Report on "Energy Efficiency BCA Volume 2, Regulation Document, Proposal for 5 Star Houses"

Prepared by Tony Isaacs Consulting

for

The Insulation Council of Australia and New Zealand

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1 Executive Summary

The new regulations provide a general increase in insulation levels in walls and roofs of about R0.5. Enclosed suspended floors are now required to be insulated in climates 4 to 8 and the floor insulation levels have risen in most cases by at least R1.5. The regulations still allow low insulation levels in climates 1 to 3 and include various trade off mechanisms to allow builders to avoid the installation of insulation in walls. This report has focused on these areas of the regulation which still allow comparatively low levels of insulation: primary insulation levels in zones 1 to 3 and the trade off mechanisms. It has evaluated the impacts of the regulations on energy savings using the AccuRate simulation tool.

1.1 Insulation levels in hot climates

This report has shown that substantial benefits can be delivered through the use of significantly higher insulation levels than those proposed by the regulations in climate zones 1 to 3. While conventional wisdom says that only minimal insulation is needed in hot climates this report shows that this is simply not true. Conventional wisdom is based on experience with conventional houses. By providing control to solar gain and adequate ventilation in hot climates houses complying with the regulations lie outside the experience of conventional wisdom and respond well to higher levels of insulation.

Using R3.5 in ceilings, disallowing the wall shading trade off as a substitute for wall insulation and insulating suspended floors over unenclosed floor spaces results in the following ***savings over and above those already achieved by the regulations***:

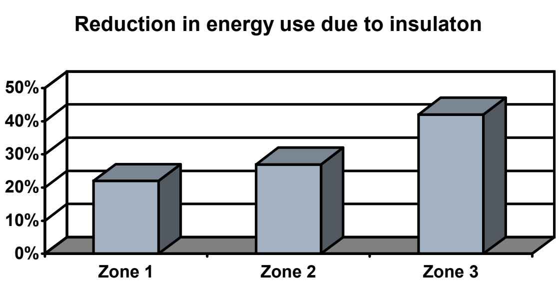

Figure 1 Energy Savings due to higher wall, floor and ceiling insulation levels

Furthermore the higher levels of insulation have the potential to make ***significant reductions in the peak load of houses likely to be the range of 10% - 15%.*** With soaring rates of air conditioning ownership – a 50% increase is predicted over the next 10 years - these load reductions will help governments to contain the growth of peak loads and deliver significant environmental, economic and political benefits. And detailed analysis of energy savings at higher R values demonstrate that even higher R values than those which produced these peak load and energy savings are likely to be economic allowing further improvements in the benefits offered by the regulations.

These higher levels of insulation DO NOT stop the building from cooling down significantly and in fact deliver a higher standard of comfort due to the improved ventilation requirements and control of solar radiation provided by the regulation.

The insulation levels recommended by the regulations in zones 1 to 3 should be substantially increased.

1.2 Trade off mechanisms

1.2.1 Wall shading

The trade off allowed for wall shading does not produce anywhere near the reduction in energy use that the wall insulation it replaces. ***Wall insulation was found to produce 6 to 10 times greater energy savings than wall shading.***

1.2.2 High performance glazing and wall insulation

The regulations also propose a trade off where wall insulation can be avoided if high performance glazing is used. It is understood that such a trade off may be necessary for unusual cases like mud bricks. However, ***the application of this trade off could lead to lower insulation wall levels across the board than those in the current regulations***. This is a highly undesirable outcome given to the difficulty of increasing insulation levels in future. This is thought to be an unintended consequence of the trade off mechanism. Its use as a mechanism to allow lower wall insulation levels should be severely restricted and be contingent on the applicant demonstrating significant construction problems leading to substantial increases in costs. In general, the complexity of the energy performance of a house means that such trade offs would be better handled through the application of ratings than through the Deemed to Satisfy (DtS) provisions.

1.2.3 Improvements to the trade off mechanism

The trade off mechanism was found to have some constructive application. It could also be used to allow a slight relaxation in the conduction target for windows. Subject to meeting radiation targets for glazing ***the use of higher insulation levels in walls floors and ceilings could be traded off against larger areas of glazing***. The building industry has been concerned about the limitation to glazing area reducing the marketability of its new homes and the trade off provides a mechanism to reward houses which exceed minimum performance with some of the greater flexibility in glazing area the industry is seeking.

1.3 Deemed to Satisfy regulations vs Energy Ratings

The necessary complexity that must be added to regulations to achieve higher performance levels means that the resources required to achieve compliance through a rating is similar to using the DtS itself. Given the limitations of DtS in representing the real complexity of building thermal performance and the substantial cost and educational benefits of ratings the rating approach will produce far superior outcomes with little additional effort. ***It is recommended that the ABCB develop a plan for the phasing out of the DtS provisions to ensure that the benefits of the rating approach are available to all members of the home building industry.***

2 Summary of recommendations

The report makes the following findings and recommendations:

1. A trade off system is proposed where wall shading may be provided instead of wall insulation. This fails to capture significant energy savings and should be deleted from the regulations.
2. A trade off system is proposed where improved glazing performance may be used to reduce or avoid wall insulation. This is presumed to be included for mud brick builders, however the report shows that its application can lead to lower levels of wall insulation than under the previous regulation. Given the importance to society of ensuring that walls are well insulated, and some methodological problems with the mechanism itself, it is recommended that this should only be used to lower levels by R0.5 unless a rating tool is used.
3. It is recommended that the trade off mechanism described above also be used to allow larger glazing areas where builders choose to install higher levels of insulation in the walls, ceilings and/or floor. This will provide an incentive for the industry to exceed the minimum insulation levels and provide additional flexibility in glazing areas that industry believes it needs to maintain the marketability of its products.
4. The report finds that the benefits of wall insulation in two storey houses are much greater than in single storey houses and recommends that higher insulation levels should be specified for walls of two storey houses.
5. R 3.5 insulation in ceilings for houses in climates 1 to 3 is found to produce substantial benefits over the current levels (R1.5 & 2.0). It is recommended that required roof insulation levels be increased in climates 1 to 3.
6. R values given for reflective foil in roofs do not allow for dust build up to lower emissivity of the upward facing surface. It is recommended that the thermal resistances in the regulations be changed to reflect recent standards association decisions.
7. While the regulations note that roof and ceiling insulation levels can not be directly added together it provides no guidance on how they can be combined. It is recommended that a guideline be developed to assist applicants.
8. Insulation of suspended timber floors over unenclosed subfloor spaces is found to produce substantial energy savings in climate zones 1 to 3. This is a serious omission from the regulations and it is recommended that a level of added insulation of at least R1.5 be required.
9. Due to the compelling benefits of energy ratings for industry ABCB should announce a plan for the introduction of rating only regulations and the phasing out of DtS

3 Introduction

3.1 Insulation levels in the new regulations generally

The Australian Building Codes Board has released new housing energy efficiency regulations for housing. These regulations aim to improve houses to a performance level of 5 stars. This can be achieved either through providing an energy rating, expert opinion or meeting the requirements of the Deemed to Satisfy clauses which specify, among other things, minimum R values.

The new R values are almost universally higher than the previous regulations by around R0.5. There is also a substantial increase to the amount of floor insulation required as enclosed suspended floors must also be insulated in addition to floors above unenclosed floor spaces. This increase to insulation levels will help Australia to contain its greenhouse gas emissions and is a welcome development.

There are still some sections of the regulations which still require scrutiny:

- climate zones where trade offs can be made to allow insulation of walls to be avoided altogether,
- a general trade off allowing lower wall insulation levels to be used where higher performing glazing types are used, and
- climate zones 1, 2 and 3 (e.g. Darwin, Brisbane Longreach) where required R values are low.

This report focuses on those areas listed above where low/no insulation levels are allowed. ***Several of the conclusions reached regarding insulation levels in the hot climates will also apply to climates 4 to 8***. While different design strategies are required in these zones insulation plays the same critical role of reducing heat flows through walls, floors and ceilings. It may well be that due to the small incremental cost of higher levels of insulation that higher levels will be economic, particularly in climates 4 and 5 where insulation R values are the lowest of all other climates.

3.2 How energy savings were evaluated

This report analyses these three key areas by performing AccuRate thermal performance simulations. The AccuRate software is a development of the NatHERS software and will become the basis of the Nationwide House Energy Rating Scheme in the near future. Other software such as BERS and FirstRate will be upgraded to be compatible with AccuRate. It will therefore be the benchmark house efficiency program for the foreseeable future. AccuRate has been extensively upgraded. Some of the most important new features include: physiological cooling effects induced by cross ventilation and accurate modelling of reflective air spaces in horizontal positions where the R value is greater for heat flow down than heat flow up. The cross ventilation improvements should ensure that AccuRate is accepted in northern climates, while the reflective foil products will now be able to properly rated. The AccuRate simulations will evaluate:

- whether the allowed trade offs have a similar performance effect as insulation they replace,
- the implications of allowing trade offs between insulation and glazing performance, and
- the benefits of higher R values in the northern climates.

3.3 Structure of report

The report contains one section on each of the three building elements covered: walls, ceilings and floors. In each section the old R values required are compared to the new R values. R values have been reported in terms of the nearest R value of insulation required in R0.5 increments. Note that the regulations do not specify insulation R values but total component R values. The insulation R values reported below were derived for common construction systems such as Brick Veneer walls, plasterboard ceilings to attic roofs and timber floors. In each section the value of higher insulation levels for those climates where requirements are low and the effect of trade offs is evaluated.

A section on the implications of higher R values in hot climates for peak air conditioning loads and comfort is also included. Finally some general comments about the regulations structure and the place of performance assessment is provided.

3.4 House plans used for evaluation of regulations

Two pans were used to evaluate the implications of the regulations and verify the validity of trade offs:

