach that takes into account non-compliance.

Benefits and costs flow from compliance with the proposed changes. The length of these impacts depends upon the particular qualities of the assets installed. For this RIS, the effective lifespan of adopted energy efficiency solutions (including double glazing) is 40 years.[10] While this may be considered relatively conservative compared with other analyses, this does keep the analysis consistent with ABCB (2006a). Also, given the nature of the investments in energy efficiency, by yielding on the 'conservative' side, the analysis is more likely to understate the benefits than overstate them.

Applying these assumptions has the following implications for the impact analysis:

- each new house incurs a once-off, lump-sum capital outlay at the start of the analytical period;
- any benefits or costs associated with the use of the energy efficient assets (such as energy savings or O&M costs) last only for the asset's lifespan (rather than being ongoing and indefinite).

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[10] In modelling the impact, it is assumed that the energy efficiency solutions adopt the service life above. Notably, this assumption overlooks the fact that in some cases the published services life is not realised because of early replacement for reasons of capacity expansion or change of use.

This approach assumes that once the asset is replaced, no further benefits or costs will be incurred.[11]

Discount rate

Costs and benefits in this Final RIS are reported in present value (PV) terms and are based on the application of a 7 per cent real discount rate. This rate is in line with the OBPR recommended central discount rate.

Through the Consultation RIS, a lower discount rate of 5 per cent was utilised to estimate costs and benefits. A lower discount rate was chosen based on two factors:

- the nature of the impacts evaluated — this factor recognises that the impacts evaluated in this RIS are long-term and concerned with environmental outcomes (climate change and global warming) that will affect future generations; and
- international best practice — this factor refers to similar studies undertaken in other developed countries.

Where a higher discount rate has been applied in the Final RIS, this reflects the following main arguments:

- The evaluation of the 5 star BCA used a higher discount rate.
- The Office of Best Practice Regulation requires that a higher discount rate should be used, so as to be consistent and comparable with other Commonwealth benefit cost evaluations and decision making.
- Home owners who will incur the costs up front and the benefits much later are likely to have a higher discount rate and not taking account of this may mean ignoring a net cost being imposed on consumers (but possibly to the benefit of future generations).

The concept behind discounting benefits and costs that occur in different timeframes lies on the assumption that, generally, consumption today is preferred over consumption tomorrow. In principle this means that discounting discriminates against future benefits. Hence, discounting will favour regulations that confer benefits in the present or near future over regulations whose benefits society realises at a later date (Farber and

11 The cost-benefit analysis does not assume like-for-like asset replacement when the energy efficient technology expires. This assumption is consistent with the recommendations in CIE (2009a) and the current state of the literature which supports the rationale for mandating energy efficiency performance standards.

Hemmersbaugh 1993). Indeed, a number of international studies and academic discussion on the appropriate discount rate for benefit-cost analysis suggest that high rates tend to favour policies that are less capital intensive and provide more immediate benefits. Appendix E provides a more detailed discussion of the discount rates used in the literature.

However, the literature also recognises that assessing environmental policies may need use of 'special' discount rates. A lower discount rate is often applied to analyses that are more future-oriented and more concerned with environmental outcomes such as climate change and global warming. A higher discount rate would reduce the value of future environmental benefits and hence policies aiming for that outcome would be regarded as less efficient.

Outcomes in these areas occur with a substantial lag and recognise the importance of intergenerational fairness. There is a lot of ethical debate around the responsibility of present generations to ensure resources are available for future generations. Although the debate has been mainly centred on the appropriateness of applying a zero discount rate (that values future equally to present), in general it is considered that lower discount rates reflect a higher valuation of those future generations.

Looking at RISs on intended energy efficiency improvements in several countries,[12] an average of 5 to 6 per cent real discount rate is used. Arguments for using lower discount rates are justified by the long-term objective of such policies which refers to addressing climate change. Additional information about the discount rates used for RISs in various countries is provided in appendix E.

Given the difference in timing between costs and benefits – that is, immediate increases in capital costs, and benefits that accrue through the life of the dwelling – the results in this Final RIS are highly sensitive to the applied discount rate. A sensitivity analysis is conducted to account for the application of alternative discount rates (3, 5, 7, 9 and 11 per cent real).

Net impact measures

The results of the cost-benefit analysis of the proposed changes to the BCA for a sample of owners-occupiers are presented using the metrics below:

- *Benefit cost ratio (BCR)* — the BCR can be interpreted as: every one dollar of costs delivers 'X' dollars of benefits. A BCR equal to one

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12 Canada, Ireland, USA and UK.

implies that the costs exactly offset the benefits; a BCR less than one means that the costs outweigh the benefits.

- *Net present value (NPV)* — this figure is the sum of the discounted stream of costs and benefits and it reflects an aggregate term.

Changes from Consultation RIS

The key elements used in the estimation of net benefits reported in the Consultation RIS were:

- 5 per cent discount rate;
- Additional build costs of approximately 1.25 per cent of total capital costs based on estimates from BMT & Associates;
- Energy prices following the government's proposed CPRS-5 scenario; and,
- Regional impact approximations based on results for representative capital cities.

Responses to the Consultation RIS raised a number of questions surrounding these assumptions and the potential impact that variations may have on the final outcomes as reported in the RIS. An outline of the major issues raised in response to the Consultation RIS are presented in Chapter 5.

5 Consultation responses

This section presents a summary of the stakeholder responses that were received through the consultation period for the RIS. The Consultation RIS was open for public comment until 30 October 2009, and received 41 responses from stakeholders (see appendix M). These responses were received from a wide range of stakeholders, including industry associations, state and federal government departments, local councils, academics, and professionals associated with the building industry.

The objective of the consultation process in developing the RIS is to ensure that the data, the methodology and the results are as indicative as possible of the outcomes of the regulation. This ex ante form of assessment, prior to the implementation of the regulation, is often considered to suffer from a number of forms of bias as well as contention around methodological and factual areas. Bias within the assumptions can fall either as optimism bias which would indicate that the net benefits are over estimates of the actual net benefits of the regulation, or alternatively the bias could fall as pessimism bias in which the assumptions result in a reduction in calculated net benefits compared to actual net benefits. Finally, there are generally observed contentions around factual matters that need to be resolved.

Given there has not been an ex post assessment and review of the 5 star energy efficiency requirements in BCA2009 upon which the incremental costs and benefits have been calculated, as well as the draft RIS results being quite close to break even, these issues of optimism and pessimism bias, as well as factual and methodological issues require careful consideration.

Stakeholder submissions throughout the public consultation period raised queries and supplied additional information to support claims in all of these three areas. In addition, there was also discussion raised on issues of implementation and appropriateness of the regulation in a wider GHG policy framework. The main topics of discussion under each of these headings are discussed below.

Following public stakeholder comments, OBPR also provided a directive that the results in the Final RIS were to be reported based on utilisation of a 7 per cent discount rate. As such, the results presented in Chapters 6, 7 and 8 have altered form the Consultation RIS and are reported under a 7 per cent discount rate. Further issues raised in response to the Consultation RIS have been considered in Chapter 10 where both scenario based sensitivity analyses are presented as well as a Monte Carlo simulation based sensitivity analysis of the final results.

Optimism bias

Assumptions within the analysis that suffer from optimism bias will have the effect of increasing the estimated net benefits of the proposed regulation, to varying degrees depending on the level of bias, and the relative importance of the issues. The assumptions that were discussed within the public consultation period identified as likely to be suffering from optimism bias were:

- Partial equilibrium methodology;
- Building costs;
- Non-tangible costs;
- Impact of climate change;
- Indirect compliance costs;
- Housing market effects; and
- Lifetime of the regulation

Partial equilibrium methodology

The estimated net benefits of the proposed methodology are results from a partial equilibrium model. While this methodology should capture first round effects of the proposed regulation in the construction industry, and the effects on home owners and residents, second and third round effects, as well as impacts from other policies, on associated industries are omitted. Where these second and third round effects are substantial this could have a notable impact on the final costs and benefits of the regulation.

Where the impacts of associated policies have been included, they have been limited to discrete areas of the analysis. For example, the impact of the proposed CPRS policy has been drawn in through electricity prices only. In a broader, national policy framework, there is a significant possibility that the impact of the CPRS on GHG emissions, and energy efficiency more specifically will achieve the majority of the benefits that have been accrued to the proposed BCA 2010 changes. In this case, it would be the CPRS impact on carbon prices that drives the reductions in energy use and provides incentives for improved energy efficiency in buildings. In this case, the methodology in the RIS would be double counting the benefits.

Further issues with the partial equilibrium analysis and CPRS modelling is the effect that any carbon prices may, or will, have on building materials. The methodology with the RIS has not taken into account issues of embodied energy within building products, and therefore, there is no account taken of the effect of the CPRS on relative building material costs. However, this methodology may be somewhat simplistic and again may be overstating the benefits from the proposed BCA 2010 changes that should be attributed to the CPRS.

Throughout the consultation period, there has been some submissions directed towards the mixed incentives potentially being presented in the proposed regulatory changes for altering building materials towards those such as concrete slabs with greater energy efficiency ratings, but higher GHG emissions values and embodied energy. It is in this case that the combined effects of the proposed regulatory changes and the proposed ETS are potentially able to generate incentives that cover construction and embodied energy issues, as well as operational energy usage issues to deliver a life cycle energy efficiency model. The impact of the ETS on altering the relative prices of energy intensive construction materials will likely move construction processes towards more energy efficient materials and methods, while the proposed regulatory changes are directed at ensuring that the operational energy use within the buildings are efficient.

Building and compliance costs

Concern has been raised by major stakeholders from the building industry that the additional building cost estimates included in the analysis were underestimating the true and total additional capital costs that could be imposed due to the proposed BCA 2010. These costs are a combination of factors raised including the potential need to change average house designs, sourcing of new and different building materials, changes in building practice to ensure compliance and increased supervision and education or training.

Concerns that the additional capital costs associated with the proposed regulations are underestimated are partly based on experience with the introduction of the 5 star regulation, surveys of builders, international studies and separate exercises by consultants to cost out the changes. The additional capital costs as well as additional ‘transitional costs’ reflect the costs of changed building practices, learning and becoming familiar with new requirements and training and educational costs.

Two particular stakeholder submissions from industry groups included survey data on additional 'transitional costs' associated with the proposed energy efficiency regulations. These surveys were in the form of a national survey of residential builders, case studies of single dwellings and case studies of residential apartment buildings. Survey respondents indicated that such transitional costs could potentially reflect between 3 to 6 per cent of base build costs depending on whether the building was entry level housing, or larger, architecturally designed houses.

Part of the concern raised in general over additional build costs is associated with the modelling and assumptions around the costs of compliance with the 5 star energy efficiency regulations. The methodology utilised in the consultation RIS on BCA 2010 assumed that the majority of compliance costs were expended in transitioning to the 5 star energy efficiency regulations. In turn, the incremental compliance costs associated with the 6 star energy efficiency ratings were comparatively small. Where there is contention around the modelling for the 5 star energy efficiency regulations, the view could be taken that there will still be limited additional costs moving to 6 star from 5 star regulations. However, where this assumption is not representative, capital and transitional costs of the proposed changes to BCA 2010 will be understated.

Indirect compliance costs form another category of costs in which there is some contention raised by stakeholders. These costs are associated with the limitations of a partial equilibrium analysis whereby costs are imposed on the construction industry and house owners through dynamics in associated markets. Examples of such effects include potential fluctuations in the cost of getting a new house assessed for an energy rating. As the complexity of the regulations increases, as well as the number of assessments demanded, where there is limited flexibility (inelastic supply) in the market for energy assessors there is likely to be a short term increase in prices. Stakeholder submissions have been received considering both sides of this particular market. There has been evidence noting there is sufficient flexibility within the building assessment market to absorb increased demand, while other submissions have noted a decrease in the quality of assessments, with the implication being that this market flexibility is driven by quality changes rather than absolute prices changes.

Non-tangible costs

Those attributes and services within residential buildings that are not bought and sold readily are difficult to quantify in a cost-benefit analysis, and therefore are usually treated in a qualitative manner. Where they are treated qualitatively, this should not indicate that they are of little value of influence to the overall net benefits of the RIS. Non-tangible costs imposed on consumers through for example not being able to build the desired house due to regulation requirements or reduced amenity value from living within the house complying with regulations can be quite important.

Additional non-tangible costs arise in the form of unintended consequences of a regulation. A report by BRANZ noted the most likely unintended consequences of the proposed regulatory changes to be:

- Air tightness — There is a risk that the increased air tightness of building envelopes will reduce the background air leakage of some Australian buildings below the threshold required to adequately deal with moisture and other airborne contaminants.
- Moisture — There is a risk that filling exterior envelope construction cavities with insulation may cause moisture problems.
- Insulation — There is a risk that achieved insulation levels will vary considerably and more space conditioning energy will be used in some buildings than others of the same size, although the insulation values are intended to be the same.
- Construction — There is a risk that some common construction methods and systems will not be able to contain the extra levels of insulation and may cause problems in the construction industry.
- Fire — There is a risk that the extra penetrations in the building envelope to allow (for example) external water heating devices will provide greater vulnerability to fire entry.

It is noted that all of these potential risks do currently exist but there is a chance that the proposed regulation will further exacerbate them.

Impact of climate change

Projections of changing weather patterns under climate change scenarios indicate that there is likely to be more severe summer temperatures and more moderate winter temperatures.

The impact that this is likely to have on the impact of the proposed BCA changes is driven by the proportion of savings derived in winter versus summer months. The modelling results indicate that the majority of thermal load savings are experienced in colder climates through improved energy use in winter.

To the extent that winters become warmer under future climate scenarios, the benefits of the proposed BCA changes could be mitigated compared to current weather patterns.

New and existing housing market

Where there is a disconnect between the market for existing houses compared to the market for new houses, application of increased energy efficiency regulations on new houses could potentially result in large differential effects across these two markets.

The total effect on the housing market depends on the price elasticity of demand for new houses, as well as the cross price elasticity of new and existing houses. These two effects will determine the fall in demand for new houses due to an increase in purchase price (due to improved energy efficiency performance) as well as the amount of this demand that is transferred to the existing housing market compared to a reduction in total purchases.

Where this results in a reduction in the number of new houses purchased, there will be a number of market reactions. Firstly, there will be less energy efficient homes in the market place and secondly, there is going to be an increase in the number of people per household in older, less energy efficient homes — as demand is transferred to existing houses. The ultimate impact on energy consumption per person is an empirical question. New homes are more energy efficient, but if there are more people per home in older homes, it is possible that due to the fixed costs of heating and cooling a home, energy per person consumed may be lower. Provision of per person energy use information would be needed to address this issues.

Lifetime of the regulation

The assumed lifetime of the proposed BCA 2010 changes in the RIS is 10 years. However, stakeholders have noted that this is not in line with COAG resolutions to progressively revise energy efficiency standards in the near future. It has been suggested that a more appropriate lifespan would be 3 years.

A simplistic methodology of reducing the lifetime of the regulations from 10 years to 3 years has the effect of reducing the BCR to approximately 0.8.

This methodology is extremely simplistic however, as it does not take into account the additional benefits that would accrue to future energy efficiency standards from the 6 star regulations being in place for these three years. That is, as stricter energy efficiency regulations are brought into force, the market responds, adapts, and learns different methods of addressing these regulations, progressively the costs of implementation are likely to reduce. Incrementally, by moving from 6 to 7 star energy efficiency regulations in 3 years rather than in 10 years, there would remain carry over benefits that are not accounted for in the above estimation.

Pessimism Bias

Pessimism bias is a result of conservative assumptions being utilised in the cost benefit analysis. The result of conservative assumptions and pessimism bias is to reduce the estimated net benefits of the proposed regulation. Issues that were raised within the public consultation period highlighting potential pessimism bias included:

- Building cost assumptions;
- Projected electricity prices;
- Business as usual lighting base load;
- Non-market benefits — for example health effects;
- Lifetime of buildings;
- Replacement of smaller appliances; and
- Network generation costs.

Building costs through time

Through the consultation period, there was discussion around the potential conservative methodology for estimating additional capital costs over time due to the regulation. Some stakeholder submissions noted that the cost measures did not allow for full flexibility in changing design aspects of houses, including orientation and passive heating and cooling options. Taking into account these potential market responses to the regulations, there was discussion that additional build costs could potentially be reduced.

So called ‘learning effects’ have also not been included, instead, additional capital costs are assumed to be constant over the life of the regulation. The learning effects would possibly, over time, reduce the costs of compliance as industry becomes more familiar with the regulations and adapts and innovates around building methods. International studies have suggested that the combination of economies of scale in production (over time) and the associated learning effects could result in a 20 per cent reduction in compliance costs with an associated doubling of production. In one stakeholder submission it is suggested that the incorporation of these effects could reduce the NPV of compliance costs by approximately 25 per cent, resulting in a tripling of the reported net benefit of the proposed regulation.

Additional benefits associated with the proposed regulations include the ability of current regulations to assist with the learning and economies of scale effects of potential future regulations, that is, that the lifetime benefits of current proposed regulations, could potentially extend beyond the current 10 years allowed for, thus the current methodology may be understating the life time benefits of the proposed regulations.

Where these ‘learning by doing’ benefits accruing over time potentially counter balance (to some extent) the submissions that building costs have been under estimated within the draft RIS it should be noted that due to the future nature of these learning benefits, they will necessarily be discounted over time, where the additional construction costs will be faced with very little discounting.

There was also some discussion posed on the base line that should be used in measuring the costs of the regulation. Where it is more expensive to retrofit an existing house to stricter energy efficiency standards compared to newly constructing a house to meet these standards, and it is assumed that some form of stricter energy efficiency regulation will be imposed in the future (possibly retrospectively on existing house stock), it should be this relativity that should be considered in the cost estimates.

The methodology for estimating capital costs implicitly assumes that altering the glazing levels and insulation are the predominant options for improving energy efficiency, this potentially over estimates the costs if orientation and other design features eventuate as a general market response to the regulations.

Projected electricity prices and CPRS policy

The only climate policy scenario that was utilised within the draft RIS was CPRS-5. Currently, there is uncertainty surrounding the future stringency of climate policy both within Australia and internationally. A number of stakeholder submissions have suggested increased attention be paid to the effect of different climate policies on the net benefits of the proposed BCA changes.

Where there is a change in climate policy stringency, these effects are assumed to be predominantly felt through increased electricity prices only — due to the limitations of the partial equilibrium methodology as discussed earlier.

An increase in GHG emission targets would result in higher electricity prices and hence increased valuation of electricity savings, raising the net benefits of the proposed changes. Alternatively, a reduction in GHG emissions targets would result in lower electricity prices, and hence reduce the net benefits of the proposed BCA changes.

Other stakeholder submissions have discussed the relationship between wholesale and retail electricity prices, indicating that retail electricity prices generally move faster than do wholesale electricity prices. Further submissions have noted the limited consultation with jurisdictional energy suppliers. All of these issues are considered with a sensitivity analysis around electricity prices within the RIS.

Business as usual lighting base load

Average lighting loads for all Australian houses was used as the baseline for lighting savings in the RIS. Stakeholder submissions have noted that this would potentially underestimate the lighting load savings from the proposed BCA changes and that a more representative base line would be average lighting loads of newly built houses. The discrepancy is driven by the reported higher energy loading in lights in new houses, from halogen down lights.

While changing the base line lighting load of the BAU case would alter the estimated net benefits of the lighting provision, data difficulties limit the potential for this to be incorporated.

Non-market benefits — health effects

As with the optimism bias issues, there is the potential for omission of non-market benefits to result in pessimism bias in the analysis. Examples of these non-market benefits that have been discussed through the consultation period are mainly associated with additional health benefits from more energy efficient homes. Where there has been informal estimation of these potential benefits at one avoided visit to the doctor per household per year, there has been an Australian study conducted attempting to quantify these potential health benefits from improved energy efficiency.

In September 2009, Adelaide Research and Innovation Pty Ltd provided the report 'An investigation of potential health benefits from increasing energy efficiency stringency requirements: Building Code of Australia Volumes One and Two'. The report was commissioned by the ABCB to 'explore the possible health effects (both positive and negative) as temperature and other conditions change within a building to satisfy the energy efficiency provisions resulting from the most recently proposed BCA changes'.

The findings of the report suggest that on average, the net present value of health benefits achieved by an increase in the star rating of new houses from 5 to 6 stars could be $9.50 per household. This figure equates to approximately $1.425 million of net benefits.

The modelling of the report is based on a study undertaken in New Zealand, targeting uninsulated homes in economically disadvantaged areas. The study estimated the value of health benefits from moving from a previously uninsulated home, where residents were known to suffer from some form of respiratory ailments, to a fully insulated home. The value of health benefits estimated in the New Zealand case were proportionally reduced to fit the move from 5 to 6 star energy efficiency moves in a purely linear transformation, assuming a linear relationship in health benefits across the star rating, and across climate zones. The results only included consideration of improved health benefits from reduced winter heating loads required due to improved insulation.

While there are large uncertainties and computational difficulties in applying international studies to the Australian situation, inclusion of these results makes no difference to the BCR at 2 decimal places.

Lifetime of buildings

Where the lifetime of buildings used in the draft RIS was 40 years, stakeholder submissions have noted that this is potentially an underestimate of buildings lifetime, by approximately 30 years.

Allowing benefits to accrue for an additional 30 years, in 40 years' time will have a limited effect on the net benefits of the proposed BCA changes, due to the discount rate. The further in time benefits are being accrued, the lower is the NPV of these benefits. Where a 5 per cent discount rate is used, the benefits would be increased at most by approximately 20 per cent, and where a 7 per cent discount rate is used, the benefits would increase by a maximum of approximately 10 per cent.

It should be noted however, that there is some academic discussion that the further the point in time that benefits are being discounted from, the higher should be the discount rate to account for increased risk of changing market conditions (for example, the building may be pulled down and/or rezoned within 20 years, or by then new homes may be so technologically superior or demanding that homes being built now will be obsolete) and the potential for these benefits not to be achieved. Truncation at 40 years could be considered to be an arbitrary method of accounting for this uncertainty.

Replacement of smaller appliances

Where smaller heating and cooling appliances being utilised in more energy efficient houses, and upon replacement, they are replaced with smaller models than they would otherwise be replaced with, had they been installed in less energy efficient houses. Within the Consultation RIS differences in replacement costs of appliances were not taken into account and this was noted in a few submissions. However the total benefits accrued from smaller appliances at initial installation is only a small proportion of the total benefits, discounted after 10 years at replacement will be even smaller and unlikely to have an impact on the estimated net benefits.

Network generation costs

There has been one submission making note that the estimated network generation cost savings could be being underestimated. However, there is no additional sensitivity analysis undertaken on this variable as contention around this issue is high. Contention is raised due to the potential impact that the CPRS policies may have on generation and distribution asset investments, as well as other related policies such as smart metering and time of use tariffs.

Factual and methodological discussion

Factual and methodological issues that require consideration within the cost benefit analysis affect how and where information is drawn from into the analysis. Factual and methodological concerns that were raised in the consultation period include:

- Choice of discount rate;
- Weightings of regions and cities;
- Negative impacts in certain cities; and
- Housing affordability methodology.

Discount rate

The discount rate utilised in the consultation RIS as part of the cost benefit analysis, to measure the net present value (NPV) of the costs and benefits of the proposed regulation, was 5 per cent. This figure is below the recommended discount rate of 7 per cent, put forward by the OBPR in evaluating regulatory impacts in general, and a justification for this divergence was included in the Consultation RIS.

A number of stakeholder submissions put forward the argument that this discount rate is too low to accurately reflect the decision making process of consumers, citing a number of international studies indicating that consumers generally make decisions over relatively short timeframes, or between 3-5 years. The implication of this shorter repayment time frame is that the implicit discount rate is quite high. References are made to publications from the World Energy Council considering private discount rates of up to 20 per cent, compared to public discount rates of less than 10 per cent.

In contrast, other stakeholder submissions have suggested that there is room for a further lowering of the discount rate, in line with international studies of the effects of climate change, to between 2.65 per cent and 3.5 per cent.

The key underlying factor in the choice of discount rate is whether the costs and benefits are being evaluated at a social or private level. Where a private evaluation is being undertaken, the appropriate discount rate is closely associated with the private decision making process of individuals. However, if the effects of the regulation are being evaluated at a social level, where there is the potential for benefits to be accumulating for a number of years, as well as to future generations, there is scope for these future benefits to hold a greater value, and hence attract a lower discount rate.

It should be noted that where a social discount rate is being imposed on consumers, who have a higher private discount rate, there is an additional private cost being borne by consumers because of the regulation that has not been incorporated within the estimate of net benefits.

Within the Consultation and Final RIS documentation, sensitivity analyses have been undertaken to closely consider the effect that altering the discount rate has on the valuation of the net benefits of the regulation, and as has been noted by stakeholders, there is a significant effect. While an argument has been put forward for the lower discount rate of 5 per cent to be applied, OBPR has required full reporting of results based on a 7 per cent discount rate.

Weightings and negative BCRs for capital cities

A number of submissions have noted the counter-intuitive nationally positive BCR where there are a number of larger capital city areas with reported negative BCRs. Issues associated with regional weightings and the use of cities to represent entire climate zones are driving these results, as well as inclusion of national level benefits of reduced electricity network costs at the national but not regional levels. The effect of different regional aggregation assumptions are considered in the sensitivity analysis.

Housing affordability

The extent of the impact of the proposed energy efficiency regulations on house prices depends heavily on both the estimated capital costs due to the proposed regulations as well as the ability of builders to pass these costs on to house buyers. While the issues of costs and pass through have already been considered, a number of stakeholders have questioned the methodology used to measure the effect on housing affordability.

The methodology used in the Consultation RIS was to incorporate both the increased capital costs of new houses, as well as the estimated savings in energy bills through the life of the house. This methodology was rightly identified as a change from entry level access to a life time housing cost approach. It recognises that where a house is more energy efficient and is able to generate lower on-going energy bills, there is a greater ability to meet house repayments through the life of a mortgage. However, it is important to ensure that banks and lending institutions take this approach when considering whether to provide financing to home buyers. A quote from John Symond in the Australian Financial review, 3 June, 2009, provided in a stakeholder submission suggests that they do not.

The resolution of the deposit gap, viewed by banks and lending institutions, for new home buyers is important when considering the effect of the proposed regulations on housing affordability. Until the capital market failure is resolved, this issue should be incorporated in the housing affordability methodology. The results of using only capital costs on housing affordability are included in the sensitivity analysis.

Appropriateness of regulation

A final category of concerns raised by stakeholders is the generally appropriateness of the regulations to achieve their stated objective. This includes:

- targeting new buildings compared to existing building stock;

- appropriate design for climate, software modelling issues; and
- the interaction of the proposed regulations with associated regulations to achieve GHG emission reductions.

Existing building stock

Where there is a relatively large stock of existing buildings compared to newly built buildings, stakeholders have questioned whether there could be greater national improvements achieved through targeting existing buildings rather than newly constructed buildings.

This point is associated with a general view expressed across stakeholder submissions that there are diminishing returns earned through moving up the energy efficiency star ratings on newly constructed buildings only.

Appropriate design for climate, software modelling issues

Limitations of the current modelling software to achieve the goals of energy efficiency have been raised by a large number of stakeholders. These concerns have included:

- Inconsistency in results across modelling software;
- Inability of software to account for passive heating and cooling.

Where the first point has received both positive and negative responses, indicating both large and small discrepancies, the second has generated a large amount of concern, particularly from stakeholders in northern and tropical regions of Australia.

Where there is the potential to use passive cooling methods in tropical regions as well as permanent ventilation, the simulation compliance software currently available is unable to provide a star rating on these features. Concern has been raised that by imposing such energy efficiency requirements on houses in tropical regions, there will be an increasing reliance on insulation and air conditioning rather than on passive, less energy intensive options.

Interaction effects

Where the government's stated objective is to reduce GHG emissions, there were submissions noting that energy efficiency regulations that are not able to discern for example GHG intensity of power use, have the potential to miss this GHG objective. Additional concerns were raised over the greater ability of transport, and water supply policies to achieve GHG and sustainability objectives.

Stakeholders have also questioned why air conditioners are not included in the scope of the BCA2010 and as such, the energy use and efficiency measures of installed air conditioners are not regulated through the BCA. Where air conditioners are not 'plug in' appliances they could be included in a whole of house energy efficiency measures along with hot water and lighting and building fabric. This methodology could improve the effectiveness of current computer based energy efficiency rating tools on a building's fabric alone, and allow for an assessment framework that relates energy use to GHG emissions. Where air conditioners are controlled through MEPS which work in conjunction with the BCA fabric requirements, this query raises questions of how the regulations are interacting with associated regulations to achieve stated objectives.

6 Analysis of benefits

The proposed changes to the BCA are likely to involve a range of positive benefits. Some benefits will be private (such as energy savings), while others will be public (such as the impact on the energy supply network). The relevancy of particular benefits to the analysis however, is largely dependent on the degree of aggregation. For example the likely capital cost savings from avoiding electricity network augmentation may be relevant at the economywide level, but less relevant when analysing individual dwellings. On the other hand, savings in energy consumption are relevant at both aggregations. As such, benefits for dwelling and economywide aggregations are discussed separately. Table 6.1 below, summarises the benefits discussed at different levels.[13]

6.1 **Analysis of benefits**

	Dwelling analysis	***Economywide analysis***
Energy savings from improved thermal performance (electricity, gas)	✓	✓
Energy savings from lighting provisions	✓	✓
Energy savings from water heating provisions[a]	✓	✓
Outdoor areas	✓	✓
Reduction in plant cost savings	✓	✓
Electricity generation and network impacts		✓
Gas network impacts		✓
Greenhouse gas abatement[b]		✓
Non-market benefits		✓

a Benefits relating to the changes in water heating have been assessed in a separate analysis, and are not reported here. A more detailed discussion of water heating provisions can be found in appendix B. Under the CPRS, the value of greenhouse gas abatement is captured in the price of energy, and therefore the benefits of greenhouse gas abatement can be considered a subset of the benefits of energy savings. In detail however, the impact analysis only considers greenhouse gas abatement at the economywide level.

Source: The CIE.

[13] Note that it has not been possible to quantify all benefits listed in the table.

Dwelling benefits

At the household level, the primary benefit of the proposed change is the expected savings in energy consumption. Energy savings may accrue via the following ways:

- through improved thermal performance;
- from increased lighting energy efficiency;
- improved energy efficiency of outdoor areas;
- savings from the installation of smaller appliances; and
- from the increased energy efficiency of hot water heating.

(Note again that the likely energy savings from the improved energy efficiency of hot water heaters has been assessed in a separate document. These results have not been reproduced here —only the net impact of these provisions is discussed).

Additionally, as a dwelling's thermal performance improves, a dwelling can expect to further benefit from a reduction in the necessary capacity of heating and cooling appliances. Simply put, improvements made to a building's fabric reduce the need for high capacity air-conditioning and space heating appliances.

The expected savings of reduced capacity, as well as energy savings from improved thermal performance and lighting provisions are discussed below.

Improved thermal performance

The ABCB provided data for this study that identified the expected change in annual 'heating and cooling loads' expected as a result of the BCA amendments. The data provided was the result of an extensive modelling exercise undertaken on behalf of the ABCB using a thermal modelling tool for residential dwellings, *AccuRate*.

Notably, the data provided by the ABCB:

- did not differentiate the thermal performance of the two compliance methods (rather, it has been implicitly assumed the elemental and simulation compliance pathways would produce the same energy savings);[14]

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[14] Further, no separate estimates of heating and cooling load savings were provided to the CIE to estimate the energy savings stemming from these measures and undertaking additional thermal performance modelling to obtain these estimates was outside the scope of the project.

- did not identify energy savings in a malleable form (that is, energy savings were expressed in 'reduced energy loads' not as MJs or MWhs saved); and
- did not identify separately the amendments' expected impact on specific fuel types (rather, the data identified only heating and cooling loads).

The 'translation' of the ABCB's data into a more malleable format (from energy loads to MJs) was conducted by a group of thermal performance modelling and building sector energy efficiency experts from the Faculty of the Built Environment at the UNSW (Prof Deo Prasad, Steve King and Dr Mark Snow).[15] Aspects of their methodology are discussed in appendix I.

Table 6.2 reports estimates of the change in energy consumption induced by the proposed amendments by dwelling type and population centre. The ABCB expects that elemental and simulation compliance will produce the *same* energy savings, and consequently only one set of results is produced. The results can be interpreted as the 'typical' energy savings that could be expected for a house/townhouse/flat, in a particular location, when built under the proposed 2010 BCA, rather than the existing BCA.[16]

The table reports both the change in electricity and gas consumption. To separate the impact on specific fuels, data was obtained from DEWHA (2008b) regarding fuel sources used for space heating by State. The change in a dwelling's heating load was allocated to fuel sources (consistent with DEWHA 2008b);[17] and the impact on a dwelling's cooling load is assumed to be all electricity. Only the impact on electricity and gas consumption has been assessed.

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15 The UNSW team used data from the Energy Efficiency calculator tool provided by the ABCB to estimate the energy savings from achieving the 6 star requirements based on thermal performance modelling software. The EER calculator identifies the annual heating and cooling load savings from moving from 5 to 6 stars, but does not provide savings in energy consumption. The UNSW team converted the heating and cooling loads into energy savings.

16 Note that while the building sample used to create these estimates may be indicative of the economy as a whole, some caution should be used when interpreting results at a local level.

17 DEWHA (2008b) identified ducted gas heating as the single largest share of space heating energy use by the residential stock. However, DEWHA notes that as the building shell improves over time, some households may find it more attractive to use reverse cycle air-conditioning in preference to gas. DEWHA estimates that about 60 per cent of Australia's residential heating energy was fuelled by gas, and 10 per cent by electricity. The remainder is fuelled primarily by wood, but also other sources.

6.2 **Annual decrease in thermal energy consumption, MJ**

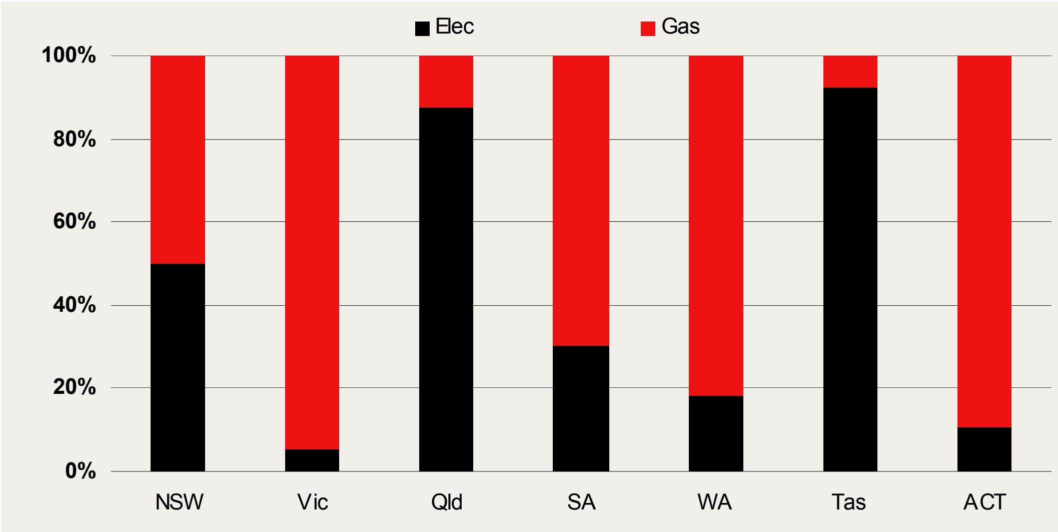
	Darwin	*Brisbane*	*Longreach*	*Mildura*	*Adelaide*	*Perth*	*Sydney*	*Melbourne*	*Canberra*	*Hobart*	*Cabramurra*
Gas											
House	0	43	26	1339	1077	1090	373	6561	6051	283	9314
Townhouse	0	4	20	550	465	511	295	2728	2350	144	4132
Flat	0	124	552	1007	1709	1709	1709	2613	3606	3606	6334
Electricity											
House	5259	862	2822	2440	1552	985	808	124	385	3325	9207
Townhouse	2561	465	1439	1244	955	546	357	182	271	1 709	4122
Flat	10 869	781	3744	4484	2449	2449	2449	1903	1259	1259	876
Energy											
House	5259	905	2848	3780	2629	2076	1181	6685	6436	3608	18 521
Townhouse	2561	468	1459	1794	1420	1057	652	2910	2621	1853	8254
Flat	10 869	906	4296	5490	4157	4157	4157	4516	4865	4865	7210

Note: The data provided by the ABCB implicitly assumes that both elemental and simulation compliance measures produce the same energy savings.

Source: CIE estimates based on Prassad, King and Snow (2009) and data provided by ABCB.

The largest energy savings tend to be in cooler climate zones, such as climate zones 8 (Cabramurra), 6 (Melbourne) and 7 (Canberra and Hobart), however climate zone 1 (Darwin) proved to be an exceptional case. This statement generally holds when comparing across the residential building types. The difference in the amendments' impact on specific fuel consumption is largely driven by the different fuel sources used across the locations. Space heating in Victoria for example, is predominately fuelled by gas (77 per cent); where as NSW uses significantly more electricity and wood (combining for 78 per cent). Chart 6.3 shows the relative use of electricity and gas in space heating (excluding other fuel sources).

6.3 Relative use of electricity and gas in space heating by jurisdiction



Note: The chart depicts the relative use of electricity and gas for space heating. The consumption of wood and other fuel sources for space heating are not reflected in this chart. Data for NT heating has not been required for this analysis.
Data source: CIE estimates based on DEWHA (2008b).

The estimated reductions in energy consumption will generate benefits to households in the form of reduced expenditure on energy bills. The value of these reductions has been estimated using the forecasts of electricity and gas prices provided in appendix D. Given the potentially significant impact the Australian Government's proposed CPRS will have on energy prices, this analysis draws on its modelling (Australian Government 2008 and MMA 2008b).[18]

Table 6.4 provides estimates of the annual savings in household expenditure based on estimated reductions in energy consumption due to the proposed amendments. The estimated savings is based on average State-level retail energy prices in 2011. As could be expected from table 6.2 dwellings in those climate zones with the largest decreases in energy consumption also enjoy the greatest saving in energy expenditure. Houses generally can be expected to make the greatest savings, but expenditure in some townhouses and flats can be expected to decrease by similar magnitudes. The smallest savings are expected for more temperate climates such as for Sydney, Perth and Brisbane.

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[18] Note that there are some indications that the energy price forecasts describe in Australian Government (2008) may be conservative. A study by the QLD Department of Mines and Energy suggests that energy prices are already on the rise. Details of this study can be found at: http://www.dme.qld.gov.au/zone_files/Electricity/elec_prices_across_australia_final.pdf

6.4 **Value of annual thermal energy savings per dwelling, $**

	Darwin	*Brisbane*	*Longreach*	*Mildura*	*Adelaide*	*Perth*	*Sydney*	*Melbourne*	*Canberra*	*Hobart*	*Cabramurra*
Gas											
House	0	1	0	19	15	15	5	92	85	4	131
Townhouse	0	0	0	8	7	7	4	38	33	2	58
Flat	0	2	8	14	24	24	24	37	51	51	89
Electricity											
House	225	47	155	111	79	40	37	4	17	96	418
Townhouse	110	25	79	56	49	22	16	6	12	49	187
Flat	465	43	205	203	125	99	111	61	57	36	40
Energy											
House	225	48	155	130	94	55	42	96	102	100	549
Townhouse	110	25	79	64	56	29	20	44	45	51	245
Flat	465	45	213	217	149	123	135	98	108	87	129

Note: The data provided by the ABCB implicitly assumes that both elemental and simulation compliance measures produce the same energy savings.

Source: CIE estimates based on Prassad, King and Snow (2009), Australian Government (2008) and data provided by ABCB.

Indicatively, the present values of energy savings enjoyed by a residential building built in 2011 are presented in table 6.5. Over the life of the building the amendments are expected to save a typical household between $270 and $7 300 (in present value terms), depending on location. Note that dwellings located in different cities, but the same climate zone, may differ because of difference in the energy prices applied.

Lighting provisions

As detailed in appendix A, BCA 2010 proposes to include new requirements for artificial lighting in residential buildings. In particular, the BCA proposal is to limit the lamp power density to 5 watts per square metre (W/m^2) of floor area for building Classes 1, 2 and Class 4 parts.

The changes in energy consumption associated with the lighting provisions are calculated through the following steps (additional details of this methodology and the lighting provisions are provided in appendix K).

- Estimate lighting energy consumption under the baseline for each house in the ABCB building sample. The following parameters are used to calculate these figures:

6.5 Present value of thermal energy savings over dwelling lifetime, $

	Darwin	Brisbane	Longreach	Mildura	Adelaide	Perth	Sydney	Melbourne	Canberra	Hobart	Cabramurra
Gas											
House	0	9	5	272	219	221	76	1331	1227	57	1889
Townhouse	0	1	4	111	94	104	60	553	477	29	838
Flat	0	18	78	143	243	243	243	371	512	512	899
Electricity											
House	2955	608	1988	1445	1023	527	479	54	228	1316	5452
Townhouse	1439	328	1014	737	630	292	212	79	161	676	2441
Flat	6107	551	2638	2655	1615	1310	1450	831	746	498	519
Energy											
House	2955	616	1994	1717	1242	748	554	1385	1455	1373	7342
Townhouse	1439	328	1018	848	724	396	271	633	637	706	3279
Flat	6107	568	2717	2798	1857	1553	1693	1202	1258	1010	1418

Note: Present value calculated using a 7 per cent real discount rate. Household building life is 40 years.

Source: CIE estimates based on data provided by ABCB.

- an estimate of the current lighting energy consumption for the average Australian dwelling calculated using information from DEWHA's consultation RIS for the proposal to phase-out inefficient incandescent light bulbs (DEWHA 2008c) (approximately 441 kWh per year);[19]
- an estimate of the floor area for an average Australian house (194 m^2);
- an estimate of the current lighting energy use per m^2 of floor space; and
- average floor area for each of the houses in the ABCB building sample.

- Estimate the lighting energy consumption under the new BCA 2010 for each house in the ABCB building sample. The following parameters are used to calculate these figures:
  - the required power density under the BCA 2010 (5 W/m^2);

[19] More details about how this figure was estimated are provided in appendix K.

  - share of floor area for living and non-living areas (40 per cent/60 per cent modelled);
  - total floor area per house (based on the building sample provided by ABCB); and
  - light usage assumptions (2 hours per day for living areas and 0.4 hours per day for non-living areas modelled).
- Aggregate lighting energy use from the ABCB building sample to ABS dwelling types (house/townhouse/flat) using the weights presented in appendix K.
- Compare the lighting energy use under the proposed BCA 2010 with the lighting energy use under the BAU case.

Pre-emptively, any energy savings achieved through improved lighting energy efficiency are only likely to be small in absolute terms. DEWHA (2008b) estimates that lighting accounts for only 13 per cent of residential electricity consumption, and only 6 per cent of total energy use. Implicitly then, there is a limit to how much energy can be saved here. Table 6.6 provides estimates of the annual savings in household energy consumption due to the proposed amendments. It is estimated that the amendments will reduce the energy used for lighting by a typical dwelling by about 17 per cent. (The energy savings from the amendments' lighting provisions are expected to be the same across all locations.)

6.6 **Annual decrease in household lighting energy consumption due to BCA lighting provisions, MJ**

	BAU	***BCA 2010***	***Savings***
House	1682	1400	282
Townhouse	739	615	124
Flat	969	806	162

Note: Estimates of lighting energy use by population centre are not available. As such, savings in lighting energy consumption are only provided by an average Australian house/townhouse/flat.

Source: CIE estimates based on DEWHA (2008b and 2008c) and data provided by ABCB (Constructive Concepts & Lighting Art & Science).

Similar to thermal performance, the estimated reductions in energy consumption will generate benefits to households through reduced energy bills. Table 6.7 provides estimates of annual savings in household expenditure based on estimated reductions in lighting energy use due to the new proposed requirements for artificial lighting in residential buildings. The savings on this table are based on national average retail energy prices in 2011. As shown in table 6.7, houses will experience the greatest savings, but expenditure in some townhouses and flats can be expected to decrease by similar magnitudes.

Indicatively, the present values of energy savings enjoyed by residential buildings built in 2011 are presented in table 6.8. Over the life of the building, the new proposed lighting requirements are expected to save a typical household between $151 and $66 (in present value terms).

6.7 **Value of annual dwelling energy savings from lighting provisions, 2011**

	Savings ($)
House	12
Townhouse	5
Flat	7

Note: Estimates of lighting energy use by population centre are not available. As such, savings in lighting energy consumption are only provided by an average Australian house/townhouse/flat.
Source: CIE estimates based on DEWHA (2008b and 2008c), Australian Government (2008) and data provided by ABCB (Constructive Concepts & Lighting Art & Science).

6.8 **Present value of energy savings from lighting provisions, over dwelling lifetime**

	Savings ($)
House	151
Townhouse	66
Flat	87

Note: Present value calculated for a building built in 2011 using a 7 per cent real discount rate. Household building life is 40 years.
Source: CIE estimates based on DEWHA (2008b and 2008c), Australian Government (2008) and data provided by ABCB (Constructive Concepts & Lighting Art & Science).

Outdoor living provisions

As part of the proposed suite of measures, Section 3.12.5.7 of Volume 2 now includes energy efficiency requirements for heating and pumping of swimming pools or spas. While these measures are likely to generate energy savings at some additional cost, these impacts have not been quantified in this RIS. Appendix L provides additional commentary on this.

Appliance savings

The improved thermal performance of new residential buildings may have implications for the choice of air-conditioning and space heating appliances installed. Air-conditioning and heating appliances need to be of sufficient capacity to ensure that comfortable temperatures can be maintained within the dwelling under most climatic conditions (ABCB 2006b). As thermal performance improves, the dependence on these appliances to provide this comfort decreases. It follows then, that owner/occupiers — acting rationally and informed —will seek to alter their choice of appliance for these expected changes.

ABCB (2006a) estimated that a 1kW reduction in cooling and heating capacity could save a building up to $200.[20] The ABCB has not estimated the amendments' direct impact on capacity, but it can be inferred from the percentage reduction in cooling heating and cooling loads. For instance, a 20 per cent reduction in heating and cooling loads can be reflected as a 20 per cent reduction in the optimal air conditioning capacity required. Notably, market rigidities may exist which prevent this optimisation from occurring (such as a lack of available products) — and to account for this, the reduction in optimal capacity has been reduced by 50 per cent.

Table 6.9 reports the proportional decrease in total heating and cooling loads for each dwelling, and by location. Using an Australia wide average estimate of the installed air-conditioning capacity,[21] the table also reports the estimated capacity and cost savings a new dwelling will accrue from installing a smaller (but still optimal) appliance. For example, the proposed amendments will reduce the required energy loads for a house in Sydney by 23 per cent, and consequently, builders can install smaller appliances. Discounting for market rigidities (50 per cent), it is estimated that under the 2010 BCA, this house would be able to install an appliances with 0.6 kW less capacity. At a cost of $200 kW, the house saves $124.

Savings from the installation of smaller appliances are only accrued in the year the dwelling is constructed.

Total dwelling benefits

Finally, table 6.10 summarises the benefits above, and accounts for:

- energy savings from improved thermal performance;
- energy savings from provisions to improve energy efficiency of lighting; and
- savings from smaller appliances.

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[20] ABCB (2006a) estimates the marginal cost of reverse cycle air conditioning (room air conditioner) at $180 in 2006 dollars. This figure provides the basis of the estimates here, and has been adjusted for inflation.

[21] DEWHA (2008b) estimates that the average capacities for split system reverse cycle and split system cooling only air-conditioners at 5.8kW and 5.0kW respectively. An indicative figure of 5.4kW is used here to represent the average.

The benefits accrued are very much dependent on the climate the dwelling is located. Notably, flats perform particularly well in all locations.

6.9 Reduction in optimal appliance capacity

	Darwin	Brisbane	Longreach	Mildura	Adelaide	Perth	Sydney	Melbourne	Canberra	Hobart	Cabramurra
Reduction in energy loads/required appliance capacity, per cent											
House	15.6	21.6	20.0	22.3	23.3	22.3	23.0	25.4	25.3	22.8	25.3
Townhouse	14.9	20.4	19.4	21.5	23.9	22.1	23.8	22.4	20.8	22.3	22.8
Flat	18.1	16.8	18.1	25.6	20.1	19.6	23.8	27.2	24.4	27.5	19.8
Reduction in required appliance capacity, kW											
House	0.4	0.6	0.5	0.6	0.6	0.6	0.6	0.7	0.7	0.6	0.7
Townhouse	0.4	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Flat	0.5	0.5	0.5	0.7	0.5	0.5	0.6	0.7	0.7	0.7	0.5
Savings from reduced appliance requirements, $											
House	84	117	108	121	126	120	124	137	137	123	136
Townhouse	81	110	105	116	129	119	128	121	112	120	123
Flat	98	91	98	138	108	106	128	147	132	149	107

Note: Appliance capacity estimated at 5.4kW; marginal cost of appliance capacity $200; market rigidities prevent 50 per cent of optimisation occurring.
Source: CIE estimates based on data provided by ABCB.

6.10 Present value of dwelling energy savings, over dwelling lifetime, $

	Darwin	Brisbane	Longreach	Mildura	Adelaide	Perth	Sydney	Melbourne	Canberra	Hobart	Cabramurra
House	3039	733	2102	1837	1368	868	679	1522	1592	1497	7478
Townhouse	1519	439	1123	964	853	515	400	754	749	826	3403
Flat	6205	659	2814	2936	1966	1659	1821	1349	1390	1159	1525

Source: CIE estimates based on data provided by ABCB.

Economywide benefits

Economy wide benefits have been assessed for the range of performance compliance options.[22] At the economy wide level, it is likely that the proposed amendments will produce the following positive impacts:

- a decrease in the residential sector's energy consumption from improved thermal performance — with a present value of $1.5 billion;
- a decrease in the residential sector's energy consumption from improved energy efficiency of lighting — with a present value of $174 million;
- savings from the installation of smaller appliances — with a present value of $97 million;
- delayed capital investment for network augmentation — with a present value of $186 million;
- non-market benefits; and
- a decrease in the residential sector's greenhouse gas emissions.

Each of these items is discussed below for Class 1 (houses and townhouses) and Class 2 (flats) buildings.

Improved thermal performance

The investment in energy efficiency however, will in some cases save more than a MWh of electricity per house per year. In total, this is likely to reduce energy consumption by the *residential sector* by an average of nearly 1 per cent per annum.

Each year a new 'cohort' of dwellings is added to the post-amendment stock. The economywide annual energy savings of each cohort is reported in table 6.11, and includes an allowance for refurbishments.[23] Each cohort produces energy savings for the assumed life of the building stock (40 years).

Notably, while the savings for an individual house may be considerable, relative to the residential sector's total energy consumption, the induced energy savings are small. This is largely because the amendments only

[22] Notably, as it is expected that elemental and simulation compliance methods will produce the same energy savings, there is no difference between these results when considering benefits. The ABCB has commissioned two studies to detail the difference (if any) between these compliance pathways.

[23] As discussed in the previous chapter, refurbishments are assumed to account for an additional 10 per cent of the new residential building stock.

apply to *new* dwellings and not the existing stock. Chart 6.12 compares the electricity consumption by the residential sector under the business as usual case, and with the amended BCA in place.

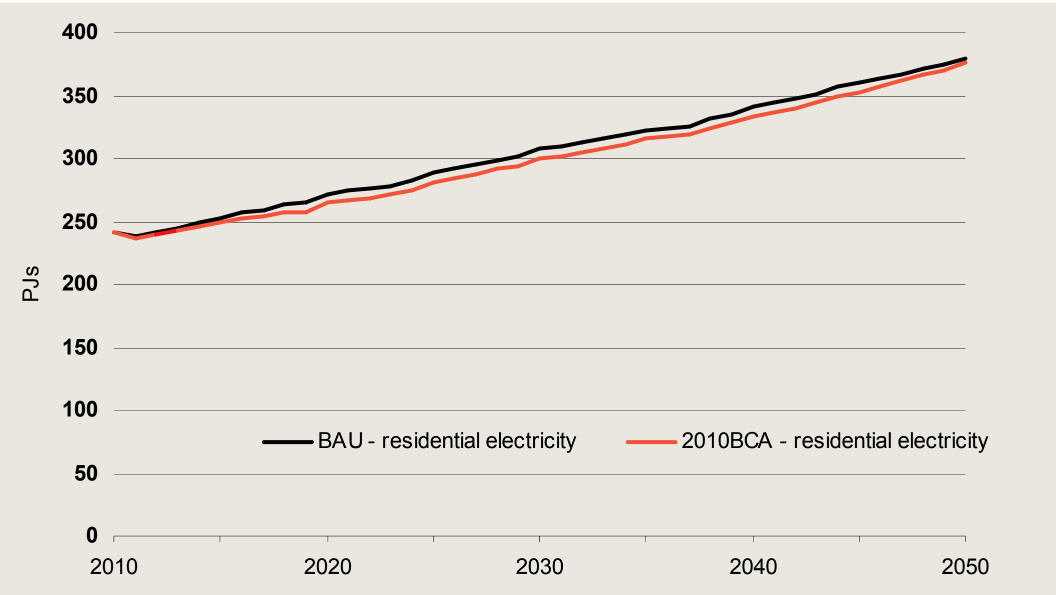
6.11 Cohort annual decrease in thermal energy consumption, PJs

	Australia
Class 1	
Gas	0.29
Electricity	0.15
Energy	0.44
Class 2	
Gas	0.01
Electricity	0.03
Energy	0.04
Residential buildings	
Gas	0.31
Electricity	0.18
Energy	0.48

Note: The data provided by the ABCB assumes that both elemental and simulation compliance measures produce the same energy savings. Cohort savings based on estimates of housing stock in 2011. As growth in subsequent years may vary, so too may cohort savings. Elemental and simulation reflects the weighted average of savings that reflects the market uptake of elemental and simulation compliance pathways.

Source: CIE estimates based on Prassad, King and Snow (2009), Australian Government (2008) and data provided by ABCB.

6.12 Electricity consumption by the residential sector



Data source: CIE estimates based on ABARE (2008) and Australian Government (2008).

The present value of the energy saved by a dwelling built in 2011 is approximately between $400 and $7 500 (based on a 7 per cent real discount rate, and an asset life of 40 years) depending on location. Cumulatively, the present value of the energy savings by all new houses built between 2011 and 2021 sums to nearly $1.5 billion. This takes into account cohort effects, growth of the housing stock and changes in electricity prices. Table 6.13 reports the present value of energy savings.

6.13 **Present value of energy savings, $ million**

	Australia
Class 1	
Gas	529
Electricity	782
Energy	1311
Class 2	
Gas	17
Electricity	129
Energy	146
Residential buildings	
Gas	546
Electricity	911
Energy	1457

Note: The data provided by the ABCB assumes that both elemental and simulation compliance measures produce the same energy savings. A 7 per cent real discount rate has been used to calculate the value of energy savings.

Source: CIE estimates based on Prassad, King and Snow (2009), Australian Government (2008) and data provided by ABCB.

Over the period 2011-2021 the housing stock built under the new BCA accumulates energy savings at an increasing rate. In 2021 the policy is no longer effective (or it is surpassed) and no new buildings are added to the affected stock. Energy savings between 2021 and 2051 stem from only those buildings built in the decade prior to 2021. After 2051 (40 years after the policy is introduced), cohorts of buildings begin to leave the affected stock of dwellings. And eventually (from 2061) no more energy savings are enjoyed.

Lighting provisions

The benefits accrued at the individual dwelling level from improved lighting provisions have been aggregated to an economywide level. Similar to improving a dwelling's thermal performance, the total amount of energy saved by the *community* increases over time as more dwellings are added.

Again, each year a new 'cohort' of dwellings is added to the post-amendment stock. The annual energy savings of each cohort is reported for Australia in table 6.14, and includes an allowance for refurbishments.[24] Each cohort then produces energy savings for the assumed life of the building stock (40 years).

The present value of the energy saved by a house built in 2011 is on average about $150 (based on a 7 per cent real discount rate, and an asset life of 40 years). Cumulatively, the present value of the energy savings by all new dwellings built between 2011 and 2021 sums to about $174 million. This takes into account cohort effects, growth of the housing stock and changes in electricity prices. (The value of energy saved for selected years is reported in appendix K). Table 6.15 reports the present value of energy savings from lighting provisions.

6.14 **Cohort annual decrease in energy consumption from lighting provisions, GJs**

	Australia
Class 1	60 037
Class 2	25 134
Residential buildings	85 172

Note: The data provided by the ABCB assumes that both elemental and simulation compliance measures produce the same energy savings. Cohort savings based on estimates of housing stock in 2011. As growth in subsequent years may vary, so too may cohort savings.

Source: CIE estimates based on Prassad, King and Snow (2009), Australian Government (2008) and data provided by ABCB.

6.15 **Present value of energy savings from lighting provisions, $ million**

	Australia
Class 1	165.0
Class 2	9.2
Residential buildings	174.3

Note: The data provided by the ABCB assumes that both elemental and simulation compliance measures produce the same energy savings. A 7 per cent real discount rate has been used to calculate the value of energy savings.

Source: CIE estimates based on Prassad, King and Snow (2009), Australian Government (2008) and data provided by ABCB.

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24 As discussed in the previous chapter, refurbishments are assumed to account for an additional 10 per cent of the new residential building stock.

Appliance savings

The benefits accrued at the individual dwelling level have been aggregated to an economywide level and are reported in table 6.10. Again, these savings reflect the decrease in air-conditioning and heating capacity necessary for thermal comfort as the building fabric improves.

Savings on appliance capacity reflect a reduction in capital expenditure, and are not recurrent. Therefore these savings accrue only over the life of the policy. The present value of these savings has been estimated at $97 million (see table 6.16).

6.16 **Present value of energy savings from reduced appliance capacity, $ million**

	Australia
Class 1	87
Class 2	10
Residential buildings	97

Note: The data provided by the ABCB assumes that both elemental and simulation compliance measures produce the same energy savings. A 7 per cent real discount rate has been used to calculate the value of energy savings.

Source: CIE estimates based on Prassad, King and Snow (2009), Australian Government (2008) and data provided by ABCB.

Electricity generation and network impacts

The proposed BCA changes will deliver gains in the form of avoided costs enjoyed by electricity generators and the businesses delivering power to end users. These will be modest gains. The relatively small impact on energy conservation compared with BAU will make it unlikely that generation augmentation plans, already heavily impacted by the likely implementation of the CPRS and renewable target requirements, will be altered as a result of the envisaged changes to residential consumption. Reductions in generation operating costs will occur but are unlikely to be more than 0.1 per cent below BAU. Avoided carbon costs will be of a similar small order of magnitude, along with any unserved energy savings.

More substantial savings may be realised in the network businesses due to favourable demand reduction responses that reduce their unit costs. Based on studies prepared to evaluate other energy conservation measures, it is estimated that average annual savings attributable to the proposed BCA changes could reach $20 million by 2030 in this sub-sector relative to BAU. The present value of these likely savings is estimated at $186 million.[25]

The likely impacts on network generation, as well as details of how this figure was estimated are provided in appendix F.

Gas network impacts

Just as the proposed amendments are likely to reduce electricity consumption, they are also likely to reduce gas consumption as well. Consequently it may be reasonable to expect that the amendments might have a similar impact on the gas sector as they will on electricity.

Unfortunately, a comparable body of literature is not available to conduct the sophisticated analysis necessary to provide a robust estimate of the impact on gas networks (or the gas market more generally). Further, any attempt to do so would be speculative at best. Consequently, these impacts have not been quantified in this analysis.

Non-market benefits

Improving the thermal performance of buildings confers a range of non-financial benefits in addition to reductions in energy-related expenditures. As an example, enhancing the thermal performance of buildings can enhance weather proofing of homes, the overall outdoor amenity (for example, where verandas or substantial eaves are incorporated). Or alternatively, double glazing can improve acoustic attenuation. Non-market benefits can be especially important in medium to high density housing developments. Energy Efficient Strategies (2002) identified the following broad classes of non-market benefits:

- improved amenity values;
- health improvements; and
- productivity boosts.

Notably, however, these benefits are difficult to measure and value.[26] A review of the literature provides mainly qualitative discussions of these benefits. Health benefits are associated with improved indoor air quality, limitation on internal temperature swings and elimination of condensation

[25] No network energy savings are assumed over the period 2010-2015. From 2015 on, network savings are estimated at $20 million per annum.

[26] The ABCB is currently in the process of commissioning studies on the benefits of avoiding heat stress— directly related to this issue. These studies can be expected to be released later this year.

and associated mould growth. One study reports that people remain indoors 90 per cent of the time and pollutants indoor exceed 10 to 100 times the pollutants outdoors (Kats 2003). Improving indoor air quality can lead to lower rates of absenteeism, respiratory diseases, allergies and asthma. Lighting, temperature and ventilation are found to influence illness symptoms such as headaches, eyestrain, lethargy, loss of concentration and mucosal symptoms.

Greenhouse gas abatement

As well as reducing energy consumption, the proposed changes also have the potential to reduce greenhouse gas emissions. In short, as the sector consumes less energy, less energy will need to be produced, and fewer greenhouse gasses will be emitted.

The GHG abatement achieved through the proposed amendments generate benefits for society by easing the burden for other sectors obligated to reduce their emissions under the proposed CPRS. The CPRS will internalise the cost of carbon emissions within the cost of ordinary economic activity. Under the CPRS the price of electricity will *already account for the value of greenhouse gasses avoided*. The carbon price impost on electricity is already reflected in earlier estimates of energy savings. Valuing avoided emissions separately would double count this benefit.

Similarly, while the amendments may be expected to impact on the electricity sector's response to the CPRS (by, for example, delaying augmentation of generators, or investing in Carbon Capture and Storage technologies), this has also not been estimated. The extent to which this impact is embodied in electricity generation and network impacts is unclear. In any case, it is anticipated that the likely impact is expected to be marginal.

That said, the relative cost effectiveness of GHG abatement via the proposed amendments, and the total quantum of abated GHG emissions are nonetheless important measures when assessing the appropriateness of the amendments.

Accounting for the CPRS's likely impact on the emissions intensity of electricity, it is estimated that the amendments could reduce the sector's annual emissions by some 470 ktCO2-e by the year 2020.[27] Cumulatively to 2020, the amendments could reduce GHG emissions by 3.0 Mt CO2-e.

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[27] Estimates include thermal and lighting provisions only.

When the abatement from the water heating provisions is considered, annual abatement in 2020 could increase to 600 ktCO2-e (W&A 2009a).[28]

Estimates have been calculated assuming a building life of only 40 years. And as indicated previously, there may be a case to suggest that this estimate is rather conservative. If a dwelling's 'life' continued beyond the assumed 40 years, the total GHG abatement achieved by the policy would increase.[29]

These estimates have been calculated using the most up to date data available. They do incorporate the effects of both the Government's CPRS and RET expansion (under the CPRS-5 scenario), but other policies may be excluded. In particular though, these results have been calculated using economywide averages — and therefore, they may not be directly comparable to jurisdictional estimates. Estimating abatement at the jurisdictional level would require further analysis and detail of the State and Territory specific factors. For example, in Tasmania, the electricity produced through hydro-electric power plants has been in recent decline, at the same time as energy demand has risen. The Shortfall has had to be made up from mainly gas-fired electricity, and more recently, Basslink (IRIS 2009).[30] And as a consequence, the emissions intensity of Tasmanian electricity has necessarily risen. Local factors such as this may not be captured in the abatement figure.

Chart 6.17 plots the annual abatement achieved by the proposed amendments to 2020 (separated by Class 1 and 2 buildings). In total, over 13 MtCO2-e are abated between 2011 and 2061. It is useful to consider the chart with respect to four key phases.

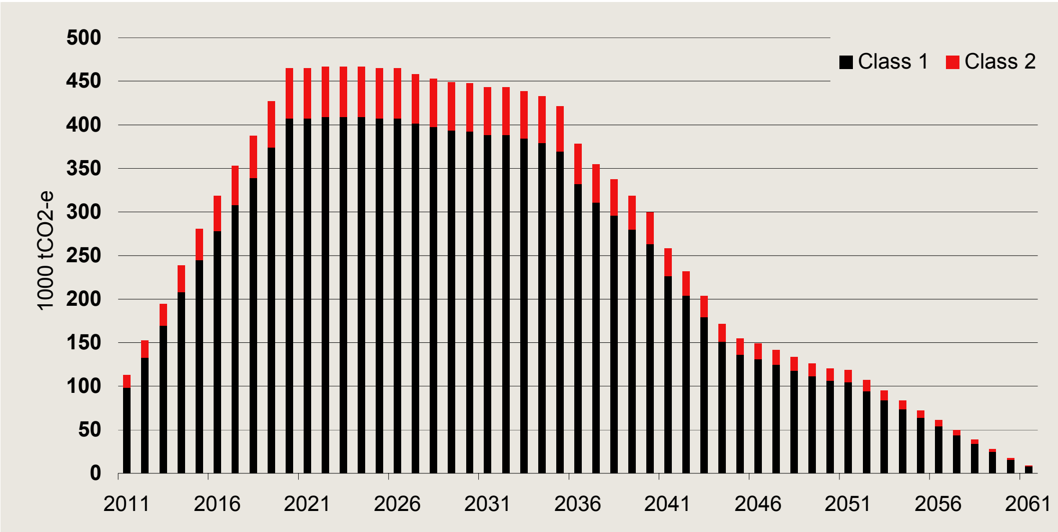
- Over the period 2011-2021, the number of 'post 2010 BCA dwellings' is rapidly increasing, and so too then does abatement.
- At the end of the policy's life (2021), the size of the 'affected' stock remains constant. However, over this period the emissions intensity of electricity declines more rapidly, reducing the annual abatement achieved both per dwelling and overall.

28

29 That said, it should also be noted that the emissions intensity of electricity by 2050 is expected to be well below current levels. Therefore, while GHG abatement will increase with a building life, the increase will not be of an equivalent proportion.

30 The Basslink interconnector enhances security of supply on both sides of Bass Strait. The Basslink project protects Tasmania against the risk of drought-constrained energy shortages while providing Victoria and southern states with secure renewable energy during times of peak demand.

6.17 Annual greenhouse gas abatement from thermal and lighting provisions



Data source: CIE estimates based on Australian Government (2008) and DCC (2009).

- From 2051, cohorts of dwellings built under the 2010 BCA begin to retire. As they do so, the stock of post 2010 BCA dwellings reduces (as does their contribution to GHG abatement).
- Eventually in 2061 (some 40 years after the last cohort of dwellings are added to the stock), all dwellings built during the 2011-2021 period are assumed to have retired, and therefore no longer contribute to GHG abatement.

Including water heating provisions, the GHG abatement that can be expected from the proposed amendments would represent about a half of one per cent of the Australian Government's annual abatement target of 138 Mt CO2-e.[31] While this may appear to be a relatively small contribution, there are several key advantages to pursuing GHG abatement in the building sector.

First, the abatement achieved through the proposed BCA amendments is likely to be low cost. It is now well documented, that energy efficiency investments in the building sector can provide significant low cost, or even negative cost, GHG abatement (CIE 2007). Given the costs and benefits assessed here, abatement can be achieved at a *negative* cost of about $20 per tonne of CO2-e.[32] An increase in a dwelling's life is likely to reduce the cost of abatement even more.

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[31] 138 Mt CO2-e represents a 5 per cent reduction in emissions (relative to 2000 levels) by 2020.

[32] This does not include the abatement from water heating provisions. Including these provisions would reduce the cost of abatement even further.

By comparison, the Treasury estimates that the carbon price under the CPRS will be around $35 by 2020. The reduced abatement cost signifies an increase in overall efficiency, and implies that fewer resources need be diverted (from other economic activities) in order to meet the Government's emissions target.[33]

Second, much of the abatement achieved by the CPRS — especially in the years after 2020 — is achieved by either switching to alternative and renewable energy sources, or by taking advantage of yet to be developed carbon-capture and storage technologies. Implicitly, the Government has assumed that a) the necessary technologies will be available by this time; b) that they will be cost effective; and c) that the economy will have installed the necessary infrastructure to realise this potential. The abatement provided by alternative means — such as through energy efficiency — acts like an insurance policy against the risk that these assumptions will not be fully realised. That is, energy efficiency can reduce GHG emissions without relying on future technological improvements and increases in capacity.

Third, the abatement achieved by the proposed amendments are 'locked in.' The amendments specifically alter the building shell, and in doing so they *install* an amount of GHG abatement that is somewhat autonomous from behavioural change, economic activity, price responses and shifting preferences. Again, it is convenient to think of the abatement delivered by the amendments as an insurance policy against unexpected factors that may affect the abatement potential of other sectors in the economy.

Total economywide benefits

Table 6.18 below summarises the total economy wide benefits assessed in the chapter above. The measures are expected to produce $1.9 billion in benefits (excluding benefits flowing from water heating provisions)

6.18 **Present value of energy savings, $ million**

	Australia
Class 1	1751
Class 2	174
Residential buildings	1925

Note: The data provided by the ABCB assumes that both elemental and simulation compliance measures produce the same energy savings. Benefits from energy saved through water heating

[33] Furthermore, while it is possible that the abatement achieved might impact on the carbon price, estimating the magnitude of this would require the use of a computable general equilibrium model, and is outside the scope of this study.

provisions are not included. A 7 per cent real discount rate has been used to calculate the value of energy savings.

Source: CIE estimates based on Prassad, King and Snow (2009), Australian Government (2008) and data provided by ABCB.

7 Analysis of costs

Similar to benefits, some of the likely costs that will be imposed by the proposed changes may not be incurred at each level of aggregation. Again it is necessary to separate out the associated costs by the scope of the analysis (table 7.1).

7.1 **Analysis of costs**

	Dwelling analysis	*Economywide analysis*
Additional capital outlays	✓	✓
Additional maintenance costs	✓	✓
Administration and enforcement costs [a]		✓
Other compliance costs	✓	✓

a Administration costs are assessed at the national level, but have not been proportioned to States and Territories.
Source: TheCIE.

Dwelling compliance costs

To comply with the proposed 2010 BCA, most dwellings are likely to face increased capital costs. The increased capital costs associated with provisions relating to thermal performance, lighting and outdoor living provisions, as well any additional costs for dwellings are discussed below.

Additional capital outlays for improved thermal performance

Based on BMT & ASSOC cost analysis, compliance with the proposed amendments generally increases construction costs for all building types (that is, house, townhouse, and flat) across all climate zones. The additional capital outlays required for a dwelling to comply with the proposed BCA depend on its location, and range between $800 (townhouse in Perth) and $4 100 (apartments in Sydney, Adelaide and Perth) through simulation compliance; and between $500 (townhouse in

Cabramurra) and $3 300 (house in Brisbane) for elemental compliance.[34] Disaggregated capital cost estimates, by component, e.g. insulation and glazing, by house type and by region are available in the BMT & ASSOC report 'Indicative Elemental Estimate'.

Importantly, being assessed here is the *incremental increase* in capital outlays. Generally speaking, it might be reasonable to expect that the elemental pathway is a more costly means of compliance. (Elemental compliance provides a 'one size fits all' pathway; where as the simulation pathway can be tailored to find the cheapest solution.) Being measured here however, is the *change* in capital costs, not the *total* compliance costs incurred. And moreover, there is no reason to necessarily expect the change in capital costs to be greater or lesser for one pathway relative to another (see box 7.2).

Table 7.3 compares the direct compliance costs for different dwelling types across in each location. Specifically, the table reports the increase in required capital outlays between the 2010 BCA and 2009 BCA elemental provisions, and between the 2010 BCA and 2009 BCA simulation compliance. In other words, the two compliance pathways are compared against their respective baselines. Because the pathway reference points are different, the compliance costs cannot be compared between pathways.

It should also be noted that capital costs are assumed to be constant over time. This is perhaps, a conservative assumption as there may indeed be significant cost savings over this life of the policy. For instance, compliance costs could be reduced as more efficient products become available. Similarly, as the industry 'learns' more about energy efficiency a change in practices and methods could also help to lower compliance costs. The extent to which these factors may reduce capital costs over time however, is unknown. And consequently then, while these savings are acknowledged, compliance costs are assumed constant in the analysis.

[34] Note that while the building sample used to create these estimates may be indicative of the economy as a whole, some caution should be used when interpreting results at a local level. Although the modelling undertaken investigated some low cost approaches to achieving the improved thermal performance standards, it did not assess all low cost options or present a least cost approach.

7.2 Comparing incremental increases

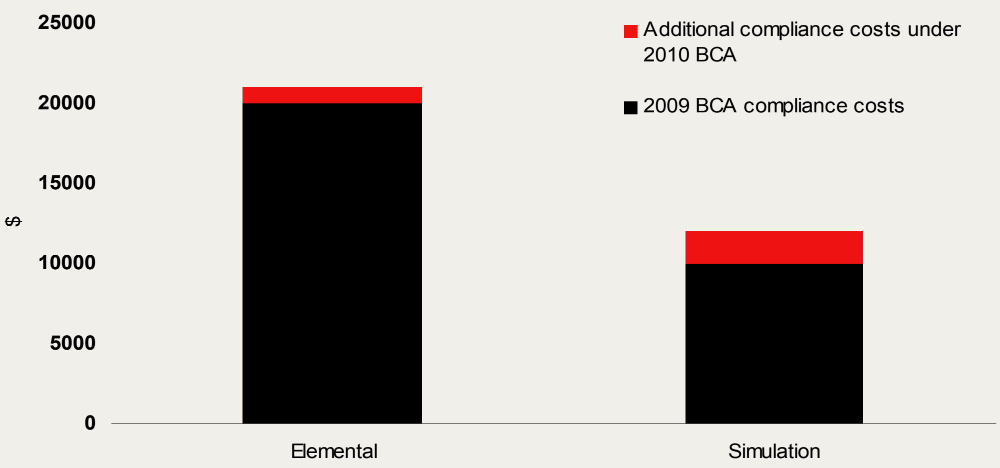
The proposed amendments are expected to require additional capital outlays. This is true for both the elemental and simulation pathways. These costs will add to the costs already imposed by the 2009 BCA.

Generally speaking, it might be reasonable to expect that the elemental pathway is a more costly means of compliance. (Elemental compliance provides a ‘one size fits all’ pathway; where as the simulation pathway can be tailored to find the cheapest solution.) Being measured here however, is the *change* in capital costs, not the *total* compliance costs incurred.

For example, say the amendments required an additional $1000 in capital outlays under the elemental pathway; and $2000 under the simulation pathway. This result would appear counter intuitive — implying that elemental compliance was the cheaper method. However, this would only be the correct inference were the 2010 BCA being compared to a ‘no regulation’ baseline. But the 2010 BCA amendments are being compared to existing regulations under the 2009 BCA. And therefore, this inference neglects the *existing* compliance costs already present.

Under the 2009 BCA, for example, the total costs of elemental compliance might be say $20 000, and only $10 000 under simulation. Although the simulation pathway has a larger *marginal* increase (that is, $1000), the total compliance cost is still cheaper than the elemental approach. This can be seen in the chart below.

In light of this then, the results above imply that the amendments *add* more costs to one compliance method than the other.



7.3 **Required capital outlays for BCA compliance**

	Darwin	Brisbane	Longreach	Mildura	Adelaide	Perth	Sydney	Melbourne	Canberra	Hobart	Cabramurra
Elemental											
House	1729	3307	2702	1924	1457	1578	1844	1669	2853	3091	1335
Townhouse	715	1600	1215	847	804	901	1100	747	1506	1546	536
Simulation											
House	1567	1633	3580	3671	2788	1804	1888	1782	1231	2336	2191
Townhouse	1458	1015	3128	2443	1829	800	1237	1626	1630	1387	2009
Flat	1900	1200	1600	1700	4100	4100	4100	2800	2500	2500	3100
Elemental-simulation average											
House	1614	2119	3325	3165	2402	1738	1875	1749	1701	2555	1943
Townhouse	1242	1184	2573	1980	1532	829	1197	1371	1594	1433	1582
Flat	1900	1200	1600	1700	4100	4100	4100	2800	2500	2500	3100

Note: The elemental-simulation average is a weighted average of the impacts based on the expected market adoption of simulation (71 per cent) and elemental (29 per cent) compliance.
Source: CIE estimates based on BMT&Assoc and data provided by ABCB (refer appendices).

Lighting and outdoor provisions

BMT & ASSOC estimates that complying with the new lighting provisions in the BCA will have minimal or no additional costs. However, it should be noted that the proposed lighting provisions can potentially cause loss of amenity.

A discussion of the amendments for outdoor provisions is provided in appendix L.

Additional costs

It is important that the impact analysis reflects only the *additional* costs of the amendments. Costs already borne by the market (either prior to the introduction of the 2009 BCA, or caused as a result of) should not be assessed in this analysis.

As such, it has been estimated here that no *additional* costs will be incurred as a result of the proposed BCA amendments. This includes no additional:

- operating and maintenance costs;

- design fees;
- costs associated with thermal performance simulation; or
- any other costs not already modelled here.

Economywide costs

Economy wide costs have been assessed assuming 71 per cent of the market adopts simulation based compliance. At the economy wide level, it is likely that the proposed amendments will produce some *negative* impacts:

- an increase in construction capital outlays — with a present value of $2.1 billion;
- industry compliance costs — with a present value of $35 million; and
- increased administration and enforcement costs — with a present value of $250 000.

Each of these items is discussed below.

Additional capital outlays

Between 2011 and 2021, the number of dwellings is expected to increase on average by about 130 000 dwellings per annum (most of which are stand alone houses). Community wide then, in any one year the proposed changes will impose up to $210 million in additional capital outlays[35] (table 7.4).

7.4 **Present value of additional capital outlays for BCA compliance, $ million**

	Australia
Class 1	1982.0
Class 2	166.2
Residential buildings	**2148.2**

Source: CIE estimates based on BMT&Assoc and data provided by ABCB (refer appendices).

Administration costs

Government costs reflect resources required to support the administration of the amended BCA, including the costs incurred to:

- increase awareness of the changes to the BCA; and

[35] All values are expressed in real terms, and no inflation is assumed for capital outlays.

- provide assistance on how to comply.

The ABCB estimates that the additional cost of administering the changes to the BCA (compared to the costs of administering the current BCA) would be around $250 000 for residential buildings. This is a once off cost and no *additional* annual costs are foreshadowed as any ongoing government costs would most likely be included in general BCA ongoing development.

Other compliance costs

In addition to the capital costs of complying with the amended BCA (for example, materials and installation), the industries affected by the BCA (for instance the construction industry and the windows and glass industries) could incur costs beyond those directly associated with the energy efficient materials and designs. For example, complying with the general increase in stringency of the energy efficiency provisions in the BCA could involve significant 'red tape' for industry or require significant up-skilling for builders and certifiers. Additionally, the new provisions may mean that the industry will require capital investment to increase production or redesign some products to meet the new thermal performance requirements under the BCA.

The Australian Institute of Building Surveyors (AIBS) acknowledges the possibility of additional up-skilling costs but suggests that most of the costs associated with changes in the regulation would be absorbed within the Continuing Professional Development (CPD) costs. The AIBS also notes that there may be some other costs which would vary from company to company and State to State, but these costs are believed to be minor. Major changes that require additional assessment work by the surveyor/certifier, such as assessing energy requirements over and above a building assessment would be charged to the consumer and not borne by industry. Given the lack of specific information about the magnitude of these costs and their small nature, they are excluded from the cost-benefit analysis.

In terms of additional capital investment to increase production or redesign some products, the biggest concern has been the capacity and capability of the windows and glass industries to respond to the BCA 2010 thermal performance requirements (to meet demand). A report produced by the Australian Window Association (AWA) in response to these concerns stated that there exists access and availability of high performance products, and that the industry has the capacity and capability to meet a significantly increased demand for these products. However, doing so will impose extra costs on fabricators and system suppliers which in turn will impact the cost of the products.

The AWA report indicates that some of their members would be investing up to $20 million to increase production of double glazed windows and doors; this could mean investment for the whole industry (affecting both commercial and residential buildings) of around $50 million. The ABCB estimates approximately 70 per cent, or some $35 million, would be attributable to BCA amendments impacting on residential buildings. This $35 million has been included in the modelling of the impacts of the BCA changes.

Total economy wide costs

Table 7.5 below summarises the total economy wide costs assessed in the chapter above. In total, the amendments are expected to impose $2.1 billion in costs on the economy.

7.5 **Present value of additional capital outlays for BCA compliance, $ million**

	Australia
Class 1	2016
Class 2	168
Residential buildings	**2184**

Source: CIE estimates based on BMT&Assoc and data provided by ABCB (refer appendices).

8 Net impact assessment

The net impact of the proposed changes has been assessed at both the dwelling and economywide level. The results of this analysis are reported below. For the economy wide results, the assessment reports results across the range of performance compliance options.

All estimates have been calculated using a 7 per cent real discount rate. This reflects the OBPR's preferred discount rate following OBPR response to the Consultation RIS amendments.

Net impact on dwellings

The above results examine costs and benefits separately. However, the proposed amendments are required to demonstrate that they are cost-effective, delivering a positive net benefit. Tables 7.1 and 7.2 below present the results of the net impact analysis. The results reflect the change in the lifetime cost (that is, 40 year life span and discounted using a real rate of 7 per cent). The tables exclude a number of costs and benefits that are accrued at the community level. Further details of the impacts (including the value of costs, benefits and net impacts) are reported in appendix G. For all dwellings and locations the net impact — whether negative or positive — is relatively marginal.

As with capital outlays, the tables assess the *additional* net benefit/cost imposed — not the *total* net benefit/cost of the 2010 BCA (see box 7.2). Caution should be taken when comparing dwellings/locations between pathways.

The impact of the provisions varies widely across building types and climate zones. Depending on the location, BCR ratios for houses using simulation compliance ranged from 0.4 to 3.3; and for houses using elemental compliance, this range was 0.3 to 6.4. Notably, the results for flats varied widely across locations. This result is in part due to a noticeable variance in capital outlays across locations. Only Darwin, Longreach and Mildura produced positive net impacts for Class 2 buildings.

Again, it should be noted that while the building sample used to create these estimates may be indicative of the economy as a whole, some caution should be used when interpreting results at a local level. There may be local influences which may affect the analysis. For instance, impact assessment for Brisbane and Darwin relate to achieving a 6 star energy rating. However, in climate zones 1 (Darwin) and 2 (Brisbane), where climates are conducive to outdoor living for most of the year, there are optional credits of up to 1 star for a covered outdoor living area that meets specific criteria. If a house has a complying outdoor living area, it is likely that people will spend much less time indoors and may not feel the need to install air-conditioning or may significantly reduce their use of any air-conditioning they have. Outdoor living areas are a desirable design feature that can provide energy savings towards achieving the COAG 6-star equivalent. Minimising the need to operate an air-conditioner can also reduce the need for infrastructure upgrades where peak load capacity is being challenged. The star rating target with an outdoor living area is 5.5 stars when either complying roof insulation or at least one complying ceiling fan is installed. The target falls to 5 stars when both are installed. the credits are intended to recognise current good practice in these climate zones.

8.1 **Present value of net impact of thermal and lighting provisions on dwellings**

	Darwin	***Brisbane***	***Longreach***	***Mildura***	***Adelaide***	***Perth***	***Sydney***	***Melbourne***	***Canberra***	***Hobart***	***Cabramurra***
Elemental											
House	1461	-2423	-450	65	62	-558	-1015	4	-1110	-1444	6294
Townhouse	871	-1095	-25	183	115	-320	-634	73	-690	-654	2933
Simulation											
House	1623	-750	-1327	-1683	-1269	-785	-1058	-109	512	-689	5437
Townhouse	128	-510	-1938	-1412	-910	-219	-771	-806	-814	-495	1460
Flat	4391	-454	1301	1323	-2047	-2355	-2192	-1364	-1024	-1254	-1488
Elemental-simulation average											
House	1576	-1235	-1073	-1176	-883	-719	-1045	-77	42	-908	5686
Townhouse	343	-680	-1384	-949	-612	-248	-731	-551	-779	-541	1887
Flat	4391	-454	1301	1323	-2047	-2355	-2192	-1364	-1024	-1254	-1488

Note: The elemental-simulation average is a weighted average of the impacts based on the expected market adoption of simulation (71 per cent) and elemental (29 per cent) compliance.
Source: CIE estimates based on data provided by ABCB (refer appendices).

8.2 **Benefit cost ratio for thermal and lighting provisions — dwellings**

	Darwin	Brisbane	Longreach	Mildura	Adelaide	Perth	Sydney	Melbourne	Canberra	Hobart	Cabramurra
Elemental											
House	1.84	0.27	0.83	1.03	1.04	0.65	0.45	1.00	0.61	0.53	5.72
Townhouse	2.22	0.32	0.98	1.22	1.14	0.65	0.42	1.10	0.54	0.58	6.47
Simulation											
House	2.04	0.54	0.63	0.54	0.54	0.57	0.44	0.94	1.42	0.71	3.48
Townhouse	1.09	0.50	0.38	0.42	0.50	0.73	0.38	0.50	0.50	0.64	1.73
Flat	3.31	0.62	1.81	1.78	0.50	0.43	0.47	0.51	0.59	0.50	0.52
Elemental-simulation average											
House	1.98	0.42	0.68	0.63	0.63	0.59	0.44	0.96	1.02	0.64	3.93
Townhouse	1.28	0.43	0.46	0.52	0.60	0.70	0.39	0.60	0.51	0.62	2.19
Flat	3.31	0.62	1.81	1.78	0.50	0.43	0.47	0.51	0.59	0.50	0.52

Note: The elemental-simulation average is a weighted average of the impacts based on the expected market adoption of simulation (71 per cent) and elemental (29 per cent) compliance.
Source: CIE estimates based on data provided by ABCB (refer appendices).

Note that the above impacts are indicative of typical houses. Even 'special case' homes, such houses H07 — the transportable home — did not produce an atypical result. The net impact H07 ranged between a net cost of $2400 and a net benefit of $1700 (for simulation compliance) depending on location. In Adelaide, where these houses are perhaps more typical, the expected impact was a net cost of $2000 (for simulation compliance).

Net impact on economy

In the preceding chapters it has been demonstrated that the proposed amendments will generate both significant costs and benefits at the economy wide level. This section considers:

- the amendments' net impact;
- the treatment of water heating provisions; and
- the analysis' sensitivity to key variables.

Water heating provisions

This analysis has so far only assessed the impacts of improved thermal performance and lighting provisions. It can be expected that proposed water heating provisions will also produce additional costs and benefits. The impact of these measures has been assessed in a separate report (W&A 2009a), and has been attached as Appendix B.

When comparing against a *no regulation* baseline, W&A (2009a) estimated in their preliminary report that the amendments could generate a net benefit with a present value of $317 million to the community at large (evaluated with real discount rate of 7 per cent). Their counterfactual case excluded current State and Territory legislation regarding water heating (which the BCA proposes to supersede with the amendments considered here).

The report however, recognised that the proposed amendments were unlikely to impact on the capital, energy consumption or GHG emissions in most States and Territories (W&A 2009ba pg. 93). In fact, only Tasmania and the NT were likely to see any noticeable change as a result of the BCA amendments.

The net impacts of the water heating provisions in this analysis are limited to only:

- Tasmania — a $6.5 million net benefit, and abatement in 2020 of 9 kt CO2-e; and
- Northern Territory — an $4.8 million net benefit, and abatement in 2020 of 48 kt CO2-e.

That is, the water heating provisions can be expected to produce a net benefit to the community with a present value of $11.3 million (evaluated with a 7 per cent real discount rate).[36]

W&A's (2009a) assessed impact is included in this analysis as a discrete sum.

Assessment of net impacts

Combined with the thermal performance and lighting provisions assessed in this RIS, the net impact of the proposed BCA amendments has a net cost of about $259 million (this is evaluated with a 7 per cent real discount

[36] Note that this provision has been evaluated at 7 per cent, not 5 per cent as in the rest of this analysis. Relatively then, this estimate is relatively conservative — the present value of this net impact evaluated at a lower rate would necessarily increase.

rate). The combined measures have a BCR of 0.88. Separately, the impact on both building Classes was positive, with Class 2 buildings enjoying a slightly higher result.

Note that the contrast between these results and those for individual dwellings is a product of 1) the distribution of houses across climate zones; and 2) the inclusion of additional 'social' costs and benefits at the economy wide level.

Table 8.3 reports the expected net impact and BCR of the amendments at the economy wide level. Measures relating to thermal performance, lighting provisions and water heating have been identified separately for building Classes 1 and 2.[37]

8.3 **Present value of net impact, economywide, $million**

	Net impact	***Benefit Cost Ratio***
	$ million	BCR
Class 1		
Thermal performance	-441	0.78
Lighting provisions	165	na
Water heating [a]	11	3.10
Total	-265	0.87
Class 2		
Thermal performance	-3	0.98
Lighting provisions	9	na
Total	6	1.03
Residential buildings		
Thermal performance	-444	0.80
Lighting provisions	174	na
Water heating	11	3.10
Total	-259	0.88

a Water heating benefits accrue only to those States that do not currently have water heating provisions.
Notes:
Thermal performance measures include the impact of requiring smaller appliances.
A BCR for lighting provisions cannot been estimated, as it has been estimated that the provision will involve zero costs.
Thermal performance net benefits include $186 million of net benefits accruing through electricity network sourced benefits.

[37] Costs and benefits 'shared' between both building Classes and provisions — such as the impact on electricity generators and government costs — have been allocated to thermal performance. The allocation between building Classes is based on their respective contributions to energy savings (about 95 per cent by Class 1; and 5 per cent by Class 2).

Source: CIE estimates based on data provided by ABCB (refer appendices).

It should be emphasised that while this analysis has drawn on the most relevant and accurate data sources available, where judgment has been used, the analysis has deliberately erred on the side of caution. In light of this then, estimates in the table above can be considered as conservative assessment. (This point is detailed further in the conclusions.)

Distribution of impacts between landlords and tenants

The analysis presented in the sections above mainly focuses on the impacts of the proposed BCA amendments on owner-occupiers of houses. However, a major concern relating to the proposed energy efficiency measures is the existence of split incentives (commonly referred to as the landlord-tenant problem).

As mentioned in a previous section of this report, split incentives is a key market barrier to the provision of energy efficient buildings. This impediment refers to the fact that the costs and benefits of energy efficiency investments may accrue to different agents. In this case, the problem is that the first owner of a residential building will be deemed responsible for the investment in higher cost energy efficiency technologies and practices (that is, for building a more energy efficient house than they would otherwise), while the tenant will receive the benefits of these measures in the form of reduced energy bills.

Arguably, owners of new residential buildings will be disadvantaged by the proposed BCA measures due to one of the underlying market failures that motivated the amendment of the BCA in the first place. However, this will only be the case if potential tenants and buyers of residential buildings systematically undervalue the improvements in energy efficiency.

While the existence of rental premiums and additional capital gains for energy efficient houses are not yet proven in all cases, efforts are underway to quantify these benefits. For instance, DEWHA commissioned the Australian Bureau of Statistics (ABS) to produce a statistical report modelling the relationship between the energy efficiency rating (EER) of houses and house prices in the Australian Capital Territory (ACT) (DEWHA 2008). This report was the first study of its kind in Australia.

The DEWHA report found that a statistically significant relationship exists between the EER of a house and it sales price. Indeed, the report showed that, if a house has a higher EER than another house, but in all other respects the houses are the same, the house with the higher EER will command a higher price in the market. For example, the study found in one of the models studied that if the energy performance of a house improves by 1 star level, on average, its market value will increase by about 3 per cent. Hence, this report shows that, first home buyers can recoup the extra cost of energy efficient features upon resale of the property.

Energy efficient features could also bring financial gain to landlords in the form of higher rents. The relationship between green features and rental premiums for residential buildings has not been proven in the literature. In fact, from the literature search conducted for this RIS in this topic, we were unable to find any study that examined this relationship for residential buildings. Most of the studies analysing the financial benefits of green buildings refer to commercial buildings, where it has been found that some tenants are indeed willing to pay a rental premium of around 3 per cent for a green building.

Against this background it is clear that, while concerns about the landlord-tenant issue are somewhat justified, they should not be overstated.

9 Other impacts and implementation issues

Impacts on housing affordability

The impacts that the proposed BCA changes will have on housing affordability across Australia's capital cities have been analysed using three affordability indicators: the Housing Industry Association — Commonwealth Bank of Australia (HIA-CBA) Housing Affordability Index, the median multiple and the ratio of mortgage repayment to household income.

A brief discussion of each of these indicators is provided in the sections below and additional details about the methodology used to estimate these measures are provided in appendix H.

HIA-CBA Affordability Index

The HIA-CBA Housing Affordability Index measures accessibility to home ownership for an average first-home buyer. The HIA-CBA index divided by 100 shows the number of times that average household disposable income exceeds the minimum income needed to meet repayments on an established dwelling. A decrease in the HIA-CBA index represents reduced affordability.

While the intention of this RIS was to follow the methodology (and inputs) of the HIA-CBA index as closely as possible, the following changes have been made to make it consistent with the analysis of the proposed BCA changes.

- Since the proposed amendments to the BCA will mostly affect new dwellings, for this RIS we have modified the original HIA-CBA index to reflect changes in affordability on the median *new* dwelling. This was done by using in the calculations median house prices for new dwellings instead of the median first home prices used by HIA-CBA (which include all established dwellings). Further, HIA-CBA use the median price of an average established dwelling *purchased by a* *first-home buyer*. [38] Since information about prices of new dwelling by buyer types was unavailable, we have used the 'general' median price for new dwellings (which includes all buyers of new homes) to calculate this indicator.

- Instead of the interest rate used in HIA-CBA March quarter 2009 publication (5.20 per cent), we have used the standard variable interest rate reported by the Reserve Bank of Australia (RBA) (5.8 per cent as at June 2009).
- The *average* household income figures used to calculate the HIA-CBA index remain the same as those published in the latest HIA-CBA report (March quarter 2009). This income figure differs from the income figures used to calculate the other two affordability indicators included in this report (which use the *median* household income figures from the ABS).

The changes made to the data used in the original HIA-CBA index mean that, instead of measuring accessibility to *home ownership for an average first-home buyer*, the HIA-CBA index in this RIS is measuring accessibility to *home ownership for an average new-home buyer* (see table 9.1).

Median multiple

The median multiple (or house price to income ratio) is a measure widely used to evaluate affordability in different housing markets.[39] The median multiple reflects the 'years of gross income' required to purchase a new house within individual markets. A generally accepted definition of affordability is that new house prices should not cost more than 3 times the median household gross income to be affordable.

In contrast to the HIA-CBA index, this affordability indicator measures accessibility to home ownership for the *median* Australian new-home buyer (as opposed to the *average* new-home buyer) (see table 9.1).

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[38] The 'first home buyer' prices used by HIA-CBA in their affordability publication are medians of those dwellings financed by the CBA.

[39] This measure has been used by the World Bank and the United Nations to asses the degree to which housing is affordable by the population. See: Promoting Sustainable Human Development, United Nations, http://www.un.org/esa/sustdev/natlinfo/indicators/ worklist.htm and http://esl.jrc.it/envind/un_meths/UN_ME050.htm and Sectoral Indicators, The World Bank, http://www.worldbank.org/html/opr/pmi/urban/ urban006.html.

9.1 Meaning and interpretation of different affordability indicators

Indicator	*What does it measure?*	*Interpretation*
Original HIA-CBA index	Accessibility to home ownership for an *average first-home buyer*.	Divided by 100 shows the number of times that average household disposable income exceeds the minimum income needed to meet repayments on an established dwelling for a first-home buyer. A decrease in the index represents reduced affordability.
HIA-CBA index in this RIS	Accessibility to home ownership for an *average new-home buyer*.	Divided by 100 shows the number of times that average household disposable income exceeds the minimum income needed to meet repayments on a new dwelling. A decrease in the index represents reduced affordability.
Median multiple	Accessibility to home ownership for the *median new-home buyer*.	Reflects the 'years of gross income' required to purchase a new house. To be affordable, a new house should not cost more than 3 times the median household gross income. A decrease in this measure represents increased affordability.
Ratio of mortgage repayment to household income	Accessibility to home ownership for the *median new-home buyer*.	Indicates the proportion of gross income used for mortgage repayments. A decrease in this measure represents increased affordability.

Source: CIE.

Ratio of mortgage repayment to household income

The ratio of mortgage repayment to household income indicates the proportion of gross income used for mortgage repayments.

Financial institutions have traditionally applied a rule of thumb of not allowing households to take out home loans requiring more than 30 per cent of gross income to service (APRA 2008, p. 3). A government inquiry which looked into housing in the early 1990s concluded that people on low incomes could not afford to pay more than 30 per cent of their gross income on housing (National Housing Strategy 1991, p. 7). This proportion has since become a benchmark.

Table 9.1 presents a comparison of the meaning and interpretation of the different affordability indicators provided in this RIS.

For this RIS, two sets of affordability indicators are calculated:

- a set of affordability indicators based on the price for a new house built according to the *current BCA*; and

- a set of affordability indicators based on the price of a new house built according to an *amended BCA*.

The two sets of affordability indicators are then compared to highlight the effect that the proposed changes would have on housing affordability for the average first-home buyer and the median Australian household.

Two key assumptions are made to calculate these sets of affordability indicators:

- that the current (observed) price for a new dwelling already includes the cost of complying with the current BCA; and
- that, consistent with the overall methodological approach adopted in the RIS, the additional costs and benefits of complying with the amended BCA are fully passed through to property buyers (that is, that the cost of a dwelling under the amended BCA would be the sum of the current dwelling price plus the present value of the net cost/benefit of the proposed changes).

Impacts of the proposed changes on affordability

Table 9.2 summarises the impact of the proposed BCA measures on representative houses in the capital cities of Australia. As mentioned previously in the report, while the new energy efficiency requirements in the BCA will require up-front capital (or financing), the benefits of lower energy use will accrue over time.

As shown in this table, while the new measures included in BCA 2010 will generally increase the construction costs of new dwellings across all capital cities, these increased capital costs will be offset by reduced expenditure on energy. In net terms, the proposed changes will generate costs for owner-occupiers of new houses in most capital cities, except for Canberra and Darwin where owner-occupiers will face additional net cost reductions due to the proposed BCA amendments.

Table 9.3 summarises the effect that the above costs and benefits will have on prices of new houses. As shown in this table, although the new measures will initially increase the price of new houses, these are offset by reduced expenditure on energy, resulting in a net decrease in the price of new houses (in present value terms) in Canberra and Darwin. However, reductions on energy expenditure in Melbourne, Sydney, Brisbane, Perth, Adelaide and Hobart will not be enough to offset the extra costs of the new measures, resulting in a net increase in the price of new houses (in present value terms).

9.2 Impact of the proposed BCA measures on representative house and land packages in capital cities of Australia ($, 2009)

	Total lifetime costs	*Total lifetime benefits*	*Net impact*
Sydney	1875	829	-1045
Melbourne	1749	1673	-77
Brisbane	2119	884	-1235
Perth	1738	1019	-719
Adelaide	2402	1519	-883
Hobart	2555	1647	-908
Canberra	1701	1743	42
Darwin	1614	3190	1576

a These impacts assume that new houses comply with the BCA provisions through the simulation pathway.

Note: Costs and benefits in present value (discounted using a real discount rate of 7 per cent) and compared with BAU.

Source: CIE estimates.

9.3 Impact of the proposed BCA measures on prices of new house and land packages

	Current BCA	*Amended BCA (costs only)*	*Amended BCA (including net impact)*	*Per cent change*
	$	$	$	%
Sydney	517 267	519 142	518,313	0.20%
Melbourne	388 577	390 326	388,653	0.02%
Brisbane	432 707	434 826	433,941	0.29%
Perth	488 167	489 906	488,886	0.15%
Adelaide	370 546	372 948	371,429	0.24%
Hobart	322 143	324 698	323,051	0.28%
Canberra	484 562	486 264	484,520	-0.01%
Darwin	417 807	419 420	416,231	-0.38%

Source: CIE estimates based on RP Data and ABS (2009b).

9.4 Impacts of proposed BCA changes on HIA-CBA housing affordability index

	Current BCA	*Amended BCA*	*Change*
Sydney	123.1	122.8	-0.2
Melbourne	163.9	163.8	0.0
Brisbane	147.2	146.7	-0.4
Perth	130.4	130.2	-0.2
Adelaide	171.8	171.4	-0.4
Hobart	197.7	197.1	-0.6
Canberra	131.4	131.4	0.0
Darwin	152.4	153.0	0.6

Note: Based on dwelling price data from RP Data and the median household income (that is, the midpoint when all people are ranked in ascending order of income). Includes net benefits of complying with the amended BCA shown in table 9.2.

Source: CIE calculations based on RP Data, ABS (2009b) and HIA-CBA (2009).

The above changes in prices of new houses will affect affordability. Tables 9.4, 9.5 and 9.6 show the effect of the proposed changes on the three affordability indicators estimated for this report. The key points of this analysis are summarised below.

- According to the HIA-CBA Affordability Index (see table 9.4), the proposed BCA amendments will:
  - reduce housing affordability in Sydney, Brisbane, Perth, Adelaide and Hobart; and
  - increase housing affordability in Darwin.
- The effects of the proposed changes to the BCA on the ‘years of gross income’ required to purchase a new house (median multiple) are shown in table 9.5. These results show that the proposed amendments will:
  - slightly increase the ‘years of gross income’ required to purchase a new house (median multiple) in Sydney, Brisbane, Perth, Adelaide and Hobart;
  - leave the ‘years of gross income’ required to purchase a new house in Melbourne and Canberra unchanged; and
  - decrease the ‘years of gross income’ required to purchase a new house in Darwin by 0.4 per cent.
- In terms of the effects of the BCA changes on repayments of a typical mortgage, table 9.6 shows that the changes will:

- somewhat increase the monthly loan repayment needed on a typical mortgage for a new house in Brisbane, Sydney, Perth, Adelaide and Hobart;
- leave mortgage repayments relatively unchanged in Melbourne and Canberra; and
- slightly decrease the loan repayments for new houses in Darwin.

9.5 Impacts of proposed BCA changes on the median multiple

	Current BCA	*Amended BCA*	*Per cent change*
	#	#	%
Sydney	8.86	8.88	0.2%
Melbourne	6.65	6.66	0.0%
Brisbane	7.41	7.43	0.3%
Perth	8.36	8.37	0.1%
Adelaide	6.34	6.36	0.2%
Hobart	5.52	5.53	0.3%
Canberra	8.30	8.30	0.0%
Darwin	7.15	7.13	-0.4%

Note: Based on dwelling price data from RP Data and the median household income (that is, the midpoint when all people are ranked in ascending order of income). Includes net benefits of complying with the amended BCA shown in table 9.2.

Source: CIE calculations based on RP Data, ABS (2009b) and HIA-CBA (2009).

9.6 Impacts of proposed BCA changes on the percentage of income used for mortgage repayments

	Annual Mortgage repayment			*% of income used to pay mortgage*	
	Current BCA	*Amended BCA*	*Per cent change*	*Current BCA*	*Amended BCA*
	$	$	%	%	%
Sydney	31,390	31,454	0.20%	53.8%	53.9%
Melbourne	23,581	23,585	0.02%	40.4%	40.4%
Brisbane	26,259	26,334	0.29%	45.0%	45.1%
Perth	29,624	29,668	0.15%	50.7%	50.8%
Adelaide	22,486	22,540	0.24%	38.5%	38.6%
Hobart	19,549	19,604	0.28%	33.5%	33.6%
Canberra	29,405	29,403	-0.01%	50.4%	50.3%
Darwin	25,354	25,259	-0.38%	43.4%	43.3%

Note: Based on dwelling price data from RP Data and the median household income (that is, the midpoint when all people are ranked in ascending order of income). Includes net benefits of complying with the amended BCA shown in table 9.2.