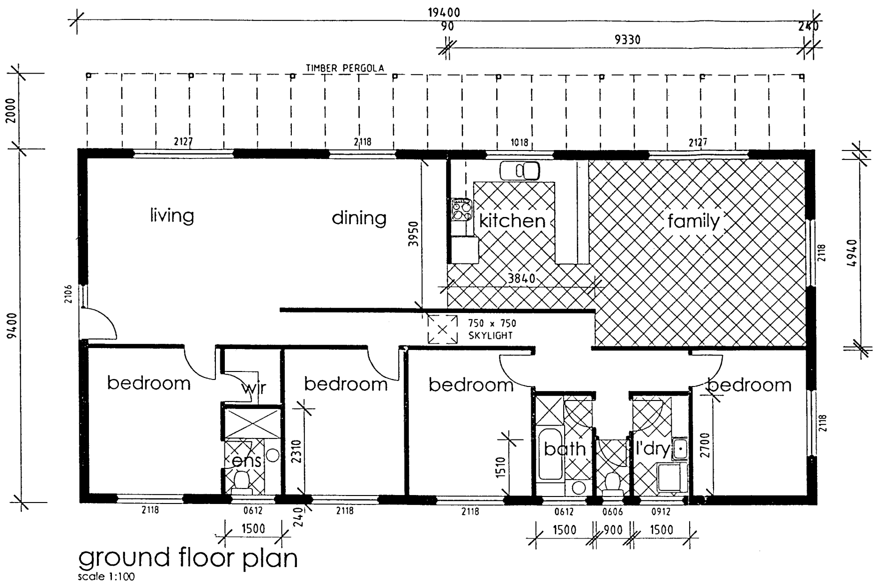

Figure 2 House 1: single storey

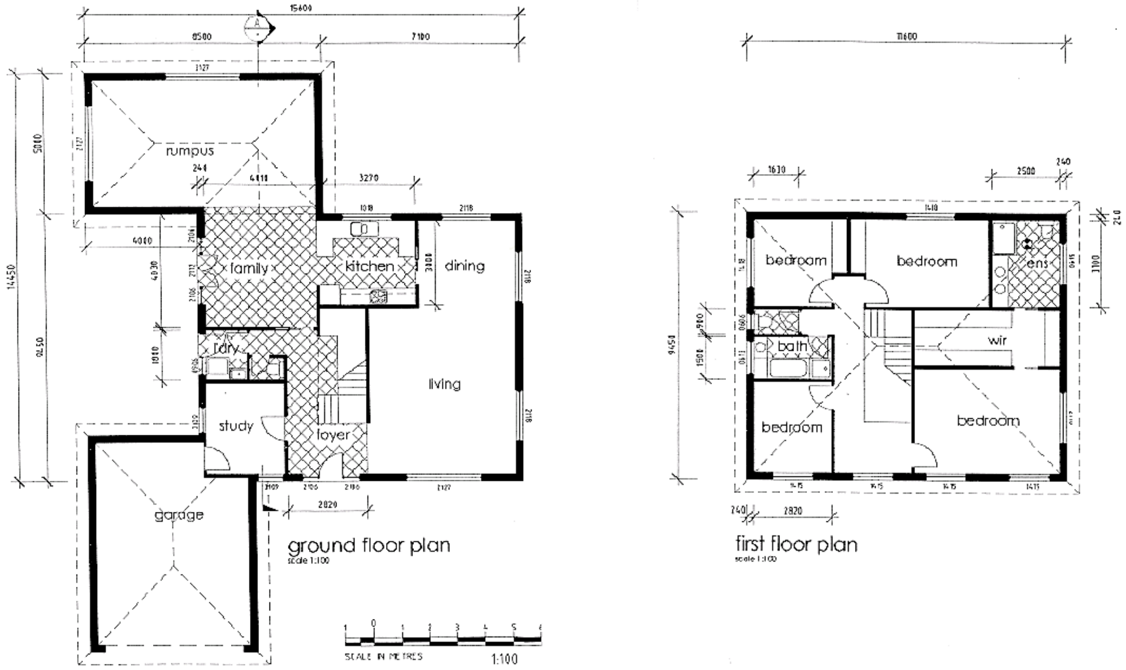

Figure 3 House 2: 2 storey house. Used by SEAV as case study for Victorian 5 stars

These houses were selected as being typical of the spec house market.

4 Walls

4.1 Overall insulation levels

The regulations require the following total R values for walls:

Climate zones	**1, 2, 3 and 5**	**4 and 6**	**7**	**8**
Minimum *required Total R-Value* for walls	1.9	2.2	2.4	3.3

Table 1 Minimum Required total R value 2006 regulations

The table below shows how the wall insulation requirements of the new regulations have been increased for Brick Veneer walls. R values reported are the minimum R value to achieve compliance in a brick veneer wall rounded to the next highest multiple of 0.5.

Reg	Wall type	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
2003	Brick Veneer	1	1	1	1.5	1	1.5	1.5	2.5
2006	Brick Veneer	1.5	1.5	1.5	2.0	1.5	2.0	2.0	3.0

Table 2 Added insulation comparison for Brick Veneer Walls 2003 vs 2006

4.2 Climate specific trade offs allowed for wall insulation

A wide variety of trade offs are allowed:

- Shading of walls by eaves or pergolas is allowed as an alternative to insulating walls in hot climates (zones 1, 2, southern part of 3). 2.4 m. high Eastern and Western facing walls would require shading of at least 577 mm depth, while northern facing walls would require only 268 mm.
- South facing walls are not required to be insulated in hot climates.
- Heavy masonry walls e.g. brick cavity, single skin concrete block are not required to be insulated if the floor is slab on ground or internal walls are also masonry in climates 4 and 5 (e.g. Mildura and Sydney).
- Heavy masonry walls in houses with timber floors only need install minimal insulation

To help get an overview of the insulation levels that are required for the various trade off combinations I have constructed a table showing the extent of wall insulation trade offs provided for Brick Veneer and Brick Cavity Walls.

				Climate Zone							
Wall Type	***Floor Type***	***Wall Shaded***	***Masonry internal walls***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***
BV	Timber	No	None	1.50	1.50	1.50	2.00	1.50	2.00	2.00	3.00
BV	Timber	No	Yes	1.50	1.50	1.50	2.00	1.50	2.00	2.00	3.00
BV	Timber	Yes	None	0.00	0.00	0.00	2.00	1.50	2.00	2.00	3.00
BV	Timber	Yes	Yes	0.00	0.00	0.00	2.00	1.50	2.00	2.00	3.00
BV	Slab	No	None	1.00	1.00	1.00	2.00	1.50	2.00	2.00	3.00
BV	Slab	No	Yes	0.00	0.00	0.00	2.00	1.50	2.00	2.00	3.00
BV	Slab	Yes	None	0.00	0.00	0.00	2.00	1.50	2.00	2.00	3.00
BV	Slab	Yes	Yes	0.00	0.00	0.00	2.00	1.50	2.00	2.00	3.00
BC	Timber	No	None	1.23	1.23	1.23	0.50	0.50	1.00	1.00	1.50
BC	Timber	No	Yes	1.23	1.23	1.23	0.00	0.00	1.00	1.00	1.50
BC	Timber	Yes	None	0.00	0.00	0.00	0.50	0.50	1.00	1.00	1.50
BC	Timber	Yes	Yes	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.50
BC	Slab	No	None	0.73	0.73	0.73	0.00	0.00	0.50	1.00	1.50
BC	Slab	No	Yes	0.73	0.73	0.73	0.00	0.00	0.50	1.00	1.50
BC	Slab	Yes	None	0.00	0.00	0.00	0.00	0.00	0.50	1.00	1.50
BC	Slab	Yes	Yes	0.00	0.00	0.00	0.00	0.00	0.50	1.00	1.50

Table 3 Table showing Added Insulation R values for Brick Veneer and Brick Cavity walls allowing for the trade offs proposed by the 2006 regulations

4.3 Trade offs allowed for higher performance glazing

One of the ways in which regulations provide flexibility is by allowing applicants to demonstrate equivalent performance. Clause 3.12.1.4 (b) is an example of this approach. If the total heat flows of walls and windows in the applicant's house do not exceed the heat flows in the same use using minimum wall insulation and glazing specified it is deemed to provide satisfactory performance. An example of how this could be applied is given in explanatory information. It shows how a 200 m^2 house built from heavy masonry walls (area 100 m^2) in Melbourne can be allowed to avoid any wall insulation by using high performance timber framed double glazing with a low e coating and a 10 mm air gap (area 50 m^2). This trade off is available for all wall types and not just masonry walls.

4.4 Evaluation of trade off provisions for walls

4.4.1 Wall shading

In climate zones 1, 2 and 3 shaded walls are not required to be insulated. A wall is defined as shaded if it meets the following conditions:

Figure 3.12.1.2
MEASUREMENT OF PROJECTION FOR WALL SHADING

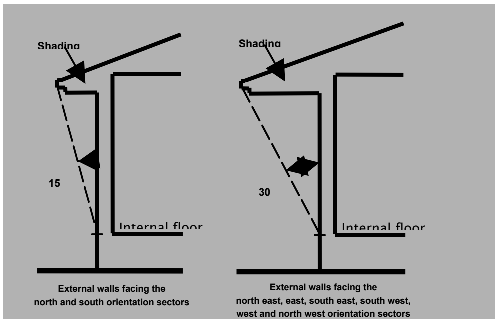

Figure 4 Minimum wall shading required to avoid the use of wall insulation in hot climates

In practice a 600 mm eave is considered sufficient for a west or east facing 2.4 m high wall and 300 mm for a northern facing wall.

The theory behind the trade off is sound. At the time of peak solar radiation in the middle of summer shading a dark wall completely from direct sun has a similar effect to insulating using R1.0 without shading. At night the lower U value will allow the house to cool down more rapidly. However, with only minimal eaves deemed to have adequate shading effect it may be that the impact of wall insulation is substantially higher than the shading effect of eaves.

To test the relative benefits of wall shading house 1 was simulated in each of climate zones 1, 2, and 3. In each zone the house was changed to conform to the requirements of the BCA and four simulations were run in each climate:

1. The house complying with the regulations using eaves shading to avoid the need for wall insulation,
2. The same house with shading removed from walls, but remaining on windows to isolate the wall shading effect,
3. As above but with the minimum required insulation in the walls to compare the effect of wall shading with insulation, and
4. With both 600 mm wall shading and minimum complying wall insulation, to show the shading effect on an insulated wall and to evaluate the combined effect of shading and insulating.

The figure below shows these results:

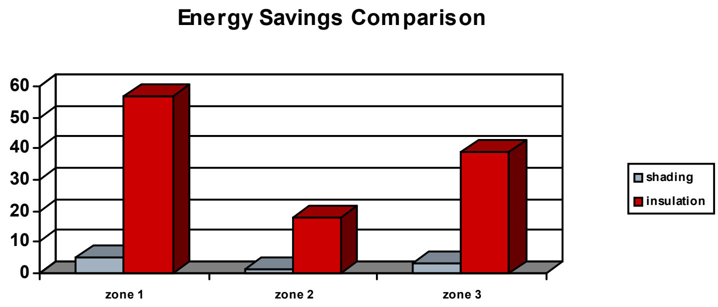

Figure 5 Energy Savings due to wall shading compared to insulation

The figure above shows that the shading required by the regulations does not reduce heat flows through the walls by anywhere near as much as the insulation. Insulation produces benefits which are in the order of 6 to 10 times greater than the minimal wall shading required by the regulations. On this analysis the trade off for wall shading provided in the BCA can not be supported. While quite deep verandahs may have a substantial effect, and some credit should properly be given for them, a requirement for minimal eaves for the purpose of reducing summer heat gain through walls is clearly not an appropriate substitution for insulation. Further, the benefits of insulation appear to be even greater for weatherboard walls.

4.4.2 Recommendation 1: the current trade off with wall shading should be removed

The trade off clearly does not work and will limit the Deemed to Satisfy clauses to deliver consistent energy ratings as a result. The trade off should be deleted. It may be appropriate to allow lower insulation levels where quite deep verandahs are use, however, evaluation of this option is beyond the scope of this report. Removal of this clause in its current form will not stop houses with highly shaded uninsulated walls from being constructed as it is still possible that such houses could meet the 5 star rating. By leaving the evaluation of this to the rating tools rather than in the DtS one ensures that wall insulation could only be omitted where the performance of the house justifies this.

4.4.3 Trade offs between wall insulation and glazing performance

In the example given in the explanatory notes high performance glazing is used to avoid insulation in walls. I estimate that the cost of wall insulation would need to be $\$25/m^2$ before using high performance double glazing was a cheaper option. It appears unlikely that this trade off would be used frequently, however, it could certainly be used to allow the use of lower insulation levels.

To evaluate the broader implications of this clause I examined how the wall insulation level could be lowered for the example given in the explanatory notes if the window frame was changed to timber and the glass area reduced by 5 m^2. Calculations demonstrating the impact (in climate 6: Melbourne) are shown below.

Step 1 Establish heat flow limits

Element	Area	Required R	Heat flow	Conductance limit	Glazing Conductance target	Target heat flows
Wall	105	2.2	47.7			47.7
Windows	200*			1.4	280	280.0
Total Limit						327.7

* Floor area of house

Table 4 Heat flow limits through building fabric for house 1 in Melbourne

Step 2 Determine actual heat flows for house with higher than minimum required R values

Element	Area	Installed R	R value total	Heat flow	Glass U	Frame factor	Glazing U	Heat flow	Total
Wall	105	1.00	1.54	68.2					68.2
Windows	45				5.9	0.97	5.72	257.5	257.5
									325.7

Table 5 Heat flows achieved with higher insulation levels and larger glazing areas

If this clause was used in this way it would wipe out the improvement in R values in walls provided by the new regulations and result in the use of LOWER R values than in the previous regulations. Simulations confirm that the changes to window frame type / area and wall R value have identical effects on energy use, so there is no technical basis to challenge this trade off mechanism because it does produce equivalent results.