Source: CIE calculations based on RP Data, ABS (2009b) and HIA-CBA (2009).

Industry capacity

The current energy efficiency requirements in the BCA can be achieved by installing roof, wall and ceiling insulation in the main with single clear glazing sufficing for modestly sized windows and glazed doors. With insulation offering diminishing returns, the greatest benefit is in the use of high performance glazing (AWA 2009, p.3). The proposed BCA 2010 effectively changes the glazing requirement from single clear to tinted and/or double glazing for the same glazing area and frame. Alternatively designers may choose to have smaller windows or a combination of reasonable glazing performance and smaller windows. These changes raised concerns about the capacity of industry to respond to the BCA 2010 thermal performance requirements (to meet demand).

In response to these concerns, the ABCB invited the window industry to conduct an assessment of the capacity and capability of the industry (serving both the housing market and the commercial building market) to meet a significantly increased demand for high performance glazing by 1 January 2011.

The Australian Window Association (AWA) conducted a survey among its members aimed at discovering the capability and capacity of the window industry to be able to supply products to meet the new deemed to comply for 6 star energy efficiency requirement in housing and the increased levels of energy efficiency for commercial buildings in Australia.

The AWA membership comprises 360 manufacturing members supplying approximately 80 per cent of the residential housing market. The AWA received responses to the survey from 166 members (equivalent to approximately 46 per cent of their membership). The AWA survey included both fabricators and system suppliers. Of the total number of respondents, 92 per cent (or 152 respondents) were fabricators and 8 per cent (or 14 respondents) were system suppliers. The fabricator demographic was made up of a mix of small, medium and large suppliers.

Results from the fabricators survey indicate that:

- Most fabricators have access to products that perform higher than the current norm for the industry (currently 75 per cent have access to a window with significant performance in U Value and SHGC).
- Most window fabricators currently have the capability to produce double glazed windows (86 per cent of them are currently fabricating high performance products).
- Manufacture of double glazed windows and doors is not a large proportion of the overall products being manufactured. For 70 per cent

of fabricators, the production of double glazed windows and door represents 30 per cent or less of their total production.

- Fabricators have the ability to increase the production of double glazed window and door products to move this product range to be the major product line (75 per cent of their production). The majority of the respondents (76 per cent) suggested that they can do this within a 12 month period. Further, there was positive feedback from the respondents that there will be minimal withdrawal from the industry.
- However, fabricators identified the following difficulties associated with increasing manufacture of double glazed windows and door products:
  - lead-times will increase with the change to the manufacturing mix and there will be a reduction in production efficiency due to the added complexity of double glazed window and door systems;
  - costs will be higher due to increased site glazing, additional cost to product, extra staff and contractors, re-tooling, training, and increased stock and space required in premises (around 28 per cent of the respondents may require new premises);
  - increased OH&S issues due to weight of product including manual handling, transport and possibly an increase in injuries;
  - possible increase in imports at standard sizes, reducing work for local businesses;
  - possible supply issues on extrusion, hardware and glass. Increased complexity in manufacturing process which impacts production time and precision (more room for error).
- Most fabricators (58 per cent) will require capital investment to increase production of double glazed windows and doors. Responses ranged from $20 000 to $1 000 000 dollars to be invested depending on the size of the fabricator. Investment would generally be required for lifting equipment, tooling, and creating site glazing departments, transport equipment, increased stock and some possible IGU lines.

The key results from the system suppliers' survey are that:

- System suppliers can make tooling available for fabricators to manufacture double glazed windows and doors within a six -month period but significant investment is required by this section of the industry for the redesign of suites.
- Most systems suppliers (86 per cent) have a full range of double glazed windows and doors available for fabricators to supply to the housing and commercial market.
- For double glazed window and door systems to become mainstream suites in the market, redesign will be needed by some of the systems

suppliers. Most of this redesign work required can be completed within 18 months.

In addition to the survey conducted by AWA, information on capacity of the glass industry to supply high performance products was supplied by the Australian Glass and Glazing Association (AGGA) and Viridian. The key points about glass availability are summarised below.

- Tinted glass products — there is unlimited supply of tinted glass products available from local and international sources. This means that the glass industry can supply the products to meet the required demand even with significant increases.
- Low E glass products — new Viridian coating line capable of producing 40 000 tones per annum which is 4 times the current market penetration. Imported product is also available from many suppliers.
- IGU products — the current utilisation of national IGU capacity is running at between 50 – 70 per cent. Capacity can be increased depending on demand. New IGU lines are being installed throughout the country increasing capacity further. The large commercial market generally sees more imported product being utilised rather than locally manufactured product.

Conclusion

There is access and availability of high performance products and the industry has the capacity and capability to meet a significant increase in demand for these products. However, doing so will impose extra costs on fabricators and system suppliers which in turn will impact the cost of the products. The AWA report indicates that survey respondents would be investing up to $20 million; this could mean investment for the whole industry of around $50 million (AWA 2009, p. 37).

Additional details about this survey can be found in AWA (2009).

Competition effects

The principles of best practice regulation outlined in COAG (2007) set out specific requirements with regards to regulatory process undertaken by all governments. In particular, Principle 4 of Best Practice Regulation states that:

> in accordance with the Competition Principles Agreement, legislation should not restrict competition unless it can be demonstrated that:
>
> a. the benefits of the restrictions to the community as a whole outweigh the costs; and

b. the objectives of the regulation can only be achieved by restricting competition.

As such, COAG requires that all RISs include evidence that:

- the proposed regulatory changes do not restrict competition; or
- the changes can potentially restrict competition but the public benefits of the proposed change outweigh the costs and the objectives of the changes can only be achieved by restricting competition.

A preliminary assessment indicates that the proposed BCA changes can potentially reduce competition through:

- a reduction of choice available to consumers as a result of the mandatory use of more energy efficient materials in the construction of new houses; and
- a reduction in the number of suppliers and/or numbers of products available in the market if existing products have to be redesigned/ improved in response to more stringent BCA requirements.

This potential reduction in competition could lead to higher prices than otherwise and increase the costs of complying with the new BCA measures. However, the BCA measures will also increase demand for energy efficient products, which may result in no net reduction in competition but just a shift in the mix of products supplied in the market. At the time of writing the consultation and final RISs, there was insufficient information to allow the CIE to fully assess the net effect that the proposed BCA amendments will have on competition in all the different industries affected by the new measures.

However, the survey conducted by the AWA and described in the previous section provides information that can be used to assess the likely effects of the BCA measures on competition in the windows and glass industry. Results of the AWA analysis show that the proposed changes are not likely to reduce competition in this industry. In particular, the study shows that:

- there will be minimal withdrawal from the industry as a result of the proposed BCA changes (95.3 per cent of the survey respondents said they will continue in the industry if demand for double glazed window and door products increases to 75 per cent);
- most fabricators have access to products that perform according to the increased energy efficiency stringency proposed in the BCA;
- while some products need to be redesigned to meet the new BCA requirements, the industry is capable of doing most of the redesign work required, and this work can be completed within 18 months.

While the AWA study sheds some light into the likely impacts on competition in the windows and glass industry, further information is required to assess the likely competition effects on other industries affected by the BCA changes (including the construction industry).[40] In this respect, the consultation process following the release of the Consultation RIS generally served as a good opportunity to overcome some of these gaps in knowledge and gather information about the extent to which the proposed changes will impact the market structure of other relevant industries. Outcomes from the consultation process are provided in Chapter 11.

Review

Effective regulation is an important tool for delivering Australia's social and economic goals. However, over-regulation is a major concern to all Australian businesses and to the community generally. Therefore regulation needs to be introduced and managed in a way that does not impede economic activity or impose unnecessary costs.

The ABCB recognises that the BCA needs to be continually developed and enhanced to take into account new initiatives, research and practices. The ABCB also recognises that the BCA needs to be reviewed periodically to ensure it continues to reflect contemporary and future regulatory needs (ABCB 2007b).

The proposed changes to the BCA would be subject to review in the same way as any other provision in the BCA. The ABCB allows any interested party to initiate a Proposal for Change (PFC) process to propose changes to the BCA. This is a formal process which requires proponents of change to provide justification to support their proposal.

PFCs are considered by the ABCB's Building Codes Committee (BCC) each time it meets. The role of the BCC, which consists of representatives of all levels of government as well as industry representatives, is to provide advice, guidance, and make recommendations relating technical matters relevant to the BCA. If the proposal is considered to have merit, the BCC may recommend that changes be included in the next public comment draft of the BCA, or for more complex proposals, it may

[40] In particular, the ability of builders to understand and apply the changes needs to be evaluated.

recommend that the proposal be included on the ABCB's work program for further research, analysis and consultation.

This process means that if the measures proposed in the 2010 BCA are found to be more costly than expected, difficult to administer or deficient in some other way, it is open to affected parties to initiate a PFC. The fact that the BCA is reviewed and, if necessary, amended every year means that the lead time for changes can be relatively short.

Additionally, to encourage continuous review and feedback on the BCA the ABCB maintains regular and extensive consultative relationships with a wide range of stakeholders. In particular, a continuous feedback mechanism exists and is maintained through State and Territory building control administrations and industry through the BCC. These mechanisms ensure that opportunities for regulatory reform are identified and assessed for implementation in a timely manner.

Apart from reviewing the technical content of the BCA, the States and Territories can review which parts of the BCA are called up in their building regulations and whether they wish to substitute their own jurisdictional appendices for certain general provisions. Alternatively, they may decide that new general provisions make it unnecessary to maintain separate provisions. In some cases State or Territory building regulations may themselves be subject to 'sunset' or regular review clauses (Wilkenfeld 2009a).

As with all other aspects of the BCA, the effectiveness and observed impacts of the proposed energy efficiency measures should be monitored. The analysis in this RIS has been undertaken based on the best information currently available and it will be necessary to verify how the building industry and suppliers of energy efficient materials and equipment do in fact respond.

10 Consultation process

This chapter provides details about current ABCB consultation processes and additional energy efficiency specific consultation for the residential proposal. It is organised under three headings:

- a discussion about the ABCB Consultation Protocol;
- an overview of the ABCB Impact Assessment Protocol; and
- a summary of the ABCB communication strategy and consultation process for the 2010 BCA.

Chapter 5 presented an overview of the submissions that were received in the consultation period, and following on from the change in discount rate as presented in chapters 6, 7 and 8, chapter 11 will present further sensitivity analyses on other issues raised in submissions to the Consultation RIS.

ABCB consultation protocol

The ABCB is committed to regularly review the BCA and to amend and update it to ensure that it meets changing community standards. To facilitate this, the ABCB maintains regular and extensive consultative relationships with a wide range of stakeholders. In particular, a continuous feedback mechanism exists and is maintained through State and Territory building control administrations and industry, through the Building Codes Committee. These mechanisms ensure that opportunities for regulatory reform are identified and assessed for implementation in a timely manner.

All ABCB regulatory proposals are developed in a consultative framework in accordance with the Inter-Government Agreement. Key stakeholders are identified and approached for inclusion in relevant project specific committees and working groups. Thus, all proposals have widespread industry and government involvement.

The ABCB has also developed a Consultation Protocol, which includes provisions for a consultation process and consultation forums. [41] The

[41] Available on http://www.abcb.gov.au/index.cfm?objectid=49960DC7-BD3E-5920-745CE09F1334889C.

Protocol explains the ABCB's philosophy of engaging constructively with the community and industry in key issues affecting buildings and describes the various consultation mechanisms available to ABCB stakeholders.

The ABCB's consultation processes include a range of programs that allow the ABCB to consult widely with stakeholders via:

- the proposal for change process;
- the release of BCA amendments for comments;
- regulatory impact assessments;
- impact assessment protocol;
- research consultations;
- ABCB approval that reports directly to ministers responsible for buildings; and
- international collaboration.

The Protocol also ensures that the ABCB engages with their stakeholders via a range of events and information series through:

- the Building Codes Committee with representatives from a broad cross section of building professions and all levels of government;
- its consultation committees;
- public information seminars;
- its biennial National Conference;
- its technical magazine, the Australian Building Regulation Bulletin (ABRB);
- its online technical update, ABR Online;
- its free 1300 service advisory line which provides information for industry and the general public to clarify BCA technical matters and access technical advice about provisions; and
- the ABCB website.

ABCB impact assessment protocol

The ABCB Impact Assessment Protocol ensures that the impact assessment processes are accountable and transparent, and allow for significant stakeholder consultation and participation. The impact assessment processes include:

- Proposals for Change (PFC) which require a change-proposer to justify any projected amendment to the BCA, in accordance with COAG regulatory principles. All PCFs are consulted on and in some instances considered by the BCC attended by industry representatives, government officials and members of the research community;

- Preliminary Impact Assessments (PIA) which allow for early-stage impact analysis of proposed changes to the BCA. Although complementary to the PFC process, a PIA allows for a more thorough impact assessment to be carried out by the ABCB; and
- Regulation Impact Statements (RIS) which provide a comprehensive assessment of the impacts of proposed regulation in accordance with the COAG guidelines.

ABCB communication strategy and consultation process for the BCA 2010 energy efficiency proposal

The communication strategy for the new energy efficiency requirements in BCA 2010 comprises a three pronged approach as outlined in the sections below. Additionally, a schedule of key events and outputs is provided in table 9.1 .

1. A series of stakeholder presentations rolled out over 12 months. Several of these major events involving live web casts made available for download shortly after the event. In addition, the proposed new energy efficiency provisions will be a key focus of the BCA 2010 information seminar series. Stakeholders will be kept informed of upcoming events via email alerts and information alerts on the website.
2. Complementary information supporting that communicated at the key stakeholder presentations, national conference and information seminars disseminated via additional awareness and training materials such as:
   - resource kits;
   - handbooks (Existing Building, Housing Extension & On-site Construction);
   - self-paced on line training modules;
   - feature articles in publications (for instance ABRB and E-ABR);
   - documents (for instance the regulatory proposals and RIS), placed on the ABCB website;
   - tools (for instance, glazing and lighting calculators), placed on the ABCB website; and
   - FAQ page on the website, including responses to 1300 enquiries.

3. Maximise multiplier opportunities by engaging with State and Territory administrations, industry associations and educational institutions and their constituents/members. The ABCB will:
   - forward the schedule of proposed key events in table 9.1 to organisations for the promotion of upcoming events;
   - provide assistance with the efforts of key organisations to disseminate information to their constituents/members;
   - offer to attend and to speak at prime national conferences of key stakeholders; and
   - offer to attend meetings of peak educators and universities.

10.1 Proposed schedule of key events and outputs

Event	*Key dates*	*Outputs*
Post proposal development		
COAG agreement to new energy efficiency requirements for BCA 2010	28 May 2009	Stakeholder Information Forum in Canberra. Q&A session. Information dissemination about energy efficiency project.
Consultation Draft of BCA proposal released for public comment	17 Jun 2009	Stakeholder Presentation of BCA draft proposal. Full day format, am Vol One, pm Vol Two. Live web cast with moderated Q&A session. Explain proposed BCA changes & encourage submission of comment.
	19 Jun 2009	On demand web cast of BCA draft proposal presentation available for download on website. Broad dissemination of information & request for comment.
Email alerts to subscribers, peak industry bodies and registered parties	Ongoing	Regular email alerts about Energy Efficiency developments and events sent to BCA subscribers, peak industry bodies and those who have registered their interest. Stakeholders invited to register to receive information about Energy Efficiency developments.
Energy Efficiency updates on website	Ongoing	Regular alerts, up to date information and new documents uploaded to Energy Efficiency page on website.
FAQ page on website	Ongoing	Inbox for questions established. 1300 inquiry relating to Energy Efficiency monitored. Q&As regularly uploaded to Energy Efficiency FAQ page on website.
Spring edition of ABRB	25 Aug 2009	Several energy efficiency articles featured.

Event	***Key dates***	***Outputs***
Consultation RIS released for public comment	Sep –- Oct 2009	Stakeholder Presentation of Consultation RIS.
		Half day format.
		Web cast with moderated Q&A session.
		Explain RIS findings & encourage submission of comment.
	Oct 2009	On demand web cast of Consultation RIS presentation available for download on website.
		Broad dissemination of information & request for comment.
National Conference BAF 2009	23 Sep 2009	Energy Efficiency day.
		Presentation on proposed BCA provisions & changes.
		Workshop on using software.
Subject to Board/government decision		
Summer edition of E-ABR	Feb 2010	Several energy efficiency articles featured.
BCA 2010 Information Seminar series in all capital cities	Mar – April 2010	Stakeholder Presentation of key amendments included in BCA 2010.
		Training to encourage practitioner uptake of software, demonstrating it is easy to use, making practitioners more comfortable with using software.
Resource Kit, Modules 3 & 4 updated	Apr – Jun 2010	Update training resource to mirror new BCA provisions.
Existing Building, Residential Extension and On-site Construction Handbooks updated	Apr – Jun 2010	Update handbooks to mirror new BCA provisions.
Glazing and Lighting Calculators updated	Apr –Jun 2010	Update calculators to mirror new BCA provisions.
Electrical Appendix to AS3000 updated	Apr – Jun 2010	Update Electrical Appendix to AS3000 to mirror new BCA provisions.
		(and possible new Handbook developed).
Self paced on-line training modules	Apr – Jun 2010	New modules in energy efficiency / calculators developed for online training.

Source: ABCB.

11 Consultation sensitivity analysis

This section considers the implications for the BCR for elements of optimism and pessimism bias, as well as contentions of fact drawn out through the stakeholder consultation period.

The main issues of fact and methodology that are considered here are:

- discount rate; and
- housing affordability.

The main issues of optimism bias that were raised and are considered here are:

- building costs (also pessimism bias); and
- regional weightings.

The main issues of pessimism bias that are considered here are:

- electricity and carbon prices.

The results and discussions in this sensitivity analysis section are scenario based. That is, where there are issues raised, the impact that these changes in estimates and assumptions could have on the BCR presented in the draft RIS are estimated. This methodology of sensitivity analysis, in contrast to the Monte-Carlo based sensitivity analysis provides insight into the direct effect of individual assumption changes rather than a collection of assumption changes.

Discount rate

The utilisation of a 5 per cent discount rate in the Consultation RIS, below the general practise set out by the OBPR raised a number of queries throughout the consultation period. In this section, the impact of a 5 and 7 per cent discount rate on the value of thermal energy savings as well as the regional BCRs are presented.

From table 11.1 below, it can be seen that the increase in the discount rate from 5 to 7 per cent reduced the value of thermal and lighting provisions on dwellings. For example, the value of thermal and lighting provisions in Melbourne under a 5 per cent discount rate is estimated at approximately $298 and under a 7 per cent discount rate, this is reduced to approximately -$29, that is, a net decrease in benefits. Under a 6 per cent discount rate, this figure is $122. Note that these results are based on 71:29 breakdown of simulation: elemental compliance.

11.1 **Present value of net impact of thermal and lighting provisions on dwellings – 5 and 7 per cent discount rates**

	Darwin	***Brisbane***	***Longreach***	***Mildura***	***Adelaide***	***Perth***	***Sydney***	***Melbourne***	***Canberra***	***Hobart***	***Cabramurra***
Elemental-simulation average 5 per cent discount rate											
House	2295	-1048	-576	-737	-553	-498	-871	298	431	-541	7415
Townhouse	691	-585	-1134	-735	-428	-136	-648	-382	-609	-356	2659
Flat	5805	299	1940	1986	-1599	-1972	-1779	-1058	-707	-991	-1131
Elemental-simulation average 7 per cent discount rate											
House	1624	-1187	-1025	-1128	-835	-671	-997	-29	90	-860	5734
Townhouse	364	-659	-1363	-929	-592	-227	-710	-531	-758	-520	1908
Flat	4419	-427	1328	1350	-2020	-2327	-2165	-1337	-996	-1227	-1461

The effect on the BCR from altering the discount rate follows the same pattern, where an increase in the discount rate lowers the value of future benefits, and reduces the estimated BCR. Following the results for a house in Melbourne again, under a 5 per cent discount rate, the BCR is approximately 1.17, under a 6 per cent discount rate it is approximately 1.07 and under a 7 per cent discount rate, the BCR reduces below 1 to 0.98.

It should be noted that changes in the discount rate have a negligible impact on housing affordability estimates as those costs incurred in the first few years are not significantly altered. The next section considers the impact of changes in the methodology of assessing housing affordability impacts which do have implications for these measures.

11.2 **Benefit cost ratio for thermal and lighting provisions on dwellings – 5 and 7 per cent discount rates**

	Darwin	*Brisbane*	*Longreach*	*Mildura*	*Adelaide*	*Perth*	*Sydney*	*Melbourne*	*Canberra*	*Hobart*	*Cabramurra*
Elemental-simulation average 5 per cent discount rate											
House	2.43	0.56	0.84	0.84	0.84	0.72	0.54	1.17	1.45	0.80	5.06
Townhouse	1.73	0.53	0.67	0.79	0.83	0.84	0.46	0.82	0.62	0.75	3.79
Flat	4.06	0.75	2.21	2.17	0.61	0.52	0.57	0.62	0.72	0.60	0.64
Elemental-simulation average 7 per cent discount rate											
House	2.01	0.44	0.69	0.64	0.65	0.61	0.47	0.98	1.05	0.66	3.95
Townhouse	1.29	0.44	0.47	0.53	0.61	0.73	0.41	0.61	0.52	0.64	2.21
Flat	3.33	0.64	1.83	1.79	0.51	0.43	0.47	0.52	0.60	0.51	0.53

11.3 **Present value of net impact, economywide**

	Net impact	***Benefit Cost Ratio***
	$ million	BCR
Total – 5 per cent discount rate	296	1.13
Total – 7 per cent discount rate	-259	0.88

The national level results from different discount rates are presented in table 11.3. That is, moving to a 7 per cent discount rate results in a $259 million net loss to the economy.

Housing affordability

The methodology used in the Consultation RIS to estimate the impact of the proposed regulation on housing affordability included measures of the net lifetime benefits of increased energy efficiencies of running the house. That is, the net benefits were utilised to offset the calculation of the increase in the house price. This methodology has been noted to be inconsistent with the capital market supplying home loans, where it is only the upfront purchase price of the house and the income of borrowers that are used to determine the conditions of a home loan.

The reasoning behind offsetting upfront price increases with the net benefits of the energy efficiency measures is that where there is a reduction in the running costs of a house, there is an increase in the amount of income available to service the loan and this should be considered in the lending criteria. Where this is not taken into consideration, this could be considered a capital market failure.

Suggestions through the stakeholder consultation period to overcome this market failure include the provision of ‘green loans’ to help bridge this deposit gap in purchasing energy efficient homes.

However, where this capital market failure is not corrected, the analysis of the proposed BCA changes to housing affordability should take this into account. The following tables replicate the housing affordability analysis that was presented previously, using only the increased capital costs without offsetting these with lifetime net benefits.

11.4 Impact of the proposed BCA measures on representative house and land packages in capital cities of Australia ($, 2009)

	Total lifetime costs	*Total lifetime benefits*	*Net impact*
Sydney	1875	0	1875
Melbourne	1749	0	1749
Brisbane	2119	0	2119
Perth	1738	0	1738
Adelaide	2402	0	2402
Hobart	2555	0	2555
Canberra	1701	0	1701
Darwin	1614	0	1614

The above table indicates that where only the increased capital costs are included, there is a net increase in representative house and land packages across Australia from the proposed changes to the BCA 2010.

Taking into account the average price of new house and land packages across Australia, table 11.5 below indicates that there will be between 0.35 per cent and 0.79 per cent increase in average costs.

In table 11.6, the impact these cost increases is estimated to have on the HIA-CBA housing affordability index is detailed. Overall, there is a reduction in housing affordability across Australia, with the change in the index depending on the proportionality of cost increases relative to base prices for house and land packages.

The median multiple estimations in table 11.7 provide an indication of the ‘years of gross income’ required to purchase a new house. The cities in which there is the greatest increase in the median multiple are Hobart, Adelaide, Brisbane and Sydney.

11.5 Impact of the proposed BCA measures on prices of new house and land packages

	Current BCA	*Amended BCA (costs only)*	*Amended BCA (including net impact)*	*Per cent change*
	$	$	$	%
Sydney	517 267	519 142	519 142	0.36
Melbourne	388 577	390 326	390 326	0.45
Brisbane	432 707	434 825	434 825	0.49
Perth	488 167	489 906	489 906	0.36
Adelaide	370 546	372 948	372 948	0.65
Hobart	322 143	324 698	324 698	0.79
ACT	484 562	486 264	486 264	0.35
Darwin	417 807	419 420	419 420	0.39

11.6 Impacts of proposed BCA changes on HIA-CBA housing affordability index

	Current BCA	*Amended BCA*	*Change*
Sydney	123.1	122.7	-0.4
Melbourne	163.9	163.1	-0.7
Brisbane	147.2	146.4	-0.7
Perth	130.4	130.0	-0.5
Adelaide	171.8	170.7	-1.1
Hobart	197.7	196.1	-1.6
ACT	131.4	130.9	-0.5
Darwin	152.4	151.8	-0.6

11.7 Impacts of proposed BCA changes on the median multiple

	Current BCA	*Amended BCA*	*Per cent change*
	#	#	%
Sydney	8.86	8.89	0.4%
Melbourne	6.65	6.68	0.5%
Brisbane	7.41	7.45	0.5%
Perth	8.36	8.39	0.4%
Adelaide	6.34	6.39	0.6%
Hobart	5.52	5.56	0.8%
ACT	8.30	8.33	0.4%
Darwin	7.15	7.18	0.4%

Revised calculations of the percentage of income used for mortgage repayments are presented in table 11.8.

11.8 Impacts of proposed BCA changes on the percentage of income used for mortgage repayments

	Annual Mortgage repayment			*% of income used to pay mortgage*	
	Current BCA	*Amended BCA*	*Per cent change*	*Current BCA*	*Amended BCA*
	$	$	%	%	%
Sydney	31 390	31 504	0.36	53.8	53.9
Melbourne	23 581	23 687	0.45	40.4	40.6
Brisbane	26 259	26 387	0.49	45.0	45.2
Perth	29 624	29 730	0.36	50.7	50.9
Adelaide	22 486	22 632	0.65	38.5	38.8
Hobart	19 549	19 704	0.79	33.5	33.7
ACT	29 405	29 509	0.35	50.4	50.5
Darwin	25 354	25 452	0.39	43.4	43.6

Building costs

Estimating the effect that new regulations will have on building costs prior to implementation is extremely difficult. A large number of factors are highly uncertain, especially in the case of the proposed changes to BCA 2010 with compounding effects of associated policies such as the CPRS. Additional complications are generated because there has not been an ex post implementation review of the impact that the 5 star energy rating regulations had on building costs.

A further issue raised with the estimates of building costs in the Consultation RIS include the omission of any transitional costs associated with the proposed regulations. These transitional costs were not included based on the assumption that the marginal move from 5 to 6 star regulations would not impose significant transitional costs.

Through the consultation period, there were submissions drawing reference to the transitional costs included in both the 5 star RIS, as well as internationally with respect to energy efficiency policy changes. In general, 5 per cent of additional capital costs are included to account for these transitional costs.

Apart from these transitional costs, a number of stakeholder submissions have provided evidence on the effect of the proposed BCA 2010 changes on base line building costs. Submissions were received that suggested:

- significant underestimation of the additional build costs (by up to four fold), based on surveys of builders;
- lower additional building cost might eventually be achieved due to learning by doing;
- design changes could further reduce additional building costs; and,
- the initial estimates presented in the Consultation RIS seemed to be consistent with experience of voluntarily introducing 5 and 6 star standards in Western Australia.

Although estimated by an independent quantity surveyor, the additional building costs estimated and reported in the Consultation RIS are, by their very nature, somewhat theoretical and untested. Moreover, because there has not been an independent ex post assessments of the costs incurred with the introduction of the 5 star BCA provisions, considerable uncertainty (and suspicion) surrounds the estimates of increased building costs. Equally, the claims of considerably higher building costs from industry stakeholders have not been independently verified. Nonetheless, the claims are from those with practical experience of building costs.

Initially, an additional 5 per cent has been added to the capital costs to allow for potential transitional costs, resulting in a loss of $366 of net benefits, returning a BCR of 0.84. These results are presented in table 11.9.

With respect to uncertainty around the base building costs, building industry associations presented submissions with evidence on potential changes to building costs due to the proposed BCA 2010 changes. While there was a large spread in these estimates, scenarios on 50 per cent higher, and 100 per cent higher build costs than those presented in the Consultation RIS are presented here. This range covers the majority of estimates presented in these two submissions. To further identify the sensitivity of the BCR estimates, a 20 per cent reduction in additional build costs – to account for potential market responses – has also been included.

In table 11.9, the results of these scenarios are presented. It should be noted that the base line for these scenarios is that of the Consultation RIS, with a 7 per cent discount rate.

11.9 **Present value of net impact, economywide, $million**

	Net impact	***Benefit Cost Ratio***
	$ million	BCR
Total – 20% reduction (1% of total capital costs)	171	1.10
Total – base building costs	-259	0.88
Total – 5% loading (1.31% of total capital costs)	-366	0.84
Total – 50% loading (1.9% of total capital costs)	-1333	0.59
Total – 100% loading (2.5% of total capital costs)	-2407	0.44

With an initial BCR of 0.88, increasing the capital construction costs by 50 per cent has the effect of reducing the BCR to 0.59, with net costs to the economy of $1 333 million. A doubling of the estimated capital costs results in a net costs to the economy of $2.4 billion, with a BCR of 0.44. In contrast, a 20 per cent reduction in the additional build costs results in a net benefit of $171 million and a BCR of 1.10.

Regional weightings

Throughout the RIS, benefits and costs of the regulation are calculated at a regional level, and aggregated to a national level based on the value of costs and benefits at these regional levels, and projections of households across climate zones and capital cities.

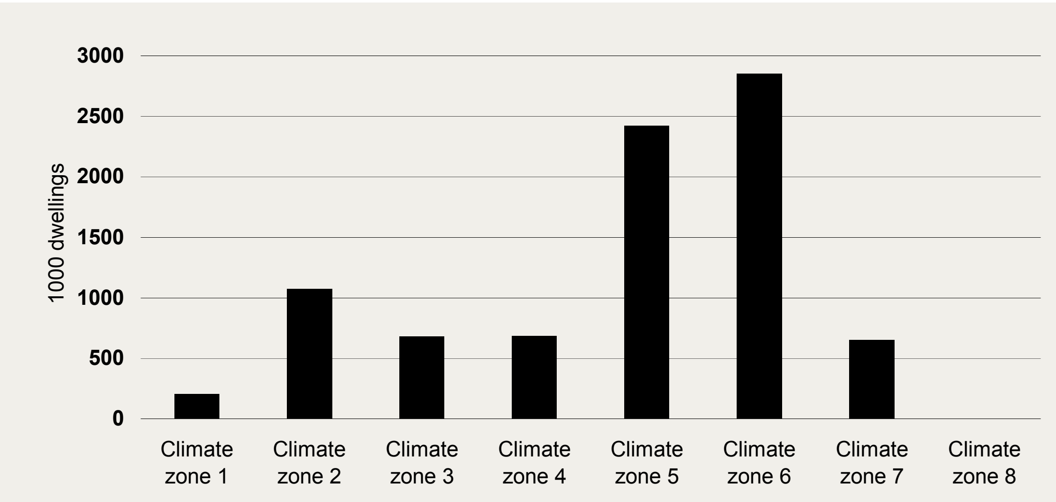
A number of stakeholder submissions have raised questions on these aggregation methods, specifically how a positive BCR can be derived where there are more major capital cities with negative regional BCRs than positive.

Due to computational limitations within the Consultation RIS, cities across Australia were chosen to be representative of climate zones. Chart 11.10 shows the proportion of total housing stock by climate zone for reference.

Through the calculations, capital cities were used to represent savings across climate zones. For example, climate zone 7 is a weighted average of Canberra and Hobart and climate zone 5 is a weighted average of thermal savings from Sydney, Adelaide and Perth. In contrast, climate zone 6 results are drawn solely from estimated thermal savings of Moorabbin in Melbourne. This potentially causes some discrepancies as 32 per cent of new houses expected to be built in NSW are located in climate zone 6, and most of these are located in the western areas of Sydney.

However the estimated decreases in thermal energy consumption in Melbourne are approximately 6 times greater than those estimated for Sydney. More disaggregated climate data shows that while western Sydney may experience more energy savings than eastern Sydney, these estimates are nowhere near what is estimated for Melbourne. Indeed they are closer to those of the east Sydney estimates than to Melbourne.

11.10 **Total housing stock by climate zone, 2010**



Data source: Extrapolated from CIE (2009a).

11.11 **Results of re-weighting of climate zones 5 and 6**

	Net benefits, $m	***Benefit Cost Ratio***
Total	-333	0.85

Given this information, an illustrative calculation of the sensitivity of the total BCR to these locational assumptions has been made. The results of relocating 35 per cent of the climate zone 6 dwellings (by dwelling type) into climate zone 5 are presented in table 11.11. These results will be more indicative of a national BCR if Melbourne is not considered to be a good representation of all of climate zone 6. Such a movement of dwellings results in a national BCR of 0.85, with an associated reduction of net costs of approximately $333 million.

Further potential anomalies within the regional weighting calculations are associated with climate zone 8. Projections of residential housing stock growth in climate zone 8 are based on a proportion of growth in the Australian residential housing stock. Figures in the draft RIS assume approximately 1000 new houses per year to be built across climate zone 8 into the future. And climate zone 8 has the largest potential savings of any zone because it is the very cold alpine zone. This assumption results in approximately $57 million of net benefits. Given climate zone 8 is a purely alpine region with a currently very small building stock, these projections may be grossly over-estimating the future growth of the region.

If this growth in climate zone 8 is removed from the estimate of national net benefits, in conjunction with the readjustment of dwellings across climate zones 5 and 6, the net costs increase to $390 million, with an associated BCR of 0.82. These results are presented in table 11.12.

11.12 **Results of re-weighting of climate zones 5 and 6 and removal of climate zone 8**

	Net benefits, $m	***Benefit Cost Ratio***
Total	-390	0.82

Overall, these scenarios illustrate the sensitivity of the estimated BCR to assumptions of regional weightings and growth projections in the building stock across regions in Australia. Where the underlying assumptions place increased growth in regions with higher net benefits, an upward, or optimism bias in the estimates may result.

Electricity and carbon prices

The BCR estimates in the Consultation RIS consider only one climate policy scenario CPRS-5. Benefits from reduced electricity use in dwellings has been estimated based on Treasury projections of movement in average Australian wholesale electricity prices, accounting for state based retail differences, under the CPRS-5 scenario. In this scenario, global GHG emissions are required to stabilise at 550ppm, with Australia’s national emissions reaching 5 per cent below 2000 levels by 2020. By 2050, Australia’s emissions are required to be 60 per cent below 2000 levels.

CPRS-5 is the least stringent climate policy scenario that has been modelled by Treasury in the report 'Australia's Low Pollution Future'. Further policy scenarios that have been considered are:

- CPRS-15: By 2050 Australia's emissions are 60 per cent below 2000 levels, as with CPRS-5, however they are required to be15 per cent below 2000 levels by 2020;
- Garnaut-10: By 2050 Australia's emissions are 80 per cent below 2000 levels, and in the medium term, 10 per cent below 2000 levels by 2020;
- Garnaut-25: By 2050 Australia's emissions are 80 per cent below 2000 levels, as with Garnaut-10, however, they are required to be 25 per cent below 2000 levels by 2020.

Increased stringency of emissions targets has the effect of increasing the projected costs of wholesale, and hence retail, electricity prices in Australia. The impact of these policy scenarios on the estimated net benefits and BCR of the proposed changes to BCA 2010 are presented in table 11.13.

11.13 **Present value of net impact, economywide, $million**

	Net impact	***Benefit Cost Ratio***
	$ million	BCR
Total – no climate policy	-535	0.75
Total – CPRS-5	-256	0.88
Total – CPRS-15	-230	0.89
Total – Garnaut-10	-250	0.89
Total – Garnaut-25	-126	0.94

The introduction of CPRS-15 policy would have the effect of reducing the estimated net costs of the proposed changes to BCA 2010 to $230 million (due to the increased value of thermal and lighting savings), further increases in climate policy stringency to Garnaut-25 would result in approximately $126 million of net costs and a BCR of 0.94. As an indication, under the Garnaut-25 scenario, electricity prices are 250 per cent higher than currently.

If there was no carbon price introduced, and hence BAU electricity prices prevail into the future, introducing the proposed energy efficiency changes in the BCA would result in a net loss to the Australian economy of $535 million, with a BCR of 0.75.

Monte Carlo analysis

Where the previous sensitivity analyses have provided a discrete estimation of single parameter changes within the estimations, the following Monte Carlo simulation allows a test of the combined effects of changing the underlying assumptions. These variations in key assumptions are presented in table 11.14, and reflect the uncertainties both considered throughout the report, as well as those raised in the consultation period.

First, a Monte Carlo analysis is employed to test the sensitivity of the central case to all key parameters employed. The Monte Carlo analysis varies all key parameters as outlined and recalculates the benefits and costs to explore the effect of their potential interactions on the results. Some ten thousand Monte Carlo simulations have been conducted for this exercise. Second, the net impact and the BCR are evaluated at different discount rates to test how the analysis is specifically affected by this result.

The specific elements tested and their respective parameters used in the Monte Carlo analysis are identified in table 11.14.

Where possible, the analysis has attempted to be consistent with the parameters used in ABCB (2006b), with the exception of energy prices and compliance costs. Given the direction and nature of current Government policies, it is anticipated that energy prices may have inherently more 'upside' risk than 'downside' risk. The upper bound of both electricity and gas prices have been increased to 50 per cent to account for this risk[42] and in response to issues raised in response to the Consultation RIS. In addition, compliance costs have also been varied based on the sensitivity analysis presented, with a 20 per cent reduction, and up to 100 per cent increase.

The Monte Carlo analysis was conducted over 10 000 iterations, with each iteration randomly selecting values for each variable (within the ranges specified in table). The results of the Monte Carlo analysis are reported in table 11.16.

Given the likely ranges of the variables used in this report, the Monte Carlo analysis reports that on average the likely impact of the amendments was a net cost slightly lower than in the central case of $418 million (a BCR of 0.85).

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42 The impact of alternative CPRS scenarios on retail energy prices is covered within this range.

11.14 Key assumptions used in the central case

	Units	***Value***	***Notes***
Discount rate	Per cent	7.0	
Growth of the building stock	Average new dwellings constructed, thousand dwellings	132.2	Varies annually, see appendix D
Proportion of timber and slab flooring	Average per cent slab	91.0	Varies by jurisdiction, see appendix D
Compliance costs			Varies by dwelling, location and pathway, see appendix G
Compliance pathways	Per cent opting for simulation compliance	71.0	
Energy savings from thermal performance			Varies by dwelling, location and pathway, see appendix G
Fuel mix (electricity and gas use for heating)	Average per cent electricity	38.3	Varies by jurisdiction, see chart 5.3
Energy savings from lighting provisions			Varies by dwelling, see table 5.6
Appliance savings (capacity reduced)			Varies by dwelling, see table 5.9
Unit cost of appliance capacity	$ per kW	200	
Electricity prices	Annual growth (per cent)	0.7	Varies annually, see appendix D
Gas prices	Annual growth (per cent)	1.0	Varies annually, see appendix D
Refurbishments (per cent)	Per cent of new stock	10.0	
Generation and network impacts	$million (present value evaluated with a 5 per cent real discount rate)	259.2	
Government costs	$million (present value evaluated with a 5 per cent real discount rate)	0.3	
Industry costs	$million (present value evaluated with a 5 per cent real discount rate)	35	

Source: CIE estimates.

11.15 Variables tested in the sensitivity analysis

	Specific values tested/ per cent deviation from most likely value	***Values/range tested***	***Distribution***
Discount rate (per cent)	Specific values	3,5,7,9,11	Discrete uniform
Growth of the building stock	Range	+/- 25	Uniform
Proportion of timber and slab flooring	Range	+/- 10	Uniform
Compliance costs	Range	-20, +100	Uniform
Compliance pathways (per cent opting for simulation compliance)	Specific range	50 — 100	Uniform
Energy savings from thermal performance	Range	+/- 20	Uniform
Fuel mix (electricity and gas use for heating)	Range	+/- 20	Uniform
Energy savings from lighting provisions	Range	+/- 20	Uniform
Appliance savings (capacity reduced)	Range	+/- 20	Uniform
Unit cost of appliance capacity	Range	+/- 20	Uniform
Electricity prices	Range	-20, +50	Uniform
Gas prices	Range	-20, +50	Uniform
Refurbishments (per cent)	Specific	0, 10, 20, 30	Discrete uniform
Generation and network impacts	Range	+/- 20	Uniform
Government costs	Range	+/- 20	Uniform
Industry costs	Range	+/- 20	Uniform

Note: All variables tested in comparison to the parameters used in the central case (most likely value).

Source: CIE estimates.

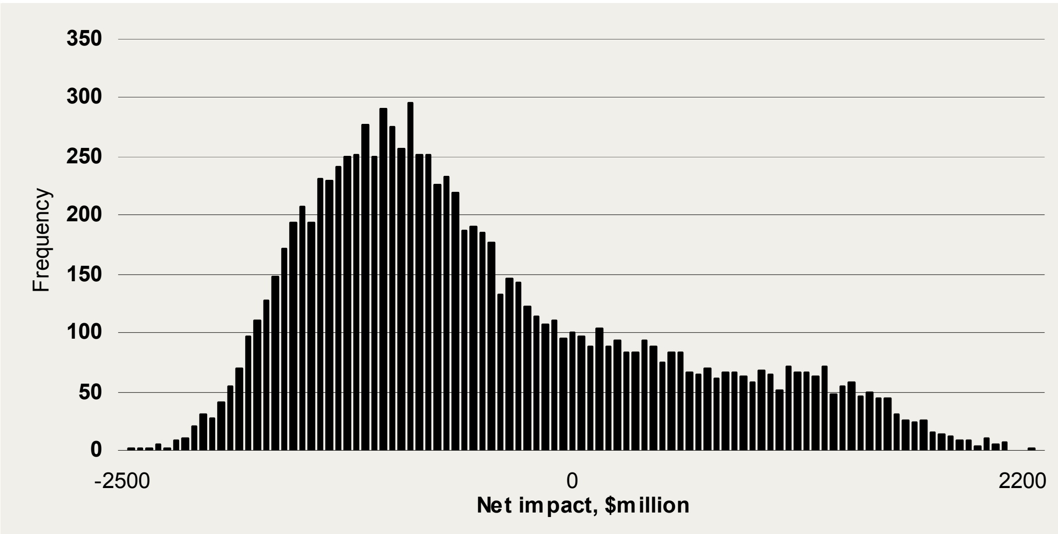
11.16 Monte Carlo simulation results

	Costs	***Benefits***	***Net impact***	***BCR***	***Annual GHG abatement in 2020***	***Cost of abatement***
	$million	$million	$million	BCR	kt CO2-e	$ per tonne of CO2-e
Minimum	1 875	1 340	-2 128	0.41	405	-188
Median	3 173	2 456	-634	0.79	464	-68
Maximum	5 255	5 394	2 215	1.78	526	134
Average	3 232	2 814	-418	0.85	464	-52
Standard deviation	592	1 182	842	0.26	17	61

Note: All variables tested in comparison to the parameters used in the central case (most likely value). Results based on 10 000 iterations.
Source: CIE estimates.

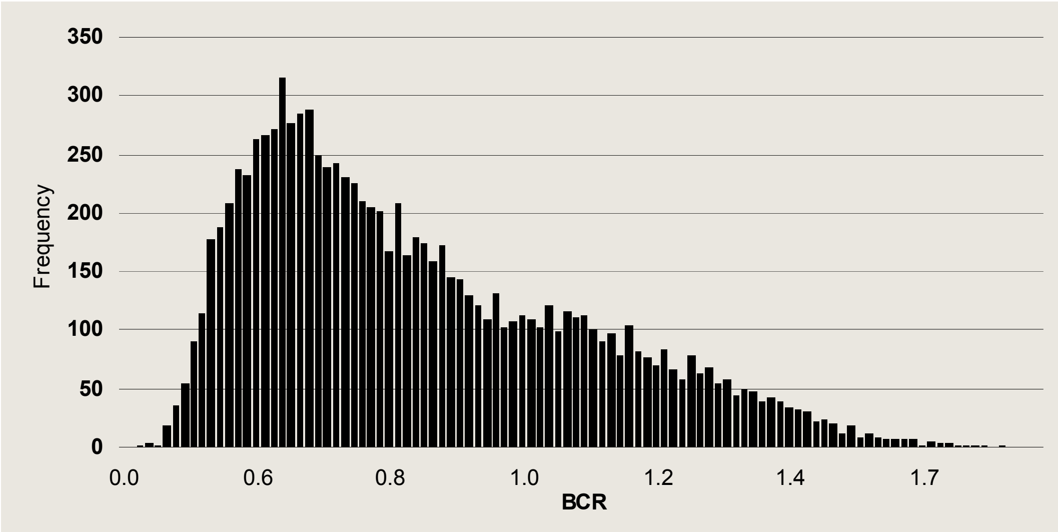
Charts 11.17 and 11.18 below contain histograms of the results of the Monte Carlo analysis. Chart 11.17 shows a histogram of the net impact, and 11.18 a histogram of the BCR. The histogram shows the net impact of the measures to be regularly negative (in 73 per cent of all cases). In about 62 per cent of simulations, the BCR was less than the central case's result. While this does indicate that even after allowing key variables to vary widely, the proposed amendments are on average unlikely to produce a net benefit to the economy, considerable uncertainty remains. This is driven predominantly because the standard deviation of the net benefits, as reported in Table 11.16, is twice the size of the average net benefit estimate.

11.17 **Histogram of Monte Carlo analysis on net impact**



Note: All variables tested in comparison to the parameters used in the central case (most likely value). Results based on 10 000 iterations.
Source: CIE estimates.

11.18 **Histogram of Monte Carlo analysis on benefit–cost ratios**



Note: All variables tested in comparison to the parameters used in the central case (most likely value). Results based on 10 000 iterations.

Source: CIE estimates.

12 Conclusion

This RIS has considered the net impact of a set of proposed changes to the Building Code of Australia, as it applies to residential buildings. The analysis has been conducted to estimate the likely net impact on the economy as a whole. While the assessment has taken into consideration regional impacts, an assessment of the BCA's impact on a particular location would require further analysis.

The findings of the Consultation RIS were that the proposed changes to the BCA, had the potential to deliver a small net benefit to the Australian economy, but the gains were marginal. The benefit to cost ratio was estimated at 1.13. This means there might be a $1.13 benefit for each dollar of cost the changes would impose. This was calculated at a 5 per cent discount rate. While the Consultation RIS also pointed out that some uncertainty surrounded the findings, feedback from OBPR was that a 5 per cent discount rate was not appropriate for the analysis, and so the Final RIS presented the analysis estimated using a 7 per cent discount rate. The results of the Final RIS indicate a net loss to the Australian economy from the proposed changes to the BCA of $259 million, a BCR of 0.88.

Throughout the consultation period, further submissions responding to the Consultation RIS raised a wide variety of issues. For some of the issues raised there is no strong evidence to conclude there is either a particular optimism or pessimism bias. For instance, in the case of intangible benefits and intangible costs, the arguments tend to be speculative and theoretical without much empirical verification. To a large extent, it is likely that these are relatively small and the benefits and costs tend to off-set each other. At a minimum they create some uncertainty.

In other cases, quantitative evidence has been provided and where it has TheCIE has assessed its potential impact. That said, TheCIE has not been able to verify this evidence and some of it is controversial. However, taken at face value, it can have substantive impacts on the preliminary benefit to cost results.

Discount rate

Where the Consultation RIS was evaluated at a 5 per cent discount rate, submissions presented arguments were presented that the discount rate should be both higher and lower. Arguments that it should be lower were centred on the fact that lower discount rates had been used in other climate change studies. The main arguments that it should be higher included the following:

- the evaluation of the 5 star BCA provisions used a higher discount rate;
- the Office of Best Practice Regulation suggests a higher discount rate should be used, so as to be consistent and comparable with other Commonwealth benefit cost evaluations and decision making; and
- home owners who will incur the costs up front and the benefits much later are likely to have a higher discount rate and not taking account of this may mean ignoring a net cost being imposed on consumers (but possibly to the benefit of future generations).

The implication of this one factor changes a positive net benefit into a net cost. The results of different discount rates are presented in Table 12.1.

12.1 **Present value of net impact, economywide**

	Net impact	***Benefit Cost Ratio***
	$ million	BCR
Total – 5 per cent discount rate	296	1.13
Total – 7 per cent discount rate	-259	0.88

Regional aggregations

Another reasonably uncontroversial issue relates to the regional results. Three of the four main growth cities were found to have negative net benefits in the Consultation RIS. Melbourne was the only significant growth centre with positive net benefits. The national net impact was based on two critical assumptions used in the aggregation exercise. The first is that Melbourne is representative of the costs and benefits for climate zone 6 and that the alpine region, zone 8, a tiny zone with potentially large savings per house, will see around 1000 new homes a year. Both of these seem unreasonable. Correcting for both of these increases the net cost by $134 million.

Building costs

More controversial are some of the estimates of capital costs. These will remain controversial until they can be more thoroughly verified. That said:

- they do come from stakeholders with practical knowledge of building costs and the impact of the introduction of the 5 star BCA provisions:
  - because there has not been an independent ex post assessments of the costs incurred with the introduction of the 5 star BCA provisions, considerable uncertainty surrounds the estimates of increased building costs;
  - the building costs estimated and reported in the Consultation RIS, by their very nature, are somewhat theoretical and untested; and
- the estimates come from stakeholders, who are not the consumers who will incur the cost, but builders who would in the main pass them on to consumers.

With a 50 per cent increase in extra building costs the BCR reduces from 0.88 to 0.59. With a 100 per cent increase, the BCR declines from 0.88 to 0.44.. However, by contrast, some submissions suggested:

- lower additional building cost might eventually be achieved due to learning by doing;
- design changes could further reduce additional building costs; and
- the initial estimates presented in the Consultation RIS seemed to be consistent with experience of voluntarily introducing 5 and 6 star standards in Western Australia.

With a 20 per cent decline in building costs, the BCR increases from 0.88 to 1.10.

These responses further highlight the unresolved uncertainty surrounding additional building costs.

Energy prices

Also controversial is argument by some stakeholders that energy prices used in the analysis may be underestimated. Accepting the most stringent climate change policy scenario modelled by either Treasury or Garnaut (Garnaut-25 rather than CPRS-5 used in the Consultation RIS), the benefit to cost ratio climbs from 0.88 to 0.94. Given the many uncertainties relating to climate change policy, the Garnaut-25 scenario must be treated as feasible. However, although feasible, it could be argued that as electricity prices rise due to the CPRS, the arguments for the BCA 2010 changes diminish. With higher electricity prices builders and consumers will face increased incentives to adopt energy saving technologies without regulation forcing them to do so. The arguments relating to the need for stricter energy efficiency codes to address market failures are also diminished by rising energy and electricity prices, a major reason for the CPRS.

Overall consideration

The initial estimates provided in the Consultation RIS indicate small potential net economic gains nationally from BCA2010, although they also indicated substantial net costs to some major growth regions. This regional disaggregation is reflected in the per dwelling estimates presented in table 12.2. The results in table 12.2 also outline the differential impact of a 5 per cent discount rate compared to the preferred discount rate of the OBPR of 7 per cent.

12.2 **Present value of net impact of thermal and lighting provisions on dwellings – 5 and 7 per cent discount rates**

	Darwin	*Brisbane*	*Longreach*	*Mildura*	*Adelaide*	*Perth*	*Sydney*	*Melbourne*	*Canberra*	*Hobart*	*Cabramurra*
Elemental-simulation average 7 per cent discount rate											
House	1624	-1187	-1025	-1128	-835	-671	-997	-29	90	-860	5734
Townhouse	364	-659	-1363	-929	-592	-227	-710	-531	-758	-520	1908
Flat	4419	-427	1328	1350	-2020	-2327	-2165	-1337	-996	-1227	-1461
Elemental-simulation average 5 per cent discount rate											
House	2295	-1048	-576	-737	-553	-498	-871	298	431	-541	7415
Townhouse	691	-585	-1134	-735	-428	-136	-648	-382	-609	-356	2659
Flat	5805	299	1940	1986	-1599	-1972	-1779	-1058	-707	-991	-1131

In general, the net benefits accrue to regions with more extreme temperature challenges where larger energy savings can be achieved. In more temperate climates (such as those in Sydney, Brisbane and Perth) it is more difficult to achieve large enough energy savings in both cold weather and hot weather, resulting in estimated net costs in these regions using contemporary house design approaches. Most regions would incur substantial net costs.

Further evidence and claims made in submissions to the Consultation RIS raise several uncertainties about the net economic impacts of the proposed changes. They present cases for both positive and negative impacts on the assessment. On balance more uncertainties appear to be raised increasing the likelihood of generating further net costs from the proposal. Indeed, the Monte Carlo analysis indicates that there is a 72 per cent chance that the BCR will be less than 1.0 nationally.

While some of these uncertainties are difficult to resolve in the short term, it has been noted that closer scrutiny of the impacts that the BCA2006 had on delivered energy efficiency and extra building costs could assist in reducing the uncertainty surrounding the net benefit and cost estimates of the BCA 2010 proposal.

Overall, based on the evidence as it now stands, the proposal outcomes point toward imposing net costs on major growth regions across Australia and to a strong possibility of imposing net costs nationally.

Appendices

A Details of the proposed BCA amendments

Draft Energy efficiency provisions in BCA Volume Two (applicable to Class 1 and 10 buildings)[43]

Part 1.1 Interpretation

Climate zones

The climate zone map has been updated to include changes to local government areas in Western Australia and a note has been added under Figure 1.1.4 to clarify that climate zone 8 is the BCA defined alpine area.

A note under Figure 1.1 has been added to clarify that climate zone 8 is the BCA defined alpine area.

Part 1.4 Documents adopted by reference

With the addition of provisions for heaters in hot water supply systems, it is proposed to reference the following Australian Standards:

• AS 1056.1 – Storage water heaters – General requirements

• AS/NZS 4264 — Heated water systems - Calculation of energy consumption.

• AS 4552 — Gas fired water heaters for hot water supply and/or central heating.

43 Note that there have been some minor changes to the proposed technical revisions as a result of public comment. These changes have not been included in this section as they had no influence on the costing used in this Final RIS.

Part 2.6 Energy efficiency

Objective

It is proposed to change the Objective to only refer to greenhouse gas emissions attributed to operational energy rather than only energy efficiency. This is so as to accommodate new provisions that are intended to reduce greenhouse gas emissions without necessarily improving energy efficiency. For example, using a gas water heater instead of an electric one actually uses more energy per unit of water heated (aspects such as insulation being equal) but is responsible for generating less greenhouse gas. This also better reflects the government's goal.

Functional statement

Likewise, it is proposed to change the Functional Statement so that it includes for both the energy efficiency of the building and services (i) and greenhouse gas emission reduction specifically for the services (ii).

Performance requirements

P2.6.1 for the building is to be retained unchanged. However, it is proposed to modify P2.6.2 to include reference to the energy source. This proposed change affects electric floor heating systems and electric supply water heaters.

Verification method V2.6.2.1

Currently the BCA contains Deemed-to-Satisfy solutions for the energy efficiency of building fabric elements with an option of using house energy rating software as part of a Verification Method. As the stringency increases it becomes increasingly difficult to develop prescriptive solutions because each element must achieve a thermal performance as there is not the ability for an over-performing element to compensate for an under-performing one. However, for the 2010 6 stars initiative, it is intended to retain prescriptive solutions but flag to industry a future change to a star-rating only approach. This is achieved, along with other necessary changes, in a new Part 3.12.

Therefore the current V2.6.2.1 would no longer be needed.

Verification method V2.6.2.2

Some minor changes are proposed for Verification V2.6.2.2, as a result of proposals made to the ABCB Office by users.

Verification method V2.6.3

A new Verification Method is proposed for a water heater in a hot water supply system. The Verification Method was recommended by George Wilkenfeld & Associates in their report titled "Specifying the Performance of Water Heaters of New Houses in the Building Code of Australia", December 2007. The report is available on the energy page of the ABCB web site.

Part 3.12 Energy efficiency

3.12 Definitions

Two new definitions are proposed.

Lamp power density

The first is lamp power density and is the same definition used in Volume One for lighting power.

Renewable energy certificate

The second is renewable energy certificate which is an established way of quantify the performance of solar water heater and heat pump water heaters. The Renewable Energy Certificates are issued by the Commonwealth Government and are suitable evidence of compliance.

Part 3.12.0 Application of Part 3.12 & 3.12.0.1 — heating and cooling loads

With the target stringency raised to 6 star, it is difficult to develop practical element-by-element prescriptive Deemed-to-Satisfy Provisions that work with all possible house designs. If governments continue to increase the stringency, at some stage the star rating approach will have to be the only one for developing solutions. For this reason, and to link in various provisions not included in the star rating such as the insulation testing standard, insulation installation provisions, thermal breaks etc, the star rating approach has been relocated to the Deemed-to-Satisfy Provisions as the primary compliance path.

This has been achieved by integrating the heating and cooling loads of the star rating into the existing application clause of the Deemed-to-Satisfy Provisions and then adding a clause specifically about the heating and cooling loads stating the star rating and also covering the outdoor living area optional credit. Clause 3.12.0 now becomes the road map for either the star rating option or the prescriptive option.

This means that the proposed Deemed-to-Satisfy provision is a 6 star rating with an alternative set of prescriptive provisions that are intended to achieve a 6 star rating. The draft alternative provisions that have been developed in the time available may not achieve the 6 star rating with all house designs in all climate zones and may need to be adjusted prior to finalising BCA 2010.

With the star rating option, It has been found that the software alone may not result in insulation to AS/NZS 4859.1 being used, compensation for ceiling penetration by down lights being provided, thermal breaks being installed and other currently Deemed-to-Satisfy provisions that are fundamental but not included in the software. The proposed application clause addresses this deficiency. In addition, the software approach may include a ceiling fan in which case the current Deemed-to-Satisfy clause for a ceiling fan is referenced when needed. If one is not needed but still installed, it need not comply.

The challenge is to get as many house designs to 6 star using the prescriptive approach. From past experience one would expect a spread of at least plus or minus one star with different house designs.

In determining what is practical and cost effective, it is assumed that the house designs have inherent features that assist achieving energy efficiency rather than house designs that do not consider energy efficiency and then endeavour to comply by adding costly energy efficiency features.

The current Queensland approach for climate zones 1 and 2 has been supported by the Northern Territory and Western Australia both of which have climate zone 1 (the only other jurisdiction that has climate zone 2 is NSW which uses BASIX). Therefore at the request of these three jurisdictions, it has been included in the BCA proposals. The proposal gives a credit of 0.5 stars and 1 star respectively if (i) an outdoor living area is covered with an insulated roof and (ii) if a ceiling fan is also installed.

BASIX rating

The COAG communiqué also announces that COAG would ask the ABCB to consider integrating other approaches such as the NSW Building Sustainability Index (BASIX) into the BCA in the future. This draft of proposals does not address how that may be achieved.

Part 3.12.1 Building fabric

The more significant changes proposed are discussed below.

3.12.1.1 Building fabric thermal insulation

There is no change to the provision proposed, only some explanatory information to clarify the need for continuity of the thermal performance of the fabric.

3.12.1.2 Roofs

It is proposed to increase the Total R-Value of the roofs significantly and in the prescriptive option prohibit dark coloured roofs in the hotter climates. A concession is also proposed for a very light coloured roof or a ventilated roof in the hotter climates. There is no concession for colour in the cooler climates because a light coloured roof is much less effective in a location requiring winter heating.

It is proposed that the Total R-Value be significantly increased and basically the same added R-Value in most of the country with the exception being alpine areas and whether the heat flow is up or down. Although there is a scientific basis for different insulation levels in different climate zones, the differences become less significant as the insulation value increases. Studies carried out show a benefit in more roof insulation in all locations and the same value in a number of locations should simplify the manufacturers stocks and trade literature.

For a pitched roof with a flat ceiling, it is also proposed that at least 50 per cent of the added insulation be located on the ceiling. This is because the ceiling space may be ventilated, either deliberately with roof vents or inadvertently due to inherently leaky construction, in which case the ceiling space will contain air at ambient temperature. Insulation at the roof line would only be taking care of the solar load whereas insulation on the ceiling would provide for the conductive load between the ambient air and the conditioned space through the ceiling. Also, with the requirement to add more ceiling insulation when there are many downlights, there may be a trend to placing all the insulation at the roof line and so not address the conductive load through the ceiling.

Figure 3.12.1.1 currently shows what R-Value is inherent in a roof construction and subtracts it from the required Total R-Value for each climate zone. With the software approach, the Total R-Value may be any value chosen as it is necessary to just state the inherent R-Value of the roof.

In BCA 2009, provisions were introduced for additional insulation where downlights and other penetrations reduced the ceiling insulation. This was presented in a form based on the required Total R-Values in table 3.12.1.1. This is appropriate for a prescriptive approach but when the provision is applied to a star rating approach, it needs to be based on the required added R-Value determined by the software. The table has been appropriately restructured to serve both purposes and values developed by James M Fricker Pty Ltd.

3.12.1.3 Roof lights

Peter Lyons & Associates were commissioned by DEWHA to report on possible changes to the BCA in order to strengthen the roof light provisions. His report is titled *Report on Roof light provisions for the BCA, May 2009* and can be found on the ABCB and DEWHA web sites.

As a result of Dr Lyon's report, the performance required of roof lights has been converted to National Fenestration Rating Council (NFRC) values from Australian National Averages Conditions (ANAC) values and also increased in stringency. Some manufacturers' products already achieve the proposed values while others will need a diffuser at ceiling level in order to meet the requirement.

The area allowances for residences have also been reduced as large roof light areas adversely impact on the target star rating. To get a greater allowance, the software approach would have to be used.

The 'free allowance' of 1.5 per cent of the floor area has been removed requiring the minimum standard in table 3.12.1.2 to be met in all cases.

The exemption for roof lights that are required to meet Clause 3.8.4.2 has been removed in anticipation of a reduced Clause 3.8.4.2 requirement for roof lights.

These proposals are consistent with those for commercial buildings.

3.12.1.4 External walls

The clause and table have been restructured with a part for insulated framed walls and a part for high mass walls. Some recent research by the University of Newcastle supports the approach of some concession for double brickwork construction, particularly in warm climates with a cool night.

It is proposed to increase the Total R-Value of the framed walls but generally limit it to 2.8 in order to avoid going beyond a 90 mm deep framing member. Walls in the hotter climates are also required to be of a light colour.

The options for high mass walls include light coloured walls, shading, minimal insulation, slab-on-ground construction, internal masonry walls and reduced glazing allowances; depending upon the climate zone. The current package that includes using ceiling fans has been integrated into the table but the ceiling fans have been removed because there is now a concession for them in the glazing allowance table.

It has been found necessary to require eaves in the hotter climates in order to achieve a 6 star rating.

As for roofs, figure 3.12.1.3 currently shows what R-Value is inherent in a wall construction and subtracts it from the required Total R-Value for each climate zone. With the software approach, the Total R-Value may be any value chosen as it is necessary to just state the inherent R-Value of the wall.

The sub-clause for thermal breaks in framed walls has been retained while the sub-clause for trading between any walls and glazing has been removed because reduced glazing options have been incorporated into table 3.12.1.3 in order to achieve the stringency.

3.12.1.5 Floors

Floor R-Values have been generally increased by 0.5 and climates zones 1 and 3 also included. Again, insulation could possibly be dispensed with in some situations by using the software and compensate for no floor insulation by improving the performance of other elements.

An issue of concern to some stakeholders is the thermal performance required of a suspended timber floor. The BCA hardly differentiates between the thermal performance of a suspended timber floor and a suspended concrete one. However, there is considerable evidence on the thermal benefit of a ground-coupled floor. The current BCA provisions and house energy rating software already recognise this difference and increasing the BCA stringency will further widen the gap. Advocates of timber flooring feel that it is not accurately treated and an argument is that timber is a sustainable product with less embodied energy. However, the governments of Australia agree that the BCA should only address operational energy at this time.

An advantage of the house energy rating scheme software approach is that a product which may not achieve a required elemental performance may be a desirable product in conjunction with other products in a holistic approach.

A note has been added to table 3.12.1.4 to permit the inclusion of an under-floor enclosure to be part of the Total R-Value calculation.

An explanatory note has been added about a publication ‘Insulation Solutions to Enhance the Thermal Resistance of Suspended Timber Floor Systems in Australia’ that was prepared for the Forest and Wood Products Research and Development Corporation’. It should be noted that an industry manual that meets the ABCB protocol for reference documents could also be referenced in the BCA as an Acceptable Construction Manual.

As for roofs and walls, figure 3.12.1.4 currently shows what R-Value is inherent in a floor construction and subtracts it from the required Total R-Value for each climate zone. With the software approach, the Total R-Value may be any value chosen as it is necessary to just state the inherent R-Value of the floor.

The R-Value of insulation under a heated or cooled slab in climate zone 8 has been increased.

3.12.1.6 Attached Class 10a building

The current solution package (c) is unique to climate zones 4 and 5 and provides a degree of thermal mass and ceiling insulation in combination.

It is intended to limit this package to climate zone 5 because climate zone 4 covers a large region that includes hotter summer days and colder winter nights than the milder climate zone 5 and does not ensure a 6 star outcome.

It is proposed to limit this package to garages with doors facing North or South as a double door facing east or west will get very hot (or cold) and reradiate energy.

For any other proposed solution the software must be used.

Part 3.12.2 — External glazing

The glazing provisions continue to focus on limiting solar heat gains in summer and reducing heat conduction through glazing in all seasons. Stringency has been increased by changes to the glazing constants (in table 3.12.2.1) and flexibility has been improved by adding exposure factors for the calculation of conductance requirements (as table

3.12.2.2a). The new exposure factor appears in a revised conductance equation in Part 3.12.2.1(b)(i).

Although slowing heat conduction into or out of a dwelling can be beneficial year round, the stringency is set by ensuring that the rate of heat loss in winter does not exceed the rate of gains that can be supplied by wintertime solar radiation. Winter gains can be at risk from what is done to control summer gains unless good orientation and beneficial shading geometries are used. The new conductance exposure factors take account of these opportunities and assist in balancing the competing summer and winter requirements.

The expanded exposure factors table shows fewer shading increments in each part in order to constrain its overall size. Interpolation between values is still permitted and this will be done automatically by the glazing calculator which will also handle the application of the new conductance exposure factors. Uptake of the calculator appears to have been strong and it is likely to be used for most calculations under the prescriptive measures.

Initial proposals for the glazing provisions called for a general 20 per cent tightening of stringency in all locations. Limited testing demonstrated that houses configured in this way would fall short of the 6 star ratings target in warmer climates. Solar heat gain limits for climate zones 2, 3 and 5 have been further tightened and the conductance exposure factors added to reward better solar orientation. With most other building elements at practical limits of thermal performance, glazing is the remaining pathway to better ratings. Energy rating houses that comply with the prescriptive provisions will continue during the public comment period with a view to reducing variability around the target and stringency settings may need some further tuning towards that goal.

Despite their apparent complexity, the prescriptive glazing provisions are rudimentary compared with the glazing calculations embodied in house energy rating software. The stringency of the prescriptive provisions needs to be demanding to produce higher ratings and this tends to constrain areas for common glazing types. A practical limit for consumer acceptance of prescriptive measures is anticipated when allowable areas with cost-effective glazing and shading selections fall to around 15 per cent of floor area. The published provisions produce values of 18 per cent and 21 per cent for tinted single glazing shaded by eaves in Brisbane and Darwin respectively (eaves of 450 mm in Brisbane and 900 mm in Darwin.) Clear double glazing with 300 mm eaves allows 18 per cent to 23 per cent in Mildura, Melbourne and Hobart.

Glazing in the foregoing cases is distributed equally between all four faces of a dwelling (with a slab floor and standard air movement provisions). Increasing the north facing share of glazing from 25 per cent to 35 per cent of the total lifts the Brisbane figure to 20 per cent. The same change in Melbourne and Hobart would allow the use of unshaded single clear glazing at 19 per cent of floor area.

The measures are less demanding in houses with high air movement levels. DEWHA has received a 'Report on the Impact of Ceiling Fans on Cooling Energy Use in Selected Australian Cities as Simulated by AccuRate v2.1.2.0'. The results show that ceiling fans can provide a rating benefit of up to 1.5 stars in northerly locations. They can also be cost effective in reaching 6 stars in milder climates such as Brisbane. In recognition of these findings, table 3.12.2.1 now allows ceiling fans to be used to meet the High air movement requirements. The standard Air Movement provisions in Part 3.12.4.1 have also been amended by reducing the minimum opening area needed for some situations in climate zone 1 from 15 per cent to 10 per cent. This change is intended to prevent the opening requirements driving glazing areas to unhelpfully high levels.

Part 3.12.3 Sealing

There are three minor changes proposed. Two are in order to remove variations. The first is for exhaust fans to be sealed in climate zone 5. The second clarifies that the seal required on the bottom edge of a door is a draft protector. The third is to now require caulking around the frames of external doors and windows which are potentially high leakage places.

Some stakeholders have also drawn the ABCB Office's attention to requirements in some countries to test building leakage, both for dwellings and commercial buildings.

Modelling carried out by the Office showed that even a modest rate of infiltration of outside air through building leaks, quickly diminished the benefits of more insulation in the roof, walls and floor. There is anecdotal evidence that a building of poor construction has the potential to use more than 20 per cent more heating and cooling energy than a well constructed building.

DEWHA has also commissioned a study into the practice overseas of leak testing buildings. That work is not yet completed and in view of the governments' time table for introducing more stringent measures by 2010, no requirement will be proposed at this time.

Part 3.12.4 Air movement

Depending upon the window system chosen, the glazing requirements in 3.12.2 could result in smaller windows, possibly as low as 15 per cent of the floor area if single clear glazing in a standard aluminium frame is facing predominately east or west. For this reason the ventilation opening areas currently in table 3.12.4.1 for climate zone 1 may sometimes be difficult to achieve without non-glazed ventilation openings which are not likely to be cost effective. Therefore the ventilation opening requirements are limited to 10 per cent of the floor area.

In view of this reduction, and the diminishing benefit of more insulation, it is proposed to amend the alternative requirements for Cyclonic Region D to remove the requirement for additional ceiling insulation. The proposed wall Total R-Value in Part 3.12.1 will achieve what was the Region D requirement.

To gain the full benefit of larger ventilation openings, designers will need to develop an alternative solution using the house energy rating software which now accommodates high ventilation.

Part 3.12.5 Services

3.12.5.3 Heating and cooling ductwork and piping

With the current provisions it is unclear whether return air ductwork passing through a conditioned space is exempted from requiring insulation. It is also unclear whether fresh air ductwork and exhaust air ductwork is exempted. It is proposed to clarify that they are exempted.

Currently evaporative cooling ductwork has a lesser insulation requirement than heating or refrigerated cooling ductwork. Even with a damper at the ceiling, heated air can leak into and along the ductwork in the winter and be lost through the ductwork walls. The clause is proposed to be modified to require the same level of insulation as for heating.

Obrart & Co, a building services engineering consulting firm, was commissioned by the ABCB Office to review the ductwork and piping insulation provisions in order to (i) investigate the potential for increasing the stringency and to (ii) consult with industry on the provisions.

Some of the recommendations have been incorporated into this proposal and their report can be found on the energy page of the ABCB web site. The main recommendations accepted at this time are an increase in the R-Values of insulation and a change to material R-Value instead of the current Total R-Value. Other recommendations will need wider industry consultation.

3.12.5.4 Electric space heating

George Wilkenfeld and Associates investigated the potential benefit of regulating the heating systems of pools, spas etc and prepared a report titled 'Swimming pools and electric space heating - The case for coverage by the Building Code of Australia'. It made recommendations with respect fixed space heating. The report can be found on the energy page of the ABCB web site.

All proposals are to avoid overheating spaces and thereby wasting energy and include for separate on-off switches and time switches for each room served by an electric heating system such as an in-floor system as well as limiting the heating capacity.

3.12.5.5 Artificial lighting

Currently there are no requirements in the Housing Provisions for lighting. COAG has also requested the ABCB to include the efficient use of artificial lighting in the BCA. This is to arrest the recent growth of the use of inefficient fittings and in some cases, excessive levels of lighting.

A study by Lighting, Art + Science Pty Ltd titled 'Building Code of Australia – Residential Lighting Control Options' looks at current provisions in Australia and overseas and a range of lighting scenarios in a set of houses. The report discusses possible approaches and recommends a maximum lighting power allowance approach similar to that in BCA Volume One. This provides a performance based solution and also maximum flexibility.

Another approach that was considered was to require a percentage of all lights to be high efficient ones, but this approach does not limit the total number of lights and also leaves the governments no scope for further reduction when all lights are efficient ones. Both approaches are discussed in the report.

The recommended power levels are 5 W/m^2 for a house and 3 W/m^2 for a garage.

In determining a maximum power allowance, the report looks at lighting designs for six houses based on a traditional lighting design, a traditional design with compact fluorescent lamps instead of incandescent lamps, a typical downlight installation including compact fluorescent lamps as is common in new homes and an installation using a relatively large number of tungsten halogen 16 lamps.

The report by Lighting, Art + Science Pty Ltd also made comment on the approach of requiring a percentage of lights being high efficiency ones.

The proposals include some prescriptive requirements, that is:

- the lamp power of the lamp must be used and not a nominal value per batten holder;
- the type of fluorescent lamps used;
- there must be separate switching for halogen and fluorescent lamps; and
- control and efficacy of lighting around the perimeter of the building.

3.12.5.6 Heater in a hot water supply system

COAG has also requested the ABCB to include hot water supply heaters in the BCA. The government's concerns are the continued use of electric heater which are responsible for a high greenhouse gas emission rate and also the efficiency of other types of heaters.

Three separate studies have contributed to this proposal, the most recent being a Regulation Impact Statement by George Wilkenfeld and Associates that was commissioned by DEWHA. Another, prepared for the ABCB was titled ‘Specifying the Performance of Water Heaters of New Houses in the Building Code of Australia’, December 2007 and is also on the ABCB website.

The findings of those reports have been adopted in these proposals and so are subject to the outcome of the public consultation on the RIS.

The BCA Clause 3.12.5.6 lists the type of heaters that are permitted in sub-Clause (a), and then specifies each type in sub-Clause (b), (c) and (d). In summary, the minimum performance of gas, solar and heat pump heaters has been specified and the use of electric resistance heaters is only permitted under certain circumstances.

Sub-Clause (b) specifies the performance of solar water heaters and heat pump heaters in terms of renewable energy certificates and also in terms of the performance to an Australian Standard, AS/NZS 4234. The certificates path is for those manufacturers who have applied for, and received, Renewable Energy Certificates for their units and the other is where the units can be shown to meet the specified standard. Details of one or both may exist but at this time it is unclear which information will be most readily available to consumers, designers and builders.

The requirements are different for different sized houses.

AS 4234 is being revised as AS/NZS 4234 and is expected to be completed by 2009.

Sub-Clause (c) specifies the performance of gas heaters and sets the standard at no less than 5 stars in accordance with the Australian Standard AS 4552.

Readers should be aware that MEPS for gas heaters is also being considered, possibly at a different level to that being proposed for the BCA. The MEPS would target the replacement market. If the outcome of public comment is that the rating for MEPS and the BCA should be the same, there would be no need for the BCA to say a 5 star rating; only to require a 'gas heater' and leave the regulating of the performance of all gas heaters to the MEPS program.

An electric resistance heater may only be used under certain circumstances including when the electricity is generated from a renewable source, when a house with a single bedroom and has only one electric resistance heater, and when the heater is instantaneous or less than 50 litres capacity.

3.12.5.7 Heating and pumping of swimming pools and spas

Over recent years stakeholders have questioned the BCA focus on the building fabric and only some services and have questioned why other services such as the heating of water and the heating of pools and spas have not been included. The reason has been that up to now the provisions have been to satisfy a performance for energy efficiency rather than greenhouse gas emission reduction, and did not consider the greenhouse emission rate of the fuel used. If the performance requirements are to be amended to address the greenhouse gas emission rate of the energy source, pool and spa heating could be considered. These are included in the provisions in some other countries.

The ABCB commissioned George Wilkenfeld and Associates to investigate the potential benefit of regulating the heating systems of pools, spas etc and their report titled 'Swimming pools and electric space heating - The case for coverage by the Building Code of Australia' can be found on the energy page of the ABCB website.

Clause 3.12.5.7 proposes that a pool can only be heated by solar energy if outdoors and by solar or gas if indoors. A spa may also be heated by heat pump.

In addition, a time switch must be provided for controlling the circulation pump while a heated pool or heated spa must have a cover for out-of-use times.

George Wilkenfeld and Associates have also recommended other possible requirements but more industry consultation will be needed in order to develop appropriate provisions.

Energy efficiency provisions in Section J, BCA Volume One (applicable to Class 2 and 4 buildings)

Section J

Objective

It is proposed to change the Objective to only refer to greenhouse gas emissions attributed to operational energy rather than only energy efficiency. This is so as to accommodate new provisions that are intended to reduce greenhouse gas emissions without necessarily improving energy efficiency. For example, using a gas water heater instead of an electric one actually uses more energy (aspects such as insulation being equal) but is responsible for generating less greenhouse gas. This also better reflects the government's goal.

Functional Statement

Likewise, it is proposed to change the Functional Statement by having a functional statement for both the energy efficiency of the building (i) and greenhouse gas emission reduction specifically for the services (ii).

Performance requirements

JP1 for the efficient use of energy and JP2 for the maintenance of features are to be retained unchanged.

A new Performance Requirement, JP3, is proposed requiring the energy that is used be from sources that generate less greenhouse gases. This proposed change affects electric floor heating systems and oil fired boilers and in 2011, may also include electric supply water heaters.

Verification method JV1

NatHERS rating

For the sole-occupancy unit of a Class 2 building and a Class 4 part of a building, BCA 2009 contains Deemed-to-Satisfy solutions for the energy efficiency of building fabric elements with an option of using Nationwide House Energy Rating (NatHERS) software as part of a Verification Method. This is because the software provides a means of treating the building holistically and enables designs to be fine-tuned so that under-performing elements are assisted by over-performing elements. With the prescriptive provisions this trading is not possible and so all elements must meet the required performance. There are also many more variables to work with using the software approach.

As the stringency increases, it becomes increasingly difficult to develop complying prescriptive solutions because each building element must comply. It will also mean that many traditional building products with poor thermal performance will be penalised. The approach now being proposed is for the software to be used for Class 2 buildings and Class 4 parts.

Therefore, it is proposed to base the fabric provisions for residential buildings in Volume One on a NatHERS rating rather than detailed prescriptive solutions. Because some other Deemed-to-Satisfy Provisions need to be retained, such as those dealing with the insulation standard, thermal breaks and building sealing, it is proposed to relocate the NatHERS rating requirement to the Deemed-to-Satisfy Provisions and link it to these clauses in a new Part J0. It also meets BCA editorial policy to have a Deemed-to-Satisfy provision whereas it is not essential to have a Verification Method.

Usually a team of professionals are responsible for the design of Class 2 buildings and the additional cost of rating the sole-occupancy units can be saved by fine-tuning the design. Over the past few years more and more practitioners have come to use the software and with the release of second generation software, practitioners have developed more confidence in the three programs available. Also the Association of Building Sustainability Assessors (ABSA) is emerging as an accreditation body.

This approach will not be used for housing at this time because it is felt that with other government initiatives such as mandatory disclosure and green-loans, there may not be sufficient assessors, however, industry is advised that it may be considered by governments in the future. In particular, any further increase in stringency will require the software to be used to develop a practical solution.

In moving the star rating for Class 2 buildings and Class 4 parts, the current JV1 number is no longer needed.

Verification method JV2

Verification Method JV2, which was a stated value for whole-of-building energy analysis simulations, was removed from the BCA in 2008 after an industry submission.

Verification Method JV3 and specification JV

Some changes are proposed for Verification JV3, Specification JV and guidance information in the Guide to the BCA, as a result of proposals made to the ABCB Office by users and a review by ACADS-BSG that was commissioned by the ABCB Office.

The most significant proposed change is to make certain aspects of the Verification Method and Specification JV optional instead of mandatory. Instead of the previously mandatory values for various aspects in the reference building when determining the energy allowance, the designer may use the characteristics of the subject building.

A number of less significant changes are proposed in order to clarify what is to be modelled and to provide more definition where needed.

Part J0 Energy efficiency

This Part assists the user to choose the approach for either dwellings or for other applications such as commercial buildings. The Application clause J0.1 is a ‘road map’ and leads the users to the appropriate clauses.

Clause J0.2 contains the star rating for the thermal performance of the fabric of dwellings that is sole-occupancy units of Class 2 buildings and Class 4 parts. The star rating provision has been relocated from Verification Method JV1.

COAG has set a target of 6 stars subject to cost effectiveness and this has been taken as an average of all sole-units in a Class 2 building with no sole-unit less than 5 stars. This follows the current BCA approach of having a 0.5 or a 1 star differential between the average and minimum depending upon the climate zone.

In moving to the Deemed-to-Satisfy Provisions it also replaces the prescriptive provisions for each building element in isolation, as has been the practice in the past.

The extra cost of a NatHERS assessment is not considered a burden because a team of professionals would generally be engaged on a Class 2 building project. Also, alterations and additions are less likely than with housing so simplified provisions are not needed.

Part J1 Building fabric

There are a range of changes proposed and the more significant ones are discussed below.

J1.2 Thermal construction general

Industry has indicated that sub-Clause (a)(i) needs more clarification as to how insulation is applied at structural members and services. There are practical issues that have caused some interpretation difficulty with insulation at structural members. The proposed wording would permit insulation to be run up to members instead of being continuous and maintaining the R-Value at the member.

J1.3 Roof and ceiling construction

As a ceiling space in a commercial building often contains cabling, recessed lighting and air-conditioning plant, the roof insulation is usually strung over the purlins in a framed roof rather than being laid on the ceiling and the practical limit with current fixing methods is claimed to be around R 3.2 to R 3.7 downwards in most climate zones. Safety mesh for the installer's safety and fixings for cyclone protection are limiting issues. Manufacturers are developing innovative solutions and values within this range are proposed as practical limits.

Colour of roof

The ventilated roof/roof colour package in Sub-Clause (b) has been removed and a concession for colour included in table J1.3a. The ventilated roof evolved from the Housing Provisions and is not common for commercial buildings where roof spaces lighting and cabling result in the insulation being at the roof line.

There are studies that demonstrate that a light coloured roof reflects more solar energy that a dark one so a light coloured one is desirable where solar radiation is a problem. However, rather than mandating a light coloured roof as the only option, an approach of regulatory ‘encouragement’ is proposed.

Some work was carried out by the ABCB Office in 2005 and the results included in the provisions for BCA 2006. That work has been repeated and extended for these proposals. Similar results have been reported in a paper titled ‘Effect of roof solar reflectance on the building heat gain in a hot climate’ by Suehrcke, Peterson and Selby, 2008. Recent ABCB modelling indicates that in the hotter climate zones, the benefit from a light roof may be more than R1 of insulation. In mild locations there is no benefit and in cold areas, particularly alpine ones, the reverse is the case as solar heating is a benefit.

For a hotter climate, requiring the R3.2 downwards to be for a very light coloured roof (cream or off-white), R3.7 to be for a medium coloured roof (yellow, light grey or galvanised) and a higher Total R-Value for dark coloured roofs (red, green or brown), designers will be encouraged to select a light coloured roof. In this way, again, there is no significant cost impact, only a restriction in choice.

It is noted that some planning schemes may prohibit very light colours so in the hotter locations a surface solar absorptance of up to 0.4 is proposed for the R3.2 downwards.

Concrete roofs are inherently darker that 0.4 so will need to be painted or carry the maximum penalty but they do not have the same practical difficulty of fixing insulation over purlins of framed roofs.

Sub-Clause (c) for a concession where there is a small area of roof lights has also be removed because the roof light provisions themselves have also been tightened.

Compensation for loss of ceiling insulation

A new sub-Clause (e) and new table J1.3b is been proposed to require compensation for a significant loss of ceiling insulation due to the penetration of uninsulated services. It would not apply to many commercial buildings but only those with the insulation on the ceiling and ‘holes’ in the insulation.

The clause is similar to that in the Housing Provisions developed by James M. Fricker Pty Ltd. There need not be a cost impact, only a restriction on the number of down lights permitted. In any case this is a clarification as the required Total R-Value of the roof would be degraded by the downlights.

J1.4 Roof lights

Peter Lyons & Associates were commissioned by DEWHA to report on possible changes the BCA in order to strengthen the roof light provisions. As a result of this report, the performance required of roof lights has been converted to National Fenestration Rating Council (NFRC) values from Australian National Average Conditions (ANAC) values and also increased in stringency. Some manufacturers' products already achieve the proposed values while others will need a diffuser at ceiling level in order to meet the requirement.

The area allowances have also been reduced as large roof light areas are a major path for energy transfer. To get a greater allowance in residences, the software approach could be used.

The 'free allowance' of 1.5 per cent of the floor area has been removed requiring the minimum standard in table J1.4 to be met in all cases.

The exemption for roof lights required to meet Part F4 has also been removed in anticipation of a reduced F4 requirement for roof lights.

These proposals are consistent with the housing proposals.

J1.5 Walls

The title of Clause J1.5 and the lead-in to sub-clause (b) for commercial buildings is proposed to be changed in order to clarify that the provisions apply to any wall that is part of an envelope. This includes internal walls of a carpark, plant room or ventilation shaft. Part (a) will be for external walls and (b) for internal walls. Table J1.5b is now about internal walls rather than the simple 50 per cent of the current external wall provision.

Below ground walls

A new sub-clause has been added to clarify that a below ground wall that is back-filled or otherwise ground coupled does not have to comply with the thermal provisions in other than climate zone 8. A basement conditioned space without glazing and a conditioned space above generally needs cooling in most climate zones. The only loads it has are lighting, people and internal equipment so the cooling benefit provided by the earth or rock face is, in most cases, beneficial. Climate zone 8 is the exception where, like a slab-on-ground floor, 2.0 Total R-Value is required.

Table J1.5

Table J1.5a has been amended to deal with external walls and table J1.5b for internal walls. The previous scope of J1.5a was residential buildings that are now covered by the software approach in Part J0.

As stringency increases the options become increasing complex so the table has been restructured with a base requirement and a 'menu' of reductions to the required Total R-Value. The reductions include colour, mass, shading, thermal conductivity and glazing index. These have been written around common building systems.

The current requirement in most climate zones is 1.8 Total R-Value and this can be achieved by a framed wall with R1.5 insulation in a 65 mm cavity. There is a cost benefit in increasing the added R-Value of insulation provided the wall construction cost is not significantly increased. Increasing the cavity to 90 mm can achieve a further R1.0 at a cost increase in insulation and framing. With some insulation systems the Total R-Value could be higher.

However, increasing the thickness of the wall beyond 90 mm is generally not cost effective. The additional framing cost alone is greater than the saving in energy cost. If the loss of rentable area is also considered 90 mm becomes even less cost effective. The exception is alpine areas where there is a greater potential to reduce energy consumption.

Colour of external wall

As for roofs, it is also proposed to give a concession on additional insulation for lighter coloured walls in some climate zones. This means that there is no change, or minimal change, in insulation levels for light coloured walls but a significant increase for dark coloured walls in most climate zones.

In this way, again, there is no cost impact, rather a restriction in choice. It is noted that some planning schemes may prohibit very light colours so a surface solar absorptance of 0.6 has been selected as the standard for determining an increase in Total R-Value. This is beige or cream. Two steps have been proposed with only dark walls being penalised.

As with roofs, this effect is reversed in climate zone 7 where solar heating is a benefit and darker coloured walls should be encouraged. This is less significant in climate zone 8 where the solar radiation falling on a surface is reduced by snow clouds.

Masonry walls

Currently there are ‘packages’ for high mass. One of the reductions to the Total R-Values proposed is for high mass walls and in most climate zones there is a greater reduction for a high mass wall with a low thermal conductance.

Walls with insulation space provided by a furring channel, top hat section or battens

Currently, if a wall has only a furring channel, top hat section or batten space for insulation there is a concession whereby the insulation Total R-Value need only be R1.4 provided the glazing complies with the index option B of table J2.4a. It is proposed to not permit this option in a building that would not have had glazing anyway, such as a theatre or cinema. It is also proposed to increase the stringency of this option by further restricting the amount of glazing permitted and in climate zones 1, 2 and 3 require a light coloured outer surface.

Clause J1.5(b) Trading conductance between walls and glazing

Currently, if a building in climate zones 4, 6, 7 and 8 does not use all of its window allowance the surplus can be used to supplement underperforming walls.

There is anecdotal evidence that in some cases the result of this provision has been walls with no insulation in buildings that were not going to have windows anyway. Clause F4.1 of the BCA only requires natural light in residential buildings, schools and early childhood centres so the result has effectively been a ‘free’ glazing allowance to use to avoid insulating walls.

In addition, some in industry feel that Section J is unnecessarily complex and this calculation, called a ‘UA’ calculation in some energy codes, is one of the more complex aspects. In any case, there is already a wall — glazing trading option where furring channels are used. Therefore it is proposed to remove this concession so that all walls must have at least furring channels and the minimal insulation in table J1.5.

Internal envelope wall

Currently walls in an envelope (other than an external wall) in some climate zones are required to achieve at least a Total R-Value of 50 per cent of that of the external wall.

More detailed provisions are proposed covering three scenarios depending upon the enclosing of the space, the rate of ventilation of the space and the amount of glazing.

J1.6 Floors

Currently this Clause is about floors on ground or floors in the envelope with an unenclosed perimeter. It does not include floors that are part of the envelope and above or below plant rooms, car parks or even enclosed sub-floors. It has been found through modelling that a suspended floor, even if enclosed, uses more energy than a slab-on-ground in which free cooling is provided through direct contact with the ground.

Table J1.6 has been restructured. It now provides 3 levels of stringency. The first is where the space above or below the suspended floor is not enclosed. The second is where the space is enclosed and significantly ventilated with outside air while the third is also enclosed but ventilated with a nominal amount of outside air. The last is for a slab-on-ground in the colder climates.

This proposal will clarify the confusion between a ceiling under a roof top plant room and a suspended floor that is part of an envelope by treating the ceiling as being part of a suspended floor rather than as a roof/ceiling.

Part J2 Glazing

As proposed for the various building fabric elements, the application of Part J2 excludes sole-occupancy units of Class 2 buildings and Class 4 Parts as these are covered by the new Part J0.

Currently there are two methods in Section J for assessing the compliance of glazing. Glazing Method 1 can be used for residential buildings and small shops. By using the house energy rating software for Class 2 sole-occupancy units and Class 4 parts of buildings, Glazing Method 1 would now only be used for Class 3 buildings and Class 9c aged care buildings. None of the compliance tables J2.3b, J2.3c or J2.3c need amending, only the constants in table J2.3a which set the allowance.

Natural light

The BCA has a minimum requirement for natural light in habitable rooms of residential buildings but not for commercial buildings. However, there is a body of knowledge on the psychological value of some connection with the outside environment while some stakeholders also feel that there is an optimum window area to wall area ratio for energy efficiency, that is, the benefit of reducing solar load verses the extra energy used for internal lighting. While large windows may increase the load on the air-conditioning system, small windows limit natural light thereby increasing the dependence on artificial light which uses energy and, in turn, also loads the air-conditioning system.

Dr Peter Lyons in his report titled ‘Daylight, Optimum Window Size for Energy Efficiency: BCA Volume One’ demonstrated that with lighting levels to AS/NZS 1680 for interior and workplace lighting, the optimum window-to-wall ratio is somewhere around 10 per cent depending upon ceiling height, ceiling reflectivity, window distribution etc.

If a conservative limit of around 15 to 20 per cent minimum window-to-wall ratio is set, there is considerable scope for saving energy by avoiding excessive window area while still permitting a reasonable indoor-outdoor connection.

Glazing option ‘B’

Glazing option ‘B’ is for use in conjunction with walls that have only a furring channel, top hat section or batten space for insulation. It is more demanding in order to compensate for a thermally underperforming wall. The revised proposal is based on maintaining the same relationship with the wall option for furring channels as currently exists.

Part J3 Sealing

There are a range of changes proposed and the more significant ones are discussed below.

Louvres

Clause J3.4b is proposed to be changed to remove the exemption for a louvred door, louvre window, or other such opening. This concession was introduced for housing in 2003 because it was understood that only one manufacturer at that time produced well sealed louvres. This exemption was continued in Volume One in 2005. Because commercial buildings are likely to be conditioned for long periods, the amount of energy lost through leaking louvres is considerable. With the exemption removed from Volume One, designers will still have the option of using better sealing louvres or isolating the louvred area from the conditioned space in the remainder of the building. It is not proposed to remove the exemption from Volume Two because houses are less likely to be air-conditioned for long periods and, with louvres, will benefit from ‘free-running’ during milder periods.

Entrances in J3.4

Clause J3.4d is proposed to be changed to require some control at all entrances, not just the main entrance as is the current requirement. This need only be a door closer.

The loss of energy through this exemption far exceeds that saved through other provisions and questions the logic of insulating the other walls if one is missing.

Calking in J3.6

J3.6 has also been amended to require calking around the frame of windows, doors, roof lights and the like; not just architraves.

Other minor changes

There are also four minor changes proposed. Three are in order to remove variations. The first is in the Application Clause J3.1 to clarify that a building that is intended to be open is exempted from the sealing provisions. The second clarifies that the seal required on the bottom edge of a door in J3.4 is a draft protector. The third is for exhaust fans in J3.5 to be sealed in climate zone 5 in addition to climate zones 4, 6, 7 and 8. The last is in J3.6 and would require calking around the frames of external doors and windows which are potentially high leakage places.

Leakage testing

No requirement will be introduced in BCA 2010.

Part J4 Air movement

This part about air movement only applied to sole-occupancy units of Class 2 buildings and Class 4 Parts and is now proposed to be covered by the new Part J0. Therefore, part J4 can be deleted.

Part J5 Air-conditioning and ventilation

There are a range of changes proposed and the more significant ones are discussed clause-by-clause below.

Variable speed fans

A new provision is being proposed for J5.2 requiring the fan of systems that are designed for a varying air flow to have a variable speed motor.

Speed control of motors is now cheaper than air dampers and the associated controls and results in lower energy consumption.

The Coffey Environments report titled ‘Section J — Review of Fan Power Provisions’ indicates that such a provision is cost effective with a 2:1 benefit to cost ratio.

Fan power allowance

Also as a result of the Coffey Environments report titled ‘Section J — Review of Fan Power Provisions’, the fan power allowance for air-conditioning systems is proposed to be reduced. The report details the likely energy savings and the positive benefit to cost ratio for each element. All up, the package of pressure reductions for ducting, filters and coils, including the additional capital cost needed, achieves a 2:1 benefit to cost ratio.

The values in the Coffey report have been adjusted as the report expresses the building load in terms of the currently defined motor input power while industry has proposed changing that expression to the fan shaft input power.

The table has different shaft power allowances for sensible air-conditioning loads. The sensible load (the load that causes a rise in temperature) is used as this is the load with which the fan flow rate is determined.

Mechanical ventilation

There has been some confusion as to what an air-conditioning system does and what a ventilation system does. Sub-clause (b) has been restructured to clarify that mechanical ventilation is about the outside air provided to met the requirements of Part F4 with (ii) for when part of an air-conditioning system and (iii) when a stand-alone system.

Outside air

J5.2(b)(ii) in BCA 2009 permits the minimum outside air required by AS/NZS 1668.2 to be exceeded by up to 50 per cent. This apparently generous allowance was to accommodate air-conditioning systems that serve a series of rooms with slightly different outside air requirements. Anecdotal feed back has been that 50 per cent was too generous and that the value could be significantly reduced without any additional cost in most situations.

However, in some situations, such as where offices were served by the same system as a conference room, a separate system may now be needed. It is proposed to reduce the 50 per cent over supply allowance to 20 per cent.

It is also proposed to amend (and relocate) the current (b)(iii)(B) for a building where the number of people per square metre is 1 or less.

Ventilation system fans

In the same report, Coffey Environments recommended changes to the fan power allowance for ventilation system fans, again on the basis of them being cost effective with a positive benefit to cost ratio. The value has also been reduced by 10 per cent.

J5.4 Heating and cooling systems

The term 'chilling' has been changed to 'cooling' to include systems that use water at slightly higher temperatures.

Pump power allowance

Coffey Environments also prepared a report titled 'Section J — Review of Pump Power Provisions', recommending that the pump power allowances also be reduced. Again, the report details the likely energy savings and the positive benefit to cost ratios for each element. All up, the package of pressure reductions for control valves, coils and piping, including the additional capital cost needed, achieves a positive benefit to cost ratio with the likely future costs of energy. Also the report used a pump efficiency of 70 per cent which is difficult to always achieve so the values have been adjusted.

The recommendation for hot water pumps in the report was a single value irrespective of heating load so this has been converted into a rate based on a range of heating load. The calculations also used 80 W/m at 120 kPa and 70 per cent efficiency as the base case and after further consideration these have been adjusted to 100 W/m at 200 kPa and 50 per cent efficiency.

The public and industry are invited to review and test the proposals and provide comment where they feel that the proposals are either too tough, or not tough enough.

Again, at the request of industry, it is proposed to clarify that floor area measurement be 'area of the floor of the conditioned space' rather than the defined BCA term '*floor area*'. This is because only part of the building may be conditioned.

Variable speed pumps

Coffey's proposed text did not retain the 3500 hours a year operation for pumps to justify variable speed control. Its removal simplifies regulation as the usage is not easy to estimate and in any case, most systems would operate for sufficient time for speed control to be cost effective.

Choice of fuel for heaters

A report by George Wilkenfeld and Associates investigated the potential benefit of regulating the energy source of various systems. It is titled 'Swimming pools and electric space heating - The case for coverage by the Building Code of Australia' and makes recommendations with respect fixed space heating. The report can be found on the energy page of the ABCB web site.

The proposal is to require gas to be preferred over oil and for heating other than by hot water, the prohibiting of electricity in most cases.

For heaters installed outdoors, a provision for automatically turning off is proposed. This would be by air temperature sensor, timer or motion detector.

Thermal plant

A report on improving the efficiency of thermal plant was prepared by Coffey Environments through DEWHA. It recommends improvements in the efficiency of boilers and improvements in the coefficient of performance of package air conditioners.

Table J5.4d for the performance of a chiller has been reduced in scope by the removal of chillers for which there will be MEPS requirements by 2010.

Heat rejection plant

The heat rejection plant in sub-clauses (e) to (h) have been simplified as a result of the change in the definition of shaft power causing the elimination of the need for a definition, and values, for input power.

Part J6 Artificial lighting and power

J6.2 Interior artificial lighting

Residential

Based on the Lighting, Art + Science Pty Ltd study mentioned above, it is being proposed that the lighting power in houses and sole-occupancy units of Class 2 buildings and Class 4 parts be included in the BCA 2010.

The recommended lamp power density within the building is 5 W/m2 and 4 W/m2 on a verandah or balcony.

J6.3 Interior artificial lighting and power control

It is proposed to exempt certain buildings from the maximum lighting area in J6.3(c) These buildings are ones in which the main lighting would either be on or off such as an auditorium, theatre, swimming pool or sports stadium.

The exemption in J6.3(g) is extended to a Class 9c building and possibly other buildings by the lead-in provide some explanatory text as to why there is the need for an exemption.

Part J7 Hot water supply, swimming pools and spa systems

Currently Part J7 is about energy efficiency in the reticulation systems of sanitary hot water and hot water for cooking. It is proposed to extend the scope to include swimming pools and spa systems.

The Australian Government has also requested the ABCB to include hot water supply heaters in the BCA for Class 1 buildings in 2010 and Class 2 and Class 4 parts for 2011. Three separate studies will contributed to these proposals, the most recent being a Regulatory Impact Statement by George Wilkenfeld and Associates that was commissioned by the DEWHA. Another, prepared for the ABCB was titled 'Specifying the Performance of Water Heaters of New Houses in the Building Code of Australia', December 2007 and is also on the ABCB web site.

The government's concerns are the continued use of electric heaters, which are responsible for high greenhouse gas emission rates, and improving the efficiencies of other types of heaters.

J7.3 Swimming pool heating and pumping

Over recent years stakeholders have questioned the BCA focus on the building fabric and only some of the services in buildings and have questioned why the heating and pumping associated with pools and spas have not been included. The reason has been that up to now the provisions have been to satisfy a performance for energy efficiency rather than greenhouse gas emission reduction, and did not consider the greenhouse emission rate of the fuel used. If the performance requirements are to be amended to address the greenhouse gas emission rate of the energy source, pool and spa heating could be considered. These are included in the provisions in some other countries.

The ABCB commissioned George Wilkenfeld and Associates to investigate the potential benefit of regulating the heating systems of pools, spas etc and their report titled 'Swimming pools and electric space heating - The case for coverage by the Building Code of Australia' can be found on the energy page of the ABCB web site.

This Clause lists what fuel source may be used to heat a pool and in doing so, prohibit heating by an oil fired heater or an electric resistance heater.

In addition, a pool heated by heat pump or gas must have a cover for when not being used while a circulation pump must be controlled by a time switch

George Wilkenfeld and Associates have also recommended other possible requirements but more industry consultation will be needed in order to develop appropriate provisions.

J7.4 Spa heating and pumping

The George Wilkenfeld and Associates report also covered spas.

As with swimming pools, this clause lists what fuel source may be used. It also requires a thermal cover and heater controls.

George Wilkenfeld and Associates have also recommended other possible requirements but more industry consultation will be needed in order to develop appropriate provisions.

Part J8 Commissioning and facilities for maintenance and monitoring

Part J8 already exists as 'access for maintenance' and it is proposed that it be extended to include other aspects such as commissioning and aspects that facilitate the ongoing operation of the plant including maintenance manuals and monitoring means.

J8.3 Commissioning of systems that use energy

In past submissions to the ABCB, practitioners have advocated the importance of correct commissioning of building services systems. For example, poorly commissioned outside air dampers will introduce more hot or cold outside air than Section F requires and so require more energy to cool or heat the air. Even worse, a heating system and a cooling system may be operating at the same time if the controls are not properly set.

There has been some reluctance in the past to include something that could be considered a matter of workmanship but with the government's desire to further improve the energy efficiency of building the proposal to include commissioning has been revisited. It should be noted that the BCA already includes commissioning through reference standards such as AS 1670.1, AS/NZS 1668.1, AS 1668.2, AS 2118 and AS/NZS 366.1.

J8.4 Information to facilitate maintenance

The focus is on manuals being provided to facilitate the ongoing maintenance required by Section I. It is difficult to carry out ongoing maintenance unless documentation is provided that describes the systems, how they were intended to operate and what were the settings of thermostats, dampers, thermal plant sequencing, balancing valves and control valves for water systems, etc, after commissioning.

J8.5 Facilities for energy monitoring

Facilities for energy monitoring takes some form of metering so that it is possible to know how much energy is being used in each significant building on a site. For a single building on an allotment metering the total energy use would be the responsibility of the supply authority but on a campus style site may have a number of buildings off the same supply authority meter making it difficult to tell which building has higher that expected energy use.