The true impact of this trade off clause will depend on how industry uses it and the guidelines give n by the ABCB as to its application. It is probable that industry will still want to use aluminium window frames and keep glazing areas as large as they can within the limits of the regulation so this may not in practice lead to significant reductions in wall R value.

It is generally desirable to provide regulations which are flexible in their application. It is conceivable that such trade offs (which allow no insulation of walls if high performance glazing is used) may be needed for warehouse conversions or mud brick houses where the high cost of installing insulation makes its use less than economical. The trade off mechanism may be seen by both regulators and industry as a necessary fall back for unusual cases and as such it may be difficult to argue for its removal altogether. In particular, the earth wall construction industry may feel this is necessary to allow mud brick houses to pass the regulations.

The fact that this clause could substantially lower insulation levels in buildings which are not the intended target of the clause is, however, highly undesirable. The heat flow through a poorly insulated wall will be with us for 50 or more years. It therefore limits the energy efficiency potential of the house in future because the cost and practicality of insulating walls after construction mean that it is unlikely that this level of insulation will ever be changed. It is important to remember that the current regulations are set at low stringency compared to international standards: for example, 150mm of wall insulation is commonplace in the

US. Further, while the current regulations are a very useful starting point, they will not be sufficient to turn around the greenhouse effect and it is likely that higher stringencies will need to be introduced over time.

There are also methodological problems with this approach that limit its ability to deliver consistent rating levels. In establishing the heat flow limit the glazing component is determined on the basis of setting an upper limit to total heat flows for the house based on its floor area. The wall heat flow limit, however, is not set to provide a limit to total heat flows for the house. Instead, the limit is derived according to the actual area of wall in the house. This means that there can be substantial variation in the heat flows allowed for houses of the same floor area but with different wall areas. Because small houses have a greater glazing to floor area ratio and wall to floor area ratio small houses will have less opportunity to use this trade off. Consequently, larger houses – which will have larger energy bills – will be more able to utilise this trade off than smaller houses. In addition because the performance rating is based on energy use per square metre of floor area this approach will make it difficult to achieve consistent rating performance levels.

4.4.4 Recommendation 2: limit the extent of the trade off against wall insulation levels

The importance of ensuring that future generations are not burdened with poorly performing walls, and the difficulty this trade off may create in establishing consistent rating levels mean that some limits should be imposed on the extent of trade off allowed.

If the trade off is to be retained a better methodology could be derived by setting fixed wall area limits that represent a reasonable area to be achieved at each floor area. The use of lower R values should be contingent on the applicant demonstrating that there are legitimate cost and construction problems with installing required R value such as the use of earth walls.

4.4.5 Allowing two way trade offs between insulation and glazing

The explanatory notes to the regulations describe current trade off in terms of allowing lower insulation levels to be used where higher performance glazing is installed. The regulatory principle of demonstrating equivalence would imply that it is acceptable to reverse the trade off and use higher insulation levels to offset either larger glass areas or the use of lower performance glazing. Allowing slightly larger windows (subject to meeting radiation requirements) through such a trade off may well be attractive to industry where it has often been said that limiting glazing size limits the marketability of the house. Further, if credit was given for additional insulation in floors and ceilings as well as in walls this could provide an effective solution for many builders. The following provides an example of how this could work for house 1 in climate zone 6 (Melbourne):

Step 1 Establish heat flow limits

Element	Area	Required R	Heat flow	Conductance limit	Glazing Conductance target	Target heat flows
Wall	100	2.2	42.7			45.5
Roof/Ceiling	200	3.7	54.1			54.1
Floor	200	3	66.7			66.7
Windows				1.1	220	220.0
Total Limit						386.3

Table 6 Heat flow limits through building fabric for house 1 in Melbourne

Without the trade off glazing area would need to be limited to 34.5 m2 and improve aluminium frames need to be used.

Step 2 Determine actual heat flows for house with higher than minimum required R values

Element	Area	Installed R	R value total	Heat flow	Glass U	Frame factor	Glazing U	Heat flow	Total
Wall	105	2.5	3.04	34.5					34.5
Roof/Ceiling	200	4.75*	5.1	39.2					39.2
Floor	200	3	3.7	54.1					54.1
Windows	39.8				5.9	1.1	6.49	253.1	258.5
									386.3

*R 4.0 + foil

Table 7 Heat flows achieved with higher insulation levels and larger glazing areas

This allows the house to increase its glazing area by 16% and still comply with the regulation. This is a win for all involved:

- the insulation industry gains recognition for its higher performance products,
- the glazing industry does not face the same restriction on the sales of its products, and
- the builder has a more marketable product.

4.4.6 Recommendation 3: extend the trade off mechanism between insulation and glazing to allow larger areas of glass as a reward for higher insulation levels.

Note: subject to establishing wall area limits consistent with recommendation 2.

4.4.7 Higher insulation for two storey walls

Heat flow is dependent not only on the thermal resistance of the element but also its area. It would make intuitive sense to require higher R values in walls where their surface area is larger. This would also help the application of the DtS regulations to deliver more consistent rating results. Such an allowance has probably not been evaluated due to the added complexity it would involve. Such an approach would require wall R values to be set according to wall to floor area ratios in each climate zone and the wall R values are already the most complex part of the regulations next to the evaluation of glazing. Rather than evaluate wall surface area effects on a case by case basis therefore it is suggested that for two storey houses where the wall to floor ratios are fundamentally higher than for single storey houses a higher R value be recommended. The following table shows the simulated energy savings due to various wall insulation levels in the single and two storey house in Melbourne.

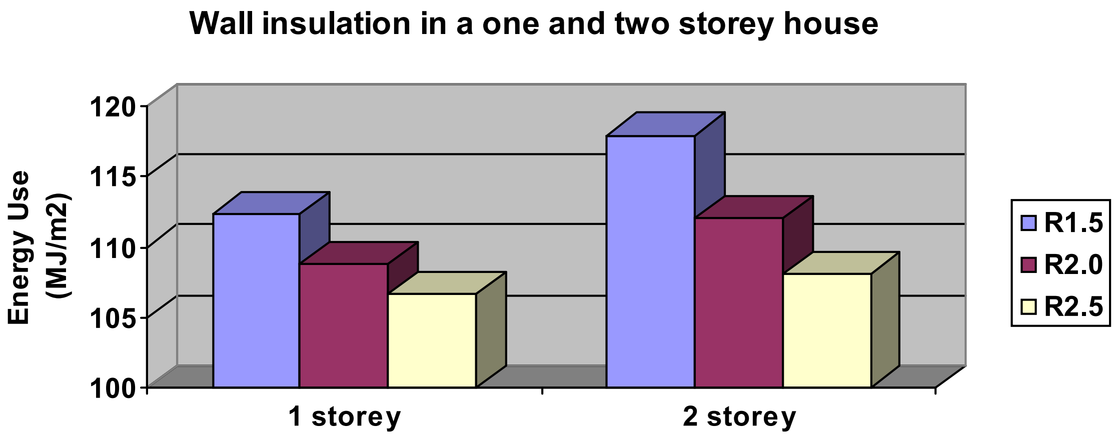

Figure 6 Comparison of energy use for various wall insulation levels in a one and two storey house in Melbourne

The figure above shows that while the savings for R2.5 insulation compared to R2.0 are small in the single storey house this is not the case in the two storey house. The savings of going from R2.0 to R2.5 in the two storey house are only slightly lower than the savings of increasing from R1.5 to R2.0. This demonstrates that higher wall R values are likely to be cost effective in two storey houses.

4.4.8 Recommendation 4: higher wall insulation levels should be specified for two storey houses

It is beyond the scope of this project to develop recommended R values for all climate zones, however, it would appear that an increase in wall R values for two storey houses of at least R0.5 would be justified. The ABCB should investigate this option.

5 Roofs

5.1 Overall insulation levels

The regulations require the following total R values for ceilings:

Table 3.12.1.1 **ROOFS - MINIMUM TOTAL R-VALUE**										
	Solar absorptance of roof upper surface	***Climate zone***								
		1	**2** **Below 300 m altitude**	**2** **At or above 300 m altitude**	**3**	**4**	**5**	**6**	**7**	**8**
Minimum *Total R-Value*	**Less than or equal to 0.55**	2.2	2.2	2.5	2.2	3.5	3.2	3.7	4.3	4.8
	More than 0.55	2.7	2.7	3.0	2.7	3.5	3.2	3.7	4.3	4.8
Direction of heat flow		Downwards		Downwards and upwards	Upwards					
Note: Altitude means the height above the Australian Height Datum of the location where the building is to be constructed.										

Table 8 Roof total R values required by the proposed regulations

The table below shows how the roof insulation requirements of the new regulations have been increased. R values reported are the minimum R value to achieve compliance in an attic roof with a flat ceiling rounded to the next highest multiple of 0.5.

Reg	Roof type	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
2003	Tiles	1.5	1.5	1.5	2.5	2	2.5	3	4
	Metal	2	2	2	2.5	2	2.5	3	4
2006	Light	1.5	1.5	2.0	3.5	3.0	3.5	4.0	4.5
	Dark	2.0	2.0	2.5	3.5	3.0	3.5	4.0	4.5
2006	Light + foil	0.5	0.5	1.5	2.5	2.5	3.0	3.5	4.0
	Dark + foil	1.0	1.0	2.0	2.5	2.5	3.0	3.5	4.0

Table 9 Insulation levels required by 2003 and proposed 2006 regulations

The resultant installed ceiling insulation levels in climate zones 1, 2 and 3 are very low, particularly if foil is installed in the roof and the roof has a light colour (equivalent to weathered galvanised steel). I will deal with the foil issue in the next section. To examine the benefits of higher insulation levels I have simulated house 1 with R3.5 insulation and compared this to the benefits of going from no insulation to the minimum required R value in walls in the following graph:

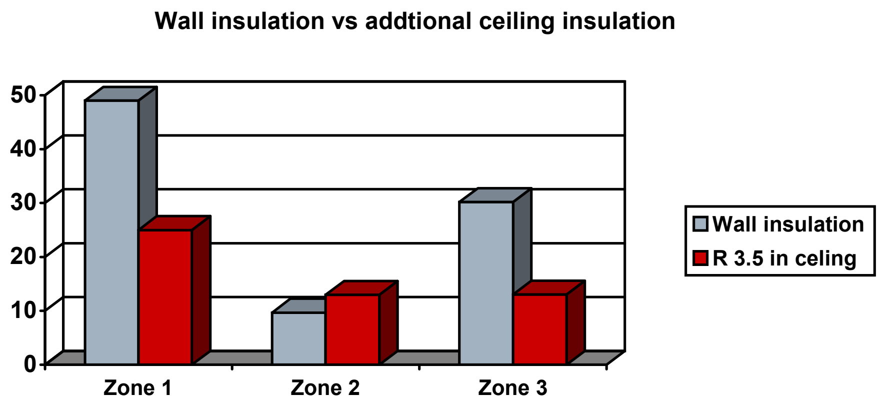

Figure 7 Comparison of R 3.5 ceiling insulation with wall insulation savings

The figure above shows that going to R3.5 ceiling insulation in climates 1 and 3 produces savings which are around half those of installing wall insulation at a substantially lower incremental cost. In climate 2 the additional savings for using R 3.5 in ceilings actually exceeds the energy savings of the wall insulation. Given the substantial benefits of higher levels of ceiling insulation it is difficult to see how such low levels of ceiling insulation could be justified in climate zones 1 to 3.

5.1.1 Recommendation 5: Required roof total R values should be increased to R3.5 in climate zones 1, 2 and 3.

The magnitude of the savings indicates that R3.5 would be cost effective in these climate zones, however, because the ABCB have yet to release cost benefit analysis this recommendation is made subject to the release of this information but it is highly likely that higher R values would be justified.

5.2 R values allowed for foil

The assumptions employed in the calculation of R-values for reflective insulation products is currently being reviewed by an expert working group as part of Standards Australia's revision of AS/NZS 4859.1. The draft revision incorporating the foil assumptions is due to be circulated for committee comment on 11th April 2005 and available for public comment shortly after. These foil assumptions should be the basis for published foil R-values provided in the explanatory information accompanying figures 3.12.1.1, 3.12.1.3 and 3.12.1.4.

5.2.1 Recommendation 6: Revise R values for reflective attic spaces to allow for dust build up over time on upward facing surfaces consistent with recent decisions by the Australian Standards Association.

5.3 Insulation installed under roof lining in attic roofs with flat ceiling

The explanatory information for roof insulation the regulations note that 'insulation installed under a roof rather than on a ceiling… is less effective'. The regulation provides no information on how the R value is affected and users will be forced to simply add the R value of under roof insulation to ceiling insulation when this is known to significantly overstate the value of the under roof insulation in colder climates. The FirstRate software provides the following advisory information on this topic:

	Equivalent ceiling insulation		
	Roof Insulation R value		
Ceiling Insulation R value	1	1.5	2.5
0	0.5	0.5	0.6
0.5	1.0	1.1	1.2
1	1.4	1.6	1.7
1.5	2.0	2.2	2.4
2	2.6	2.7	2.9
2.5	3.1	3.3	3.4
3	3.5	3.7	3.9
3.5	3.9	4.1	4.3
4	4.5	4.7	4.8

Table 10 FirstRate guidelines for combining roof and ceiling bulk insulation levels

These figures may be dependent on roof colour, do not include the impact or reflective foil or roof ventilation and as FirstRate does not include climates north of the tropics have not been checked in hot climates. Consequently they will not meet all the needs of the new regulations, but they do show that it would cause substantial errors to simply add roof and ceiling insulation.

5.3.1 Recommendation 7: Further research is required to provide users of the regulations with advice on how roof and ceiling insulation R values may be combined to give a total effective insulation R value.

6 Floors

6.1 Overall insulation levels

The regulations require the following total R values for floors:

Table 3.12.1.4												
SUSPENDED FLOOR – MINIMUM TOTAL R-VALUE												
Perimeter treatment	**Unenclosed**						**Enclosed**					
Climate zone	**1**	**2 and 3**	**4 and 6**	**5**	**7**	**8**	**1**	**2 and 3**	**4 and 6**	**5**	**7**	**8**
Minimum *Total R-Value* for a suspended concrete slab	Nil	1.0	2.5	1.0	3.0	3.5	Nil	Nil	1.0	1.0	2.0	3.0
Minimum *Total R-Value* for a suspended floor other than a concrete slab	Nil	Nil	3.5	2.0	4.0	4.5	Nil	Nil	2.0	2.0	3.0	4.0

Table 11 Minimum total R values for floors required by proposed regulations

The table below shows how the floor insulation requirements of the new regulations have been increased. R values reported are the minimum R value to achieve compliance in an attic roof with a flat ceiling rounded to the next highest multiple of 0.5.

Reg	Floor type	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
2003	Timber enclosed	0	0	0	0.0	0	0.5	0.5	2.0
	Timber unenclosed	0	0	0	0.0	0	0	0	0
	Concrete enclosed	0	0	0	0.0	0	0.5	0.5	2.0
	Concrete enclosed	0	0	0	0.0	0	0	0	0
2006	Timber enclosed	0	0	0	1.5	1.5	1.5	2.5	3.5
	Timber unenclosed	0	0	0	3.0	1.5	3.0	3.5	4.0
	Concrete enclosed	0	0	0	0.5	0.5	0.5	1.5	2.5
	Concrete unenclosed	0	0.5	0.5	2.0	0.5	2.0	2.5	3.0

Table 12 Effective insulation levels required by proposed regulations

The table above shows that in zones 4 to 8 not only have insulation levels been substantially increased – some by as much as R3.0 – but that floors over enclosed sub floor spaces are now also required to be insulated. This will result in a substantial growth in the use of insulation to suspended floors. In climate zones 1 to 3 however, no floor insulation of any kind is required. This is probably reasonable for these climates because the temperature in an enclosed subfloor is much lower due to its interaction with the cooler ground. A spot check for Darwin showed a 15 MJ/m^2 saving due to R 1.5 floor insulation compared to 49 MJ/m^2 with the same level insulation in the wall. Given the higher installation cost of floor insulation - partly due to industry's relative unfamiliarity with the correct procedures – it is likely that the cost benefits will be marginal. By contrast insulation of unenclosed timber floors shows benefits in excess of those provided by wall insulation as demonstrated in the table below:

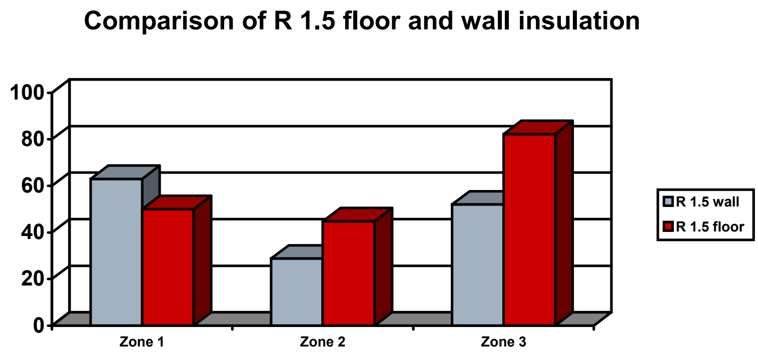

Figure 8 Energy savings due to insulation of unenclosed suspended timber floors compared to wall insulation savings

The table above shows that floor insulation to timber floors over an unenclosed subfloor saves significantly more energy in climate zones 2 and 3 than wall insulation. In climate zone 1floor insulation is less effective than wall insulation but twice as effective as an increase in ceiling insulation from R1.5 to R 3.5. Clearly there are substantial benefits for insulating unenclosed subfloors in hot climates and installation costs for unenclosed subfloors are cheaper than for enclosed subfloors. This appears to be a major oversight.

6.1.1 Recommendation 8: Floor insulation to at least an insulation value of R1.5 over unenclosed subfloors in climates 1 to 3 is likely economically justified. The regulations should add provisions for the insulation of such floors.

7 The impact of high insulation levels in hot climates

7.1 Energy Savings

The energy use simulations reported in Appendix A show substantial benefits to increasing insulation levels in hot climates. By insulating ceilings to R3.5, disallowing the current wall trade off for shading and insulating unenclosed sub floors to R1.5 such houses could save a further 22% of energy use in climate 1, 27% in climate 2 and 42% in climate 3 over and above the energy savings that would already be achieved by the regulations. Given the small incremental cost of this insulation it is likely that these savings will be economically justified and provides a more effective regulation. There has been substantial reluctance to use high levels of insulation in hot climates, however, so this section will examine the broader implications of the use of higher insulation levels for both house comfort and peak utility loads to demonstrate the strong case for higher insulation levels in regulations.

To check whether such improvements to insulation levels are cost effective the energy savings per dollar of additional cost were compared for the following cases:

1. The insulation cost per MJ energy saved for wall insulation installed to required level without wall shading. Because this is already part of the regulation it is presumed that if higher insulation levels achieve a similar $/MJ figure these too will be cost effective.
2. Insulation cost per MJ energy saved for R3.5 ceiling insulation, and
3. Insulation cost per MJ energy saved for R3.5 ceiling insulation and R1.5 floor insulation.

The chart below shows the comparative figures:

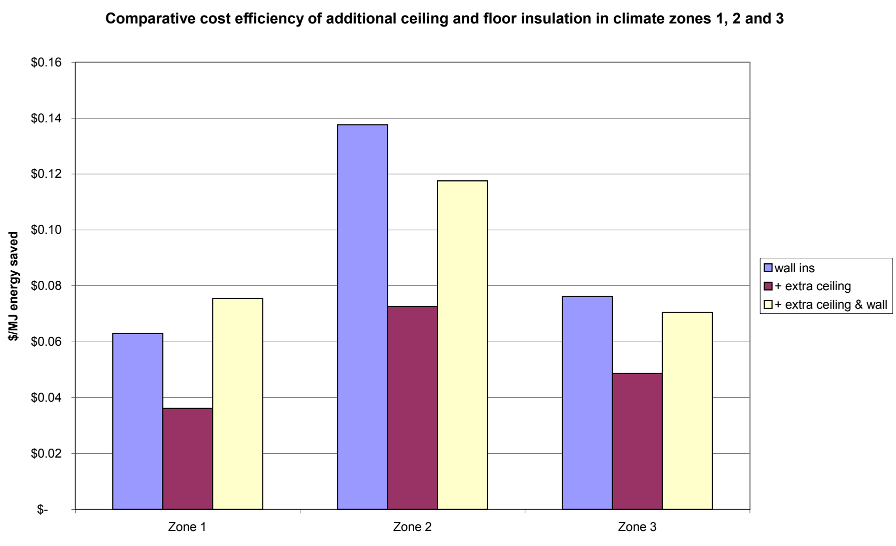

Figure 9 Comparative $/MJ energy saved for various insulation options in climates 1, 2 and 3

As the figure above shows the cost effectiveness of the additional ceiling insulation is better than the cost effectiveness of the wall insulation, while the additional ceiling and floor insulation is more cost effective in climates 2 and 3 and only slightly more expensive in climate 1. Because these costs are on a par with wall insulation to the required level it is presumed that the higher insulation levels will be cost effective.

7.2 Cost effectiveness

To demonstrate the cost effectiveness of insulation relative to other methods of improving summer performance six scenarios were modelled in climates 1, 2 and 3 using house 1:

1. The energy savings due to R1.5 wall insulation,
2. The energy savings due to increasing the ceiling insulation from the minimum to R3.5,
3. The energy savings due to R1.5 floor insulation for a suspended timber floor over an unenclosed subfloor space,
4. The energy savings due to 600 mm eaves,
5. The energy savings due to toned glazing,
6. The energy savings from using canvass awning external blinds to all north, east and west windows.

The cost of each measure is then divided by the energy saved so that the relative efficiency of the measures can be compared. Measures with lower $/MJ values are more cost effective.

7.2.1 Insulation and other improvement costs

The following insulation costs were assumed:

Ceiling insulation costs	R	Installed Cost $/M^2 Zone 2	Installed Cost $/M^2 Zone 3	Installed Cost $/M^2 Zone 1
Batts	1.5	$4.26	$9.60	$10.24
Batts	2	$4.60	$10.06	$10.58
Batts	2.5	$5.23	$10.70	$11.85
Batts	3	$5.52	$11.10	$12.54
Batts	3.5	$6.10	$11.67	$13.69
Batts	4	$6.67	$12.25	$14.26
Wall Insulation costs				
Foil		$2.88	$5.29	$5.98
Batts	1.5	$4.26	$9.60	$10.24
Batts	2	$4.60	$10.06	$10.58
Batts	2.5	$5.23	$10.70	$11.85
Batts	3	$5.52	$11.10	$12.54
Floor Insulation Costs*				
Batts	1.5	$5.29	$10.64	$11.27
Batts	2	$5.64	$11.10	$11.62
Batts	2.5	$6.27	$11.73	$12.88
Batts	3	$6.56	$12.13	$13.57

* floor insulation costs are based on the cost of wall insulation + $0.90 per m^2. This additional allowance is for the installation of string restraints to ensure the insulation is held in place. While installing floors is more awkward than in walls, wall insulation requires more complex fitting of insulation around windows so it is expected that installation costs would be around the same plus a nominal amount for fitting restraints.

Costs for other energy efficient improvements are as follows:

1. Eaves to 600 mm: $55/m^2, total area of eave 36 m^2,
2. Tinted glazing to 37 m^2 of glass, cost of $22/m^2,
3. External Blinds to 20.2m^2 at a cost of $95/m^2.

All prices include GST and overheads.