It is also proposed to require separate metering of the main services including the air-conditioning, lighting, appliance power, hot water supply and lifts, etc. Although appliance power is not regulated by the BCA, the monitoring consumption will assist energy management.

The energy efficiency of internal transport devices (lifts and escalators) are not currently included in the BCA although many stakeholders feel they should be included. As other energy consuming services are improved the energy used by lifts become, an increasingly greater part of the remaining consumption and, even if the modern lift is efficient, those remaining in buildings being refurbished may not be. To date, the ABCB has not been able to get the support of the lift industry however it is proposed that the energy consumption of lifts be metered to enable their sequencing to be fine tuned or scheduling changed such as taking some out of service when there is a low demand.

Specification J5.2

Obrart & Co, a building services engineering consulting firm, was commissioned by the ABCB Office to review Specifications J5.2 and J5.4 in order to investigate the potential to increase the stringency and to consult with industry on its implementation. The Air-Conditioning & Mechanical Contractors Association has also made a submission highlighting some difficulties with the way the Specifications are being interpreted and suggesting some changes.

The first proposal is to change Total R-Value to R-Value or material R-Value. Philosophically the building fabric ‘insulating’ values in the BCA are best express in overall performance terms and even pipe insulation was expressed this way because of claims that plastic pipes were inherently insulated. However, the benefit is marginal. The Obrart & Co recommendation is to ignore the duct or pipe and state the added insulation required.

With the current provisions it is unclear whether return air ductwork passing through a conditioned space is exempted from requiring insulation. It is also unclear whether fresh air ductwork and exhaust air ductwork is exempt. In 3(d) it is proposed to clarify that they are both exempt.

Currently table 3 of Specification J5.2 is in two parts. The first permitted domestic type systems to be used, with domestic level of insulation, for systems under 65 kW capacity. This concession has now been removed as a system in a dwelling may only operate for less than a 1,000 hours per year while one in a commercial building will operate for in excess of 2,000 hours per year.

The recommendations on increased insulation in table 3 are based on reducing the per cent loss in energy through the ductwork or piping to less than 3 per cent.

Currently evaporative cooling ductwork has a lesser insulation requirement than heating or refrigerated cooling ductwork. Even with a damper at the ceiling, heated air can leak past the damper and travel along the ductwork in the winter and be lost through the ductwork walls. The clause is proposed to be modified to require the same level of insulation for heating and cooling ductwork.

Some other Obrart & Co recommendations have not been incorporated into this proposal at this time as peer review and more consultation is appropriate.

Specification J5.4

In addition to the Obrart & Co recommendations for clarification on the last conditioned spaces served, other exemptions, the change to material R-Value and increasing stringency, Specification J5.4 has been amended to include piping for cooling water, steam and refrigerant.

Specification J6

The report by Mr Peter McLean of Lighting, Art + Science Pty Ltd, titled ‘Review of Section J6 of the BCA’ also contained recommendations for Specification J6. The report can be found on the energy page of the ABCB website. The recommended changes to the Specification are relatively minor and of minimal cost impact. They have been incorporated into these proposals.

Proposals include the removal of lighting timers and minor amendments to the specifications for a time switch, motion detector and a daylight sensor and dynamitic lighting control device.

B Specifying the performance of water heaters for new Class 1 buildings in the Building Code of Australia

This appendix presents (in full) the Final RIS conducted on the water heating provisions by George Wilkenfeld and Associates (W&A 2009c). This study has been used to support some of the findings contained in this RIS.

The appendix is provided as an attachment to this document.

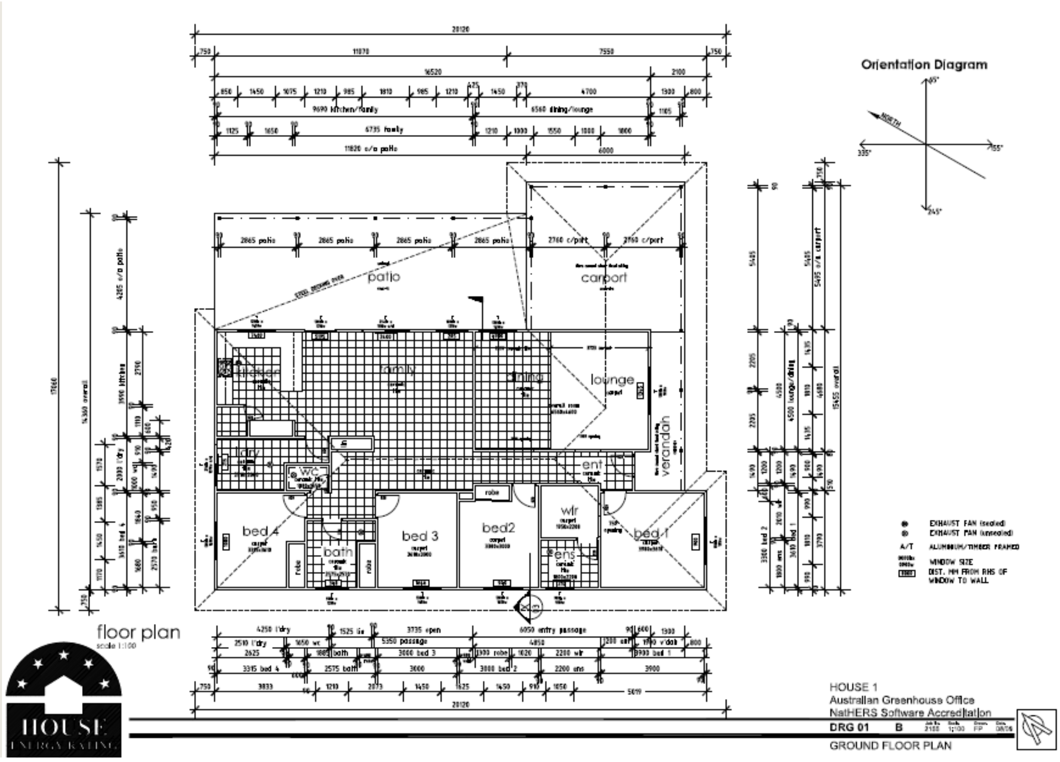
C ABCB sample houses

The charts below provide details of sample dwellings provided by the ABCB. Not included below are details of the Class 2 (flat) example used in the study. Details of the Class 2 building can be found in Burghardt (2008).

C.1 **House 01 — single storey 165m^2**

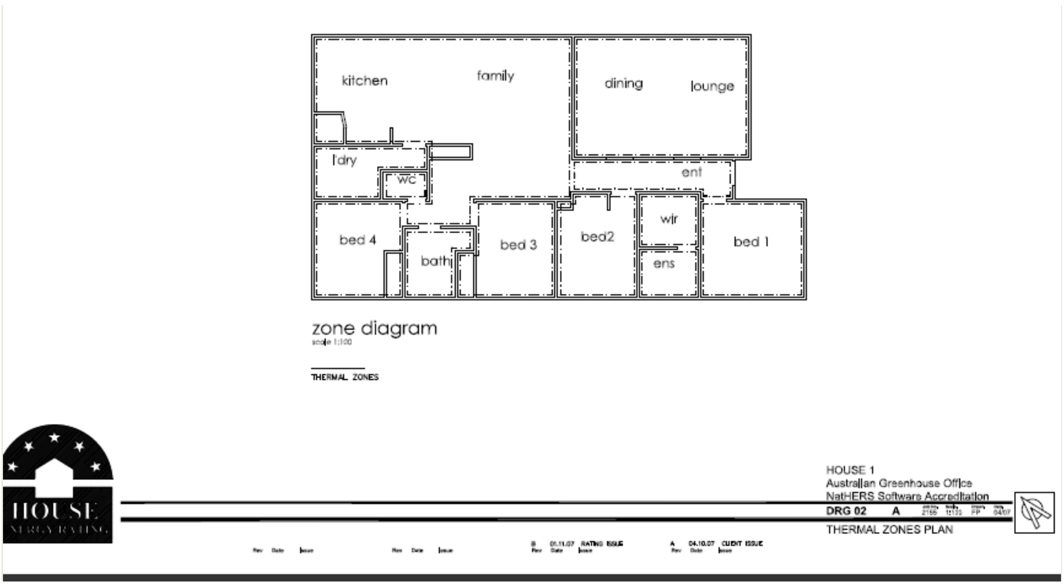
Data source: Constructive Concepts (2009).

C.2 **House 01 — floor plans**



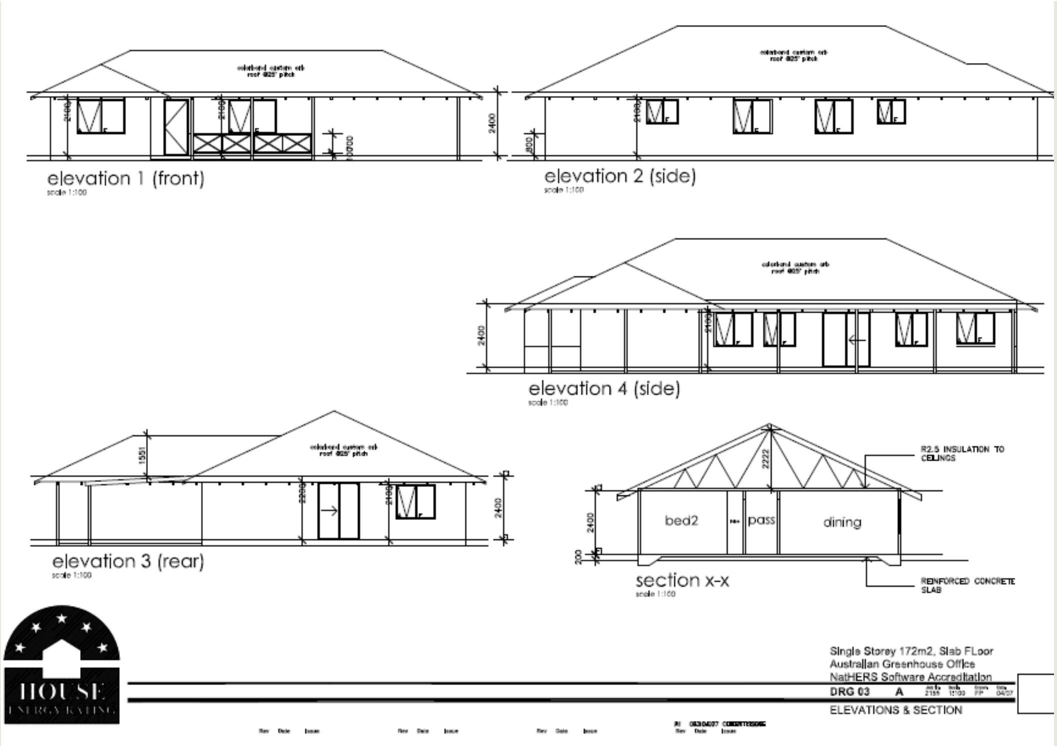
Data source: Constructive Concepts (2009).

C.3 **House 01 — zone diagram**



Data source: Constructive Concepts (2009).

C.4 **House 01 — evaluation**

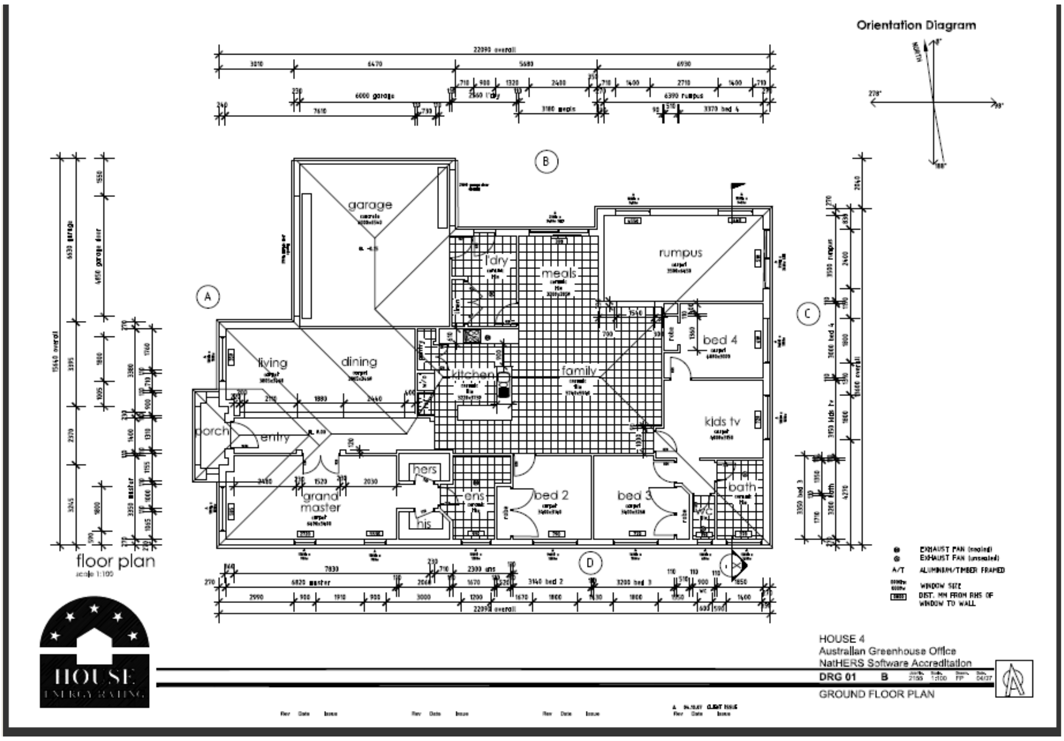


Data source: Constructive Concepts (2009).

C.5 **House 04 — single storey 232m^2**

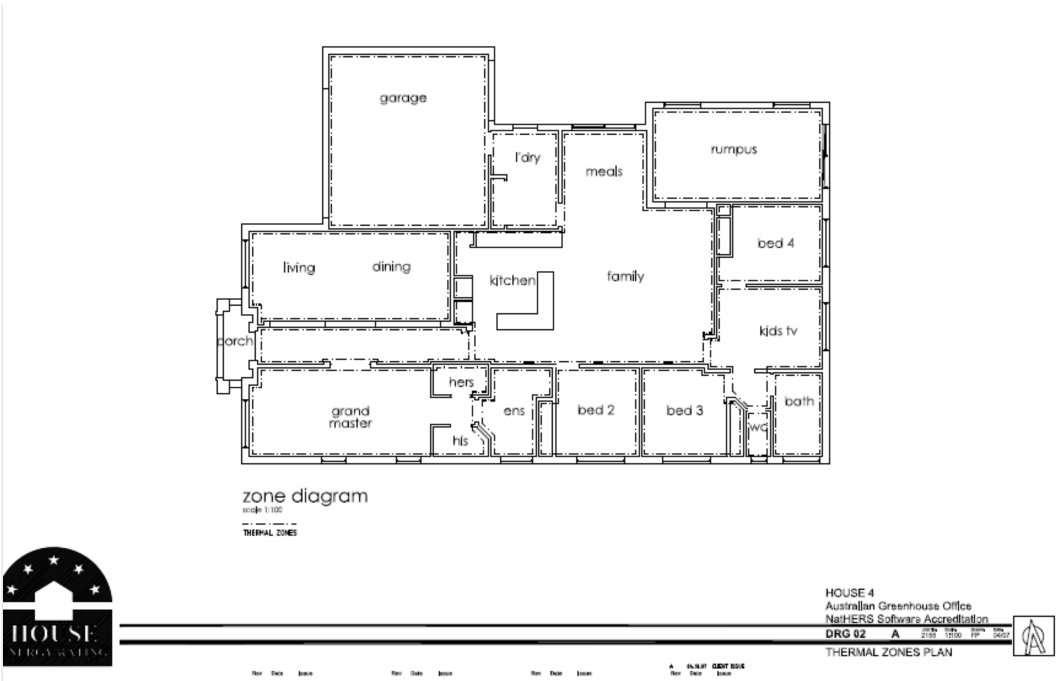
Data source: Constructive Concepts (2009).

C.6 **House 04 — floor plans**



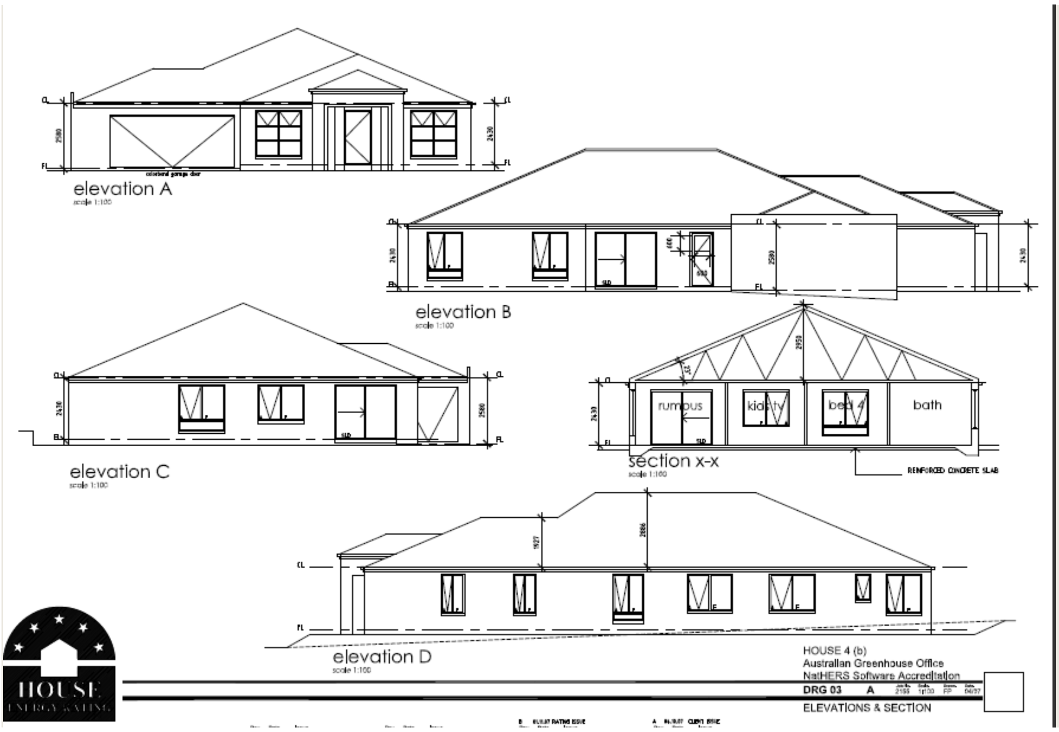
Data source: Constructive Concepts (2009).

C.7 **House 04 — zone diagram**



Data source: Constructive Concepts (2009).

C.8 **House 04 — elevation**

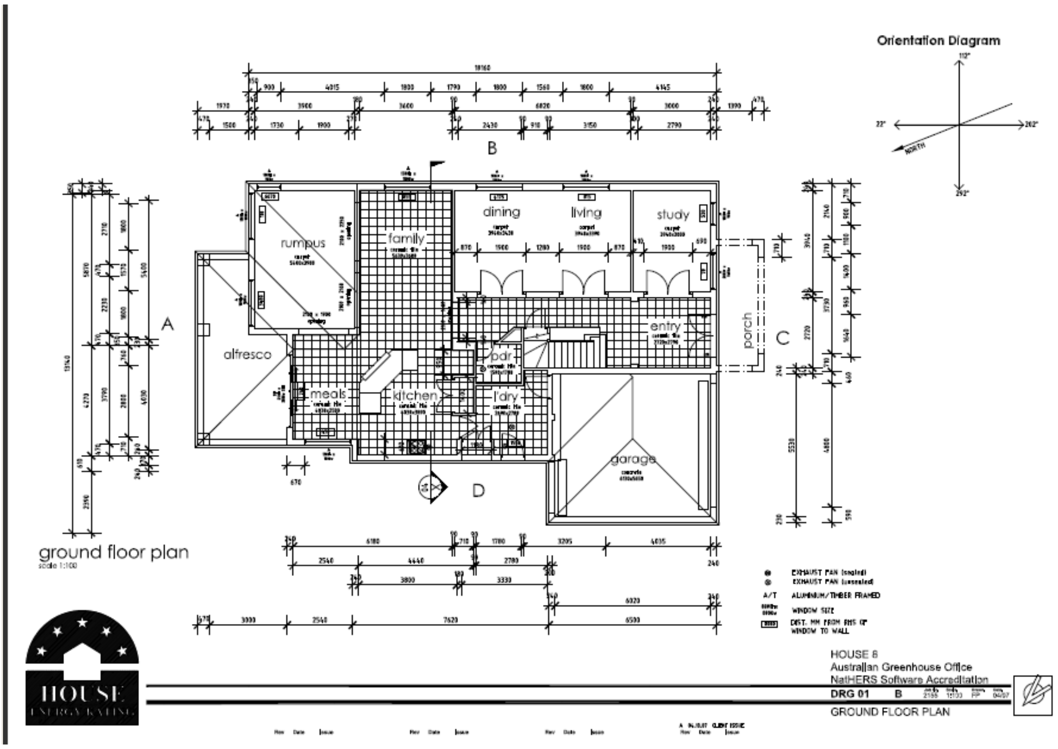


Data source: Constructive Concepts (2009).

C.9 **House 08 — double storey 263m^2**

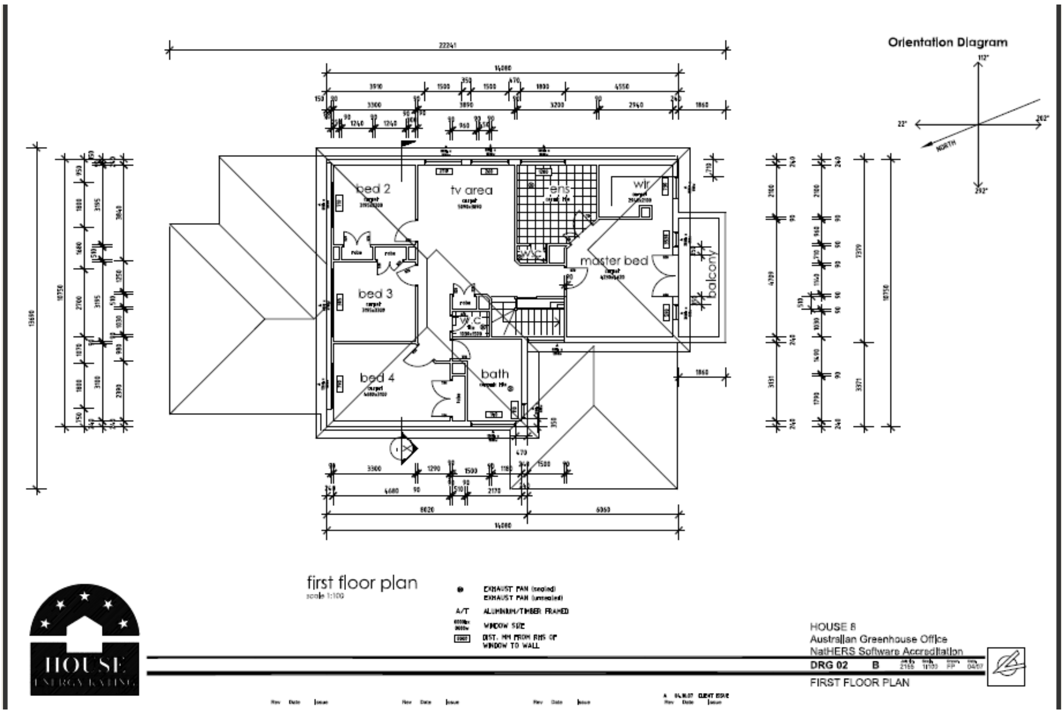
Data source: Constructive Concepts (2009).

C.10 **House 08 — ground floor plans**



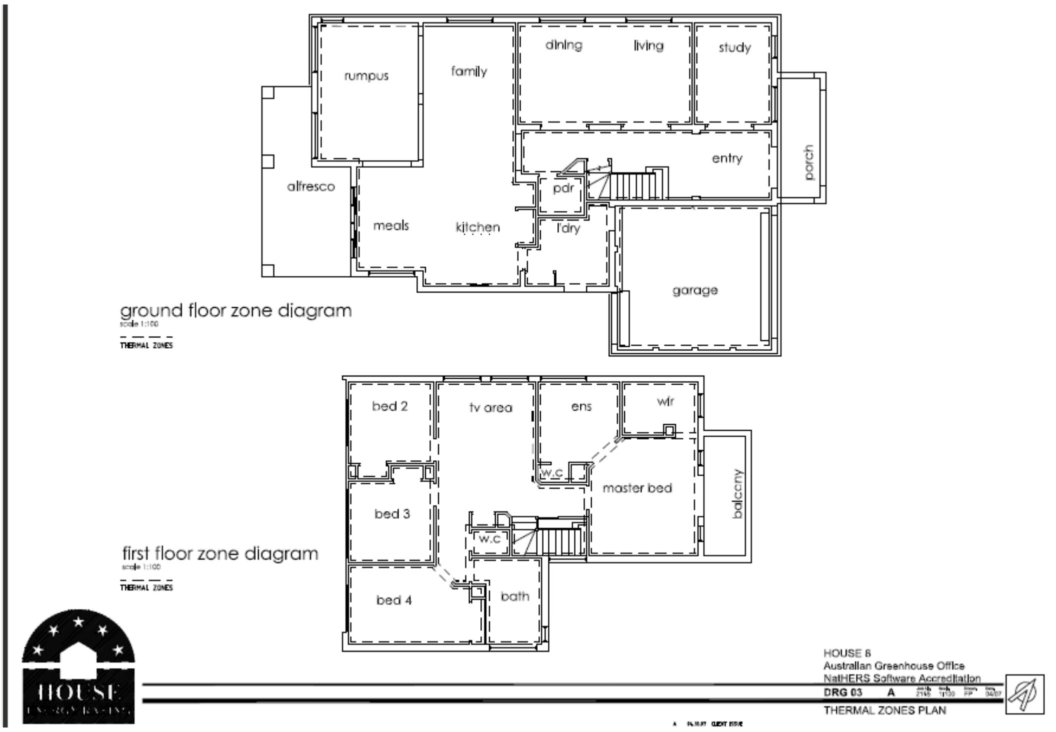
Data source: Constructive Concepts (2009).

C.11 **House 08 — first floor plan**



Data source: Constructive Concepts (2009).

C.12 **House 08 — zone diagram**



Data source: Constructive Concepts (2009).

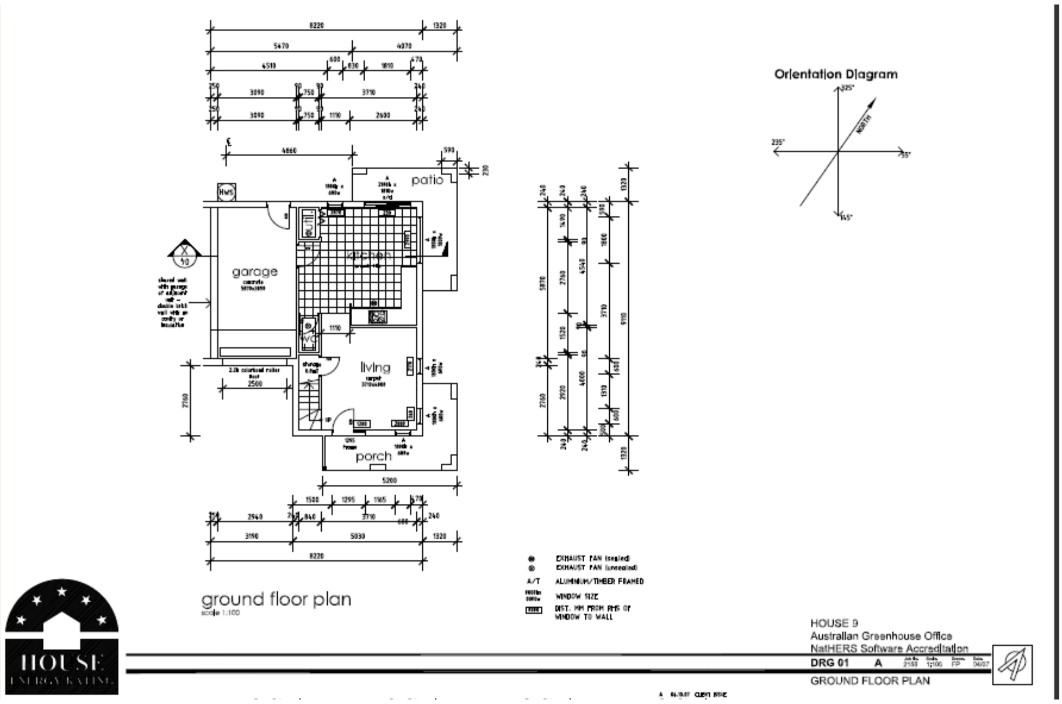
C.13 **House 08 — elevation**

Data source: Constructive Concepts (2009).

C.14 **House 09 — Double storey townhouse 90m^2**

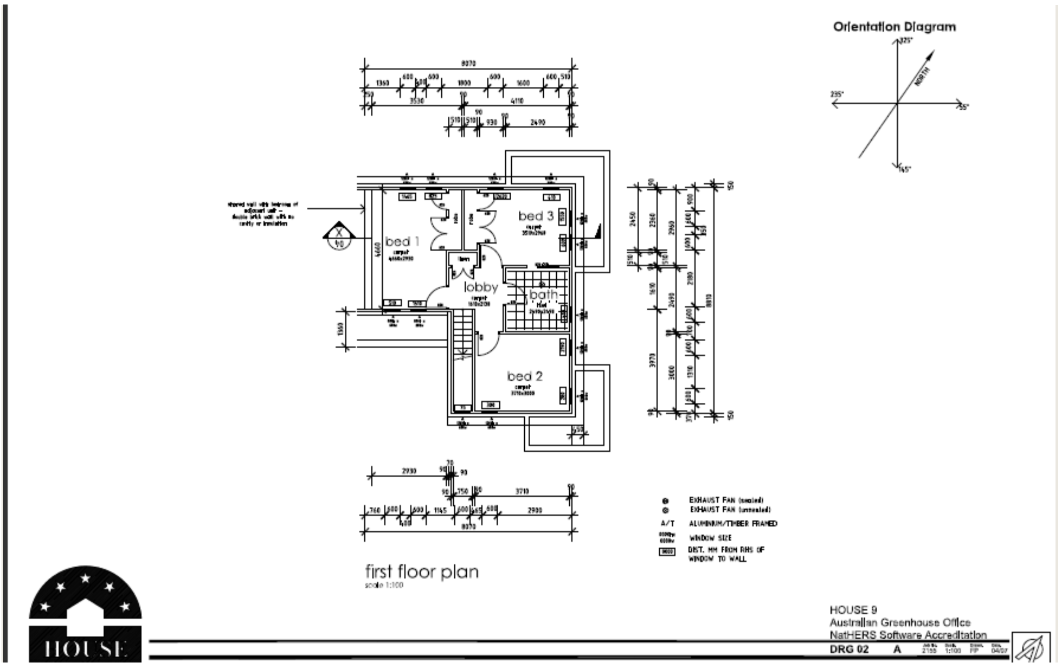
Data source: Constructive Concepts (2009).

C.15 **House 09 — ground floor plan**



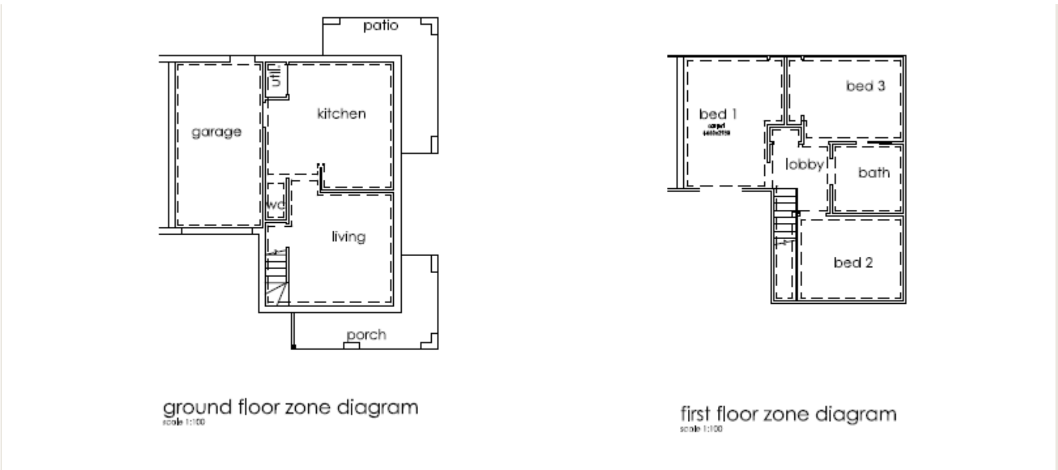
Data source: Constructive Concepts (2009).

C.16 **House 09 — first floor plan**



Data source: Constructive Concepts (2009).

C.17 **House 09 — zone diagram**



Data source: Constructive Concepts (2009).

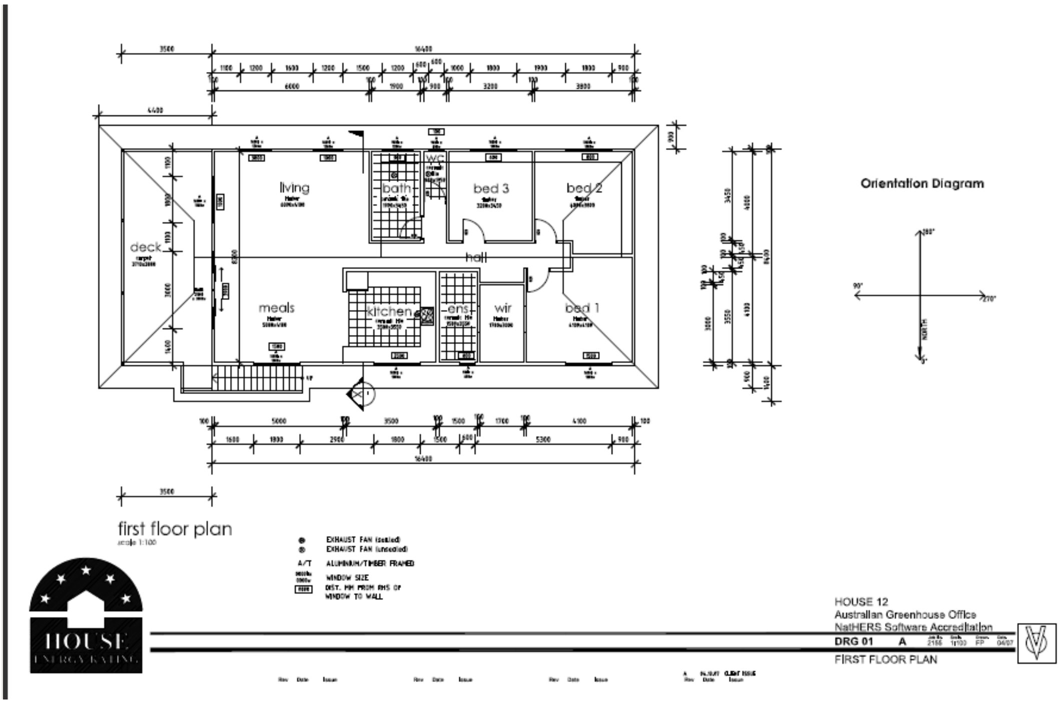
C.18 **House 09 — elevation**

Data source: Constructive Concepts (2009).

C.19 **House 12 — single storey 165m^2**

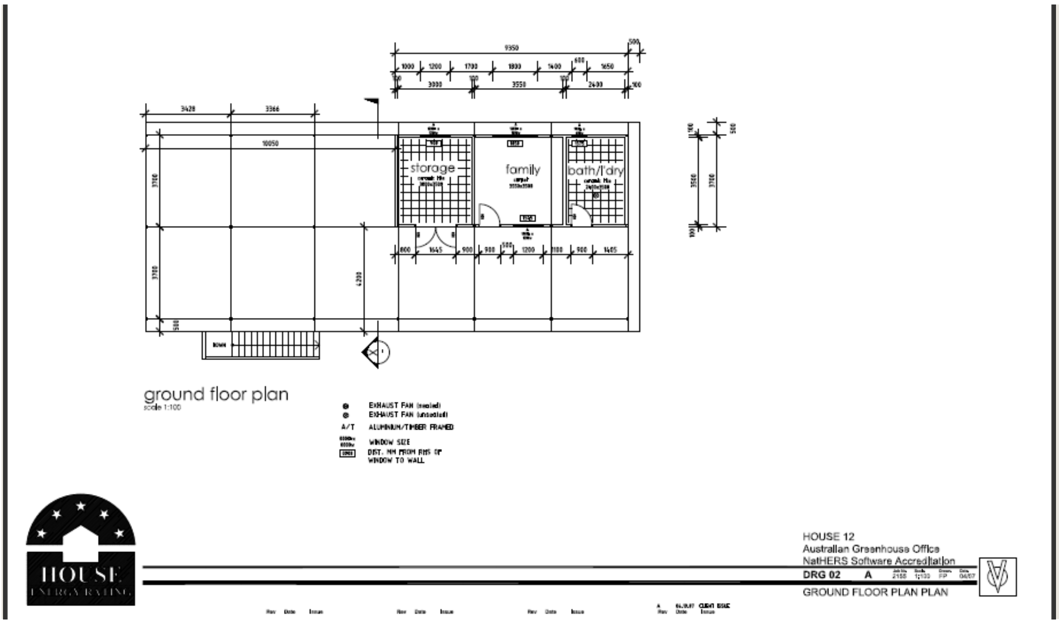
Note: H12 is an elevated "single storey" house, and for all intents and purposes is considered a single storey dwelling.
Data source: Constructive Concepts (2009).

C.20 **House 12 — first floor plans**



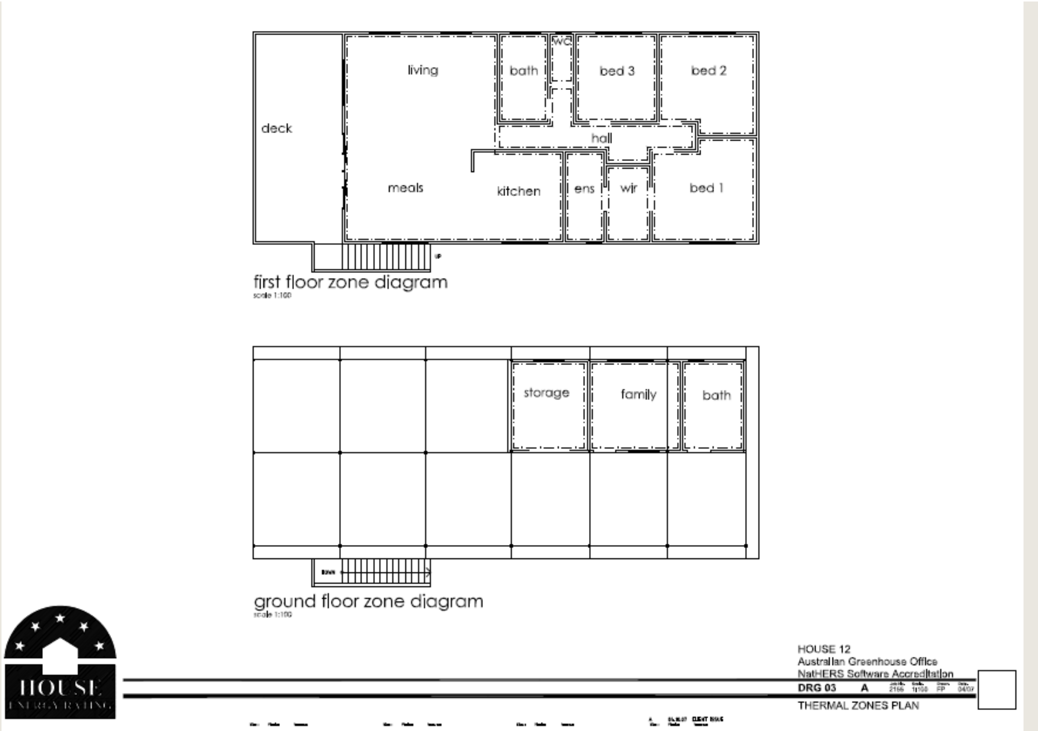
Note: H12 is an elevated house, and for all intensive purposes is considered a single story dwelling.
Data source: Constructive Concepts (2009).

C.21 **House 12 — ground floor plan**



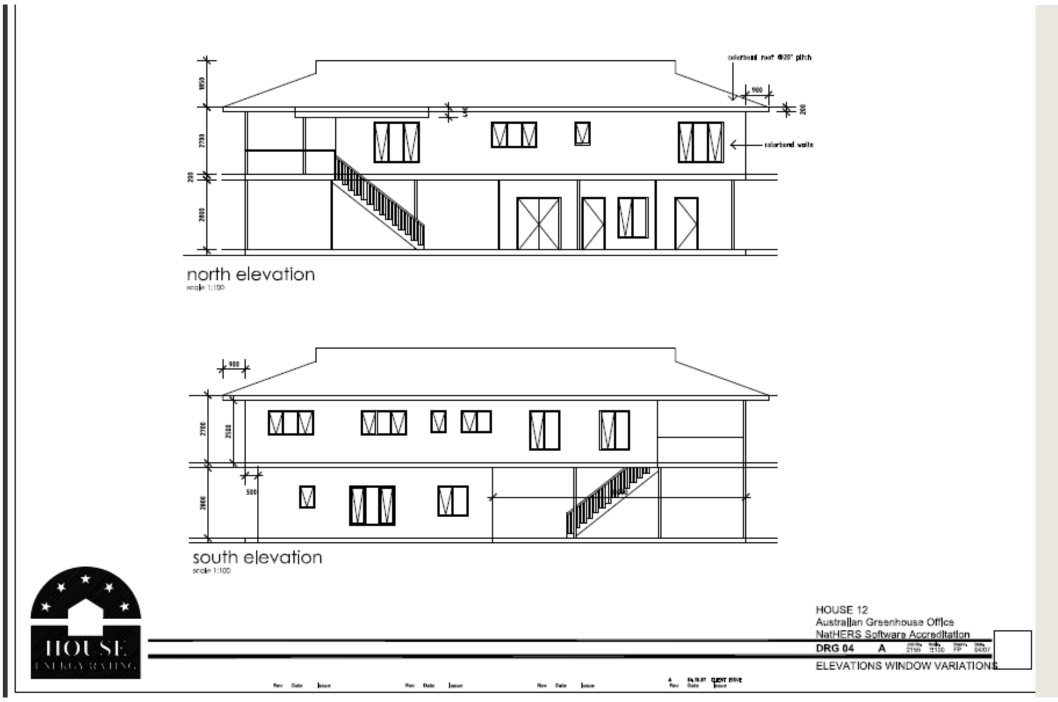
Note: H12 is an elevated house, and for all intensive purposes is considered a single story dwelling.
Data source: Constructive Concepts (2009).

C.22 **House 12 — zone diagram**



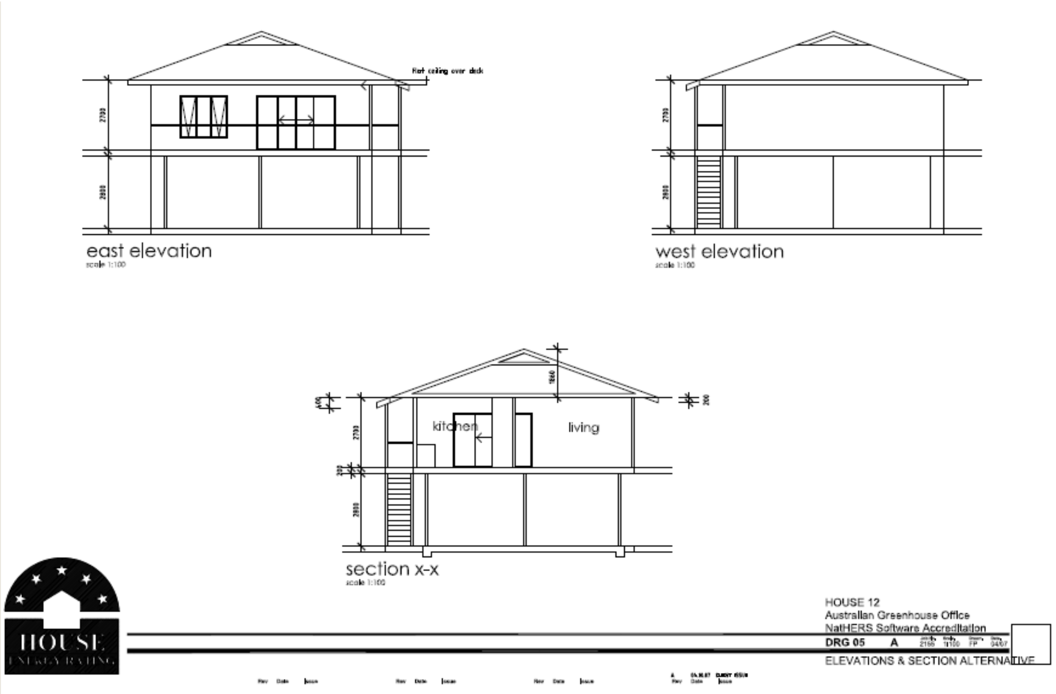
Note: H12 is an elevated house, and for all intensive purposes is considered a single story dwelling.
Data source: Constructive Concepts (2009).

C.23 **House 12 — elevation**



Note: H12 is an elevated house, and for all intensive purposes is considered a single story dwelling.
Data source: Constructive Concepts (2009).

C.24 **House 12 — elevation**

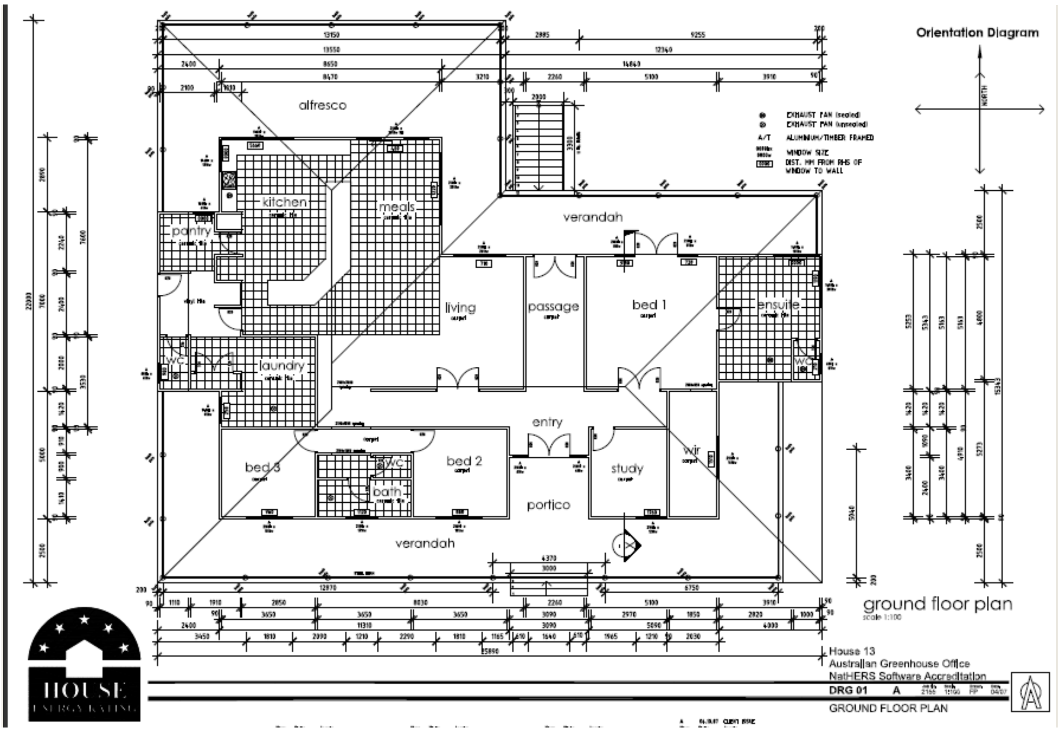


Note: H12 is an elevated house, and for all intensive purposes is considered a single story dwelling.
Data source: Constructive Concepts (2009).

C.25 **House 13 — single storey 261m^2**

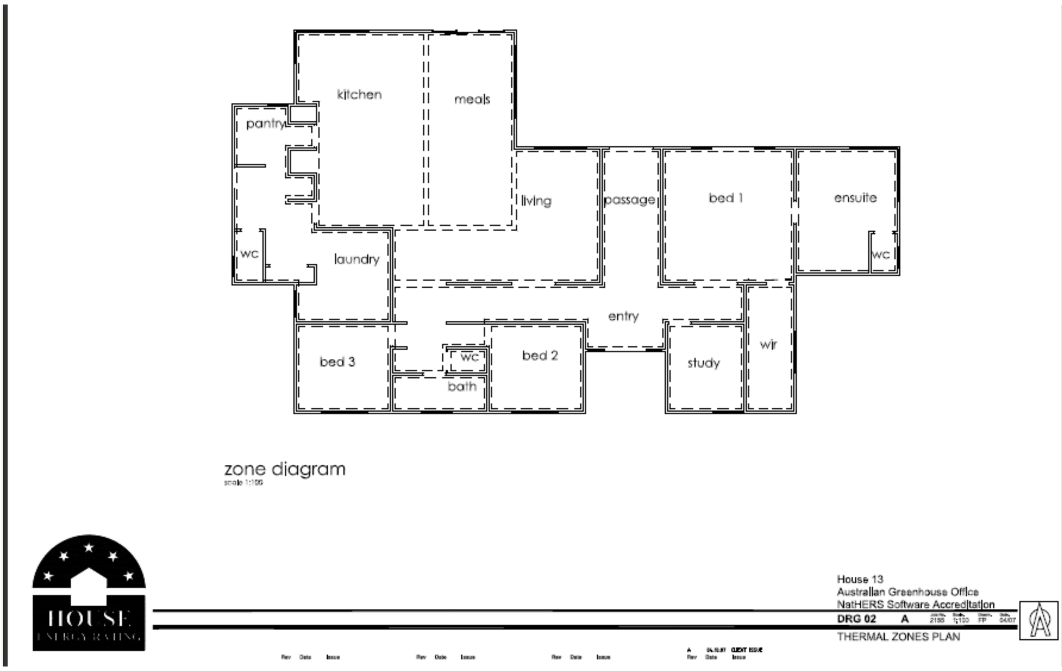
Data source: Constructive Concepts (2009).

C.26 **House 13 — floor plans**



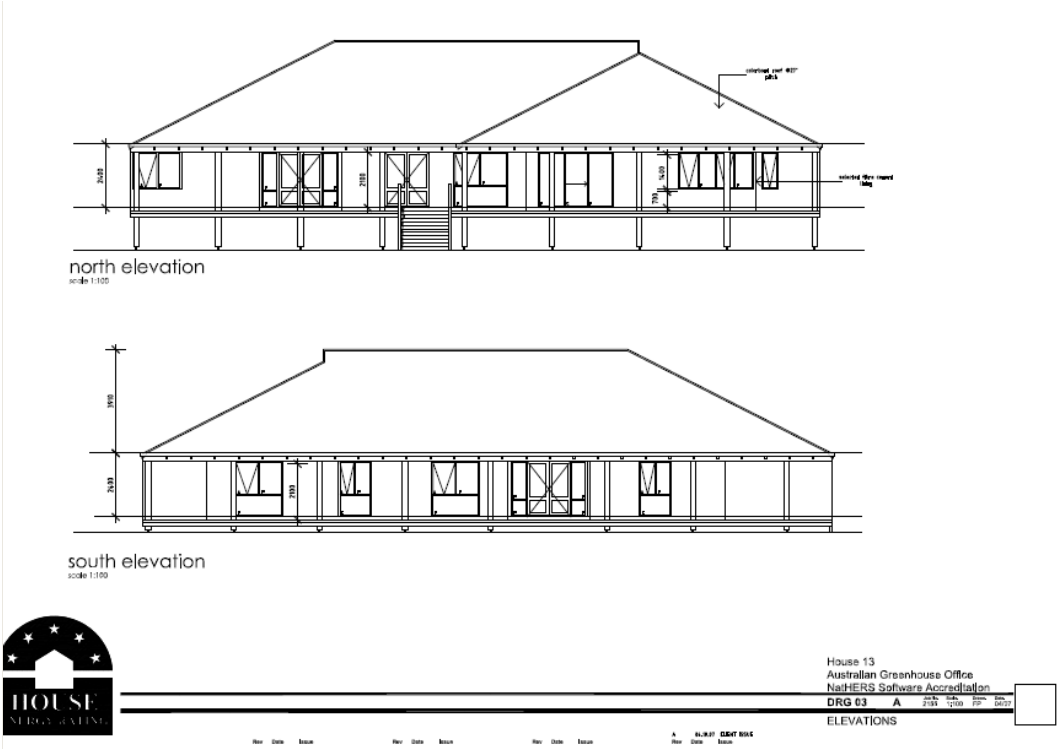
Data source: Constructive Concepts (2009).