7.2.2 Insulation: the most cost effective way of achieving reduced energy bills

The figure below compares the cost per MJ energy saving for the six scenarios studied:

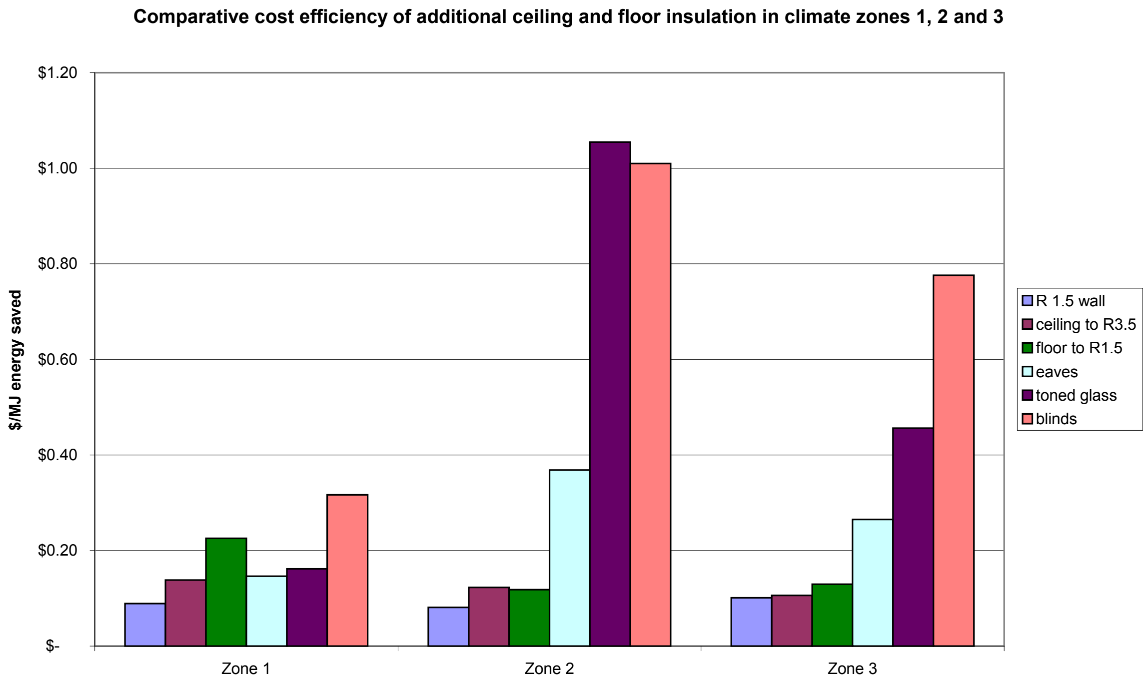

Figure 10 Comparative costs per MJ saved of various energy efficiency improvements

The chart above shows that *insulation is by far the most cost effective improvement of the various energy saving strategies studied*. Floor insulation in zone 1 is slightly less cost effective than eaves or toned glass but this is primarily due to the higher cost of insulation delivered to the NT. In Brisbane where energy savings are lower the cost benefits are higher due to the significantly lower cost of providing insulation in this market.

The building industry has expressed concern over the impact that additional cost of building improvements required by regulation will have on housing affordability. They are concerned that these price rises will reduce demand, particularly for first home buyers who have tighter budgets. Energy efficiency regulations *are unlike any other regulation*. Energy efficiency regulations bring a direct financial benefit to the home owner by reducing energy bills. These savings can often exceed the increase to mortgage payments required to pay for the additional energy efficiency features. Estimating energy savings is difficult as it is requires information on average usage patterns. The only data available on this is now almost 20 years old and there is no doubt that the intensity of use of heating and cooling as well as the ownership of appliances has increased significantly over the period. The energy savings reported above are simulated savings using AccuRate. This assumes zoned whole house heating and cooling with differential hours of use and thermostat settings for living and sleeping areas. NatHERS was understood to over predict energy savings and the increase in cooling thermostats and reduction in heating thermostats in AccuRate has significantly lowered energy use predictions. In the absence of better data the AccuRate results are presumed to give a reasonable estimate of savings.

The figure below shows the annual energy savings and increase to mortgage payments assuming a 7.5% interest rate. Heating is assumed to be provided using resistive electric heating (100% efficient) on a day tariff and air conditioning is assumed to be refrigerative (efficiency 250%). Electricity costs were assumed to be around 10c/kWh in zones 2 and 3 and 13c/kWh in zone 1, consistent with previous ABCB Regulatory Impact Statements for housing.

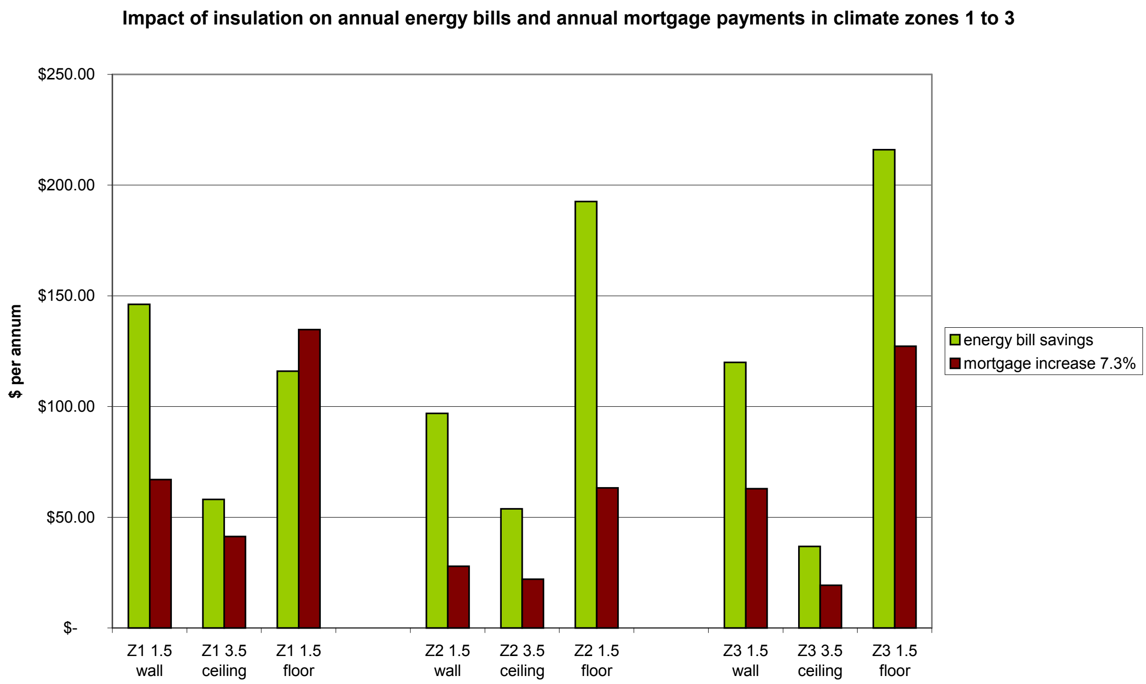

Figure 11 Impact of insulation on energy bills and mortgage repayments

The figure above demonstrates that insulation improves the home owner's financial position as energy savings comfortably exceed or break even with increases to mortgage payments. Energy efficiency improvements increase the capacity of the householder to meet mortgage payments and should therefore not result in any reduction in housing demand. Furthermore, higher levels of insulation provide slightly better cash flow impacts for the householder. In most cases, *even if the actual energy savings are half the value estimated by AccuRate, insulation still has a positive impact on household cash flow.*

The table below shows the cash flow position i.e. energy saving – increase to mortgage payments for various levels of insulation in the walls, floors and ceilings in zones 1, 2 and 3.

climate zone	element	Impact on household annual cash flow* R value					
		1.5	2	2.5	3	3.5	4
1	wall	$79	$86	$83	na	na	na
	ceiling	bm	$18	$19	$22	$25	$24
	floor	-$19	-$18	-$30	-$36	nt	nt
2	wall	$69	$72	$72	na	na	na
	ceiling	bm	$23	$34	$44	$48	$49
	floor	$128	$133	$130	$131	nt	nt
3	wall	$56	$61	$62	na	na	na
	ceiling	bm	bm	-$8	$29	$29	$27
	floor	$88	$92	$90	$89	nt	nt

* compared to R0.0 in walls (shaded), R0.0 in floors and R1.5/2.0 in ceilings
1 bm: below minimum required R
2 na: not applicable insulation thickness greater than stud frame
3: nt: not tested

Table 13 Householder cash flow impacts of various levels of insulation in climates 1, 2 and 3

The table above shows that insulation generally has a small positive impact on household cash flow ***regardless of the level of insulation installed.*** There would therefore be no adverse affect on housing demand in regulating for levels of insulation even higher than those tested in this report : 1.5 in walls, 3.5 in ceilings and 1.5 in floors because at virtually all levels of insulation the householder is in a better financial position. Even where insulation has a negative effect for floor insulation in zone 1 the householder is only 70c/week worse off.

This finding has implications beyond the climate zones specifically studied in this report. The March 2002 Draft Regulatory Impact Statement[1] reports the costs and predicted energy bill savings for all insulation measures applied to walls floors or ceilings. These figures were not used in the final RIS however, they provide an indication of the relative ratios of costs to benefits that insulation provides across the various climate zones. Figure 5.3 on page 29 shows that the NPV of energy savings and improvement costs was LOWEST in climate 2 i.e. all other climates derived a higher economic benefit from insulation. This would imply that the analysis reported above is likely to hold true for other climates, however direct analysis of this is beyond the scope of this report. The ABCB would therefore be well advised to undertake a similar analysis once the costs and benefits of the proposed regulations have been determined in the Regulatory Impact Statement.

[1] Energy Efficiency Measures, BCA – Volume 2 (Housing Provisions), Regulatory proposal and Regulatory Assessment, ABCB, Canberra, March 2002

7.3 Peak Loads

7.3.1 Peak loads caused by residential air conditioning: a looming crisis

Higher insulation levels will also reduce the peak demand of houses for air conditioning. Given the problems with peak loads caused by residential air conditioning throughout Australia the benefits of higher insulation in hot climates will be a significant political and economic bonus. It is beyond the scope of this report to do detailed analysis of the impacts on the electricity grid as this would require the simulation of a representative sample of houses, require more information on air conditioner user behaviour patterns than is currently available and utility load profiles for each region. There is plenty of evidence to suggest that the problems caused by peak loads due to residential air conditioning will only worsen, and that reductions in these loads bring substantial environmental and economic benefits.

There is predicted to be substantial growth in the ownership and use of air conditioners in Australia as shown in the graph below:

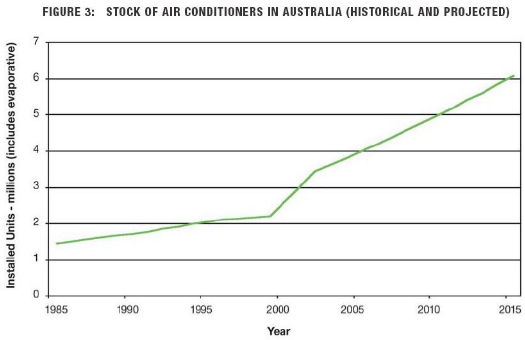

Figure 12 Projected stock of air conditioners in Australia

Between 2005 and 2015 the stock of air conditioners in Australia will increase by 2,000,000 – a 50% increase in the stock of air conditioners overall. With the current stock of air conditioners already causing peak load problems the projected increases will further exacerbate the difficulty of maintaining supply during hot periods.

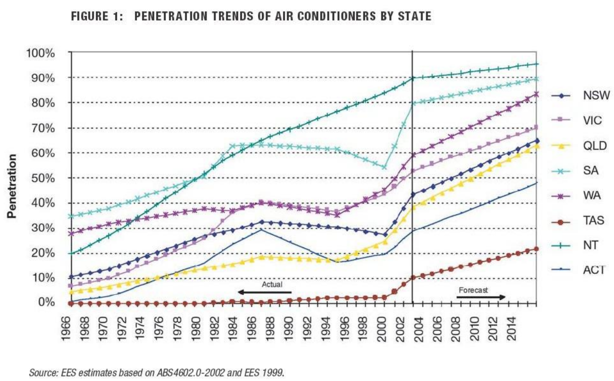

Figure 13 Growth in ownership of air conditioners to 2014[2]

Penetration rates in the warmer states of NT. Qld. and WA also show trends that should be alarming for these state governments. In the NT penetration of appliances is nearing saturation point with ownership expected to reach 95% by 2015. While ventilation of houses will help to reduce the hours of use of air conditioners it is clear that Australians in climates like those in the NT have already found that they can not maintain adequate comfort without air conditioning: the ABS reports greater hours of use for air conditioners in the NT than hours of heating in Victoria[3]. This makes those measures which can reduce peak loads like insulation essential if the growth in peak loads is not to continue at its current rate.

In the next 10 years the penetration of residential air conditioners in WA is expected to reach 85% while in Qld. it is expected to reach 65% - an increase of around 50% in the stock of appliances in each state. These states already have difficulty in supplying peak demand so improvements to houses to limit the growth of this load are essential. While the ownership of air conditioners contributes to peak load problems the actual energy use of air conditioners is small. In Queensland it is estimated that the greenhouse gas emissions arising from air conditioning is only 3% of average household emissions. Qld. and WA have half the reported hours of air conditioning use of the NT, despite the fact that they share many similar climate types. A further concern with the use of air conditioners in Australia is therefore not only the growth in ownership, but also the significant potential for growth in the number of hours of use of these appliances. Australians traditionally take a variety of strategies to keep cool in summer in preference to air conditioning such as going to the beach. The rapid uptake of air conditioning suggests that these avoidance strategies are becoming less popular so not only are the number of appliances in use growing we may also see a growth in the average hours of use.

While the implementation of energy efficient buildings policies will ultimately reduce the need for new power stations and energy supply infrastructure there will be a more immediate benefit to utilities. As the

[2] Australia's Standby Power Strategy 2002-2012, AN INITIATIVE OF THE MINISTERIALCOUNCIL ON ENERGY FORMING PART OF THE NATIONAL GREENHOUSE STRATEGY, June 2004

[3] ABS 8218.0 'National Energy Survey, Weekly reticulated energy and appliance usage patterns by season, Households Australia, 1985-6

market price for electricity rises when the balance between demand and supply is tight, in the short term the reduced peak demand will lower the overall cost of electricity by reducing the amount of high cost peak kW purchased. A paper presented to the Business of Energy Efficiency Conference (BEEC) by the AGO showed that the highest 0.2% of peak electricity generated in Australia accounts for 16% of the cost of electricity. Reduction in peak loads will help to contain he cost of electricity for all consumers.[4] McLennan Magasanik and Associates demonstrated significant reductions in electricity prices as a result of reduced peak loads from adoption of energy efficiency policies.[5]

Studies for the National Framework for Energy Efficiency show that reducing peak loads can contribute to economic growth[6] making load reduction a 'negative cost' greenhouse reduction measure. Other means of reducing greenhouse gas emissions may not contribute to economic growth so the government would be well advised to pursue those measures which deliver both economic and environmental benefit to their fullest extent.

7.3.2 The impact of insulation on peak air conditioning loads in hot climates

The reductions in load shown in the table below are for house 1 in each of the three hot climates. Total load assumes central air conditioning to the whole house from 4pm to midnight in living areas and 4 pm to 7am in sleeping areas and an appliance efficiency of 2.5. The actual magnitude of the loads will be considerably less for part house cooling. The percentage reductions in load are therefore the most important figures.

The extent of load reduction will depend on the installed capacity of the appliance. Equipment sizing in residential installations is fairly primitive and conservative. At its worst the actual load of the house is not calculated but is assumed to be proportional to volume and the size of equipment is designed to cope with the most severe conditions. To allow for the variability that such an unsophisticated approach to appliance sizing may give three representations of peak load are given for certain percentiles of load i.e. the 95.5 percentile is the load which is not exceeded for 95.5% of hours. It is common engineering practice to design equipment to meet the 95^{th} or more percentile of loads. Because current practices are conservative I believe the load reductions obtained are likely to be closer to the 99.5 percentile than the 95.5.

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4 Gene McGlynn, September 2004,:Realising the economic and environmental opportunities from improved energy efficiency", Business of Energy Efficiency Conference, Sydney

5 McLennan Magasanik and Associates 2004, op. cit.

6 National Framework for Energy Efficiency. "Towards a National Framework for Energy Efficiency — Issues and challenges" Discussion paper. Energy Efficiency and Greenhouse Working Group, November 2003.

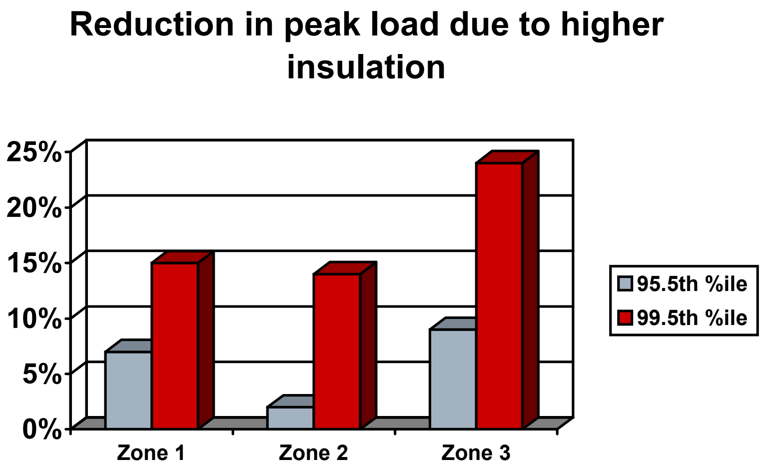

Figure 14 Reduction in peak air conditioning loads due to higher insulation in walls, floor and ceiling

The figure above shows substantial additional reductions in peak load could be obtained by the proposed regulations if higher insulation levels were specified in hot climates. The benefits of reduction in peak loads have never been evaluated in the history of the development of energy efficiency regulations for houses. Given the significant benefits peak load reduction brings the ABCB's evaluation of the benefits of its regulations must include these benefits if the true value of the regulations is to be ascertained. Such evaluation will only strengthen the case for higher levels of insulation.

7.4 Greenhouse Gases

Higher insulation levels will lead to higher energy savings. These energy savings in turn will produce reductions in greenhouses gas emissions caused by heating and cooling houses. It is important to remember that the efforts of Australia and the world to reduce greenhouse gas emissions as embodied in the Kyoto protocol and demonstrated in the proposed regulations will not stop global warming, it simply buy more time to take action. It is likely that in future further measures greenhouse gas reductions will become necessary. In this light it would be prudent to seek the highest level of greenhouse gas reduction possible now rather than continue to lock in poor performance of building elements for decades to come by under insulating. This case is made even stronger by the cash flow analysis in the previous section which showed that at virtually ***all*** insulation levels householder cash flow is improved. If one can reduce greenhouse gas emissions without any financial disbenefit it makes sense to try and maximise the reductions obtained through these measures. Add to this the findings in Victoria: that energy efficient housing regulations can provide a mild stimulus to economic growth and the case is complete. High insulation levels in hot climates (and the rest of Australia) has a small positive impact on household cash flow, probably provides a mild stimulus to economic growth, reduces peak loads and allows greater greenhouse gas reduction.

The table below shows the reduction in greenhouse gas emissions brought about through the energy savings reported in previous sections. Again, actual savings will vary depending on individual user behaviour.

climate zone	element	Reduction in annual Greenhouse Gas emissions due to insulation (tonnes)* R value					
		1.5	2	2.5	3	3.5	4
1	wall	1.3	1.3	1.4			
	ceiling		0.2	0.3	0.4	0.5	0.6
	floor	1.0	1.0	1.1	1.1	1.1	1.1
2	wall	1.1	1.2	1.2			
	ceiling		0.2	0.4	0.5	0.6	0.7
	floor	2.2	2.3	2.3	2.4		
3	wall	1.4	1.4	1.5			
	ceiling			0.3	0.4	0.4	0.5
	floor	2.4	2.5	2.6	2.7		

* compared to R0.0 in walls (shaded), R0.0 in floors and R1.5/2.0 in ceilings

Table 14 Tonnes of Greenhouse Gas savings due to various levels of insulation in climates 1, 2 and 3

The table above shows that insulation of suspended timber floors over unenclosed subfloor spaces produce significant benefits. This further reinforces the need to address this overlooked area in the regulations. Further, small though significant savings can be made by selecting higher insulation levels.

7.5 Comfort

If the recommendations of this report were to be adopted by the ABCB insulation would be used in hot climates at very high levels compared with conventional wisdom. The ABCB may then find that industry is critical of the regulations because industry will claim that the insulation will stop the house cooling down making it less comfortable and therefore force the occupants to install air conditioning. To investigate whether this concern is reasonable I conducted AccuRate simulations of house 1 in Longreach (zone 3). This is an extremely hot climate with a large diurnal range. If insulation is creating problems with cooling down it is likely to be felt in this climate.

Two simulations of House 1 were performed in ‘free running’ mode i.e. with no air conditioning or heating. Each house was constructed with weatherboard walls on an unenclosed suspended timber floor. The first was constructed to meet the proposed regulations. It used wall shading to avoid wall insulation, has only R2.0 in the ceiling and no floor insulation. The second was similar in all respects except that it had R1.5 wall and floor insulation and the ceiling insulation was increased to R3.5.

The graphs below compare the temperature performance of the two houses. The first set shows a histogram which sorts temperatures into 3 degree ranges between 9 and 42 degrees and the second set shows a temperature graph of internal temperatures in the hottest week.

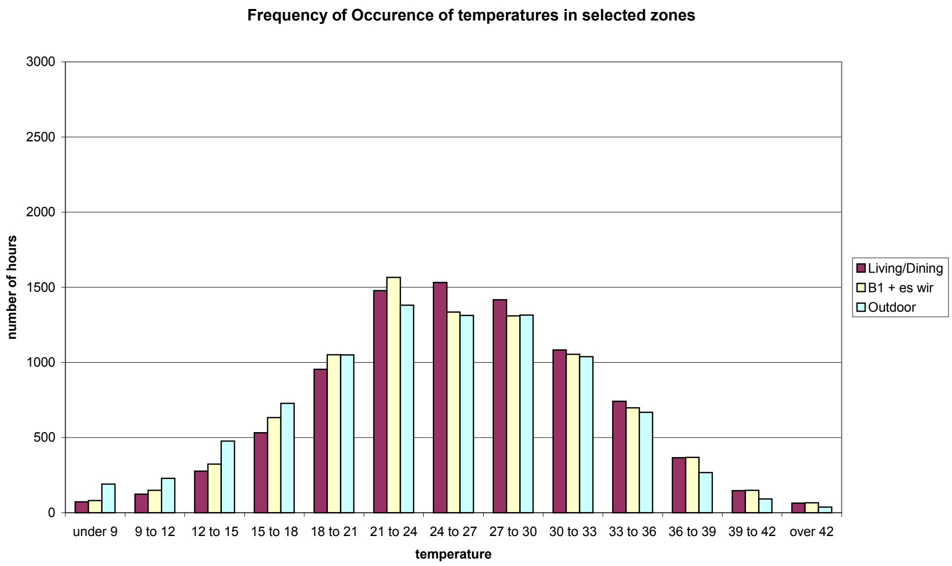

Figure 15 Temperature histogram for compliant house

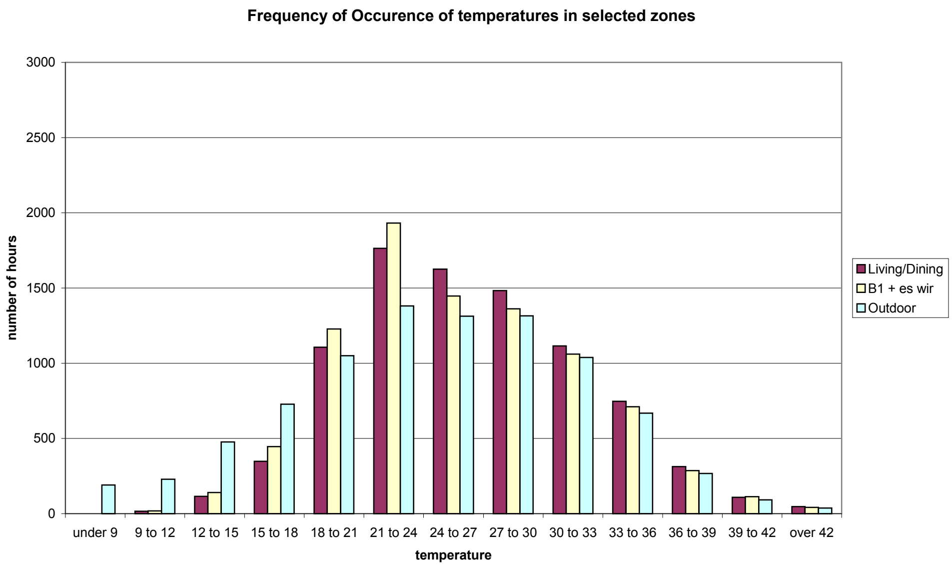

Figure 16 Temperature Histogram for highly insulated house

The graphs above show that the highly insulated house has a lower incidence of high and low temperatures than the compliant house.