C.27 **House 13 — zone diagram**



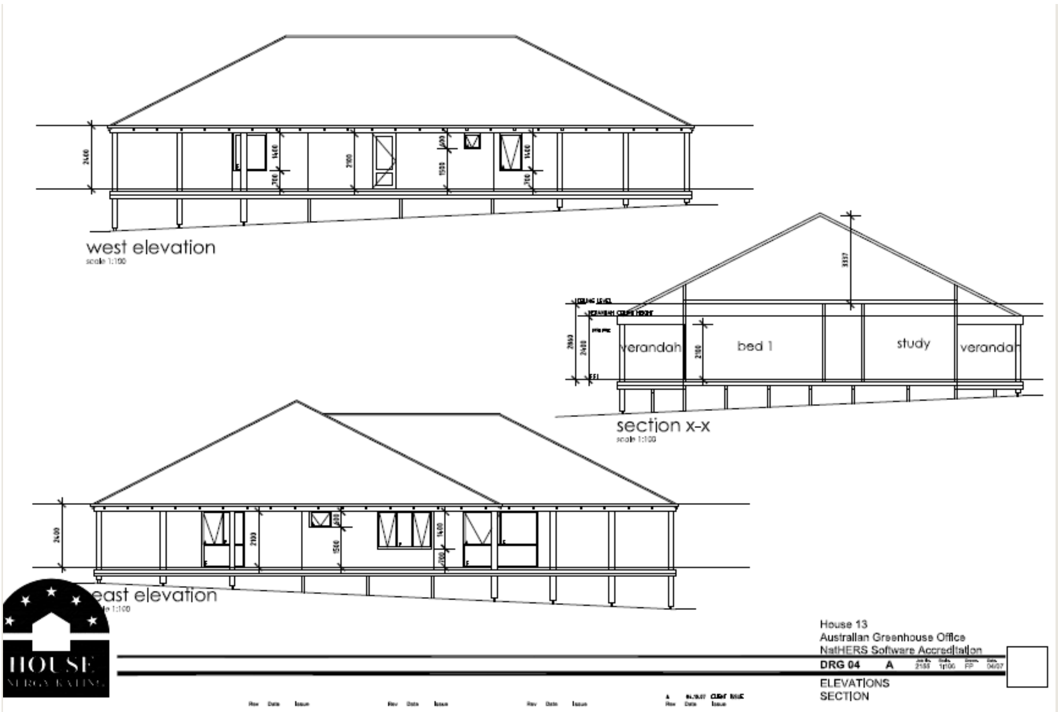
Data source: Constructive Concepts (2009).

C.28 **House 13 — elevation**



Data source: Constructive Concepts (2009).

C.29 **House 13 — elevation**



Data source: Constructive Concepts (2009).

D Aggregation and creation of a baseline

This RIS considers the costs and benefits of the proposed BCA amendments over time and is made with reference to a benchmark of maintaining the status quo. As highlighted in the CIE's report *Economic evaluation of energy efficiency standards in the Building Code of Australia* (CIE 2009a), defining the 'business as usual' (BAU) scenario when undertaking a RIS is of upmost importance. This is because a cost-benefit analysis aims to reflect the difference between the BAU and the proposed regulatory action.

The BAU benchmark assumes no amendments will be imposed by the BCA, but this does not imply that the baseline is static. There may exist, for example, a background level of voluntary adoption that occurs without changes in the BCA.

Essentially, the baseline should portray the 'best' depiction of the foreseeable counterfactual. Costs and benefits associated with the amendments are gauged by the extent to which they depart from this baseline. The baseline therefore, needs to consider:

- changes in energy prices;
- growth of the housing stock;
- changes in the structure of the housing stock;
- population movements;
- the fuel mix;
- changes in the greenhouse gas intensity of energy; and
- other relevant 'background' variables.

The sections below describe how the baseline for the residential building sector was constructed.

A building blocks approach

To estimate the likely impact of the proposed amendments to the BCA, this analysis uses a 'building blocks' approach. Here, the impact of the amendments will first be measured against a sample of illustrative buildings, and are then aggregated to a national level using known distributions of buildings. This allows for the amendments to be evaluated at individual, regional, climatic, State and national aggregations.

A sample of representative dwellings has been provided by the ABCB, and provides the ‘building blocks’ of this analysis. The sample includes one- and two-storey houses, a townhouse and a flat. House 12 is the ABCB’s representation of a ‘transportable home.’[44] All housing structures (except the flat and House 12) are modelled with a concrete or timber flooring. Table D.1 provides a brief description, and further details of the sample are provided in appendix C. Details of the flat follow table D.2.

D.1 **ABCB sample houses**

House name	***Type***	***Storeys***	***Floor type***
H01	Separate house	Single	Concrete and timber
H04	Separate house	Single	Concrete and timber
H08	Separate house	Double	Concrete and timber
H09	Townhouse	Double	Concrete and timber
FLAT	Flat	Single	Concrete
H12	Separate house	Single	Timber
H13	Separate house	Single	Concrete and timber

Note: House H12 in the sample is considered a transportable home.
Source: ABCB (Constructive Concepts, 2009).

As the costs and benefits of the amendments are likely to be dependent on both climatic conditions and the market environment, the net impact on a particular house is likely to be location specific. Costs and benefits have been assessed for each of the house types above for a representative sample of locations.

Table D.2 reports the locations employed in this study, as well as their respective ABCB and NatHERS climate zones. This sample includes a representative of each capital city and climate zone.

D.2 **Representative locations**

BCA Climate Zone	***Population centre***	***State***	***NatHERS Climate Zone***
Climate zone 1	Darwin	NT	1

[44] For the purposes of this report a transportable house can be considered any home with a suspended timber floor.

BCA Climate Zone	***Population centre***	***State***	***NatHERS Climate Zone***
Climate zone 2	Brisbane	Qld	10
Climate zone 3	Longreach	Qld	3
Climate zone 4	Mildura	NSW	27
Climate zone 5	Adelaide	SA	16
	Perth	WA	13
	Sydney	NSW	17
Climate zone 6	Melbourne	Vic	21
Climate zone 7	Canberra	ACT	24
	Hobart	Tas	26
Climate zone 8	Cabramurra	NSW	25

Source: ABCB (Constructive Concepts, 2009).

Note that the ABCB's example of the Class 2 building has been extrapolated from Burghardt (2008). This study analysed the energy savings that would accrue to a representative apartment tower from an increase in the building's energy star rating. The study tested the impact on essentially the same building, in each of the climate zones.

For this study, the size of the building, in terms of the number of sole occupancy units, has been varied to be more representative of its location (see table D.3). Whole-of-building energy savings and costs were assessed, and then reported for a single flat (named FLAT in table D.1). For each location then, the representative flat took on both the specific climatic features, as well as characteristics of apartment blocks 'typical' to the area. Representative flats[45] would form the building block for flats in each location.

The first step in the aggregation process is to extrapolate the ABCB's buildings to a city-level aggregation. Exactly how this is performed is detailed below, but chart D.4 provides an overview of what must be achieved for each population centre identified in table D.2.

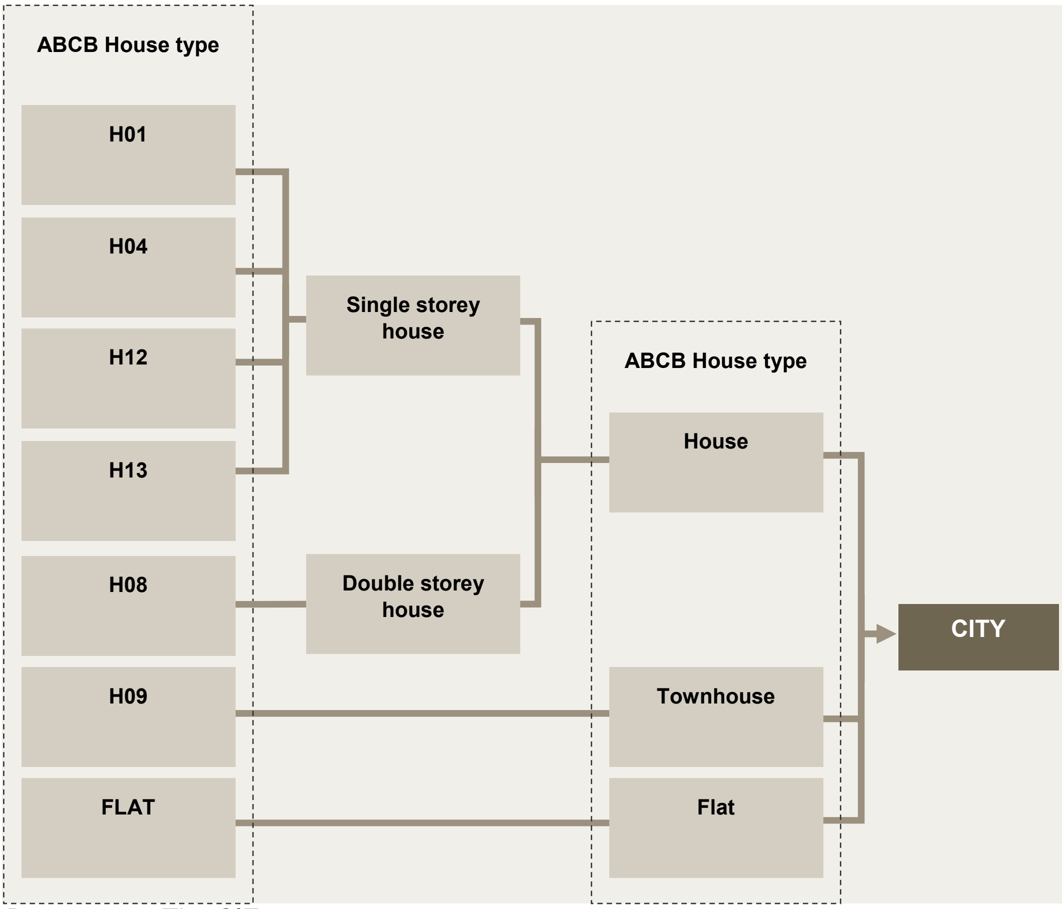
[45] Not the tower blocks themselves.

D.3 **Modelled apartment towers**

Location	*Number of sole occupancy units*	*Total building size, m²*	*Size of individual flat, m²*
Darwin	16	1426	89.1
Brisbane	24	2121	89.1
Longreach	8	713	89.1
Mildura	8	713	89.1
Adelaide, Perth, Sydney	16	1426	89.1
Melbourne	16	1426	89.1
Canberra, Hobart	8	713	89.1
Cabramurra	8	713	89.1

Source: ABCB based on Burghardt (2008).

D.4 **Aggregating from ABCB house sample to city**



Data source: The CIE.

To transform the ABCB's sample buildings into a more malleable currency, sample buildings have been categorised and aggregated as one of the ABS's three dwelling types: houses; townhouses and flats. Technical definitions of the ABS dwelling types are listed in box D.5.

D.5 **ABS dwelling types**

The ABS identifies three residential dwelling structures. These being:

- Separate house — this is a house which stands alone in its own grounds separated from other dwellings by at least half a metre.
- Semi-detached, row or terrace house, townhouse, etc — these dwellings have their own private grounds and no other dwelling above or below them.
- Flat, unit or apartment — this category includes all dwellings in blocks of flats, units or apartments. These dwellings do not have their own private grounds and usually share a common entrance foyer or stairwell. This category also includes flats attached to houses such as granny flats, and houses converted into two or more flats.

Source: ABS 2901.0 Census Dictionary.

Note that the ABCB sample includes five houses (four single storey and one double storey) which must be aggregated to the ABS's 'separate house' category. The houses included in the sample represent a diverse range of houses and need to be weighted to reflect a representative sample. Among the single storey houses, the ABCB has advised that houses H04 and H01 are the most typical representations. The assumed distribution of the single storey houses are provided in table D.6.

Note that this weighting reflects an economywide distribution. The distribution of houses throughout a particular location may differ from that in the table.

The distribution of single and double storey houses is jurisdiction specific (following ABCB 2006a) and is reported in table D.7.[46] Generally speaking, single storey houses are by far the norm in the major cites.

Similarly, table D.7 also reports the distribution of timber and concrete slab flooring. Slab flooring is the dominant base across the country, but this is less the case in the major capital cities.[47]

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46 Unfortunately, data on the number of storeys in *new* houses is unavailable. Nor are projections about how these rates are likely to change over time. It has been necessary to assume then, that the 2006 data presented in table D.7 is a good approximation of future trends.

47 Again, no data is available regarding the flooring choice of *new* buildings. It is assumed that 2006 data present in table D.7 is a 'good' approximation of future trends.

D.6 **Distribution of single storey sample houses**

House	***Per cent***
H01	30
H04	60
H12	5
H13	5

Source: ABCB.

D.7 **Storey and floor distributions by location, per cent**

	Storeys		***Floor type***	
	Single storey	*Double storey*	*Slab*	*Timber*
Mildura	76	24	95	5
Adelaide	96	4	75	25
Perth	99	1	75	25
Sydney	94	6	75	25
Melbourne	77	23	65	35
Canberra	97	3	74	26
Hobart	54	46	74	26
Cabramurra	82	18	80	20
Brisbane	85	15	76	24
Longreach	86	15	95	5
Darwin	86	15	95	5

Source: ABCB 2006a.

The final step of this first aggregation process considers both the distribution and number of dwellings for each city considered. The ABS provides estimates of the Australian housing stock to 2026 (ABS 2004) based on the long term trends for a variety of social and demographic indicators.[48] These estimates are reported at a State level, and regional population data (CIE 2009a) can be used to provide further disaggregation (consistent with CIE 2009a). In 2010, there will be an estimated 8.5 million dwellings, four fifths of which will be free standing houses (see table D.8).

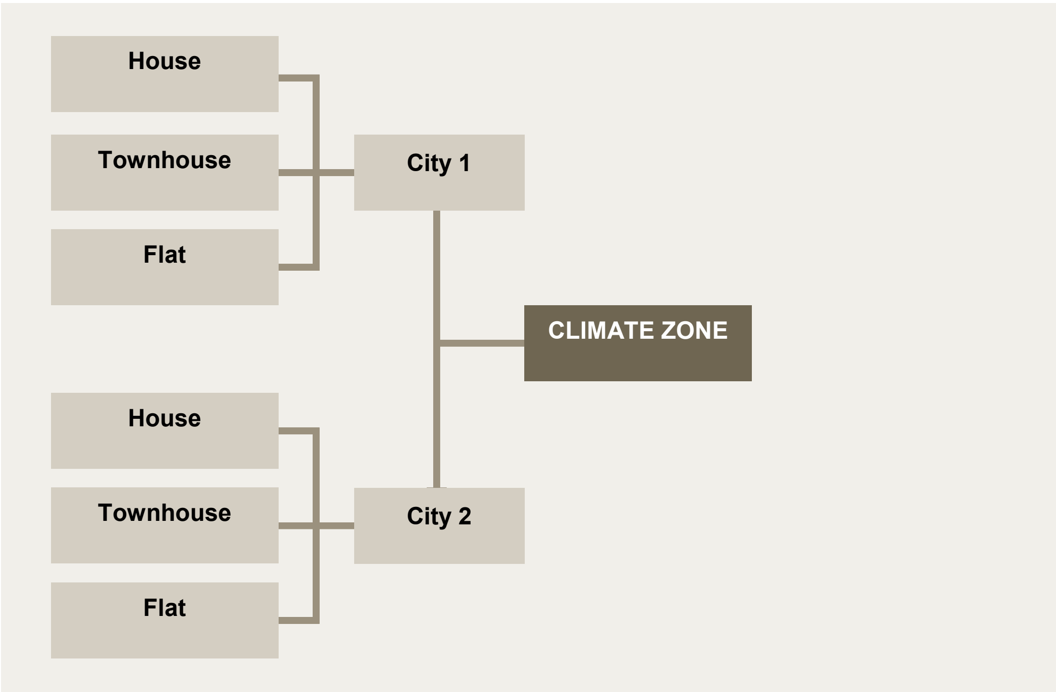
48 The ABS reports projections only of dwellings. Trends in the composition of dwellings have been used to disaggregate the ABS's projections to forecast the number of dwellings.

D.8 Distribution of dwelling structures by State, per cent

	Flat	*Townhouse*	*House*
ACT	11.0	13.8	74.9
NSW	15.3	8.6	75.5
NT	12.4	11.3	76.6
Qld	11.6	7.7	78.3
SA	5.1	12.6	82.0
TAS	6.9	9.3	83.3
Vic	9.2	10.3	80.6
WA	3.9	13.7	81.8

Source: Extrapolated from CIE (2009a).

D.9 Aggregating from city to climate zone



Data source: The CIE.

Aggregating to climatic, State and national levels involves a similar process. Extrapolations can be made from city-level data to form estimates for a particular climate zone (see chart D.9) by observing the characteristics of the analysed stock.[49] Within each State, the stock of households in each climate zone have been proportioned with respect to the share of the population residing in each climate zone (see table D.10).

[49] Necessarily, it has been assumed that those cities not mentioned in table F.2 adopt the same characteristics as those cities in the same State and/or climate zone.

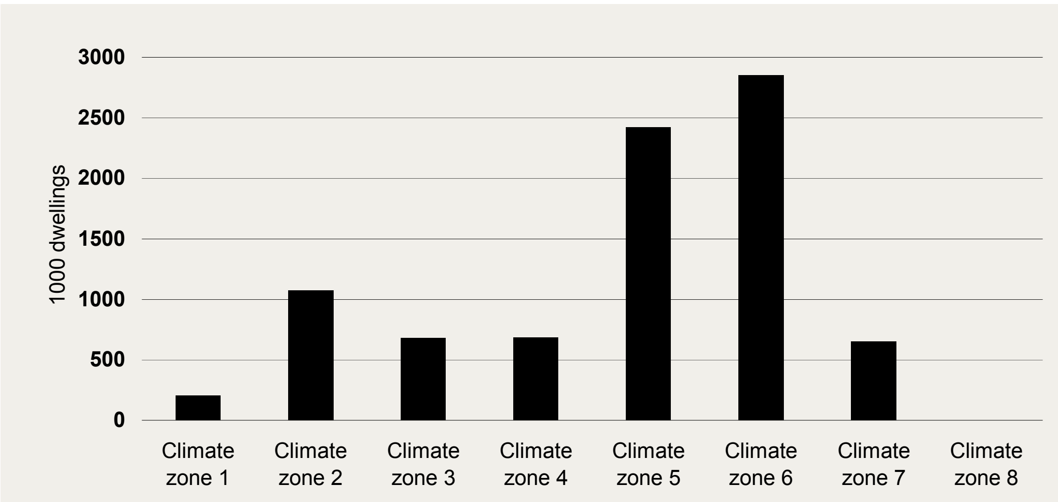
Again, estimates of the housing stock (and its makeup) have been formed in a way consistent with the CIE (2009a). Chart D.11 reports the size of the housing stock for each climate zone. Climate zones 5 and 6 describe the climates of Sydney, Adelaide, Perth, Melbourne and much of the urban centres in NSW and Victoria. And consequently, they house the majority of the stock (5.3 million dwellings). The sum of the eight climate zones provides for a national aggregation (see chart D.12).

D.10 **Proportion of State and Territory population by climate zone, 2010**

	ACT	*NSW*	*NT*	*Qld*	*SA*	*Tas*	*Vic*	*WA*
Climate Zone 1	0.0	0.0	87.8	7.6	0.0	0.0	0.0	1.4
Climate Zone 2	0.0	0.0	0.0	61.9	0.0	0.0	0.0	0.0
Climate Zone 3	0.0	6.0	12.2	28.2	0.0	0.0	0.0	1.9
Climate Zone 4	0.0	9.1	0.0	0.0	4.0	0.0	4.5	35.8
Climate Zone 5	0.0	49.8	0.0	2.3	79.4	0.0	0.0	52.6
Climate Zone 6	0.0	31.9	0.0	0.0	16.6	0.0	85.3	8.3
Climate Zone 7	100.0	3.2	0.0	0.0	0.0	100.0	10.3	0.0

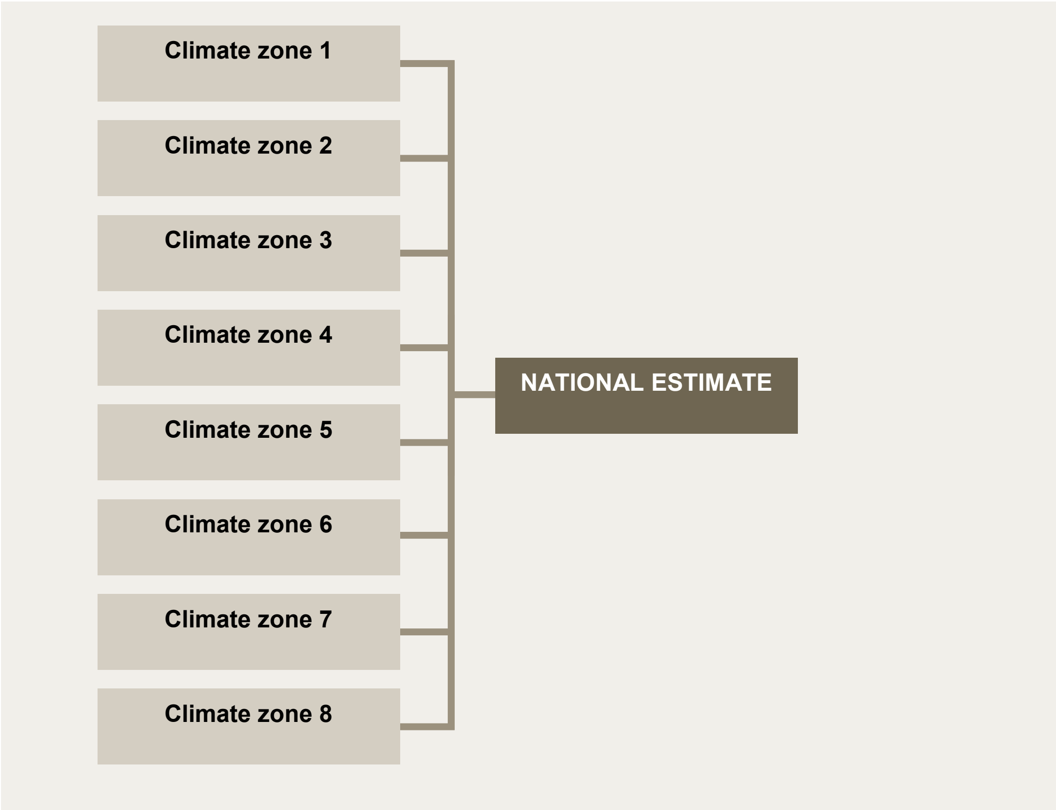
Source: Extrapolated from CIE (2009a).

D.11 **Total housing stock by climate zone, 2010**



Data source: Extrapolated from CIE (2009a).

D.12 **Aggregating from climate zone to total economy**



Data source: The CIE.

Ultimately, the building block approach outlined above has produced an estimate of the national housing stock which has accounted for:

- dwelling type;
- configuration;
- flooring;
- size (storeys);
- location; and
- climate.

Forward projections

As mentioned above, the BAU is not static. In addition to identifying the distribution of the housing structure today, it is important to understand what shape the stock will take on in the future.

Where appropriate, estimates adopted here follow that of CIE (2009a). As a general rule, where a series provided by Australian Government (2008) does not extend beyond 2050, the remainder of the series estimated assumes that data remains constant thereafter.

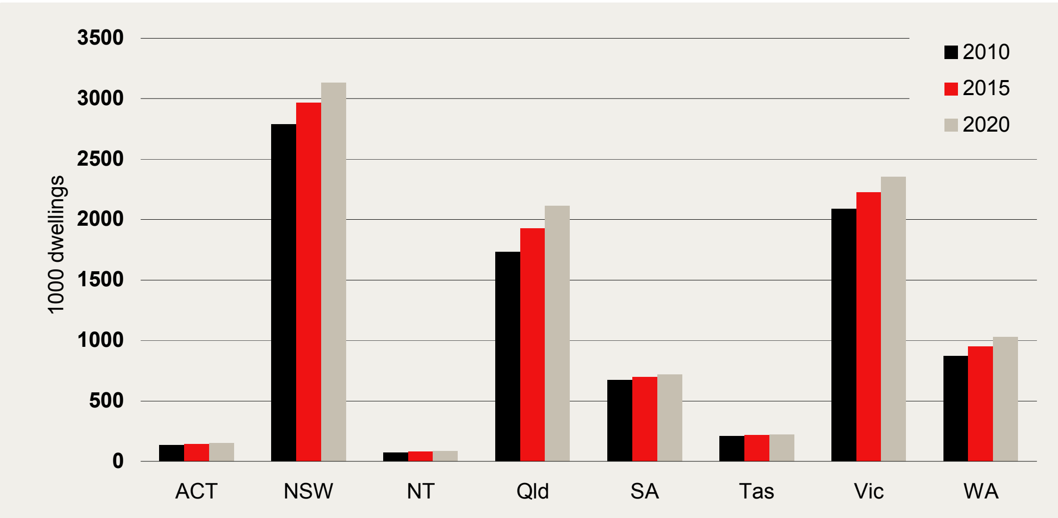
Housing stock projections

Projections of the housing stock are taken directly from CIE (2009a), which in turn are based on forecasts provided by the ABS.[50] The ABS forms these projections based on long term trends observed for:

- population growth;
- household size;
- social and demographic factors; and
- construction trends.

Charts D.13 and D.14 respectively report the growth of the housing stock by State and dwelling type for the decade beginning 2010. In total, the housing stock is expected to be some 14 per cent greater by 2020. The fastest growing state is Queensland, followed by Western Australia. And unsurprisingly, the fastest growing climate zones are climate zones 1, 2 and 3 which envelope Queensland and surrounding areas. On average, the building stock is forecast to grow by 1.3 per cent per annum over the period.

D.13 **Growth in the housing stock by State and Territory**



Data source: Extrapolated from CIE (2009a).

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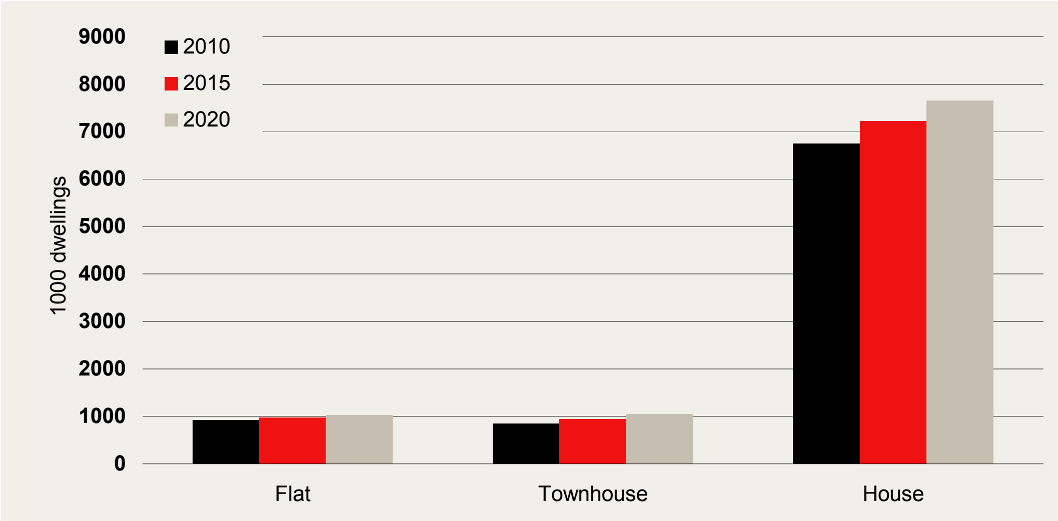
50 Alternative forecasts of the housing stock are available from DEWHA (2008b). These estimates project, generally speaking, a faster growth rate for residential buildings. Using the ABS data however has several advantages. First, as the ABS project a slower growth rate, this implies that the analysis is more conservative. Second, while the DEWHA report is a considerable piece of analysis, it is unlikely to be updated on a regular basis. ABS data has been sourced form a recurrent publication making it easier for future analyses to be consistent with this report. And third, the ABS's data is reported in a way that can be more accurately translated into the ABCB's Climate Zones without loss of accuracy.

D.14 **Growth in the housing stock by State and Territory**



Data source: Extrapolated from CIE (2009a).

Note that growth across the stock of dwelling structures is relatively evenly spread. This is the largely the result of limited information regarding forecasts of dwelling structures specifically.

Importantly, the proposed amendments to the BCA will only impact new residential buildings and not the stock in total. Table D.15 reports in detail the number of new dwellings constructed over the period. Again these forecasts have been taken from CIE (2009a) and reflect trends projected by the ABS[51]. In any one year an average of 130 000 new dwellings will be constructed — most of which are houses. Chart D.16 shows the increasing share of new stock over the coming decade. Initially the share of new buildings is very low, but by 2020, nearly 16 per cent of all residential buildings will have been constructed under the new BCA.

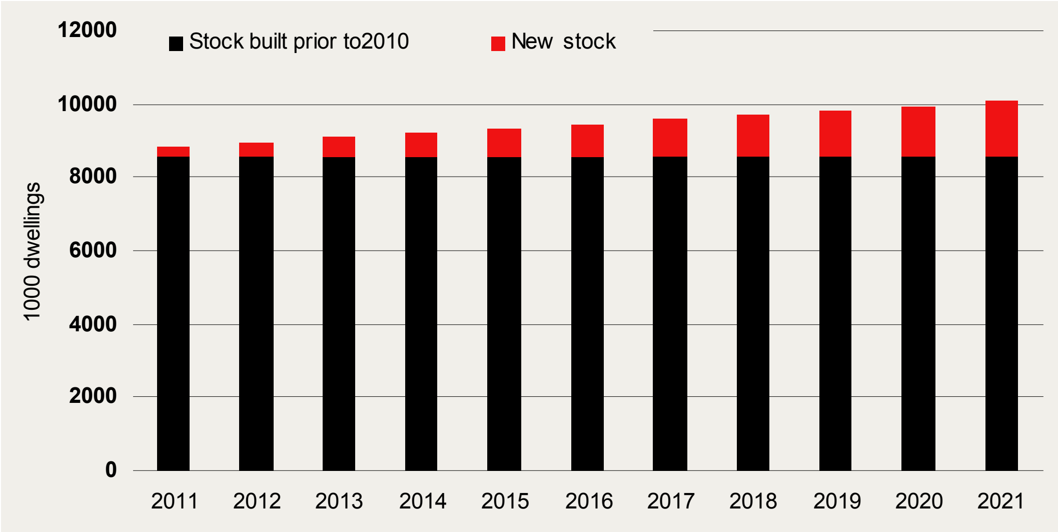
51 The numbers reported in D.15 may differ from actual planned development. In some years table D.15 may overestimate development, and underestimate development in others. On *average* however, the table is consistent with the long term trend over the period.

D.15 **New household constructions**

	2011	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*	*2021*
Flat											
ACT	197	186	175	186	175	186	164	164	153	164	154
NSW	5616	5433	5326	5342	5372	5342	5097	5006	4975	4945	4858
NT	161	148	148	148	148	136	148	148	124	136	131
Qld	4511	4384	4384	4407	4453	4453	4280	4234	4234	4234	4202
SA	296	266	256	256	261	245	210	210	194	199	181
TAS	117	89	89	89	89	82	62	48	62	48	41
Vic	2614	2504	2486	2495	2486	2477	2367	2321	2302	2284	2247
WA	648	617	617	617	621	613	582	578	578	570	561
Town-house											
ACT	248	234	220	234	220	234	206	206	193	206	193
NSW	3177	3073	3013	3021	3039	3021	2883	2832	2814	2797	2748
NT	146	135	135	135	135	124	135	135	113	124	120
Qld	3012	2927	2927	2943	2974	2974	2858	2827	2827	2827	2806
SA	729	653	628	628	641	603	515	515	477	490	444
TAS	159	121	121	121	121	112	84	65	84	65	55
Vic	2934	2811	2790	2801	2790	2780	2656	2605	2584	2564	2522
WA	2271	2162	2162	2162	2176	2148	2039	2025	2025	1998	1967
House											
ACT	1348	1274	1199	1274	1199	1274	1124	1124	1049	1124	1054
NSW	27 795	26 889	26 360	26 436	26 587	26 436	25 227	24 774	24 623	24 472	24 044
NT	995	919	919	919	919	842	919	919	766	842	812
Qld	30 555	29 693	29 693	29 850	30 163	30 163	28 988	28 674	28 674	28 674	28 455
SA	4757	4265	4101	4101	4183	3937	3363	3363	3117	3 199	2 898
TAS	1416	1083	1083	1083	1083	1000	750	583	750	583	494
Vic	22 985	22 017	21 856	21 937	21 856	21 775	20 807	20 404	20 243	20 082	19 754
WA	13 579	12 924	12 924	12 924	13 006	12 843	12 188	12 106	12 106	11 943	11 757

Source: Extrapolated from CIE (2009a).

D.16 **New residential dwellings**



Data source: Extrapolated from CIE (2009a).

Energy market projections

It is important that the BAU is forward looking and provides and an accurate reflection of the likely state of the future Australian energy market. The key factor affecting Australian energy markets are likely to be the Australian Government's major policy initiatives. Specifically, the Australian Government's Carbon Pollution Reduction Scheme (CPRS) and expanded Renewable Energy Target (RET) are likely to have significant implications. Further, given the potential significance of this impact, this analysis draws directly on the Government's own modelling of the impact on wholesale electricity prices due to CPRS-5 (Australian Government 2008 and MMA 2008b) to produce our estimates.

The Treasury (Australian Government, 2008) estimates that the CPRS and RET expansion will cause a significant increase in wholesale electricity prices (nearly doubling by 2020). Higher wholesale electricity prices flow into retail prices which are faced by households. The impact on average Australian retail electricity prices has been reproduced in chart D.17.[52] The steps taken to construct these estimates follow below.

- First, the average Australian retail electricity price was estimated for the year 2006 by combining data on the total expenditure on electricity from

52 The Treasury (Australian Government, 2008) do provide estimates of the expected impact on retail electricity prices, but the estimates reported are only indicative increases for certain periods between 2010 and 2050. Here, it has been assumed that the increase in wholesale electricity prices has been wholly passed on to the consumer.

the ABS Household Expenditure Survey (ABS 2006) and estimates of residential electricity consumption from ABARE (2008).

- Second, the change in the retail electricity price was next assumed to mirror changes in the Treasury's forecast of wholesale electricity prices under the CPRS-5 scenario. Retail prices were assumed to increase by the full amount of the wholesale price increase.
- Third, estimates were calculated by State and Territory based on ABS Household Expenditure data and ABARE estimates of energy consumption. Changes in retail prices at the jurisdictional level were estimated by replicating the proportional changes in the national average price.

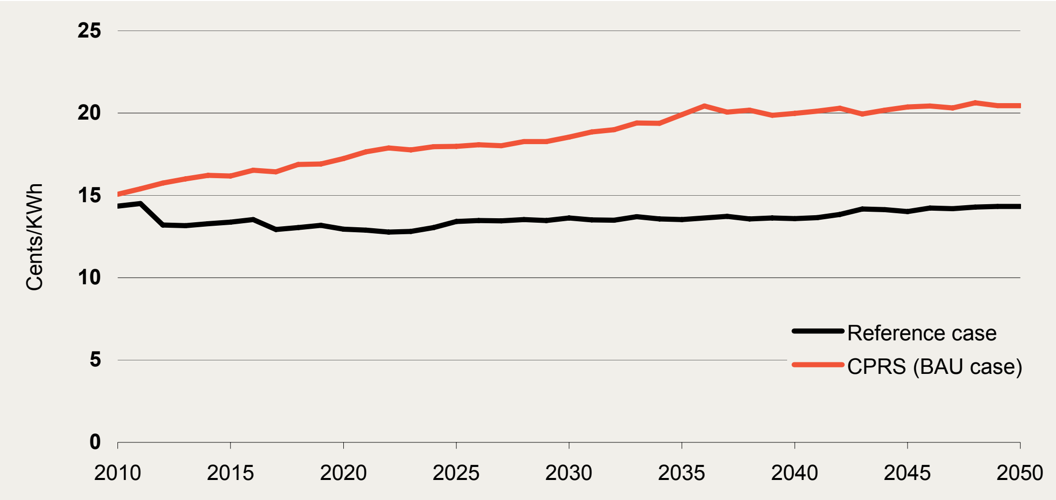
The first two steps in the methodology allow for determination of the impact on the average retail price of electricity across Australia transposed from projected changes in average wholesale electricity prices. The simplifying assumption made was to assume that the full increase in wholesale electricity prices is mirrored in the changes in retail electricity prices – that is, there is full cost pass through to consumers.

The third step allows for estimation of State by State changes in average retail electricity prices by accounting for current estimations of household expenditure across States. The initial household expenditure data from the ABS is utilised to determine the current average retail price. Future projections of state specific prices are based on the current average retail price with fluctuations and growth again mirroring changes in the average retail price across Australia. That is, while the trend in retail electricity prices is identical across States (following the path projected by the Australian Treasury for average wholesale prices) the realised level of average retail prices differs across States. The differences in the levels are determined by the differences measured in current average retail prices and these differences are maintained across the projection period.

By 2030 average retail electricity prices are expected to be 36 per cent higher than the reference case, and 43 per cent higher in 2050. This is relatively consistent with the Treasury's reported estimates.

Note that it would be expected that the increase in electricity prices would have *some* effect on the amount of energy consumed. However, because the demand for electricity is relatively unresponsive to changes in price (CIE 2007), it is unlikely that this effect would be large. In any case, for this exercise it is not necessary to estimate the amount of energy consumed with and without the proposed amendments. Rather, what is necessary is to show the change the amendments will induce. For this purpose, it is not necessary to forecast how the CPRS will impact on the projections outlined in chart D.17. For those years beyond 2050, it is assumed that prices stay constant at their 2050 levels.

D.17 **Forecasts of average retail electricity prices, cents per KWh**



Note: CPRS case relates to the CPRS-5 scenario as modelled by the Treasury in Australian Government (2008).

Data source: CIE estimates based on Australian Government (2008).

Notably, the impact of the Government's major policy initiatives on gas prices is less well understood. A report commissioned by the Treasury, MMA (2008b) estimated the implications introducing the CPRS would have for different fuel sources — gas included. MMA estimated that the CPRS would increase gas prices by about 40 per cent by 2020 and remain relatively constant thereafter. These estimates[53] underpin the forecasts of gas prices used in this analysis.

Estimating gas prices employed a similar method as was used for electricity prices:

- First, the average Australian retail gas price was estimated for the year 2006 by combining data on the total expenditure on gas from the ABS Household Expenditure Survey (ABS 2006) and estimates of residential gas consumption from ABARE (2008).
- Second, the change in the retail gas price was next assumed to mirror changes in the MMA's forecast of city node gas prices in NSW (see chart D.18). Retail prices were assumed to increase by the full amount of this price increase.

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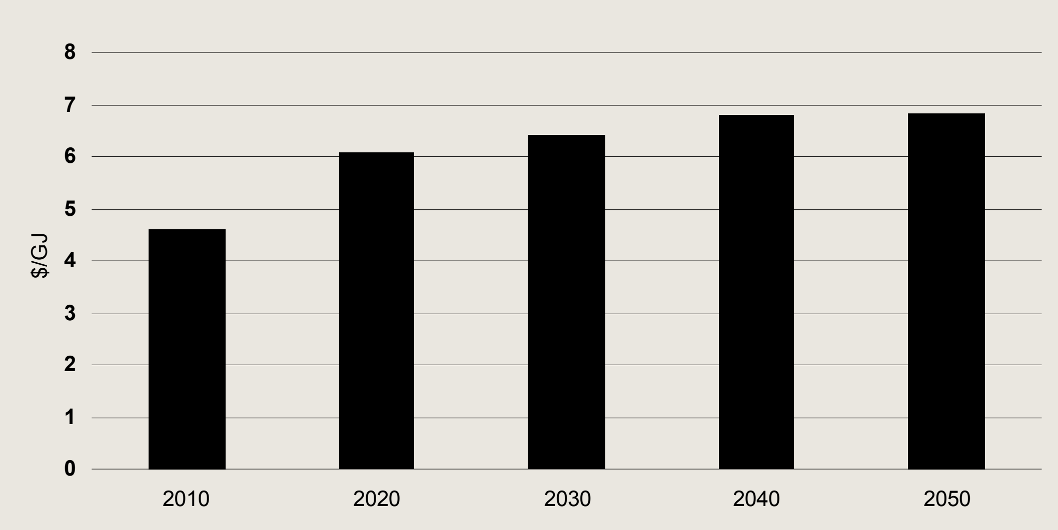
53 MMA (2008) uses city node gas prices in NSW as an indicator of Australian gas prices. Note that this data source differs from that used to estimate gas prices in CIE (2009a), which was based on forecast wholesale prices of IGCC and did not include the effects of the CPRS.

D.18 **Trends in city node gas prices, NSW**



Data source: MMA (2008b)

Estimates of retail gas prices are reported in chart D.19. Again, for those years beyond 2050, it is assumed that prices stay constant at their 2050 levels.

Lastly, it should be noted that in the BAU case only the CPRS and the expanded RET scheme have been accounted for. The effects of no other State, Territory or Australian Government policies have been modelled. This includes:

- smart meters;
- roof insulation initiatives;
- subsidies to promote energy efficiency in the building sector; or
- any other government initiatives.

Greenhouse gas emissions

The CPRS is expected to have a significant impact on the emissions intensity of electricity. The CPRS provides an incentive to electricity generators to produce electricity with fewer emissions. Whether this can be achieved by sourcing alternative fuel sources (RET requirements will encourage this also), or by retro fitting existing facilities, the CO2-e emissions per KWh consumed are expected to fall. A forecast of the emissions intensity of electricity consumption is reported in chart D.20.[54]

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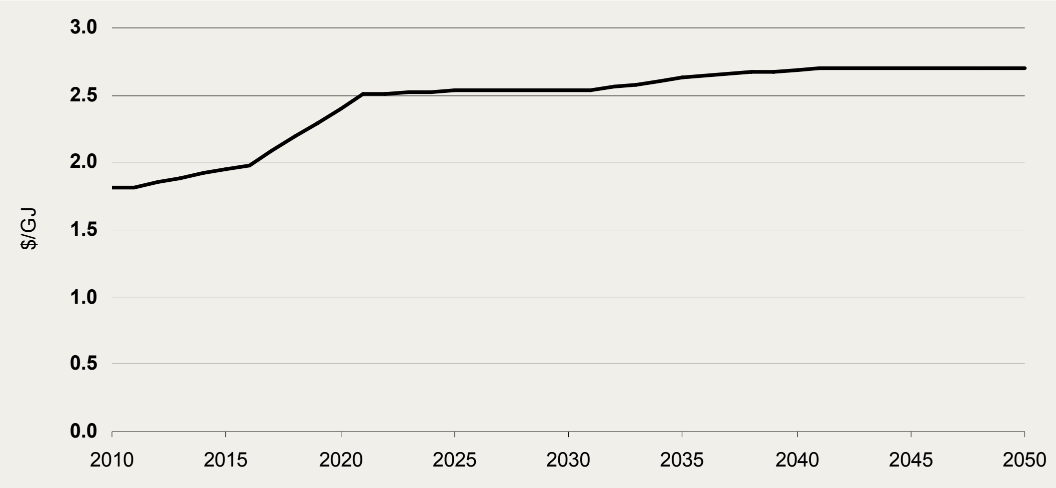
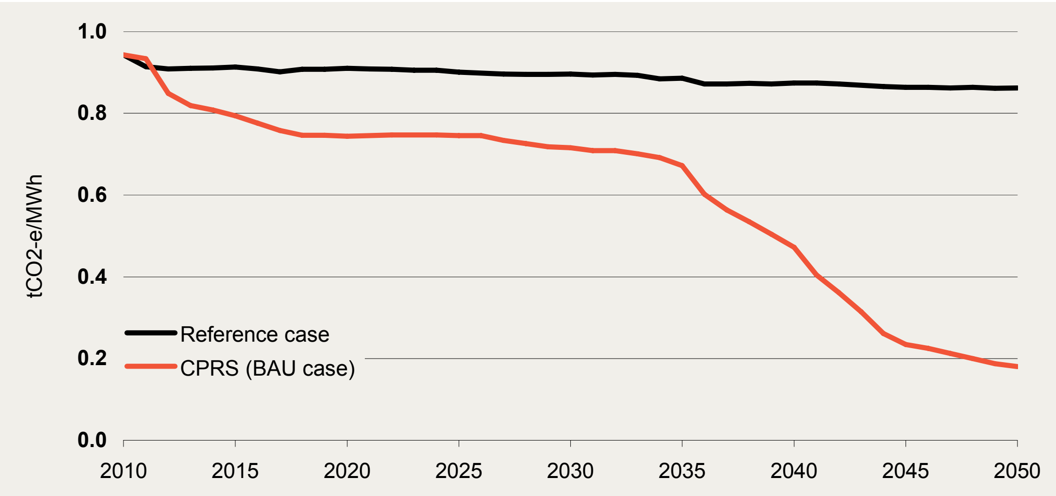
[54] This estimate differs from the emissions intensity of electricity *generation* reported in Australian Government (2008). The Treasury's modelling of the CPRS did not report the emissions associated with electricity distribution. Emissions from distribution have

D.19 **Australian average retail gas price, cents per MJ**



Data source: CIE estimates based on MMA (2008b), ABS (2006) and ABARE (2008).

D.20 **Emissions intensity of electricity**



Note: CPRS case relates to the CPRS-5 scenario as modelled by the Treasury in Australian Government (2008).

Data source: CIE estimates based on Australian Government (2008) and DCC (2009).

Between 2010 and 2050, the emissions intensity of final electricity consumption is expected to fall by over 80 per cent.

Estimates of emissions intensity beyond 2050 are not provided in Australian Government (2008). For those years beyond 2050, it is assumed that the emissions intensity remains constant at 2050 levels.

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been accounted for using the ratio of scope 3 and scope 2 emissions as reported in DCC (2009).

The emissions intensity of gas is expected to remain constant over the period at 51.2 kg CO2-e per GJ. This figure is as reported in the National Greenhouse Accounts (NGA) Factors report for 2009.

E Selecting an appropriate discount rate

There is a vast amount of literature on the ‘correct’ method to determine the discount rate for RISs. The chosen discount rate would need to correctly reflect the opportunity cost of the displaced resources by the policy action. Those resources can refer to capital or consumption.

There are mainly three ways to approach the discounting exercise:

- the Opportunity Cost of Capital (OCC), which can be based on:
  - the average market interest rates (pre-tax rates of return); or
  - the Government’s borrowing rate (risk-free rate of capital);
- the Social Time Preference Rate (STPR), which reflects consumer’s time preference/utility and are based on:
  - market after-tax interest rates (interest rate on savings); or
  - consumer’s valuation of future consumption (implicit discount rates); and
- the social Weighted Average Cost of Capital (WACC) which combines the marginal cost of foreign resources with the above two approaches.

Discount rates based on OCC reflect financial concerns on the use of resources (returns), while discount rates based on STPR reflect ethical issues on treatment of future generations.

New Zealand, Canada and Australia seem to converge on using a real WACC of between 7 and 8 per cent for undertaking RISs. Victoria, the EU and the US use an OCC based on the risk-free rate of capital (Treasury bonds). The UK’s recommended discount rate is a STPR based on consumer’s utility (see table E.1).

E.1 Discount rates for RISs in various countries

Country	*Recommended Discount rate*	*Comments*
	%	
UK	3.5	*Basis of the rate* Represents the Social Time Preference Rate (STPR). It is based on comparisons of utility across different points in time or different generations. It takes into account the time preference of individuals, the elasticity of the marginal utility of consumption and the annual growth in per capita consumption. *Range* No recommendation on specific range for sensitivity analysis. *Adjustment for time period* If analysis is done for a period over 30 years, is recommended to lower the discount rate. *Year of the recommendation* Updated rates for 2009.
USA	3 and 7	*Basis of the rate* 7 per cent represents an OCC rate based on the average before-tax rate of return to private capital. Rates of around 3 per cent are recommended when regulation primarily and directly affects private consumption. Uses a STPR based on the historical real rate of return on long term government debt (interest rates on Treasury Notes and Bonds of specified maturities) *Range* No recommendation on specific range for sensitivity analysis. *Adjustment for time period* The STPR ranges from 0.9 to 2.9 per cent depending on the time frame (from 3 to 30 years). *Year of the recommendation* Updated rates for 2009.
Canada	8	*Basis of the rate* Represents a real WACC. Includes costs of funds from three sources: the rate of return on postponed investment, the rate of interest (net of tax) on domestic savings, and the marginal cost of additional foreign capital inflows. The weights are equal to the proportion of funds from each source existing on the market. *Range* No recommendation on specific range for sensitivity analysis.

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E.1 Discount rates for RISs in various countries (continued)

Country	Recommended Discount rate	Comments
	%	
		Basis of the rate Represents a real WACC. Includes costs of funds from three sources: the rate of return on postponed investment, the rate of interest (net of tax) on domestic savings, and the marginal cost of additional foreign capital inflows. The weights are equal to the proportion of funds from each source existing on the market. *Range* No recommendation on specific range for sensitivity analysis. *Adjustment for time period* No suggestions are made for different timeframes. *Year of the recommendation* 2007.
CountryEU	4	*Basis of the rate* It represents an OCC rate based on a real rate of return. It broadly corresponds to the average real yield on longer-term government debt in the EU since the early 1980's. *Range* State members may have their own guidelines for undertaking RISs (that is, Ireland 5 per cent and Denmark 6 per cent). *Adjustment for time period* No suggestions are made for different timeframes. *Year of the recommendation* 2009.
NZ	8	*Basis of the rate* Represents a real WACC rate. The pre-tax return from investments in the private sector as a measure of the opportunity cost of capital for public sector investments. *Range* Differentiated discount rates are provided depending on the application: buildings 6 per cent, infrastructure 8 per cent and technology 9.5 per cent. No specific discount rates are suggested for sensitivity analysis. *Adjustment for time period* No suggestions are made for different timeframes. *Year of the recommendation* 2008.

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E.1 **Discount rates for RISs in various countries** (continued)

Country	***Recommended Discount rate***	***Comments***
	%	
OECD	3-12	*Basis of the rate* Represents a real OCC for various countries. The rate is based on the average of commercial interest reference rates plus a margin. *Range* No specific discount rates are suggested for sensitivity analysis. *Adjustment for time period* Rates vary according to the period to be discounted. For Australia, recommended rates go from 6.6 per cent, for periods under 15 years, to 7 per cent, for periods up to 30 years. *Year of the recommendation* Updated rates for 2009.
Australia		
OBPR	7	*Basis of the rate* Represents a real WACC. It is a social rate that accounts for consumption and capital opportunity cost. *Range* Sensitivity analysis is recommended using 3 and 11 per cent rates. *Adjustment for time period* No suggestions are made for different time frames. *Year of the recommendation* 2007.
Country NSW	7	*Basis of the rate* Represents a real OCC rate. *Range* Sensitivity analysis should be undertaken using rates of 4 and 10 per cent. *Adjustment for time period* No suggestions are made for different timeframes. *Year of the recommendation* 1997.