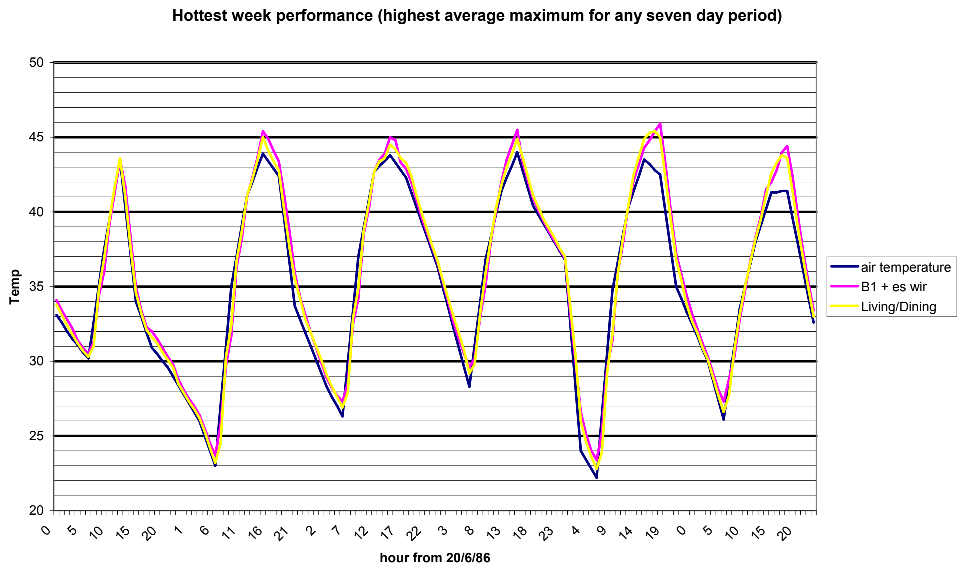

Figure 17 Hot day performance compliant house

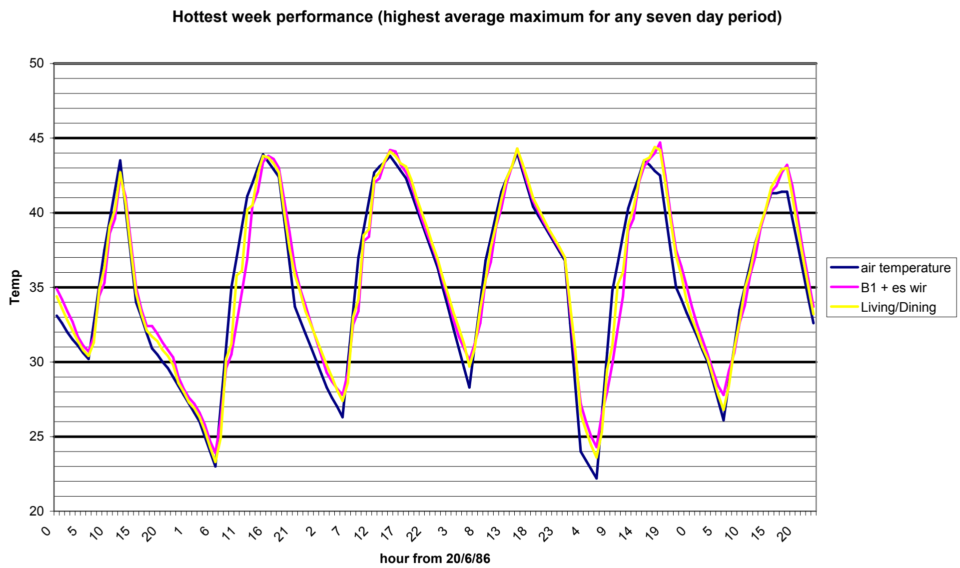

Figure 18 Hot day performance highly insulated house

The graphs above show that the highly insulated house has lower maximum temperatures than the compliant house by around 2 degrees and has only slightly higher minimum (around 1 degree).

The week selected is extreme with every day being above 40 degrees and only twice cooling down to below 25 degrees. Without thermal mass and additional active cooling systems there is little that most houses could do than hope to delay the impact of heat gains till later in the day and cool down as much as possible overnight.

Contrary to conventional wisdom the AccuRate simulations show that the highly insulated house performs better than the compliant house. This is not to say that conventional wisdom had it all wrong. Conventional wisdom draws its conclusions from experience with the current housing stock. In houses with large solar gains and without necessary ventilation insulation can certainly cause problems with cooling down. Houses which comply with the regulations have limits set to total solar gains and are required to have large adjustable openings to promote ventilation. Conventional wisdom does not apply to houses constructed to meet energy efficiency regulations because such houses are not conventional.

8 General Comments on the Regulations

8.1 Substantially increased complexity

The proposed regulations represent a significant step forward in effectiveness but also represent a substantial increase in complexity. The complexity of the impacts of building element performance on the energy demand of houses suggests that this step up in complexity is necessary if the regulation in order to deliver improved effectiveness. The extent of trade offs allowed and the calculations needed to support these tradeoffs and the need to calculate the conduction and radiation performance for each window and then recalculate using various options to determine how best to meet the house radiation and conduction targets will require substantial effort even where spreadsheets are used to simplify this process. Given the industry's significant experience with house energy ratings the amount of time taken to determine compliance with the deemed to satisfy provisions could easily exceed the time taken to perform a rating.

8.2 'Deemed to Satisfy' (DtS) still less accurate than ratings

There are a number of factors which make a rating a more accurate measure of building performance than the Deemed to Satisfy clauses:

- The impact of wall surface area is not included,
- The benefit of winter solar gains has not been allowed for,
- Actual ventilation of a house will depend on the orientation of openings to prevailing breezes and not simply the area of openings,
- The flow resistance to ventilation is more complex than the simple limit to the length of the ventilation path provided in the regulations,
- The impact of solar gains on cooling loads is NOT proportional to total gain but depends on other factors such as air temperature e.g. an east window may have the same solar gains as a west window but the cooler morning temperatures mean that this gain has a lower impact on air conditioning energy use,
- Heat losses through a floor depend on the ventilation rate under the floor. In rating tools floors with partially enclosed subfloors are distinguished from fully open or enclosed and have a heat loss level in between these two extremes. The regulation only differentiates between the two extreme cases.
- The impact of solar gains depends on the amount of thermal mass in the house but the regulations give only two selections: timber floor and slab floor. In reality the extent of carpet and the presence of internal masonry walls will have a substantial effect on the impact of these solar gains on actual energy use but this is not accounted for by the regulation.
- The impact of overshadowing buildings may mean that the radiation figures in the regulations are grossly overestimated.

It is not possible to determine how the Deemed to Satisfy requirements compare to ratings as the new 5 star rating level has not yet been built in to AccuRate. However, given the range of limitations described above it seems likely that there will be many cases where the rating performance of deemed to satisfy houses will be worse than 5 stars.

8.3 Cost benefits of ratings vs 'DtS'

The evaluation of the Victorian 5 star regulations by Energy Efficient Strategies[7] shows that a performance rating delivers substantial cost savings over elemental performance requirements. In the case of Victoria this was predicted to be around $1500 per house i.e. a cost saving of over 40%. This saving together with the complexity of developing DtS regulations that deliver a consistent rating performance level led the Victorian government to abandon the use of DtS altogether. It is not yet clear whether the proposed regulations will show similar savings as the 5 star rating levels, at time of writing, were still to be advised. However, it is intuitively clear that if the regulations do deliver a reasonable minimum performance they will require some houses to over specify and that there will be cost advantages for these houses in using the rating. While one could argue that the market will take such decisions it probably will not be clear to many builders and which houses will achieve compliance more cheaply using a rating than the DtS, particularly among smaller building companies (which build a substantial proportion of houses) as they have less resources to devote to this task.

8.4 Educational benefits of ratings

The energy performance of a house represents a complex set of interdependent design and construction relationships. The true complexity of this interaction can only be approached by hourly simulation using rating tools. The educational resources available to the industry about energy efficient house design have not yet shown the benefit of the more sophisticated analysis rating tools provide. In general the information on energy efficient design is limited to passive solar principles, yet rating tools show there are many more bona fide options to achieving an energy efficient outcome.

By involving industry in the use of ratings significant educational benefits arise. Experimentation with the rating shows builders and designers solutions which they would have otherwise been unaware of. It is possible to break all the passive solar 'rules of thumb' but still deliver an energy efficient outcome. Where industry has focussed more on the rating the improved sophistication of the design response has resulted in significant cost savings. Henley Properties in Victoria shifted all their designs to five stars 24 months in advance of the introduction of the 5 star regulations. They report that their cost to achieve 5 stars is more like $1,000 - $1,500 per house rather than the $3,300 predicted by the Victorian Governments 5 star cost benefit study. This has been primarily achieved through their

[7] EES, 2002, Comparative Cost Benefit study of Energy Efficiency Measures for class 1 buildings and high rise apartments in Victoria, prepared for the Sustainable Energy Authority and the Building Commission, Final report July 2002.

detailed understanding of the working of the rating scheme and building this understanding into the development of new designs.

8.5 Regulations should move to be rating only as soon as possible

The benefits of rating as described above mean that their use is far superior to the application of DtS clauses. Ratings no longer represent a significant increase in complexity, are inherently more accurate, and provide educational and cost advantages for industry. The long experience with rating only regulations in the ACT, NSW and Victoria shows that industry can successfully adapt to such regulations. The controversy over ratings in hot climates has, however, limited the industry's experience with ratings in these climates.

In the ACT there was a limited transition period where a tabular method of calculating house performance was allowed and use of the existing '4 star' DtS was allowed in Victoria for those builders who sought to achieve the 4 star rating in the initial 12 month transition period. It is therefore understood that industry may need DtS solutions for a period while they adapt to the rating. However the benefits of a rating approach are so compelling that ABCB should be seeking to remove the DtS clauses completely within 24 months of introduction. While the ABCB has acknowledged that there may be a need to move to a full performance rating system in future it has been noncommittal on specific detail. It is therefore recommended that the ABCB commit to the introduction of full performance rating across Australia and the phasing out of the DtS provisions.

8.6 Recommendation 9: Due to the compelling benefits of energy ratings for industry ABCB should announce a plan for the introduction of rating only regulations and the phasing out of DtS.

9 Conclusion

The new regulations are a step in the right direction. They generally increase insulation levels and should be supported by the insulation industry. However, these regulations continue the myth that only minimal insulation is needed in hot climates. This report has found that substantially higher insulation levels should be used in northern climates. Further, a number of the trade offs proposed allowing lower insulation levels are either unjustified or could have the unintended consequence of potentially lowering the level of insulation installed across the board. Several recommendations have been made to adjust the application of the trade off mechanisms.

The concern that high insulation levels would lead to houses that were unable to cool down was also examined. Lightweight insulated houses which have proper control of solar radiation gains through windows and have adequate ventilation are not adversely affected by high insulation levels. In fact the insulation helps such houses to maintain more comfortable conditions.

Finally the benefit of the energy rating approach over the use of DtS regulations was examined. These benefits are so great that the report recommends phasing out of the DtS altogether.

10Appendix A Simulation results

Zone	Floor	Walls			Heat	Cool	Tot	Shade savings	Insulation savings
		Type	shade depth	Ins R					
1	Slab	BV	0	0	0	562	562		
	Slab	BV	0.6	0	0	553	553	9	
	Slab	BV	0	1.5	0	505	505		57
	Slab	BV	0.6	1.5	0	503	503	2	50
	Timber	Weatherboard	0.6	0	0	635	635		
	Timber	Weatherboard	0	1.5	0	572	572		63
2	Slab	BV	0	0	17.3	69.2	86.5		
	Slab	BV	0.6	0	17.7	67.8	85.5	1	
	Slab	BV	0	1.5	10.7	64.5	75.2		11.3
	Slab	BV	0.6	1.5	10.9	64.9	75.8	-0.6	9.7
	Timber	Weatherboard	0.6	0	96.2	95.8	192		
	Timber	Weatherboard	0	1.5	79	84.2	163.2		28.8
3	Slab	BV	0	0	3.4	169.7	173.1		
	Slab	BV	0.6	0	3.5	164.9	168.4	4.7	
	Slab	BV	0	1.5	1.7	137.2	138.9		34.2
	Slab	BV	0.6	1.5	1.8	136.4	138.2	0.7	30.2
	Timber	Weatherboard	0.6	0	53.3	297.3	350.6		
	Timber	Weatherboard	0	1.5	42.9	255.7	298.6		52

Table 15 Simulation results comparing impact of shading walls with insulation

Storeys	Wall Ins R	Heat	Cool	Total	
1	1.5	73	39.3	112.3	
1	2	70.1	38.7	108.8	96.9%
1	2.5	68.2	38.5	106.7	95.0%
2	1.5	85.6	32.3	117.9	
2	2	80.2	31.8	112	95.0%
2	2.5	76.6	31.5	108.1	91.7%

Table 16 Comparison of energy savings achieved through various wall insulation levels for the one and two storey houses

Zone	Floor	Walls			Ceil.	Floor	Heat	Cool	Total	Energy Saving		
		Type	shade depth	Ins. R	Ins. R	Ins. R				Walls	Ceiling	Floor
1	Timber	WB	0.6	0	1.5	0	0	635	635			
1	Timber	WB	0	1.5	1.5	0	0	572	572	63.0		
1	Timber	WB	0	1.5	3.5	0	0	547	547		25.0	
1	Timber	WB	0	1.5	3.5	1.5	0	497	497			50.0
2	Timber	WB	0.6	0	1.5	0	96.2	95.8	192			
2	Timber	WB	0	1.5	1.5	0	79	84.2	163.2	28.8		
2	Timber	WB	0	1.5	3.5	0	68.8	79.4	148.2		15.0	
2	Timber	WB	0	1.5	3.5	1.5	26.3	77.1	103.4			44.8
3	Timber	WB	0.6	0	2	0	53.3	297.3	350.6			
3	Timber	WB	0	1.5	2	0	42.9	255.7	298.6	52.0		
3	Timber	WB	0	1.5	3.5	0	38	247.2	285.2		13.4	
3	Timber	WB	0	1.5	3.5	1.5	11.7	191.2	202.9			82.3

Table 17 House 1 impact of wall, ceiling and floor (unenclosed suspended) insulation changes

Climate Zone	Floor Construction	Reduction in peak cooling load due to higher insulation levels			
		Percentile of load	kW load on grid		% reduction in load due to higher insulation
			Higher Ins	BCA Ins	
1	Slab	95.5%	3.6	4.2	14%
		97.5%	5.1	5.5	8%
		99.5%	6.5	7.0	7%
	Timber	95.5%	3.8	4.5	15%
		97.5%	5.6	6.1	8%
		99.5%	7.2	7.8	7%
2	Slab	95.5%	0.8	1.0	14%
		97.5%	1.2	1.4	13%
		99.5%	2.1	2.4	9%
	Timber	95.5%	0.9	0.9	2%
		97.5%	1.3	1.4	2%
		99.5%	2.4	2.5	6%
3	Slab	95.5%	2.5	3.5	27%
		97.5%	3.7	4.5	18%
		99.5%	6.0	6.6	9%
	Timber	95.5%	3.2	4.2	24%
		97.5%	4.6	5.6	18%
		99.5%	7.8	8.6	10%

Table 18 Reduction in cooling load for house 1 due to higher insulation levels in hot climates

Wednesday, 6 April 2005

The Energy Efficiency Project
Australian Building Codes Board
GPO Box 9839
Canberra ACT 2601
Attention Mr. Mark Davis

Dear Mark,

RE: Proposed 5 star housing energy efficiency regulations

The Insulation Council of Australia and New Zealand (ICANZ) was formed in July 2004 to replace the industry association, FARIMA. This body now includes New Zealand membership reflecting the trend towards common building standards, closer ties in research, testing and other trans-Tasman building initiatives. Please find attached further brief details on ICANZ.

Issues of energy supply, energy efficiency, climate change and sustainability are now high on the agendas of both government and industry. The insulation industry has an important role to play in addressing these issues.

ICANZ commissioned Tony Isaacs Consulting (TIC) to evaluate the impacts of the new regulations. Tony is one of Australia's foremost experts in energy efficient housing and thermal modelling. Tony used the AccuRate simulation software (v0.99 2.0) to evaluate the impacts of the regulations. AccuRate is the current state of the art in Australian house thermal performance simulation. His report is attached. We believe that ABCB will find his analysis very useful in helping to improve the proposed regulations.

ICANZ supports the development of regulations to a 5 star standard. In an international context, however, this standard is still far from world's best practice. Standards in European and North American countries *with similar temperate climates* are higher and further increases to stringency are planned in response to the need to contain greenhouse gas emissions. ICANZ therefore believes that the proposed regulations are a step in the right direction, but that further improvements are likely to be necessary over time.

While ICANZ supports the development of regulations to a 5 star standard and the regulations in general, there are some specific aspects of the regulations which fail to capture cost effective energy savings. ICANZ proposes the following amendments:

1 A simple solution to insulation R values across Australia.

The TIC report demonstrates that the conventional wisdom of providing only minimal levels of insulation in hot climates so that buildings can cool down more rapidly is incorrect for houses which conform to the new regulations. Because the regulations limit solar gains and provide adequate ventilation high levels of insulation will not create 'hot boxes'.

Conventional wisdom does not apply to houses conforming to the new regulations because such houses are not conventional.

Insulation is the simplest and most cost effective way to improve comfort, energy use and greenhouse gas emissions from heating and cooling Australian houses. Increased insulation levels have small incremental costs yet deliver significant energy, peak load, comfort and greenhouse benefits that do not affect housing affordability because it pays for itself. The proposed regulations, however, recommend quite low levels of insulation in hot climates. The TIC report demonstrates a wide variety of benefits for increasing the required insulation levels in hot climates:

- ***R3.5 ceiling insulation in climate zones 1 to 3 is undoubtedly cost effective***.
- ***All insulation R values have a similar effect on household cash flow.*** In most cases ***even if energy savings were half the predicted level this impact would still be positive even at the highest R values***. While this analysis has been completed only for climate zones 1 to 3 it is very likely to apply to all other climate zones.
- ***Insulation of timber floors over unenclosed sub floor spaces produces energy savings which are greater than wall insulation*** in climates 1 to 3.
- ***A high level of insulation improves comfort as well as reducing energy use in hot climates.***
- ***Higher insulation*** levels to walls floors and ceilings in hot climates can ***reduce energy use and greenhouse gas emissions in climates 1 to 3 by 22%, 27% and 42%*** respectively.
- ***This higher insulation also helps to further reduce domestic air conditioning peak loads by typically 10 -15%*** in the houses studied. With the stock of air conditioners set to rise by 50% in all states (2,000,000 across Australia) in the next 10 years every reduction in peak loads that the regulations can achieve will provide substantial benefit.

Because higher wall ceiling and floor insulation levels are clearly beneficial in climates 1 to 3 the variation in required R values across Australia should be minimal. This provides ABCB with the opportunity to simplify the regulation, with only minor variations required for Alpine areas and enclosed subfloors. The following total R values are recommended:

Element	Total R value
Ceilings	3.9
1 storey walls	2.5
2 storey walls	3.0
Floors with unenclosed subfloor space	3.7

These insulation levels would also increase the required R values in climates 4 to 6 and in some cases climate 7. While not directly studied in the TIC report ICANZ believe that these higher R values would be easily justified due to the small incremental costs of higher insulation as the cash flow analysis for climates 1 to 3 demonstrates. High insulation levels provide improved performance of opaque elements and this allows greater flexibility in other areas such as glazing area without sacrificing efficiency and will help the regulations achieve a more consistent star rating outcomes.

2 Trade off clauses allowing lower insulation should be deleted

The TIC report shows

- The trade off between wall shading and wall insulation does not work. ***Insulation produces energy savings which are 6 to 10 times greater than the wall shading***.
- The wall insulation / higher performance glazing trade off intended for use with mud brick houses could also be used to lower wall insulation levels in general for houses which achieve better glazing performance than the minimum. The larger the house the more likely the glazing performance will be better than the minimum as such houses have lower glass to floor area ratios. Consequently ***large houses with the highest total energy use will able to use the lowest insulation levels***.

While ICANZ understands ABCB's need to provide flexibility it believes energy ratings already provide this and there is no need to allow for additional flexibility in the Deemed to Satisfy clauses. Construction of trade off clauses can not hope to represent the true complexity of the thermal performance of a house with the accuracy of a rating tool. ***Energy rating is the only reliable way to allow trade off performance between elements that does not sacrifice easily obtainable energy savings***.

3 The Deemed to Satisfy clauses should be phased out

Energy Ratings have many benefits. The Victorian Sustainable Energy Authority has shown they can lower compliance costs, and they help to educate the user in good design. The increased complexity of the proposed regulation means that the time taken to determine compliance using an energy rating is similar to establishing compliance using the DtS. There seems to be little reason to persist with DtS in future particularly as the industry has shown that it can cope with rating only regulations in the ACT, Victoria and the NSW energy smart homes program.

While the DtS are generally a great improvement over the 2003 regulations there are still many important factor that rating tools handle far better such as winter solar gains, overshadowing, surface area effects and area correction. This means that inevitably the DtS will struggle to deliver a consistent rating level and may even fail to achieve 5 stars at all for some houses. Further, as the rating scheme evolves and improves in response to the needs of industry and technological development the existing DtS will depart further and further from the 5 star solution.

ICANZ believes that these regulations should be the last to contain DtS clauses and that a time table for the phasing out of the current clauses should be developed. The earlier such an announcement is made the sooner industry can begin to adapt, so ICANZ believes ABCB should spell out a time frame for the sunset of the DtS prior to their introduction.

ICANZ notes that the ABCB is yet to release its Regulatory Impact Statement which will presumably detail the costs of energy efficiency improvements and their associated energy, greenhouse and peak load benefits. ICANZ looks forward to providing further comment when this is released.

The parameters of the new rating schemes are yet to be finalised. ICANZ believes it is important that the DtS do achieve consistent rating levels across the board and would like to take the opportunity to make further comment on this issue when the parameters of the new rating scheme are finalised.

Finally ICANZ wishes to advise the ABCB that the R values attributable to reflective foil products are currently being updated by the Australian Standards committee. This would mean that the R values listed in the regulations for foil products in horizontal or sloping applications will need to be revised once the committee has made its decision.

Yours sincerely

Dennis J D'Arcy

ICANZ President.