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E.1 Discount rates for RISs in various countries (continued)

Country	*Recommended Discount rate*	*Comments*
	%	
QLD	8	*Basis of the rate* Based on a real pre-tax discount rate. *Range* Sensitivity analysis should be undertaken using rates of 6 and 10 per cent. *Adjustment for time period* No suggestions are made for different timeframes. *Year of the recommendation* 1999.
VIC	3.5	*Basis of the rate* Represents a real OCC, based on an average of the ten-year Commonwealth bond rate (risk free opportunity cost of capital), after adjusting for the expected inflation rate. *Range* No specific discount rates are suggested for sensitivity analysis. *Adjustment for time period* No suggestions are made for different timeframes. *Year of the recommendation* 2007.

Note: UK (United Kingdom), USA (United States of America), EU (European Union), NZ (New Zealand), OECD (Organization for Economic Co-operation and Development), OBPR (Office of Best Practice Regulation), DFA (Department of Finance and Administration), NSW (New South Wales), QLD (Queensland), VIC (Victoria).

Sources: UK Department for Business, innovation and Skills (2007), NZ Department of Treasury (2008), European Commission (2009), OBPR (2007),OECD (2009), US Office of Management and Budget (2008), Queensland Treasury (1999), The Cabinet Office of New South Wales (1997), Treasury Board of Canada Secretariat (2007),Victorian Competition and Efficiency Commission (2007).

F Electricity generation and network impacts

The proposed amendments to the BCA are likely to reduce residential electricity consumption by approximately 1 per cent and overall consumption by 0.3 per cent by 2020 compared with the BAU scenario. These savings will remain fairly stable through 2030.

In common with other demand side reduction measures, changes brought about by the BCA will have the potential to affect outcomes for electricity generation operators, transmission and distribution (T and D) network operations and the retail businesses ultimately supplying residential, commercial and other customers. The gas supply and distribution network is also affected, though principally as suppliers to electricity generators. The gas industry effects are treated as second order effects for purposes of the RIS and are not considered in detail here.

The energy efficiencies generated by the proposed BCA changes present opportunities for energy savings that could translate into avoided supply side costs, therefore benefiting different parts of the electricity supply chain. These energy savings, depending on their size and timing, have the potential to:

- defer costly augmentation of generation and T and D capacity;
- relieve network stress at peak times, reduce load losses and Unserved Energy demand (USE);
- reduce generation operating costs;[55] and
- reduce hedging costs within the national electricity market.

These potential benefits will, in turn, flow through in varying degrees to customers through lower increases in prices than would have otherwise occurred. The flow through will depend on the degree of effective competition in the wholesale and retail electricity markets. Benefits in the

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55 In an environment where an emissions trading scheme (such as the proposed CPRS) is in place, these reductions will in part be the result of reduced purchases of carbon credits compared to a higher consumption scenario. It is important, to avoid double counting, that if these GHG related benefits are calculated and accounted for separately they not be included as benefits here.

form of avoided costs that are not passed through will manifest as higher profits for suppliers' owners. No attempt is made here to allocate these benefits. Benefits to end users as calculated in this study are valued at average energy tariffs *before* the impact of the proposed BCA changes. They will therefore tend to underestimate the value of end user benefits to the extent that they exclude any beneficial cost pass through effects.

The avoided energy costs attributable to the proposed changes in the BCA will have an avoided energy network cost component that relates to the impact of these measures on the capital augmentation costs of the supply networks and on operating costs compared with a BAU set of outcomes. Energy generation, transmission and distribution businesses will be faced with investment decisions that reflect demand growth, modified by the effects of the CPRS which are embodied in the BAU case.

The reduction in electricity consumption in response to the BCA measures will be accompanied by potential changes in the *load profile* facing suppliers because the measures are likely to impact on the relationship between peak and average load in the systems of the various jurisdictions. That impact will vary from State to State because of climatic differences, the differing relative importance of the residential sector in each State and the difference between the peak-non peak consumption patterns of the residential and non residential sectors.

The impact on avoided costs of suppliers will depend on both the magnitude and timing of the reductions in energy consumption relative to the base case. Savings are cumulative and will start from negligible levels as the share of electricity consumption accounted for by *new* residential housing stock is currently around 0.4 per cent. Consumption from residential buildings accounts for approximately 28 per cent of total electricity consumption. By 2020 under BAU the share of residential consumption attributable to *new* stock would rise to 16 per cent (or 4.3 per cent of total electricity consumption). It is from this small but growing share that any BCA-generated avoided costs to suppliers will arise.

Estimates of any impact of the proposed BCA changes on generation or transportation of energy need to be made in the light of forecast capacity growth directed at managing expected consumption growth, peak demand growth and variability. Impacts on suppliers will be twofold – the effect on total consumption and the effect on maximum demand. Ideally, the potential impacts of the BCA would reflect the change in expected share of peak and non-peak load demand attributable to that part of the energy consuming sector impacted by the BCA changes — in this case the new residential building sector. This breakdown is not available. The proposed amendments to the BCA will have an impact on the relationship between maximum demand and total consumption through the change in the load profile of the new residential sector. While the cumulative impact on total consumption has been estimated in the RIS, the effect on maximum demand, brought about through these load profile changes, has not.

The impact on the electricity component of the energy sector (and indirectly on the gas sector through changes in gas fired power stations and gas pipe networks delivering to generators) of the BCA-driven electricity savings will depend on the following:

a) any avoided operating costs achieved through 'load smoothing' because of the reduction in peak demands relative to other demands compared with their BAU levels;
b) any reduction or delay in augmentation of generating, transmission or distribution network capacity because of this effect;
c) any reduction in operating costs due to BCA induced reduction in total consumption;
d) any reduction or delay in capacity due to this effect; and
e) any reduction in hedging or other costs due to BCA induced changes in the load profile.

These effects will take place in an environment in which CPRS, renewables targeting and potential climate change will be driving large scale investment in both energy generation and distribution investment, as the discussion below illustrates.

Potential effects on the generation sector

Peak load effects on the capital costs of the electricity sector stem from the need to have back up capacity and/or additional interconnection network capacity to supply extreme demand levels that typically prevail for less than 1 per cent of the year. Systems which operate with a typical load factor of 60 per cent, involving peak, intermediate and base loads may have base load factors as high as 90 per cent and peak load plant with load factors of 10 per cent or lower. Reserve capacity set as a buffer over and above estimated maximum demand can amount to 10 per cent or more of the total capacity. Average peak loads are typically at least 50 per cent above average loads (critical peaks on extreme days can be much higher than this).

Residential use currently contributes disproportionately to peak demand and the need for peak load capacity, particularly through the impact of summer loads driven by home air-conditioning, whose penetration is increasing.

While accounting for 28 per cent of total consumption, residential use could more reasonably be considered to underpin 35 per cent [56] of maximum demand — when peak influences are added to the commercial and industrial and mining demands. Any significant reduction over time in peak demand growth rates relative to total consumption growth would have the effect of supporting a given level of total consumption at lower cost of supply and at lower price to consumers than otherwise.

Impacts on augmentation of generation capacity

Whether demand reductions relative to BAU will affect generation augmentation decisions will depend on the size of the reduction relative to the size of the planning regime, available reserve capacity or 'headroom', the load profile at any time and the underlying consumption growth rate.

Through time, in the BAU case, generating capacity will need to grow to accommodate growth in maximum demand and provide reserve capacity. ACIL Tasman (2008), in a report for Energy Supply Association of Australia (ESSA) estimates increases in maximum demand of more than 5 800 MW between the present and 2020 with a 10 per cent emissions cap in place. This represents more than 530 MW annually in additional generating capacity, even before allowing for preservation of headroom.

In assessing the implications of the proposed BCA changes for avoided capital costs we would ideally calculate the reduction in the long run marginal capital cost of supply brought about by the BCA changes' impact on the maximum demand for energy in each year and the impact of that on the least cost capacity augmentation program. This cannot be done as such since the least cost steps in the BAU capacity augmentation program that suppliers will need to follow to satisfy demand with adequate reserve capacity is not readily calculable. Those steps will depend in part on the

56 In this review no direct estimate has been obtained as to the share of peak demand attributable to the residential sector. However, if, in the extreme case residential demand is responsible for most of the 50 per cent difference between peak loads and average load, then, rather than approximating households 'capacity share' on the basis of their share of total consumption driving 28 per cent of the capacity needs Australiawide, this capacity share is better approximated as 35 per cent. (This assumes 28 per cent of the average load with a weight of 0.67 and 50 per cent of the peak load with a weight of 0.33, giving 0.35). Data for the regulated residential sector for NSW 2004 suggests that this sector contribute roughly 50 per cent of the rise in the evening peak consumption. ESSA in a submission to the Productivity Commission inquiry into energy efficiency in 2005 reported that, of the 15 per cent of peak demand that occurs for just 24 hours per year in Sydney, 75 per cent stems from domestic air conditioners.

impact of the CPRS and renewables plant substitution and the price effects of those influences on consumers' energy use.

However, any potential impact of the proposed BCA measures on the energy supply networks' long run marginal cost of supply needs to be seen in the context of the scale of capacity changes and the costs accompanying them that will occur in a BAU context that includes CPRS and RET pressures. ACIL Tasman (2008) have estimated that electricity generating capacity investment costs of $33 billion will be expanded between now and 2020 to meet a 10 per cent reduction in emission targets and a 20 per cent RET by that date. A further $4.5 billion would be required as augmentation of the electricity transmission network and gas pipe line augmentation to meet these caps and targets.

In capacity terms an additional 15 000 MW of capacity would be required to 'replace stranded plant, satisfy the MRET and meet load growth' ACIL Tasman (2008 p.3). Retirement of 6 700 MW is likely to be required. ACIL Tasman modelling suggests a 13-14 per cent increase in maximum demand to 48 048 MW from a current 42 212 MW (29 per cent growth without the targets). Suppliers will need to bring on additional capacity to meet this growth while retiring existing assets to progressively change the generation mix to comply with renewables targets.

Modelling for this RIS suggests that between 2010 and 2020 total electricity consumption will grow by 12.7 per cent and total residential consumption will grow by 12.5 per cent in the absence of the BCA measures but with the CPRS in place. [57] The proposed BCA changes will depress these growth rates by 2020 to 12.4 per cent and 11.4 per cent respectively. Total consumption will be 0.3 per cent lower than it would be in the absence of the changes. By 2020 the cumulative effects of the measures will be embodied in 16 per cent of the total housing stock. The estimated effect will be to make residential electricity consumption approximately 1 per cent lower than otherwise. This may mean that *maximum demand* will be reduced by more than the estimated 0.3 per cent reduction below baseline in *total* consumption in 2020 and 2030 because of favourable residential impacts on peak demand stemming from the measures. This will depend on whether the favourable effects on residential peak demand in new residential building is large enough to offset the apparent increasing penetration of air-conditioning in existing stock. Note that the estimated *share* of residential consumption in

[57] This is somewhat more pessimistic than ACIL Tasman projections for the household sector where there are assumed to be stronger responses to the projected 24 per cent increase in real tariffs that emerge from their modelling.

total consumption of electricity is only estimated to fall by around 1 per cent by 2030 as a result of the changes.

Modelling by ACIL Tasman provides estimates of the relationship through time of total consumption and maximum demand with CPRS and renewable targets in place. With a 10 per cent Emissions Trading Scheme (ETS) cap for the electricity sector and 20 per cent renewables target, there is a small change in the relationship between modelled total consumption and maximum demand between 2010 and 2020. (The ratio of total GWh of total consumption to MW maximum demand falls from 5.45 to 5.3 signifying a slight deterioration in the relationship between peak and average loads, despite the fact that CPRS effects and targets are modelled to slow the growth rate in maximum demand more than they slow the growth rate in total consumption will bring about relatively larger conservation in the household sector than in the economy at large).

To assess whether the predicted energy savings are likely to defer generation augmentation it is useful to refer to conclusions from other studies which have modelled demand reduction measures. One of the most recent is the work done by CRA (2008a) as an input to the evaluation of the net benefits of introducing smart metering. CRA state (p.30) that 'while the peak demand reductions that result are small in percentage terms, in absolute terms they comprise 200 to 300 MW depending on the functionality and jurisdiction. Although these are not small numbers it must be noted that this level of demand is still well within the band of statistical uncertainty of system peak within these jurisdictions and therefore it is quite possible that they could be significantly or totally discounted in generation capacity investment decisions.' The report goes on to assume that this will indeed be the case.

It is reasonable to infer from this that if the energy savings in each jurisdiction resulting from the BCA changes are likely to be less than 200 MW when expressed in terms of maximum demand, then there will be no savings from deferral in generation augmentation. The 0.3 per cent savings in total consumption flowing from the BCA changes by 2020 represents a saving in total electricity consumption of approximately 800 GWh nationally compared with BAU in 2020. By 2030 that conservation effect will be similar. Applying the same initial ratio between total consumption measured in GWh and maximum demand (MW) as is implied by the ACIL-Tasman modelling (5.45 in 2009) would correspond to a reduction of around 150 MW in maximum demand nationally below BAU in 2020 and 2030. This would not explicitly allow for the (unknown) potential improvement in the relationship between maximum demand and total consumption brought about by the BCA changes. However it would imply that the improvement would be sufficient to fully offset the expected deterioration in that overall relationship which is modelled to occur even with the impacts of CPRS and targets but without the proposed BCA changes. Such an offset is unlikely given the slow renewal of the housing stock. Accordingly, since the overall maximum demand savings in any individual jurisdiction will be a fraction of this MW figure they will be very unlikely to defer significant augmentation in this timeframe.

This conclusion is reinforced when the results of another earlier study are taken into account. George Wilkenfeld and Associates (2006) advised that '…an increase in thermal performance level of the entire housing stock in the State of Victoria to '5 star' from … 2.2 star average would have reduced the peak load in the residential sector by 530 MW on extreme days'. When it is recalled that by 2020 only 16 per cent of the housing stock affected by the BCA changes examined in this RIS will be affected and that progress from 5 star to 6 star is likely to yield smaller per household conservation than the earlier Victorian example, their impact on generation augmentation decisions is likely to be negligible.

Impacts on operating costs of generation

Operating costs do not fall proportionately with reductions in supply. The impact of energy savings on the operating costs of generation businesses cannot be estimated directly for the purposes of this RIS. However, an insight into the likely upper bound of these savings can be obtained from the smart meter studies referred to above. In the market modelling performed for that inquiry the highest impact scenario, in which penetration rates of smart meters was assumed to be 35 per cent and there was high functionality of metering combined with an element of direct load control, maximum demand (peak demand) savings in any of the Australian jurisdictions was calculated to be 4.2 per cent below the base case, which involved no smart metering but included carbon pricing effects. The conservation effect in these studies (the impact on total consumption) varied between 3 per cent and 7 per cent depending on functionality. This compares with a 2030 conservation effect of less than 0.5 per cent estimated for the proposed BCA changes. The resulting national smart meter - plus Direct Load Control (DLC) impact on operating costs in 2030 was estimated to be a 0.73 per cent reduction below base case. The corresponding NPV of operating cost savings was put at $381 million when calculated over the period 2007 to 2030 with an 8 per cent discount rate.

The gains from these demand side measures arise partly from the flattening effect on the load curve that would have their counterpart in the measures envisaged in the proposed BCA changes although it is not possible to compare the two directly. However, the ultimate conservation effects relative to BAU are much stronger than in the BCA change case (up to 7 per cent). While the differing impacts on load profile of the two sets of measures remains uncertain it seems likely that, given the large end point disparity in total conservation effects between the modelled smart meter impacts and the BCA changes, the operating cost savings of the latter could be 0.1 per cent or lower.

These savings are distinct from the carbon cost savings to generators that would accompany conservation. In the smart meter case these were projected to be approximately 1 per cent below BAU costs, with an NPV value of $267 million, but again on the basis of substantial conservation effects.

There will also be some impact on savings from reductions in USE demand resulting from any improvement in load profiles brought about by the proposed BCA measures. On the basis of the smart meter study estimates, these could be expected to be intermediate between the operating cost and carbon cost savings.

Other avoided cost impacts

Network businesses also stand to benefit from favourable demand reduction responses to the extent that they reduce unit costs. Again there is the potential for gains through deferred capital expenditure, improved system load factor, and possibly an improved system reliability and return on fixed assets.

The individual network complexities prevent the calculation of these relevant components. However, again information from the smart metering studies provides a reasonable reference point. In estimating the network augmentation deferral benefits from demand reduction via smart meters and DLC, CRA (2008 b) have used an annualised cost of network capacity for each jurisdiction, based on data provided by the network distribution businesses. They report that these costs ranged between $115/kVA/yr to $165/kVA/yr. Adjusted by a power factor of 0.85 (to convert kVA to kW) for the residential sector these were then used to estimate the value to a network of a reduction in end use demand of 1 kVA, with a default value of $130/kW/yr for businesses for which data was not available.

Estimated network avoided costs approached in this way are relatively large for the case considered by CRA (2008b) under assumptions of high penetration of smart meters (35 per cent) and contributory direct load control. Average annual savings to distribution businesses were estimated at $212 million over the period 2009-2030 with an NPV value of $1.1 billion.

As in the case of impacts on generation businesses, the impacts of the proposed BCA measures can be expected to be an order of magnitude smaller than these. However, by 2020, if the BCA measures are resulting in reductions of 150 MW relative to BAU (corresponding to constant and improved relationships between maximum demand and total consumption) the corresponding annual network savings at an assumed value of $130/kW would be approximately $20 million. This figure would be similar in 2030. It could be expected that it would take at least 5 years to ramp up to network savings of this magnitude.

Conclusions

The proposed BCA changes will deliver gains in the form of avoided costs enjoyed by electricity generators and the businesses delivering power to end users. These will be modest gains. The relatively small impact on energy conservation compared with BAU will make it unlikely that generation augmentation plans, already heavily impacted by the likely implementation of the CPRS and renewable target requirements, will be altered as a result of the envisaged changes to residential consumption. Reductions in generation operating costs will occur but are unlikely to be more than 0.1 per cent below BAU. Avoided carbon costs will be of a similar small order of magnitude, along with any unserved energy savings.

More substantial savings may be realised in the network businesses due to favourable demand reduction responses that reduce their unit costs. Based on studies prepared to evaluate other energy conservation measures, it is estimated that average annual savings attributable to the proposed BCA changes could reach $20 million by 2030 in this subsector relative to BAU.

G Detailed impacts on individual dwellings

The tables below report the capital outlays and energy savings of the BCA amendments, as estimated by BMT&ASSOC and our thermal modelling partners from UNSW. Estimates are reported for both elemental and simulation compliance pathways and for concrete slab and timber flooring.

BMT&ASSOC provided costings for both 'enclosed' and 'unenclosed' timber flooring. On their advice, the table below reports 'unenclosed' timber flooring for dwellings in Darwin, Longreach and Brisbane (climate zones 1-3), and 'enclosed' timber flooring elsewhere.

G.1 **Estimated capital outlays ($ per dwelling) — simulation compliance**

	H01	*H04*	*H08*	*H09*	*FLAT*	*H12*	*H13*
Concrete slab							
Mildura	2200	4200	3200	1900	1700	na	3400
Adelaide	1700	3000	3100	1800	4100	na	2800
Perth	400	1100	4400	800	4100	na	2200
Sydney	-1200	3000	2300	1100	4100	na	1900
Melbourne	-600	1800	1900	1300	2800	na	1700
Canberra	-500	1300	1900	1600	2500	na	4100
Hobart	400	2900	2000	700	2500	na	4100
Cabramurra	900	1900	4100	1900	3100	na	1200
Brisbane	1000	1900	2100	1000	1200	na	-2400
Longreach	1800	4800	5100	3200	1600	na	1700
Darwin	1500	1200	2500	1400	1900	na	2300
Timber							
Mildura	3900	4200	5500	4200	na	2800	5900
Adelaide	6000	3300	5800	2500	na	2400	5500
Perth	1900	1900	1600	800	na	2000	4300
Sydney	3200	3100	3900	3200	na	2900	3700

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G.1 Estimated capital outlays ($ per dwelling) — simulation compliance (continued)

	H01	H04	H08	H09	FLAT	H12	H13
Melbourne	3300	2700	3700	2700	na	2200	5500
Canberra	3200	4700	3600	2600	na	2200	5500
Hobart	2600	2400	2700	2200	na	2100	4300
Cabramurra	3000	2700	2300	2500	na	2500	5500
Brisbane	700	1700	4100	1100	na	1800	1900
Longreach	2700	2200	3800	2700	na	1800	4600
Darwin	1700	2900	2200	1800	na	2300	2800

Note: Timber flooring in Darwin, Longreach and Brisbane is 'unenclosed.' In all other locations, timber flooring is 'enclosed.'
Source: BMT&ASSOC based on data provided by the ABCB (Constructive Concepts 2009 & Burghardt 2008).

G.2 Estimated capital outlays ($ per dwelling) — elemental compliance

	H01	H04	H08	H09	FLAT	H12	H13
Concrete slab							
Mildura	1300	1900	1900	800	na	na	2500
Adelaide	1100	1500	1600	800	na	na	1900
Perth	1200	1600	1800	900	na	na	2100
Sydney	1400	1900	2000	1100	na	na	2400
Melbourne	1100	1600	1600	700	na	na	2100
Canberra	2000	2900	3300	1500	na	na	3900
Hobart	1900	2900	3300	1500	na	na	3800
Cabramurra	900	1300	1200	500	na	na	1800
Brisbane	2300	3500	3600	1600	na	na	4400
Longreach	1900	2800	2700	1200	na	na	3500
Darwin	1200	1800	1700	700	na	na	2300
Timber							
Mildura	2200	2600	2400	1000	na	2100	3300
Adelaide	1500	1700	1800	900	na	1600	2200
Perth	1600	1800	1900	1000	na	1700	2300
Sydney	1900	2100	2200	1100	na	2000	2700
Melbourne	2000	2300	2100	900	na	1900	2900
Canberra	2800	3600	3800	1700	na	3400	4700
Hobart	2800	3500	3700	1600	na	3300	4600
Cabramurra	1700	2100	1800	700	na	1600	2600

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G.2 Estimated capital outlays ($ per dwelling) — elemental compliance (continued)

	H01	H04	H08	H09	FLAT	H12	H13
Brisbane	2500	3800	3800	1600	na	3000	4700
Longreach	2700	3900	3400	1300	na	3200	4800
Darwin	1700	2500	2200	800	na	1900	3000

Note: Timber flooring in Darwin, Longreach and Brisbane is 'unenclosed.' In all other locations, timber flooring is 'enclosed.'
Source: BMT&ASSOC based on data provided by the ABCB (Constructive Concepts 2009 & Burghardt 2008).

G.3 Estimated energy savings (MJs per annum)

	H01	H04	H08	H09	FLAT	H12	H13
Concrete slab							
Mildura	3399	3895	3860	1805	5188	na	4063
Adelaide	2118	2907	2551	1425	3645	na	2726
Perth	1703	2499	1635	1057	3645	na	2029
Sydney	915	1306	1235	654	3645	na	1102
Melbourne	5738	7377	6720	2964	3732	na	6167
Canberra	6016	6851	6161	2621	3783	na	5886
Hobart	2864	4031	3493	1853	3783	na	4537
Cabramurra	14 005	21 121	18 293	8254	5310	na	16 750
Brisbane	571	931	1178	477	869	na	859
Longreach	2798	2844	3904	1433	4131	na	2302
Darwin	3766	6015	5813	2562	10 869	na	5684
Timber							
Mildura	3014	4500	3205	1756	na	2918	3001
Adelaide	1909	2780	3560	1302	na	1984	2726
Perth	1648	1769	2965	1049	na	1560	1971
Sydney	915	1238	977	630	na	1007	1093
Melbourne	5676	6168	7305	2734	na	4510	5946
Canberra	6016	6851	6161	2621	na	4274	6050
Hobart	2864	4031	3493	1853	na	2860	3580
Cabramurra	14 005	21 121	18 293	8254	na	12 670	15 542
Brisbane	765	991	1029	421	na	0	756
Longreach	2693	2806	2808	1609	na	2343	3814
Darwin	3676	5663	5403	2552	na	3103	5146

Note: For this study, the ABCB has implicitly assumed that both elemental and simulation compliance will produce the same energy savings.
Source: Prasad, King and Snow based on data provided by the ABCB, and CIE estimates based on Burghardt (2008).

H Methodology to estimate impacts on housing affordability

The impacts that the proposed BCA changes will have on housing affordability across Australia's capital cities have been analysed using three affordability indicators:

- the Housing Industry Association- Commonwealth Bank of Australia (HIA-CBA) Housing Affordability Index;
- the median multiple; and
- the ratio of mortgage repayment to household income.

A discussion of how these indicators were calculated is provided in the sections below.

HIA CBA First Home Buyer Affordability Index

The HIA-CBA Housing Affordability Index measures accessibility to home ownership for an average first-home buyer. It is calculated as follows (Kryger 2006):

HAI= (Average disposable income per household / qualifying disposable income) x 100

Where:

Average disposable income per household = Average annual gross household income less income tax payable and other payments to government.

Qualifying disposable income = Qualifying income x (average disposable income/gross income).

Qualifying income = income required to meet repayments on a 25 year loan, for 80 per cent of the median price of an average established dwelling purchased by a first-home buyer (that is, assumes a 20 per cent deposit). [58] In calculating qualifying income it is assumed that repayments cannot exceed 30 per cent of before-tax household income.

The HIA-CBA index divided by 100 shows the number of times that average household disposable income exceeds the minimum income needed to meet repayments on an average established dwelling. A decrease in the HIA-CBA index represents reduced affordability.

While the intention of this RIS was to follow the methodology (and inputs) of the HIA-CBA index as closely as possible, the following changes have been made to make it consistent with the analysis of the proposed BCA changes.

- Since the proposed amendments to the BCA will mostly affect new dwellings, for this RIS we have modified the original HIA-CBA index to reflect changes in affordability on the median *new* dwelling. This was done by using in the calculations median house prices for new dwellings instead of the median first home prices used by HIA-CBA (which include all established dwellings). Further, HIA-CBA use the median price of an average established dwelling *purchased by a first-home buyer*. [59] Since information about prices of new dwellings by buyer types was unavailable, we have used the 'general' median price for new dwellings (which includes all buyers of new homes) to calculate this indicator. The median prices for new houses across capital cities used in the calculation of this indicator are provided in table H.1.[60]
- Instead of the interest rate used in HIA-CBA March quarter 2009 publication (5.20 per cent), we have used the standard variable interest rate reported by the Reserve Bank of Australia (RBA) (5.8 per cent as at June 2009).
- The *average* household income figures used to calculate the HIA-CBA index remain the same as those published in the latest HIA-CBA report (March quarter 2009). This income figure differs from the income figures used to calculate the other two affordability indicators included in this report (which use the *median* household income figures from the ABS).

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[58] The median price of an established dwelling is obtained from a census of CBA home loan approvals in a given period, adjusted to approximate 'first home buyer' prices (Kryger 2006).

[59] The 'first home buyer' prices used by HIA-CBA in their affordability publication are medians of those dwellings financed by the CBA.

[60] The median value of new houses for the financial year 2007 08 is sourced from RP Data and updated to 2008 09 using ABS house price indexes.

Table H.2 provides additional details about the inputs used in the calculation of all the affordability indicators.

The changes made to the data used in the original HIA-CBA index mean that, instead of measuring accessibility to *home ownership for an average first-home buyer*, the HIA-CBA index in this RIS is measuring accessibility to *home ownership for an average new-home buyer.*

H.1 **Median new house prices, $ 2008-09**

	$
Sydney	517 267
Melbourne	388 577
Brisbane	432 707
Perth	488 167
Adelaide	370 546
Hobart	322 143
Canberra	484 562
Darwin	417 807

Source: RP Data and ABS (2009b).

Median multiple

The median multiple (or house price to income ratio) reflects the 'years of gross income' required to purchase a new house within individual markets. The median multiple is calculated as follows:

Median Multiple = median new house price/gross median household income [61]

To calculate this indicator, the CIE used the following inputs:

- the national median value of new houses in different capital cities for the financial year 2008–09. The median value of new houses for the financial year 2007–08 is sourced from RP Data and updated to 2008–09 using ABS house price indexes; and
- the median household income in Australia as at February 2009 (approximately $58 400 per annum, gross pre-tax). The median income

[61] The median household income divides households into two equal segments with the first half of households earning less than the median household income and the other half earning more (that is, the midpoint when all people are ranked in ascending order of income).

figure is based on ABS Census 2006 data and updated using ABS average weekly earnings.

Table H.2 provides additional details about the inputs used in the calculation of all the affordability indicators.

Ratio of mortgage repayment to household income

The ratio of mortgage repayment to household income indicates the proportion of gross income used for mortgage repayments. This indicator is calculated as follows:

Ratio of mortgage repayment to household income= annual mortgage repayment / gross median household income

To calculate this indicator, the CIE used the following inputs:

- the national median value of new houses in different capital cities for the financial year 2008–09. The median value of new houses for the financial year 2007–08 is sourced from RP Data and updated to 2008–09 using ABS house price indexes;
- the median household income in Australia as at February 2009 (approximately $58 400 per annum, gross pre-tax). The median income figure is based on ABS Census 2006 data and updated using ABS average weekly earnings;
- the standard variable interest rate reported by the RBA (5.8 per cent as at June 2009); and
- the following loan assumptions:
  - Loan repayment period: 25 years.
  - Loan to valuation ratio (LVR):[62] 80 per cent (that is, assumes a 20 per cent deposit).
  - Loan type: a standard loan is assumed for the calculations in this study.
  - Borrower type: for this study we assume a prime borrower with no adverse credit history.
  - Mortgage repayments include principal and interest payments.

[62] LVR refers to the ratio between the size of the loan and the value of the property.

H.2 **Inputs used to calculate the affordability indicators**

Indicator/ input	*House price*	*Interest rate*	*Income figures*
Original HIA-CBA index (March quarter 2009)	Median first home price of established dwellings in each capital city.	Standard variable interest rate in HIA-CBA March quarter 2009 report (5.20 per cent)	Average annual household income figures published in HIA-CBA March quarter 2009 report (Australia): Total = $128 800 Disposable = $93 700
HIA-CBA index in this RIS	Median price of a new house (includes all buyers of new houses) in each capital city.	Standard variable interest rate reported by the RBA (5.8 per cent as at June 2009).	Average annual household income figures published in HIA-CBA March quarter 2009 report (Australia): Total = $128 800 Disposable = $93 700
Median multiple	Median price of a new house (includes all buyers of new houses) in each capital city.	N/A	Median household income figures by ABS (as at February 2009, Australia) (approximately $58 400 per annum, gross pre-tax).
Ratio of mortgage repayment to household income	Median price of a new house (includes all buyers of new houses) in each capital city.	Standard variable interest rate reported by the RBA (5.8 per cent as at June 2009).	Median household income figures by ABS (as at February 2009, Australia) (approximately $58 400 per annum, gross pre-tax).

Source: CIE, HIA-CBA (2009), RBA (2009) and ABS (2007,2009a, 2009b).

I Methodology used to estimate impacts on owner-occupiers

Identifying costs and benefits at the household level is a complicated task. This is because impacts are likely to differ by factors such as:

- dwelling type;
- household configuration;
- size (storeys);
- flooring;
- climate zone; and
- jurisdiction.

Additionally, the BCA allows for new construction to comply with the BCA through either performance compliance or by satisfying DTS requirements. This RIS only assesses the DTS route to compliance. Satisfying DTS can be achieved two ways, by elemental prescriptive methods or though software simulation. It will therefore be necessary to also account for the difference in the costs and benefits between elemental and simulation compliance methods. For each population centre, benefits and costs are assessed for each dwelling structure, by flooring type, and for elemental and simulation based compliance.

Estimating energy savings

Estimates of energy savings were provided by a consortium of thermal modelling experts from the University of New South Wales. This consortium consisted of Prof Deo Prasad, Steve King and Dr Mark Snow. Their estimates (reported in table I.3 and I.4) were based on data provided by the ABCB which was the result of work undertaken by Tony Isaacs Consulting, Constructive Concepts and Envirohome (Greg Burghardt). The methodology and assumptions employed by this consortium follow below.

Conversion of predicted space loads to projected expenditure

The mandated rating software used throughout Australia for residential construction is variously based on the CSIRO developed thermal calculation engine CHEENATH, and implemented through the 'second generation' software AccuRate, BERS Pro, and FirstRate. The settings and assumptions of AccuRate, and in particular its predecessor, NatHERS version 2.32 have been a subject of considerable debate —the modelled energy use has not generally corresponded well with existing energy use data from the limited surveys undertaken.

No methodology has been established to reliably correlate simulated household energy use for heating and cooling with actual likely use, either on individual dwelling, or aggregated basis. Only a very few discrete studies addressing this problem can be found in the literature. Energy Partners (2001) and Energy Efficient Strategies (1999) used simple constraint factors, which were employed for the cost-benefits studies of the introduction of energy efficiency measures into the BCA. They would normally be considered to represent unacceptably over aggregated data to be applied to estimates of the kind proposed in this evaluation, and in any case vary unacceptably between the studies.

The third, a study of a small number of dwellings of diverse design, Williamson et al (2001) has shown that it is possible to achieve an acceptable statistical correlation by incorporating appliance efficiencies and fuel type considerations into NatHERS predictions. But while the study suggests a regression for the relationship, it is not suggested that the predictive power of the model is appropriate for the use required here.

A more detailed approach was adopted in a study to improve on previous simulation outcomes, undertaken by the SOLARCH for Landcom NSW, and described in detail in Energy Smart Urban Solutions (Mark Ellis & Associates, 2003). In the current study, there has been limited opportunity to implement all of the methods adopted in that more detailed approach.

The variables in relating predicted 'unconstrained' space loads as calculated by the software, to likely energy expenditure on heating and cooling are as follows.

Exclusion of seasonally redundant heating or cooling operation

In the two climate zones for the Sydney region, as required for the Landcom study (ibid.), aggregated heating loads for November to March, and aggregated cooling loads for May to September, were discarded. This overcame the problem that NatHERS (AccuRate) allows ‘redundant’ cooling in winter and heating in summer when the thermostat settings are reached.

There is no specific citation from the literature that may be employed for designating such periods of discounted heating and cooling, for other climate zones. That has been the position for some time, and was the advice of CSIRO to TAC during the final stages of development of AccuRate, as an explanation for why the anomaly persists in the second generation software.

Notwithstanding that problem, provisional heating and cooling seasons for each of the climates subject of the current study could have been identified by expert opinion. However, the database in the ABCB’s energy efficiency rating calculator (EER calculator) does not include the relevant hourly detail to allow the filtering and deduction of ‘redundant’ heating and cooling from the predicted aggregated loads.

Conversions applying plant efficiency of coefficient of performance factors

These conversion factors are required to account for the actual type of appliance assumed to provide heating or cooling, in order to translate space loads into heating and cooling energy use. Once the predicted space load is established, an efficiency factor or Coefficient of Performance (COP — for heat pump systems) may be applied.

Where cooling is considered to be operated, a COP applicable to an efficient refrigerative AC unit is assumed. The corresponding heating is then expected to be largely provided by reverse cycle operation of the same AC unit. For both modes, a variable COP dependent on external ambient temperature should be applied. As this calculation is not possible in the dynamic simulation, and hourly loads based on internal and external temperatures were not provided, we have employed a single COP for each mode, for each climate but apportioned COP cooling to Spring and Summer months and COP heating to Autumn and Winter months. The relevant value is based on a simplified assumption of weighted average external temperatures during the heating and cooling periods, applied to operating characteristics of single stage unmodulated heat pump (ASHRAE 45.9). The external temperature mean monthly values are calculated from 2007 reference meteorological year (RMY) locational data sourced from the 2007 updated Australian Climate Databank (ACDB). This data is also used in EES (2008) from which additional references for COP heating values are sourced. The Sustainable Energy Development Office

(SEDO) in Western Australia also published relevant COP heating values used in the calculations.

Heating COP values used for the study compliment the appliance penetration rates study by EES (2008). These are reported in table I.1 and I.2 respectively.

I.1 Coefficient of performance (COP) values by heating types

Heating type	***COP***
Electric main space heating	0.85
Gas main space heating (LPG & Mains)	0.80
Wood main space heating	0.38
Other heating space heating (mainly coal, kerosene)	0.43

Source: EES 2008 SEDO heat run calculations.[63]

I.2 Heating and cooling COP values extrapolated from EES (2008) appliance penetration rates by location

	Estimated COP	
	Cooling	***Heating***
Sydney (Mascot)	2.5	1.74
Darwin	2.3	0.96
Canberra	2.5	1.19
Brisbane	2.5	1.85
Mildura	2.5	0.89
Longreach	2.3	1.85
Adelaide	2.5	1.30
Perth	2.5	1.04
Hobart	2.5	1.71
Melbourne (Moorabbin)	2.5	0.88
Cabramurra (Alpine)	2.5	0.87

Source: (EES 2008 Appendix F), values for cooling and heating are taken from projected 2009 values. [64]

63 SEDO website (2009) —- approximate running costs and greenhouse gas emissions for different types of heaters in an average home with an insulated ceiling http://www.sedo.wa.gov.au/pages/heat_run.asp.

64 Includes Reverse Cycle (RCC) heating but unclear from EES data % of heating from table below. Without a clearly apparent alternative RCC values are included in electric mains space heating component and COP adjusted accordingly.

Aggregation of the predicted average heating and cooling loads should be based on notional diversity factors, which describe the range of adoption of reverse cycle air-conditioning. Where cooling is not expected, the predicted cooling load is not included in the total consumption, but the equipment factors applied to heating then become the less favourable efficiencies for electric resistance heating and/or gas fired space heating.

We note the additional uncertainty relating to mixed modes of heating, where smaller and partial heating loads may be handled by appliances such as portable electric resistance heaters, even where whole house ducted air-conditioning is installed. This phenomenon is identified in the literature, but there appears to be no satisfactory basis for incorporating it into the numerical treatment of heating energy use, except by absorbing it into the 'constraint factor' discussed below.

Correction for user behaviour (Constraint Factor)

A correction factor has to be applied to the simulation predictions for heating and cooling, to account for the discrepancy between the software default predicted hours of use, and data on appliance use from Australian Bureau of Statistics (ABS 8218.0).

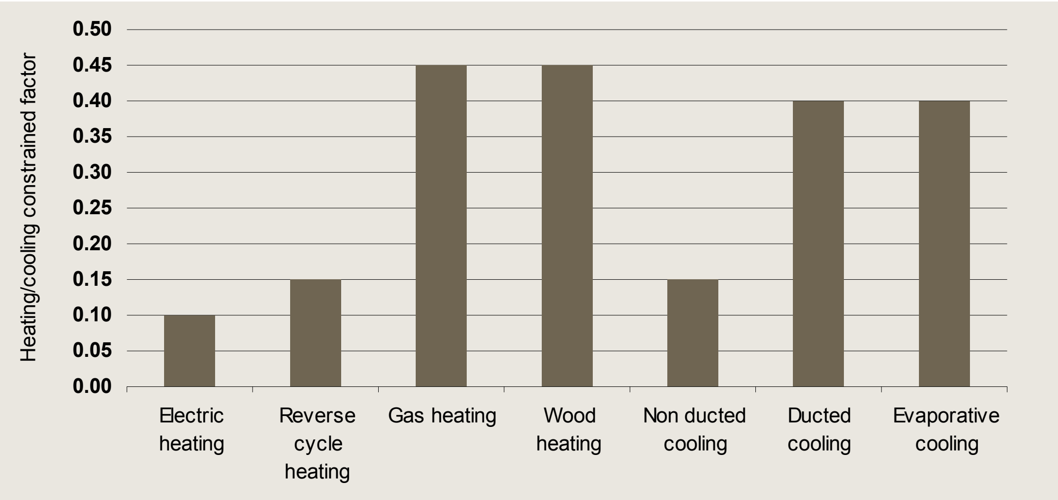
The detailed rationale for this 'constraint factor' is set out in *Australian Residential Building Sector Greenhouse Gas Emissions 1990–2010 Final Report 1999,* and again by the same authors in *Impact of Minimum Performance Requirements for Class1 buildings in Victoria 2000*. Quoting from the latter (EES 2000):

> User Behaviour
>
> In addition to the thermostat set points and times of occupation and the operation of ventilation and shading options in response to weather conditions set out under the relevant headings below, other factors are entrenched in the FirstRate/NatHERS internal settings which do not necessarily reflect common household patterns:
>
> - no allowance for part house heating and/or cooling;
> - no allowance for vacation absences at any time;
> - no differentiation between weekdays and weekends or public holidays; and
> - present patterns of lighting and internal appliance efficiency and use.

Factors 1 and 2 will both result in overestimation of actual energy consumption for real households while factor 3 may result in a lesser or greater overestimation of energy consumption depending on the actual 'normal' and 'holiday' occupancy patterns of the household concerned. Factor 4 is probably neutral in terms of current practice but will not account well for predicted improvements in appliance and lighting efficiencies and user diligence. In terms of forecast energy consumption, this may overestimate cooling energy and underestimate heating energy due to the lower amounts of 'internal loads' that we would anticipate in future households.

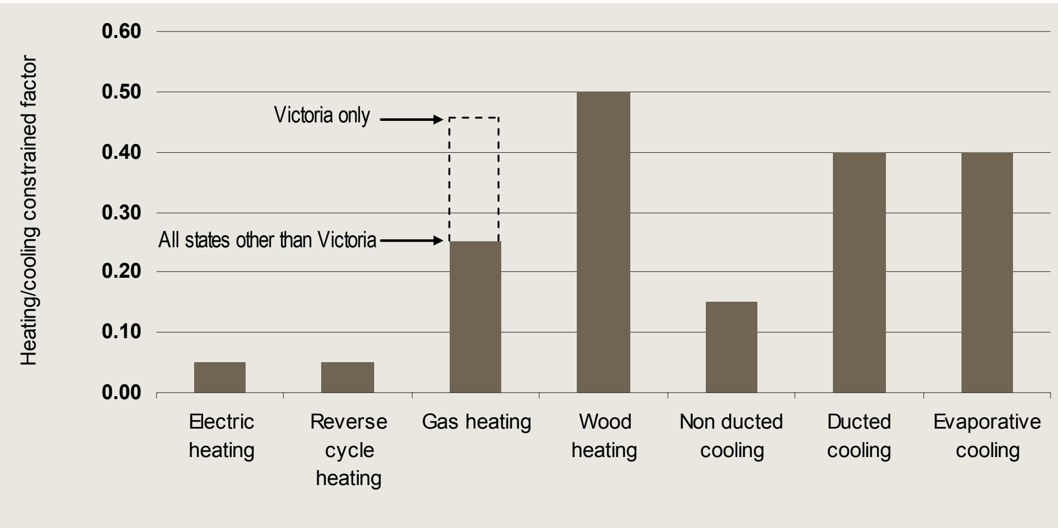
These two studies offer the following tabulations, with little further explanation:

I.3 Constraint factors for heating and cooling by technology



Data source: EES 2000.

I.4 Constraint factors for heating and cooling by technology



Data source: ABCB 2002.

In trying to settle on the critical value for this ‘constraint factor’, two further studies for the ABCB — prepared for the purpose of evaluating the likely impacts of proposed changes to the Building Code of Australia — are relevant.

The first, by Energy Partners and BRANZ, discusses constrained occupancy scenarios, and employs one restricted scenario for the purpose of establishing the sensitivity of the predicted energy use (Energy Partners, 2001). It does not examine any variables other than the occupancy hours, and sets aside the alternative scenario in the actual calculations. The energy consumption predictions of this study were widely criticized, as not achieving acceptable correlation with the limited evidence of actual heating and cooling consumption. The final version of the study (unpublished) relies on constraint factors to the combined heating and cooling space loads predicted by NatHERS (with unmodified rating mode settings) for ‘unimproved’ and ‘improved’ reference house configurations. The resulting predicted potential energy savings are then used as the basis of the cost benefit assumptions for the formulation of recommended deemed to satisfy provisions for the BCA.

The constraint factors were derived from the work of Lloyd Harrington in the national baseline study of greenhouse gas emissions (EES, 1999). The factors were derived by the *ABCB/AGO Class 1 Buildings Financial Analysis Tool* (AGO, 2001), which examined the sensitivity of approximately five million variations of six reference house designs. As reported by the authors, the constraint factors were ‘embarrassingly uniform’ at 0.5, except for natural gas heating in Melbourne.

The second is the RIS prepared in 2002, for the amendments for incorporating Energy Efficiency provisions in the BCA (ABCB, 2002). Inter alia, that document refers to similar constraint factors, but of more variable magnitude, shown in the table below. Note that these factors are combined for heating and cooling.

For the present study, the usefulness of the constraint factors suggested by these sources is severely limited, if for no other reason than their unexplained variability.

In the previous study by SOLARCH for Landcom (Mark Ellis & Associates, 2003) we employed a single constraint correction factor of 0.7 applied to the simulation predictions for heating — based on the discrepancy between NatHERS predicted hours of use and data from Australian Bureau of Statistics (ABS 8218.0). For cooling, we applied a constraint factor of 1.0.

I.5 Constraint factors for heating and cooling predictions using NatHERS

	Ratio of constrained to unconstrained estimates (%)
New South Wales	19
Victoria	62
Queensland	5
South Australia	25
Western Australia	28
Tasmania	53
Northern Territory	11
ACT	32
Australia	32

Source: adapted from table 4.1, Energy Efficiency Measures BCA Volume Two (Housing Provisions) 2002.

However, our preferred factor was relevant after we had previously modified the software determined occupancies in a manner not available in this present study. A plausible bracket of possible heating and cooling hours for the living and sleeping zones of the dwellings was nominated a priori. The hours were much more limited than those used by NatHERS/AccuRate ratings (which effectively assume maximum heating and cooling potentials for all conventional waking hours). The total heating and cooling loads calculated on the basis of these plausible bracket of use hours is still more than any statistical survey of actual energy use for space heating and cooling would indicate.

There are a number of major causes of such a discrepancy:

- the software assumes full plant capacity necessary to achieve virtually instant setpoint conditions after switch-on. This is clearly not the case in practice, with 'under-rated' plant taking some time of continuous running at full power to overcome larger temperature differences. The software may not be readily adjusted to overcome this problem;
- the sleeping zone may not be conveniently subdivided into a number of different bedrooms. The software therefore fails to allow for some of the scenarios for use of such spaces, for example, individual study by teenagers over extended hours vs. possibly very limited use of the master bedroom by the principal adults; and
- more limited hours of use by a significant majority of households. No appropriate 'diversity factor' is known to allow a simple adjustment of the aggregate demand, nor is there a basis in the literature for any particular representative use pattern at that level of detail.

An adjustment factor is therefore introduced, based on a nominal ratio of average surveyed appliance usage to predicted hours of heating or cooling. The stringency of this factor is itself limited by:

- the variety of predicted hours depending on dwelling configuration; and
- the over-aggregation of State-wide data.

It is notable that within the assumed plausible usage bracket, NatHERS tended to predict greater heating hours, and cooling hours that vary from marginally less, to drastically more, than the State average appliance use. The simulations are therefore separated into cooling and heating components, which are treated differently.

With respect to cooling, the results of the comparison are thought to be valid. If the majority of existing air-conditioning appliances are under-rated, actual hours of use from usage surveys could be expected to be higher than modelled hours. In addition, once switched on, cooling would certainly be run to a lower setpoint than the initial ‘switch on’ temperature (unlike the AccuRate assumption), again suggesting that the software may understate the actual hours of operation. However, if we allow for the compensating likely discrepancy in ratings of the cooling plant, the aggregate cooling energy use can be satisfactorily estimated without further discount factors.

With respect to heating, predicted hours of appliance use appear to be more than those surveyed. This is probably logical, in that dwelling occupants often will not switch on heating when conditions fall marginally below comfort, or when local radiant effects from sunlight create distinctive zones of thermal comfort in spite of lower air temperatures. We therefore use a **constraint factor** based on the **median value of the surveyed/predicted ratio**, derived for the range of dwelling types for heating energy use. Individually calculated factors (for different house types) are not applied, as this would have the effect of masking performance differences resulting from dwelling orientations and other variables.

Readers would note that the constraint factors in the Landcom study, and applied again here, are much higher than those suggested by the previous studies cited. We believe the higher constraint factors appear justified by the evidence of greater reliability of the simulated cooling by the second generation software AccuRate, on the one hand, and on the other hand, increasing ‘takeback’ for heating energy use, which appears to accompany improving fabric performance. We believe that any possible over-estimate of actual energy use that might result is better handled by the sensitivity analysis.

Estimating compliance costs

BMT & ASSOC Pty Ltd (BMT) estimated the cost associated with upgrading the BCA energy efficiency measures for residential buildings. Specifically, BMT estimated the *incremental* costs of:

- introducing a 6 star requirement based on thermal performance modelling software (simulation) for Class 1 and 10 buildings;
- a general increase in stringency of the elemental provisions (including the introduction of maximum artificial lighting allowances) for Class 1 and 10 buildings; and
- introducing a 6 star requirement based on thermal performance modelling software (simulation) for Class 2 and 4 buildings (including the introduction of maximum artificial lighting allowances).

Simulation compliance

To estimate the incremental costs associated with simulation compliance, BMT first estimated the costs of compliance under the current BCA provisions, then they estimated the costs of compliance associated with the proposed BCA amendments and then calculated the cost differential between the two compliance methods. Estimates for each dwelling structure are reported by population centre, floor type and compliance method in the table below.

To estimate the cost increase of achieving the 6 star requirement based on thermal performance modelling software for each dwelling type in each BCA climate zone, BMT used an energy efficiency rating calculator (EER calculator) developed by Constructive Concepts and provided by the ABCB. The EER calculator catalogues construction changes that can improve ratings from 5 stars in half star steps and records their impacts on simulated annual heating and cooling needs.[65] BMT performed a comprehensive review of all construction costs included in the EER calculator and re-calculated all the cost scenarios.

Notably, BMT relied on the EER calculator’s method of achieving the 5 and 6 energy star requirements and provided an independent assessment of the costs involved in achieving the construction specifications contained in the calculator. In light of this, BMT and CIE are not in a position to confirm whether the costs estimated for this report are the most cost

65 More detailed information about the EER Calculator can be found in Constructive Concepts (2009).

effective, nor are we in a position to exclude the possibility that energy efficiency requirements could be achieved using alternative methods.

A sample of the type of construction specifications included in the EER calculator and used to estimate the costs (and benefits) of achieving the 5 and 6 energy star requirements for a dwelling type (house 01) across capital cities is provided in appendix J.

Elemental compliance

To estimate the costs of the elemental compliance pathway, BMT reviewed architectural plans for each of the sample dwellings, and sought advice from the ABCB on the required elemental changes.

The cost assessment of the impact associated with increased energy efficiency requirements was modelled on quantities and construction materials likely to be used from the different types of construction. These include timber weatherboards, brickwork, varying types of glazing, two storey construction with upper floors and single storey construction. The standard base price for each house has been determined on a project home scenario.

The methodology upon which BMT's estimated costs were prepared was based largely upon cost and building price index information contained within Rawlinsons Australian Construction Handbook Edition 27 2009, with a minor amount of pricing estimated by utilising their internal construction rate library.

J Construction specifications included in the EER calculator

This appendix includes a sample of the type of construction specifications used to estimate the costs (and benefits) of achieving the 5 and 6 star energy requirements for a dwelling type (house 01) across capital cities.

J.1 House 01, Darwin, timber floor, concrete block wall

Select house details to compare energy efficiency options *(Click on each arrowed cell for a drop down list of options)*			
(1) House(s)		→ **House 1**	→ **House 1**
(2) Climate(s)		→ **Darwin**	→ **Darwin**
(3) Ground Floor type(s)		→ **Timber**	→ **Timber**
(4) External Wall type(s)		→ **Concrete Block**	→ **Concrete Block**
(5) Star Ratings to compare		→ **5.0 stars (base rating)**	→ **6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	Enclosed	Enclosed
	Wall cavity closed at base?	Yes	Yes
	Insulation above subfloor	None	None
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Concrete Block	Concrete Block
	External wall type 2	NA	NA
	Internal Walls	Concrete Block	Concrete Block
Roof	Roof form and roofing colour	Attic (light colour)	Attic (light colour)
	Roof airspace properties	No foil / Well Vented	No foil / Well Vented
	Roof and ceiling insulation	161m² R2.5	**161m² R4**
Window details			
Windows	Total area / % / main type	40.73m² / 27% / Sliding Door	40.73m² / 27% / Sliding Door
	Opening area / floor area	10% (effective area)	10% (effective area)
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	8.0m² with 0.75m shading	8.0m² with 0.75m shading
	E facing area / shading	17.7m² with 4.4m shading	17.7m² with 4.4m shading
	S facing area / shading	6.2m² with 0.75m shading	6.2m² with 0.75m shading
	W facing area / shading	8.9m² with 0.75m shading	8.9m² with 0.75m shading
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.73m² (U 6.35 / SHGC 0.77)	40.73m² (U 6.35 / SHGC 0.77)
Glazing type 2:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		5	5
Ceiling fans		None	**8 @1200 dia**

Data source: EER Calculator, Constructive Concepts (2009).

J.2 House 01, Darwin, slab floor, concrete block wall

Select house details to compare energy efficiency options *(Click on each arrowed cell for a drop down list of options)*			
(1) House(s)		→ House 1	→ House 1
(2) Climate(s)		→ Darwin	→ Darwin
(3) Ground Floor type(s)		→ Slab	→ Slab
(4) External Wall type(s)		→ Concrete Block	→ Concrete Block
(5) Star Ratings to compare		→ 5.0 stars (base rating)	→ 6.0 stars (comparison)
Construction Details			
Floors	Subfloor airspace	NA (slab floor)	NA (slab floor)
	Wall cavity closed at base?	NA (wall on slab)	NA (wall on slab)
	Insulation above subfloor	NA	NA
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Concrete Block	Concrete Block
	External wall type 2	NA	NA
	Internal Walls	Concrete Block	Concrete Block
Roof	Roof form and roofing colour	Attic (light colour)	Attic (light colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m² R1.5	**161m² R2.5**
Window details			
Windows	Total area / % / main type	40.55m² / 27% / Sliding Door	40.55m² / 27% / Sliding Door
	Opening area / floor area	10% (effective area)	10% (effective area)
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	8.0m² with 0.75m shading	8.0m² with 0.75m shading
	E facing area / shading	17.7m² with 4.4m shading	17.7m² with 4.4m shading
	S facing area / shading	6.0m² with 0.75m shading	6.0m² with 0.75m shading
	W facing area / shading	8.9m² with 0.75m shading	8.9m² with 0.75m shading
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.55m² (U 6.35 / SHGC 0.77)	40.55m² (U 6.35 / SHGC 0.77)
Glazing type 2:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		5	5
Ceiling fans		None	**8 @1200 dia**

Data source: EER Calculator, Constructive Concepts (2009).

J.3 House 01, Brisbane, slab floor, concrete block wall

Select house details to compare energy efficiency options	*(Click on each arrowed cell for a drop down list of options)*		
(1) House(s)		→ **House 1**	→ **House 1**
(2) Climate(s)		→ **Brisbane**	→ **Brisbane**
(3) Ground Floor type(s)		→ **Slab**	→ **Slab**
Default wall used - no alternatives available		→	→ Concrete Block
(5) Star Ratings to compare		→ **5.0 stars (base rating)**	→ **6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	NA (slab floor)	NA (slab floor)
	Wall cavity closed at base?	NA (wall on slab)	NA (wall on slab)
	Insulation above subfloor	NA	NA
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Veneer	Brick Veneer
	External wall type 2	NA	NA
	Internal Walls	Plasterboard	Plasterboard
Roof	Roof form and roofing colour	Attic (light colour)	Attic (light colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m^2 R2	**161m^2 R4**
Window details			
Windows	Total area / % / main type	40.6m^2 / 27% / Awning	40.6m^2 / 27% / Awning
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	8.0m^2 with 0.75m shading	8.0m^2 with 0.75m shading
	E facing area / shading	17.7m^2 with 4.4m shading	17.7m^2 with 4.4m shading
	S facing area / shading	6.0m^2 with 0.75m shading	6.0m^2 with 0.75m shading
	W facing area / shading	8.9m^2 with 0.75m shading	8.9m^2 with 0.75m shading
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.6m^2 (U 6.35 / SHGC 0.77)	40.6m^2 (U 6.35 / SHGC 0.77)
Glazing type 2:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		5	5
Ceiling fans		8 @1200 dia	**10 @1200 dia**

Data source: EER Calculator, Constructive Concepts (2009).

J.4 House 01, Brisbane, timber floor, concrete block wall

Select house details to compare energy efficiency options *(Click on each arrowed cell for a drop down list of options)*			
(1) House(s)		→ **House 1**	→ **House 1**
(2) Climate(s)		→ **Brisbane**	→ **Brisbane**
(3) Ground Floor type(s)		→ **Timber**	→ **Timber**
Default wall used - no alternatives available		→	→ Concrete Block
(5) Star Ratings to compare		→ **5.0 stars (base rating)**	→ **6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	Enclosed (with R1 inside walls)	Enclosed (with R1 inside walls)
	Wall cavity closed at base?	Yes	Yes
	Insulation above subfloor	None	None
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Veneer	**Brick Veneer (with 93m² Foil)**
	External wall type 2	NA	NA
	Internal Walls	Plasterboard	Plasterboard
Roof	Roof form and roofing colour	Attic (light colour)	Attic (light colour)
	Roof airspace properties	No foil / Well Vented	No foil / Well Vented
	Roof and ceiling insulation	161m² R3	161m² R3
Window details			
Windows	Total area / % / main type	40.8m² / 27% / Awning	40.8m² / 27% / Awning
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	8.0m² with 0.75m shading	8.0m² with 0.75m shading
	E facing area / shading	17.8m² with 4.4m shading	17.8m² with 4.4m shading
	S facing area / shading	6.1m² with 0.75m shading	6.1m² with 0.75m shading
	W facing area / shading	8.9m² with 0.75m shading	8.9m² with 0.75m shading
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.8m² (U 6.35 / SHGC 0.77)	40.8m² (U 6.35 / SHGC 0.77)
Glazing type 2:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		5	5
Ceiling fans		8 @1200 dia & 4 @1400 dia	8 @1200 dia & 4 @1400 dia

Data source: EER Calculator, Constructive Concepts (2009).

J.5 **House 01, Adelaide, slab floor, concrete block wall**

Select house details to compare energy efficiency options *(Click on each arrowed cell for a drop down list of options)*			
(1) House(s)		→ **House 1**	→ **House 1**
(2) Climate(s)		→ **Adelaide**	→ **Adelaide**
(3) Ground Floor type(s)		→ **Slab**	→ **Slab**
Default wall used - no alternatives available		→	→ **Concrete Block**
(5) Star Ratings to compare		→ **5.0 stars (base rating)**	→ **6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	NA (slab floor)	NA (slab floor)
	Wall cavity closed at base?	NA (wall on slab)	NA (wall on slab)
	Insulation above subfloor	NA	NA
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Veneer (with 95m² Foil)	**Brick Veneer (with 95m² R2)**
	External wall type 2	NA	NA
	Internal Walls	Plasterboard	Plasterboard
Roof	Roof form and roofing colour	Attic (darker colour)	Attic (darker colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m² R2.5	**161m² R4**
Window details			
Windows	Total area / % / main type	40.6m² / 27% / Awning	40.6m² / 27% / Awning
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	8.0m² with 0.75m shading	8.0m² with 0.75m shading
	E facing area / shading	17.7m² with 4.4m shading	17.7m² with 4.4m shading
	S facing area / shading	6.0m² with 0.75m shading	6.0m² with 0.75m shading
	W facing area / shading	8.9m² with 0.75m shading	8.9m² with 0.75m shading
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.6m² (U 6.35 / SHGC 0.77)	**34.6m² (U 6.35 / SHGC 0.77)**
Glazing type 2:	Glass type	NA	**Double 6 mm**
	Frame type	NA	**Improved Aluminium**
	Area / (U-Value / SHGC)	NA	**6m² (U 3.95 / SHGC 0.68)**
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		5	5
Ceiling fans		None	None

Data source: EER Calculator, Constructive Concepts (2009).

J.6 House 01, Adelaide, timber floor, concrete block wall

Select house details to compare energy efficiency options *(Click on each arrowed cell for a drop down list of options)*			
(1) House(s)		→ **House 1**	→ **House 1**
(2) Climate(s)		→ **Adelaide**	→ **Adelaide**
(3) Ground Floor type(s)		→ **Timber**	→ **Timber**
Default wall used - no alternatives available		→	→ Concrete Block
(5) Star Ratings to compare		→ **5.0 stars (base rating)**	→ **6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	Enclosed (with R1 inside walls)	Enclosed (with R1 inside walls)
	Wall cavity closed at base?	Yes	Yes
	Insulation above subfloor	None	None
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Veneer (with 95m² R2)	**Brick Veneer (with 97m² R2)**
	External wall type 2	NA	NA
	Internal Walls	Plasterboard	**Plasterboard (28% with R2)**
Roof	Roof form and roofing colour	Attic (darker colour)	Attic (darker colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m² R4	161m² R4
Window details			
Windows	Total area / % / main type	40.8m² / 27% / Awning	**39.5m² / 26% / Awning**
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	8.0m² with 0.75m shading	8.0m² with 0.75m shading
	E facing area / shading	17.7m² with 0.75m shading	**17.0m² with 0.75m shading**
	S facing area / shading	6.2m² with 0.75m shading	**5.6m² with 0.75m shading**
	W facing area / shading	8.9m² with 0.75m shading	8.9m² with 0.75m shading
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.8m² (U 6.35 / SHGC 0.77)	**18.5m² (U 6.35 / SHGC 0.77)**
Glazing type 2:	Glass type	NA	**Double 12 mm**
	Frame type	NA	**Improved Aluminium**
	Area / (U-Value / SHGC)	NA	**21m² (U 3.58 / SHGC 0.68)**
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		4	4
Ceiling fans		None	None

Data source: EER Calculator, Constructive Concepts (2009).

J.7 House 01, Perth, slab floor, concrete block wall

Select house details to compare energy efficiency options	*(Click on each arrowed cell for a drop down list of options)*		
(1) House(s)		**House 1**	**House 1**
(2) Climate(s)		**Perth**	**Perth**
(3) Ground Floor type(s)		**Slab**	**Slab**
Default wall used - no alternatives available			Concrete Block
(5) Star Ratings to compare		**5.0 stars (base rating)**	**6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	NA (slab floor)	NA (slab floor)
	Wall cavity closed at base?	NA (wall on slab)	NA (wall on slab)
	Insulation above subfloor	NA	NA
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Cavity	Brick Cavity
	External wall type 2	NA	NA
	Internal Walls	Brick	Brick
Roof	Roof form and roofing colour	Attic (light colour)	Attic (light colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m² R1.5	**161m² R3**
Window details			
Windows	Total area / % / main type	40.6m² / 27% / Awning	40.6m² / 27% / Awning
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	8.0m² with 0.75m shading	8.0m² with 0.75m shading
	E facing area / shading	17.6m² with 4.4m shading	17.6m² with 4.4m shading
	S facing area / shading	6.0m² with 0.75m shading	6.0m² with 0.75m shading
	W facing area / shading	9.0m² with 0.75m shading	9.0m² with 0.75m shading
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.6m² (U 6.35 / SHGC 0.77)	40.6m² (U 6.35 / SHGC 0.77)
Glazing type 2:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Unsealed	windows Sealed / doors Unsealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		None	None
Ceiling fans		None	None

Data source: EER Calculator, Constructive Concepts (2009).

J.8 House 01, Perth, timber floor, concrete block wall

Select house details to compare energy efficiency options *(Click on each arrowed cell for a drop down list of options)*			
(1) House(s)		**House 1**	**House 1**
(2) Climate(s)		**Perth**	**Perth**
(3) Ground Floor type(s)		**Timber**	**Timber**
Default wall used - no alternatives available			Concrete Block
(5) Star Ratings to compare		**5.0 stars (base rating)**	**6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	Enclosed	**Enclosed (with R1 inside walls)**
	Wall cavity closed at base?	Yes	Yes
	Insulation above subfloor	None	None
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Cavity	Brick Cavity
	External wall type 2	NA	NA
	Internal Walls	Brick	Brick
Roof	Roof form and roofing colour	Attic (light colour)	Attic (light colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m² R3.5	161m² R3.5
Window details			
Windows	Total area / % / main type	40.6m² / 27% / Awning	40.6m² / 27% / Awning
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	8.1m² with 0.75m shading	8.1m² with 0.75m shading
	E facing area / shading	17.6m² with 0.75m shading	17.6m² with 0.75m shading
	S facing area / shading	6.0m² with 0.75m shading	6.0m² with 0.75m shading
	W facing area / shading	8.9m² with 0.75m shading	8.9m² with 0.75m shading
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.6m² (U 6.35 / SHGC 0.77)	40.6m² (U 6.35 / SHGC 0.77)
Glazing type 2:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Unsealed	**windows Sealed / doors Sealed**
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		None	**5**
Ceiling fans		None	**4 @1200 dia & 4 @1400 dia**

Data source: EER Calculator, Constructive Concepts (2009).

J.9 **House 01, Sydney, timber floor, concrete block wall**

Select house details to compare energy efficiency options	*(Click on each arrowed cell for a drop down list of options)*		
(1) House(s)		→ **House 1**	→ **House 1**
(2) Climate(s)		→ **Sydney (Mascot)**	→ **Sydney (Mascot)**
(3) Ground Floor type(s)		→ **Timber**	→ **Timber**
Default wall used - no alternatives available		→	→ Concrete Block
(5) Star Ratings to compare		→ **5.0 stars (base rating)**	→ **6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	Enclosed (with R1.5 inside walls)	**Enclosed (with R2 inside walls)**
	Wall cavity closed at base?	Yes	Yes
	Insulation above subfloor	None	None
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Veneer (with 95m² R1.5)	**Brick Veneer (with 96m² R2)**
	External wall type 2	NA	NA
	Internal Walls	Plasterboard	**Plasterboard (28% with R2)**
Roof	Roof form and roofing colour	Attic (light colour)	Attic (light colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m² R4	161m² R4
Window details			
Windows	Total area / % / main type	40.6m² / 27% / Awning	**39.6m² / 27% / Awning**
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	8.1m² with 0.75m shading	**8.0m² with 0.75m shading**
	E facing area / shading	17.6m² with 0.75m shading	**17.1m² with 0.75m shading**
	S facing area / shading	6.0m² with 0.75m shading	**5.6m² with 0.75m shading**
	W facing area / shading	8.9m² with 0.75m shading	8.9m² with 0.75m shading
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.6m² (U 6.35 / SHGC 0.77)	**19.3m² (U 6.35 / SHGC 0.77)**
Glazing type 2:	Glass type	NA	**Double 12 mm**
	Frame type	NA	**Improved Aluminium**
	Area / (U-Value / SHGC)	NA	**20.3m² (U 3.58 / SHGC 0.68)**
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		5	5
Ceiling fans		None	None

Data source: EER Calculator, Constructive Concepts (2009).

J.10 House 01, Sydney, slab floor, concrete block wall

Select house details to compare energy efficiency options *(Click on each arrowed cell for a drop down list of options)*			
(1) House(s)		→ **House 1**	→ **House 1**
(2) Climate(s)		→ **Sydney (Mascot)**	→ **Sydney (Mascot)**
(3) Ground Floor type(s)		→ **Slab**	→ **Slab**
Default wall used - no alternatives available		→	→ Concrete Block
(5) Star Ratings to compare		→ **5.0 stars (base rating)**	→ **6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	NA (slab floor)	NA (slab floor)
	Wall cavity closed at base?	NA (wall on slab)	NA (wall on slab)
	Insulation above subfloor	NA	NA
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Veneer (with 95m² R1.5)	**Brick Veneer (with 97m² R2)**
	External wall type 2	NA	NA
	Internal Walls	Plasterboard	Plasterboard
Roof	Roof form and roofing colour	Attic (light colour)	Attic (light colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m² R2.5	**161m² R4**
Window details			
Windows	Total area / % / main type	40.6m² / 27% / Awning	**38.7m² / 26% / Awning**
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	8.0m² with 0.75m shading	8.0m² with 0.75m shading
	E facing area / shading	17.6m² with 4.4m shading	**15.7m² with 0.9m shading**
	S facing area / shading	6.0m² with 0.75m shading	6.0m² with 0.75m shading
	W facing area / shading	9.0m² with 0.75m shading	9.0m² with 0.75m shading
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.6m² (U 6.35 / SHGC 0.77)	**38.7m² (U 6.35 / SHGC 0.77)**
Glazing type 2:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		5	5
Ceiling fans		None	None

Data source: EER Calculator, Constructive Concepts (2009).

J.11 House 01, Melbourne, slab floor, concrete block wall

Select house details to compare energy efficiency options *(Click on each arrowed cell for a drop down list of options)*			
(1) House(s)		**House 1**	**House 1**
(2) Climate(s)		**Melbourne (Moorabbin)**	**Melbourne (Moorabbin)**
(3) Ground Floor type(s)		**Slab**	**Slab**
Default wall used - no alternatives available			**Concrete Block**
(5) Star Ratings to compare		**5.0 stars (base rating)**	**6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	NA (slab floor)	NA (slab floor)
	Wall cavity closed at base?	NA (wall on slab)	NA (wall on slab)
	Insulation above subfloor	NA	**161.3m² R0 (over airspace)**
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Veneer (with 95m² R1.5)	**Brick Veneer (with 95m² R2)**
	External wall type 2	NA	NA
	Internal Walls	Plasterboard	Plasterboard
Roof	Roof form and roofing colour	Attic (darker colour)	Attic (darker colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m² R3	**161m² R3.5**
Window details			
Windows	Total area / % / main type	40.6m² / 28% / Awning	**40.6m² / 27% / Awning**
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	8.0m² with 0.75m shading	**8.0m² with 0.45m shading**
	E facing area / shading	17.7m² with 0.75m shading	**17.7m² with 0.45m shading**
	S facing area / shading	6.0m² with 0.75m shading	**6.0m² with 0.45m shading**
	W facing area / shading	8.9m² with 0.75m shading	**8.9m² with 0.45m shading**
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.6m² (U 6.35 / SHGC 0.77)	40.6m² (U 6.35 / SHGC 0.77)
Glazing type 2:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		5	5
Ceiling fans		None	None

Data source: EER Calculator, Constructive Concepts (2009).

J.12 House 01, Melbourne, timber floor, concrete block wall

Select house details to compare energy efficiency options *(Click on each arrowed cell for a drop down list of options)*			
(1) House(s)		House 1	House 1
(2) Climate(s)		Melbourne (Moorabbin)	Melbourne (Moorabbin)
(3) Ground Floor type(s)		Timber	Timber
Default wall used - no alternatives available			Concrete Block
(5) Star Ratings to compare		5.0 stars (base rating)	6.0 stars (comparison)
Construction Details			
Floors	Subfloor airspace	Enclosed (with R1.5 inside walls)	**Enclosed**
	Wall cavity closed at base?	Yes	Yes
	Insulation above subfloor	None	**161.9m² R2 (over airspace)**
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Veneer (with 96m² R2)	**Brick Veneer (with 99m² R2)**
	External wall type 2	NA	NA
	Internal Walls	Plasterboard (27% with R2)	Plasterboard (27% with R2)
Roof	Roof form and roofing colour	Attic (darker colour)	Attic (darker colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m² R4	161m² R4
Window details			
Windows	Total area / % / main type	40.1m² / 27% / Awning	**37.3m² / 25% / Awning**
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	7.4m² with 0.45m shading	**6.4m² with 0.45m shading**
	E facing area / shading	17.7m² with 0.45m shading	**16.4m² with 0.45m shading**
	S facing area / shading	6.1m² with 0.45m shading	**5.6m² with 0.45m shading**
	W facing area / shading	8.9m² with 0.45m shading	8.9m² with 0.45m shading
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.1m² (U 6.35 / SHGC 0.77)	**23.7m² (U 6.35 / SHGC 0.77)**
Glazing type 2:	Glass type	NA	**Double 6 mm**
	Frame type	NA	**Improved Aluminium**
	Area / (U-Value / SHGC)	NA	**13.6m² (U 3.95 / SHGC 0.68)**
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		5	5
Ceiling fans		None	None

Data source: EER Calculator, Constructive Concepts (2009).

J.13 House 01, Canberra, timber floor, concrete block wall

Select house details to compare energy efficiency options	*(Click on each arrowed cell for a drop down list of options)*		
(1) House(s)		**House 1**	**House 1**
(2) Climate(s)		**Canberra**	**Canberra**
(3) Ground Floor type(s)		**Timber**	**Timber**
Default wall used - no alternatives available			Concrete Block
(5) Star Ratings to compare		**5.0 stars (base rating)**	**6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	Enclosed (with R1.5 inside walls)	**Enclosed**
	Wall cavity closed at base?	Yes	Yes
	Insulation above subfloor	None	**161.9m² R2 (over airspace)**
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Veneer (with 96m² R2)	**Brick Veneer (with 99m² R2)**
	External wall type 2	NA	NA
	Internal Walls	Plasterboard (27% with R2)	Plasterboard (27% with R2)
Roof	Roof form and roofing colour	Attic (darker colour)	Attic (darker colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m² R4	161m² R4
Window details			
Windows	Total area / % / main type	40.1m² / 27% / Awning	**37.3m² / 25% / Awning**
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	7.4m² with 0.45m shading	**6.4m² with 0.45m shading**
	E facing area / shading	17.7m² with 0.45m shading	**16.4m² with 0.45m shading**
	S facing area / shading	6.1m² with 0.45m shading	**5.6m² with 0.45m shading**
	W facing area / shading	8.9m² with 0.45m shading	8.9m² with 0.45m shading
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.1m² (U 6.35 / SHGC 0.77)	**23.7m² (U 6.35 / SHGC 0.77)**
Glazing type 2:	Glass type	NA	**Double 6 mm**
	Frame type	NA	**Improved Aluminium**
	Area / (U-Value / SHGC)	NA	**13.6m² (U 3.95 / SHGC 0.68)**
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		5	5
Ceiling fans		None	None

Data source: EER Calculator, Constructive Concepts (2009).

J.14 House 01, Canberra, slab floor, concrete block wall

Select house details to compare energy efficiency options *(Click on each arrowed cell for a drop down list of options)*			
(1) House(s)		→ **House 1**	→ **House 1**
(2) Climate(s)		→ **Canberra**	→ **Canberra**
(3) Ground Floor type(s)		→ **Slab**	→ **Slab**
Default wall used - no alternatives available		→	→ Concrete Block
(5) Star Ratings to compare		→ **5.0 stars (base rating)**	→ **6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	NA (slab floor)	NA (slab floor)
	Wall cavity closed at base?	NA (wall on slab)	NA (wall on slab)
	Insulation above subfloor	NA	**161.3m² R0 (over airspace)**
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Veneer (with 95m² R1.5)	**Brick Veneer (with 95m² R2)**
	External wall type 2	NA	NA
	Internal Walls	Plasterboard	Plasterboard
Roof	Roof form and roofing colour	Attic (darker colour)	Attic (darker colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m² R3	**161m² R4**
Window details			
Windows	Total area / % / main type	40.6m² / 28% / Awning	**40.6m² / 27% / Awning**
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	8.0m² with 0.75m shading	**8.0m² with 0.45m shading**
	E facing area / shading	17.7m² with 0.75m shading	**17.7m² with 0.45m shading**
	S facing area / shading	6.0m² with 0.75m shading	**6.0m² with 0.45m shading**
	W facing area / shading	8.9m² with 0.75m shading	**8.9m² with 0.45m shading**
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.6m² (U 6.35 / SHGC 0.77)	40.6m² (U 6.35 / SHGC 0.77)
Glazing type 2:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		5	5
Ceiling fans		None	None

Data source: EER Calculator, Constructive Concepts (2009).

J.15 House 01, Hobart, slab floor, concrete block wall

Select house details to compare energy efficiency options *(Click on each arrowed cell for a drop down list of options)*			
(1) House(s)		**House 1**	**House 1**
(2) Climate(s)		**Hobart**	**Hobart**
(3) Ground Floor type(s)		**Slab**	**Slab**
Default wall used - no alternatives available			Concrete Block
(5) Star Ratings to compare		**5.0 stars (base rating)**	**6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	NA (slab floor)	NA (slab floor)
	Wall cavity closed at base?	NA (wall on slab)	NA (wall on slab)
	Insulation above subfloor	NA	**161.3m² R1 (over airspace)**
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Veneer (with 95m² R2)	**Brick Veneer (with 95m² R1.5)**
	External wall type 2	NA	NA
	Internal Walls	Plasterboard	Plasterboard
Roof	Roof form and roofing colour	Attic (darker colour)	Attic (darker colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m² R4	**161m² R3**
Window details			
Windows	Total area / % / main type	40.6m² / 28% / Awning	**40.6m² / 27% / Awning**
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	8.0m² with 0.75m shading	**8.0m² with 0.45m shading**
	E facing area / shading	17.7m² with 0.75m shading	**17.7m² with 0.45m shading**
	S facing area / shading	6.0m² with 0.75m shading	**6.0m² with 0.45m shading**
	W facing area / shading	8.9m² with 0.75m shading	**8.9m² with 0.45m shading**
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.6m² (U 6.35 / SHGC 0.77)	40.6m² (U 6.35 / SHGC 0.77)
Glazing type 2:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		5	5
Ceiling fans		None	None

Data source: EER Calculator, Constructive Concepts (2009).

J.16 House 01, Hobart, timber floor, concrete block wall

Select house details to compare energy efficiency options *(Click on each arrowed cell for a drop down list of options)*			
(1) House(s)		→ **House 1**	→ **House 1**
(2) Climate(s)		→ **Hobart**	→ **Hobart**
(3) Ground Floor type(s)		→ **Timber**	→ **Timber**
Default wall used - no alternatives available		→	→ **Concrete Block**
(5) Star Ratings to compare		→ **5.0 stars (base rating)**	→ **6.0 stars (comparison)**
Construction Details			
Floors	Subfloor airspace	Enclosed (with R1.5 inside walls)	**Enclosed**
	Wall cavity closed at base?	Yes	Yes
	Insulation above subfloor	None	**161.9m² R2 (over airspace)**
	Insulation over rooms below	NA	NA
	Additional floor tiling	None	None
Walls	External wall type 1	Brick Veneer (with 96m² R2)	**Brick Veneer (with 99m² R2)**
	External wall type 2	NA	NA
	Internal Walls	Plasterboard (27% with R2)	Plasterboard (27% with R2)
Roof	Roof form and roofing colour	Attic (darker colour)	Attic (darker colour)
	Roof airspace properties	No foil / Unvented	No foil / Unvented
	Roof and ceiling insulation	161m² R4	161m² R4
Window details			
Windows	Total area / % / main type	40.1m² / 27% / Awning	**37.3m² / 25% / Awning**
	Opening area / floor area	not recorded	not recorded
	Curtains (on all windows)	Holland Blinds	Holland Blinds
	External canvas awnings	None	None
Orientations	Offset of house from North	25° westwards	25° westwards
	N facing area / shading	7.4m² with 0.45m shading	**6.4m² with 0.45m shading**
	E facing area / shading	17.7m² with 0.45m shading	**16.4m² with 0.45m shading**
	S facing area / shading	6.1m² with 0.45m shading	**5.6m² with 0.45m shading**
	W facing area / shading	8.9m² with 0.45m shading	8.9m² with 0.45m shading
Glazing type 1:	Glass type	Single clear	Single clear
	Frame type	Improved Aluminium	Improved Aluminium
	Area / (U-Value / SHGC)	40.1m² (U 6.35 / SHGC 0.77)	**30.2m² (U 6.35 / SHGC 0.77)**
Glazing type 2:	Glass type	NA	**Double 6 mm**
	Frame type	NA	**Improved Aluminium**
	Area / (U-Value / SHGC)	NA	**7.1m² (U 3.95 / SHGC 0.68)**
Glazing type 3:	Glass type	NA	NA
	Frame type	NA	NA
	Area / (U-Value / SHGC)	NA	NA
Air Leakage Control and Air Movement			
Window and door sealing		windows Sealed / doors Sealed	windows Sealed / doors Sealed
Open fireplaces and wall vents		None / None	None / None
Exhaust fans (self sealing)		5	5
Ceiling fans		None	None

Data source: EER Calculator, Constructive Concepts (2009).

K Lighting provisions

The lighting of domestic buildings is not covered by the current BCA or any other Australian Standard. As a result, the amount and type of lighting is determined by interior design requirements and personal likes. To restrain the recent growth in the use of inefficient fittings and excessive levels of lighting, COAG requested the ABCB to include the efficient use of artificial lighting in BCA 2010.

The ABCB commissioned Lighting, Art + Science Pty Ltd to conduct a study to investigate the potential for improving energy efficiency of lighting in residential buildings (Lighting, Art + Science Pty Ltd 2009). Their report looked at current provisions in Australia and overseas and a range of lighting scenarios in a set of houses. It then discusses three possible approaches to reduce energy consumption in residential buildings. After analysing the alternative options to make lighting more efficient, the report recommends a maximum lighting power allowance approach similar to that in BCA Volume One (5 W/m2 for a house and 3 W/m2 for a garage). This provides a performance based solution and also maximum flexibility.

In light of this, Section 3.12.5.5 of BCA 2010 Volume Two and Section J6.2 of the BCA 2010 Volume One now include provisions for artificial lighting. The sections below provide additional details about the provisions.

BCA Volume Two

Section 3.12.5.5 of BCA 2010 Volume Two includes the following provisions for Class 1 and 10 buildings:

1. The lamp power density of artificial lighting must not exceed:
    a) within a Class 1 building, 5 W/m2 of floor area;
    b) on the verandah or balcony attached to a Class 1 building, 4 W/m2 of floor area; and
    c) in a Class 10 building, 3 W/m2 of floor area.
2. The lamp power of the light fittings must be used rather than a nominal allowance for exposed batten holders.
3. Where fluorescent lamps are used they must:

a) have an electronic ballast; and

b) be of a type that cannot be retrofitted with an incandescent lamp.

4. Halogen lamps must be separately switched from fluorescent lamps.

5. Artificial lighting around the perimeter of a building must:

   a) be controlled by a daylight sensor; or

   b) have an average light source efficacy of not less than 40 Lumens/W.

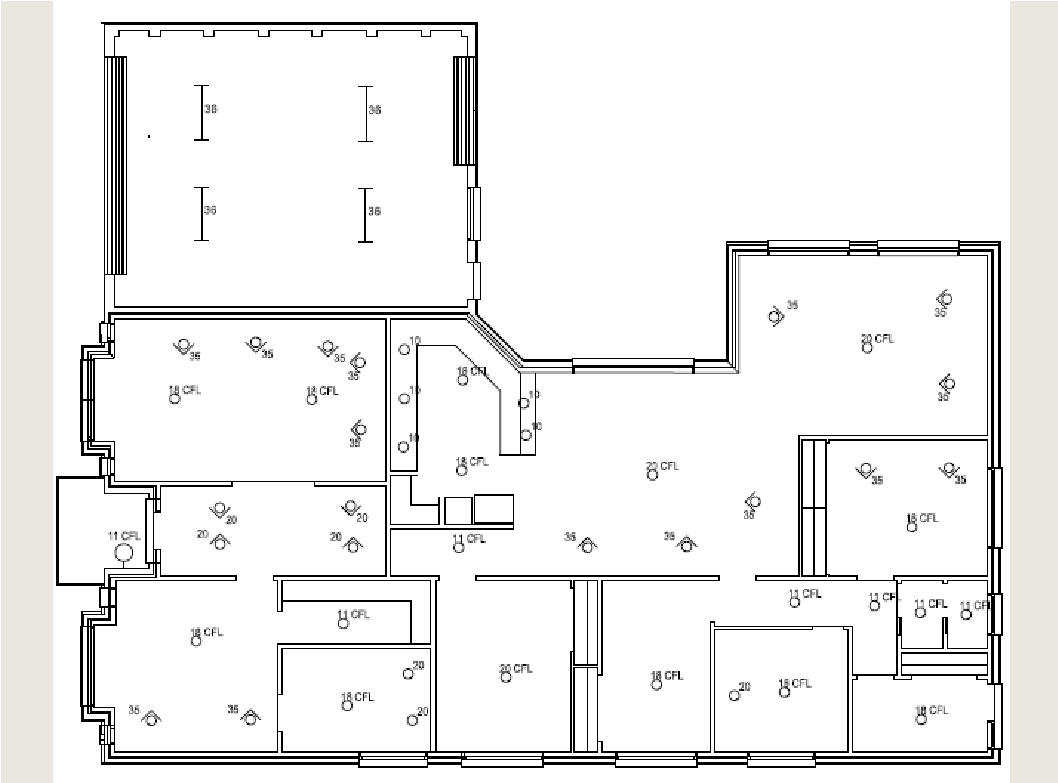
Table K.1 summarises the lighting layout for a typical medium sized, single storey, 4 bedroom house and figure K.2 provides an illustration of this layout. The layout would comply with the recommended power level of 5 W/m2 for the house and 3 W/m2 for the garage.

K.1 **Complying lighting layout for a typical medium sized house**

Space	***Compact fluorescents***		***Tungsten halogens***		
	11 W	***18 W***	***20 W***	***10 W***	***35 W***
Living/dining			1		5
Kitchen		2		5	
Meals		1			3
Family		1			3
Laundry		1			
Toilet	2				
Passage	3		4		
Porch	1				
Bedroom 1		1			2
Walk-in robe	1				
Ensuite		1	2		
Bedroom 2		1			
Bedroom 3		1			
Bed 4/Study		1			2
Bathroom		1	1		

Source: ABCB 2009c.

K.2 **Complying lighting layout for a typical medium sized house**



Source: ABCB 2009c.

BCA Volume Two

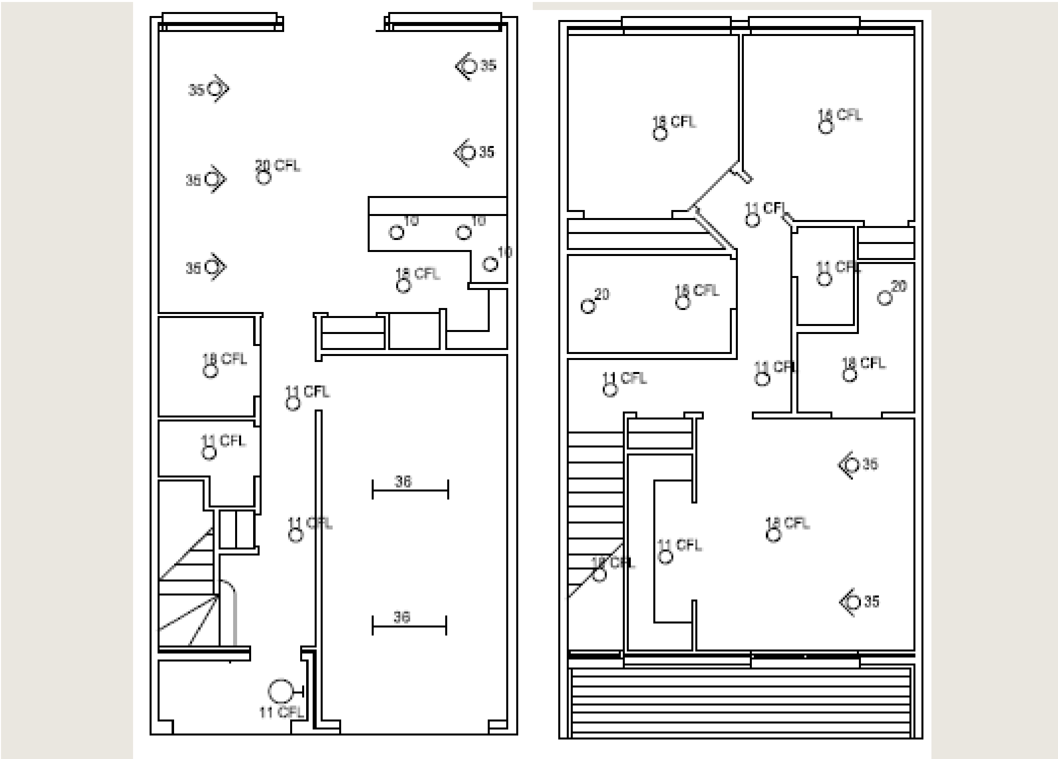
Section J6.2 of the BCA 2010 Volume One includes the following provisions for a Class 2 building or a Class 4 part of a building:

1. In a sole-occupancy unit of a Class 2 building or a Class 4 part of a building, the lamp power density of artificial lighting must not exceed:
   a) within the building, 5 W/m2 of floor area; and
   b) on a verandah or balcony of the building, 4 W/m2 of floor area.
2. the lamp power of the light fitting must be used rather than a nominal allowance for an exposed batten holder; and
3. where fluorescent lamps are used they must:
   a) have an electronic ballast; and
   b) be of a type that cannot be replaced with an incandescent lamp.
4. halogen lamps must be separately switched from fluorescent lamps.

Figure K.3 provides an illustration of a lighting layout that would comply with the proposed provisions. It is for a row house but could equally be a sole-occupancy unit of a Class 2 building. Table K.4 summarises the lighting layout that would comply with the recommended power level of 5 W/m2.

Note that the layout only uses 10 tungsten halogen fittings and they are used in the living, dining, kitchen and main bedroom where ambiance is desirable.

K.3 Complying lighting layout for a typical sole-occupancy unit of a Class 2 building



Data source: ABCB 2009c.

K.4 **Complying lighting layout for a typical sole-occupancy unit of a Class 2 building**

Space	*Compact fluorescents*		*Tungsten halogens*		
	11W	*18W*	*10W*	*20W*	*35W*
Living/dining				1	5
Kitchen		1	3		
Laundry		1			
Downstairs toilet	1				
Passages and stairs	6				
Porch	1				
Bedroom 1	1	1			2
Ensuite		1		1	
Bedroom 2		1			
Bedroom 3		1			
Bathroom		1		1	
Upstairs toilet	1				
Total number	10	7	3	3	7
Total wattage	110	126	30	60	245

Data source: ABCB 2009c.

Impacts of the new lighting requirements

Effects on energy consumption

The effects of the proposed lighting provisions on energy consumption can be separated in two:

- their impact on cooling and heating loads; and
- the individual impact of the provision on lighting energy consumption.

A brief discussion of these effects is provided in the sections below.

Impact on cooling and heating loads

While the report by Lighting, Art + Science Pty Ltd provides a useful review of current issues and trends in residential lighting, the report makes no attempt to forecast trends in likely actual energy consumption for lighting in average Australian new home construction. In considering potential regulation of lighting energy use, the report canvasses the concept of lamp power density, and as mentioned above, recommends a maximum of 5 W/m^2 for general habitable areas of the home. This compares with an estimate of modern lighting that is predominately low voltage downlights, which ranges between 8.1 and 18.8 W/m^2.

The effect on heating and cooling loads of variations in the lighting is likely to be highly dependent on climate, occupancy and zoning of the residence. Even more than the manner in which these same factors impact on the nominal constraint factor for actual heating and cooling energy use, the effect of lighting variations in cooling and heating loads is far too complex to be incorporated in the current analysis (given the data provided by the ABCB). It may be generally assumed that increasing total lamp power densities would increase cooling energy use (and therefore total energy use for heating and cooling) in warmer climates, and similarly, higher lighting power densities would have the effect of contributing to heating in colder climate zones. The possible real-world effects are, however, also complicated by significant variability of construction — such as by convective heat losses where certain styles of luminaries penetrate the insulation of ceilings.

Finally, the assumed total internal heat load setting, used in the calculation of the heating and cooling space loads, can be varied only when the initial simulation run is performed in the AccuRate software. The net effect can not be approximated by post-processing the data in the ABCB's EER calculator. Accordingly, this RIS has not attempted to quantify the likely marginal differences in heating and cooling energy use that may flow from the impact of regulating installed artificial lighting.

Impacts on lighting energy consumption

For this RIS we have calculated the direct or individual impacts of the new lighting provisions on energy consumption. The changes in energy consumption associated with the lighting provisions are calculated through the following steps.

Step 1

Estimate lighting energy consumption under the baseline for each house in the ABCB building sample. These estimates are presented in table K.5.

K.5 Lighting energy consumption under BAU, MJ/year

House name	*Type*	*Lighting energy use (MJ/yr)*
House 01	Separate house	1354
House 04	Separate house	1904
House 08	Separate house	2159
House 09	Townhouse	739
House 10	Flat	969
House 12	Separate house	960
House 13	Separate house	2142

Note: Estimates of lighting energy use by population centre are not available. As such, estimates of lighting energy consumption are only provided by an average Australian house/townhouse/flat.

Source: CIE estimates based on DEWHA (2008c) and data provided by ABCB.

The parameters used to calculate these figures are explained in more detail below:

- Current lighting energy use—a Consultation RIS for the proposal to phase-out inefficient incandescent light bulbs prepared for DEWHA (2008c) states that under the baseline scenario 'Lighting energy consumption is estimated at 684 kWh for the average Australian dwelling in 2005' (p.113). Further, DEWHA's RIS provides an estimate of the reduction in lighting energy consumption due to the measures analysed in that RIS.[66] Indeed, the report shows that the measures analysed will reduce lighting energy use in the residential sector by 32.5 per cent (DEWHA 2008c, p.120).

  Given that the measures analysed in DEWHA's RIS have been adopted by government, the estimate of the current lighting energy consumption for this ABCB RIS should account for the savings from the phase out of incandescent light bulbs. As such, it is calculated that the lighting energy use for an average Australian dwelling is currently 441 kWh per year [67] (consistent with DEWHA's RIS, the baseline scenario in this ABCB RIS assumes that lamp densities and types are frozen at the 2005 levels, which means that energy consumption grows in proportion to population).
- Floor area for an average Australian house—to be able to estimate the current lighting energy use for the different house sizes in the ABCB

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66 The removal of least efficient incandescent lamps, setting up standard for the efficiency and quality of compact fluorescent lights and the removal of the least efficient extra low voltage converters from the market.

67 684 kWh x (1-0.325) = 441 kWh.

sample, we calculated the kWh per year consumed per squared metre using an estimate of the floor area for an average Australian house (194 m^2). This floor area is a weighted average that was calculated using the floor area for each house type presented in table K.6 and the share of these houses in the total housing stock presented in appendix D.

K.6 **Floor area for the ABCB sample houses**

House name	*Type*	*Floor area (m^2)*
House 01	Separate house	165
House 04	Separate house	232
House 08	Separate house	263
House 09	Townhouse	90
House 10	Flat	118
House 12	Separate house	117
House 13	Separate house	261

Source: ABCB.

- Current lighting energy use per m^2—this figure was estimated using the estimate of the lighting energy use and the floor area for an average Australian dwelling (441 kWh per year and 194 m^2 respectively). The lighting energy use per m^2 in the baseline scenario is estimated to be approximately 2.3 kWh/ m^2 per year.
- Using the estimate of the lighting energy use per m^2 and the average floor area per house presented in table K.6, we calculated the energy use under BAU for each sample house presented in table K.5.

<u>Step 2</u>

Estimate the lighting energy consumption under the new BCA 2010 for each house in the ABCB building sample. These estimates are presented in table K.7.

K.7 Lighting energy consumption under the BCA 2010, MJ/year

House name	***Type***	***Lighting energy use (MJ/yr)***
House 01	Separate house	1127
House 04	Separate house	1585
House 08	Separate house	1797
House 09	Townhouse	615
House 10	Flat	806
House 12	Separate house	799
House 13	Separate house	1783

Note: Estimates of lighting energy use by population centre are not available. As such, estimates of lighting energy consumption are only provided by an average Australian house/townhouse/flat.

Source: CIE estimates based on DEWHA (2008b) and data provided by ABCB.

The parameters used to calculate these figures are explained in more detail below:

- Required power density under BCA 2010— based on the new proposed lighting requirements, the required power density modelled was 5 W/m^2 both for living and non-living areas.[68]
- Share of floor area for living and non-living areas—following a study by DEWHA (2008b, p. 345), it has been assumed that the living area of a house is 40 per cent of the total house floor area, while 60 per cent is non-living area.
- Average floor area per house— the average floor area for each of the sample houses was based on information provided by the ABCB. This information is presented in the table K.6.
- Usage assumptions— following DEWHA (2008b, p.97), it has been assumed that the light usage is 2 hours per day for living areas and 0.4 hours per day for non-living areas modelled.

68 Although it is recognized that BCA 2010 specified a power density of 3 W/m^2 for the garage area, the modelling has used 5 W/m^2 due to insufficient information about the garage floor area for each sample house. This makes the estimates of the lighting energy savings somewhat conservative.

Step 3

Aggregate the lighting energy use from the ABCB building sample to ABS dwelling types (house/townhouse/flat) using the weights presented in Appendix D. The estimates of the lighting energy use by ABS dwelling type under the BAU and BCA 2010, and the savings due to the new proposed lighting requirement are presented in table K.8.

K.8 **Lighting energy consumption, MJ/year**

	BAU	***BCA 2010***	***Savings due to BCA 2010***
House	1 682	1 400	282
Townhouse	739	615	124
Flat	969	806	162

Note: Estimates of lighting energy use by population centre are not available. As such, estimates of lighting energy consumption are only provided by an average Australian house/townhouse/flat.

Source: CIE estimates based on DEWHA (2008b and 2008c) and data provided by ABCB.

L Outdoor living provisions

Domestic swimming pools fall within Class 10 of Volume Two of the BCA: 'non-habitable buildings and structures'. Currently, BCA Volume Two covers access arrangements for swimming pools (that is, enclosures and gates) and measures to avoid the entrapment of persons in the water recirculation system. However, the BCA does not currently include energy efficiency requirements for swimming pools or spas.

Over recent years stakeholders have questioned the BCA focus on the building fabric and only some services and have questioned why other services such as the heating of water and the heating of pools and spas have not been included. The reason has been that up to now the provisions have been to satisfy a performance for energy efficiency rather than GHG emission reduction, and hence did not consider the GHG emission rate of the fuel used. If the performance requirements are to be amended to address the GHG emission rate of the energy source, pool and spa heating could be considered.

The ABCB commissioned George Wilkenfeld and Associates (W&A) to investigate the case for coverage of swimming pools and spas in the BCA (W&A 2009b). As a result of the recommendations in this study, Section 3.12.5.7 of BCA 2010 Volume Two now includes the following provisions for heating and pumping of swimming pools or spas:

1. Heating of a swimming pool must be by:
   a) for an indoor swimming pool:
      i. a solar heater; or
      ii. a gas water heater; and
   b) for an outdoor swimming pool, a solar heater.
2. Heating for an in-built spa must be:
   a) a solar heater; or
   b) a gas water heater; or
   c) a heat pump heater.
3. Where heating is by gas or heat pump, a swimming pool or spa must have:
   a) a thermal cover; and
   b) a time switch operation for the heater.

4. A time switch must be provided to control the operation of a circulation pump of a swimming pool or spa.

The above measures are likely to generate energy savings at some additional cost. However, these impacts are not quantified in this RIS. The sections below provide additional commentary on this.

Heating of swimming pools

In their recommendations to the ABCB, W&A noted that the prohibition of the use of electric resistance water heating for swimming pools is largely a preventative measure as very few electric resistance heaters are used on swimming pool heating (W&A 2009b p. 20). Further, the report notes that over 90 per cent of pool heating installations in the last 5 years used solar heaters and about 7 per cent used gas heaters. Against this background, it is foreshadowed that the proposed provisions for heating of a swimming pool will have little or no impact both in terms of costs and benefits.

Heating of inbuilt spas

The proposed BCA provisions for spa heating only cover in-built spas (that is, spas that share a water recirculation system with the main pool). This is because, while constructed spa pools are usually subject to local government planning approval (which represents a point at which BCA compliance could be enforced), council requirements for stand-alone spas (which are spa pools brought to site as complete assemblies) vary significantly — they may be listed as a ‘complying development’, ‘exempt development’ or not specifically mentioned at all (W&A 2009b p. 12). Therefore the effectiveness of any BCA provisions related to stand-alone spa pools would be subject to uncertainty.

The benefits of the proposed BCA amendments for the heating of in-built spas are difficult to measure because the energy consumption of a spa pool depends on several factors that vary widely, including spa design, usage patterns, heating modes and heat loss (which depends on whether the spa pool is indoors or outdoors, on how exposed its position is, on the quality of the tub insulation, on the insulation value and fit of the thermal cover and how long the spa is left uncovered) (W&A 2004).

Estimating the compliance costs of the proposed BCA measures is also a challenge given the multitude of spa designs and models for the heating equipment.

In light of this, the impacts of the proposed BCA amendments for in-built spas are not quantified in this RIS. However, the proposed amendments will affect only a small proportion of spas (indeed, according to W&A, only ‘a small proportion of swimming pools have an inbuilt spa pool’ (W&A 2009b p. 12) and ‘most spa pools are sold as independent units, with their own pumps, filters and heaters, and as relocatable above-ground units (which may be installed indoors or outdoors) rather than in-ground’ (W&A 2004 p.11).

Pool cover and time switch for heaters on swimming pools and spa pools

Similarly to the heating provisions, the impacts of these provisions are not quantified in this RIS. Estimating the benefits of the pool cover and time switches for heaters on swimming pools and spa pools is a challenging task because these will depend on factors that vary widely, such as the fit of the pool cover, the level of thermal insulation of the cover, how long the pool or spa is left uncovered (that is the management of the cover), usage patterns and owner settings. Further, the costs of complying with these provisions will depend on a series of unknown parameters such as the surface area of the pool, the choice of pool cover and the choice of time switch.

Time switch for circulation pumps on swimming pools and spa pools

It is foreshadowed that this provision will have little or no impact both in terms of costs and benefits. This is because, according to W&A (2009b) this requirement only formalises prevailing practice as ‘very few pumps are installed without timers’ (p. 20).

M Consultation responses

Submissions were received from:

1. Individual, University of Sydney
2. Kosters Steel
3. Dincel Construction System
4. Individual
5. Individual
6. MicroHeat technologies
7. Associate Professor Brad Pettit
8. Adjunct Professor Alan Pears AM
9. Electrical and Communications Association
10. Air conditioning and Mechanical Contractors' Association
11. Fremantle Consulting Group
12. Sustainability Housing
13. DEWHA
14. The Housing Industry Association
15. Tectonics Building Design
16. South Australian Department of Planning and Local Government, SA Energy Division, Department for Transport, Energy and Infrastructure.
17. Solar option
18. A Centre of Excellence in Tropical Design (Innovation and Sustainability) Network
19. Sustainability House
20. Cement Concrete & Aggregates Australia, Think Brick Australia, Concrete Masonry Association of Australia and National Precast Concrete Association of Australia
21. Think Brick – Complementary submission
22. Australian Window Association
23. AREMA

24. Penrith City Council
25. Royal Institute of Chartered Surveyors
26. Illuminating Engineering Society of Australia and New Zealand
27. Building Codes Queensland
28. Skylight Industry Association
29. Sustainable Energy Development Office
30. Association of Building Sustainability Assessors
31. Sustainable Energy Development Office
32. Master Builders Australia
33. Michael Want, Tamworth Regional Council
34. Master Builders Queensland
35. Tasmanian Government
36. Bond Homes
37. Australian Institute of Architects
38. Tropical Green Building Network
39. Victorian Department of Planning and Community Development
40. Lighting Council of Australia
41. City of Sydney
42. NSW Department of Planning
43. Property Council of Australia

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