**From:** Thompson, Ray
**Sent:** Monday, 19 April 2010 3:56 PM
**To:** Dawson, Geoffrey (SEN)
**Subject:** Home Insulation Program

Dear Geoff

Dennis Darcy from ICANZ passed on your request for information about my comments at the Senate Inquiry regarding bulk insulation's suitability in all climate zones. As you are probably aware ICANZ members Fletcher Insulation and CSR Bradford Insulation manufacture around 75% of all reflective foil made in Australia, have 5 mineral wool bulk insulation plants and supply most other insulation products except sheepswool and cellulose fibre.

Insulation is installed to improve heat transfer management in buildings. Heat transfer occurs via three main routes – convective, conductive and radiant. The building design, orientation and climatic location will impact on the relative importance of each of these in determining the insulation type and levels to be installed in a building – but they all apply to some extent in all cases. This is fundamental building science.

The measure of insulation products/systems ability to resist heat transfer and thus be a good insulator is the R value. The greater the R value the greater the resistant to the flow of heat. This works in both directions. It is simply the temperature differential which drives the rate of heat flow.

Reflective foil installations are better at resisting radiant heat transfer than bulk insulation but poorer at resisting conductive and convective heat transfer. In themselves they do not have an R value but must be installed as a system to achieve a reflective still air space as insulation. Bulk insulation also works by creating still air spaces but inside the insulation product. It is just designing the right product combination based on the information on relative importance of the heat transfer mechanisms in each building and location.

Both can be used in all climate zones and my statement that bulk insulation is suitable in a climates is basic building science. All government and scientific documents on energy savings( such as the one attached, plus the CSIRO and previous AGO documents in Australia and BRANZ in New Zealand) list all types of insulation products as usable in all applications. It is a matter of design based on relative heat transfer objectives as to what type of insulation is installed to provide the best heat transfer outcome.

Issues raised at the senate Inquiry by AFIA and their consultant Dr Aynsley have been considered by both Australian and international experts for many years.

Yes, bulk insulation will retain heat in a building in warmer ( heat flow down dominant) climates. That is because it has a higher R value and resists the flow of heat out from the building when the inside temperature exceeds the outside temperature. However because it is better at resisting the heat flow in, the heat build up will be less and the home cooler. In a foil only installation the heat flow in and out is usually higher ie lower R value, and so it does cool down the house faster at night without ventilation or air conditioning but the house will be hotter to start with so not an ideal design. So bulk insulation is essential in hot climates to reduce the heat flow in and when used in combination with ventilation will provide the optimum heat transfer management outcome for the building. Obviously foil only applications are therefore even worse in heat flow out dominant (winter heating) climates and is not usually recommended for these applications. Reflective foil is often recommended in warmer climates – in conjunction with bulk insulation but not as substitute.

To demonstrate this CSR has undertaken internal research on test buildings which have proven this effect very clearly. It does not matter whether it is reflective air space or bulk insulation it is the R value that matters. We would be happy to go through our research with any designated building scientist the Senate would like to nominate. It shows the positive impact of using higher R value insulation in warmer climates to reduce heat flow into the building. Obviously the greatest heat loss when the external temperature drops below the internal temperature will occur with no insulation but this is also leads to the highest daytime temperature.

All this applies for an non-conditioned building. If the building is air conditioned then higher R value insulation is by far the better option for reducing energy loss and bulk insulation delivers this most reliable across day and night, winter summer temperature ranges.

Also attached are comments from Adjunct Prof Tony Isaacs regarding insulation in warm climates.

With regard to claims that bulk insulation absorbs moisture in tropical climates thus reducing it's effectiveness, this is certainly not the case with mineral wool bulk insulation which have <1% moisture absorption rates and therefore insignificant impact on thermal performance. Foil on the other hands does suffer potential long term moisture deterioration which is why most foil suppliers including CSR, do not guarantee lifetime performance of foil we manufacture whereas mineral wool performance is guaranteed for life.

Managing condensation is critical in warmer climates and a vapour barrier such as reflective foil is generally recommended to provide this barrier but to keep the temperature above the dew point bulk insulation generally needs to be added. Thus the recommended product in tropical climates is foil faced bulk insulation under metal roofs. This is what building science tells us and this is what is recommended generally around the world from our experience ( Note CSR has had insulation operations in SE Asia and sub-tropical China since the 1980's.)

I hope this helps provide some background information. There would be no problem to align a long list of local and international experts including CSIRO, BRANZ in New Zealand, European and USA government and independent technical experts to support the basic building science above and we will do this if required.

Regards
Ray Thompson
Group Marketing Manager
Bradford Insulation CSR

# Insulation Levels & Climate Zones

Different rooms or parts or the house and different climates may involve different recommended amounts of insulation... You should take into account your particular climate zone, the parts of the house you want to insulate and the insulating R-Value of the material you should apply...

## Climate and Insulation

The main goal of insulation in cold climates is to reduce heat losses (to reduce the summer heat is a secondary goal), while in tropical humid climates, the insulation main goal is to reduce heat gains (a secondary goal is to keep cooled air inside).

But there are other mixed situations. In some warm climates and hot dry climates with cold winters, the insulation goal will be to reduce both heat losses and heat gains.

Besides, as expected, recommended insulation levels vary a lot with the part of the house. Roof, ceiling, walls, floors and basements have different insulation R-value needs...

## Recommended R-Values in cold and mix climates

The recommended values shown below (from the American Energy Star) for American climates, can be applied to other states worldwide (see also Recommended R-values in hot and tropical climates). Just pay attention to the the sub-types of climate considered in the table (for hot and tropical climates, see climate. The values are expressed in the non-SI rating system (conversion relation: 1 (SI)/5,67 (non SI); see, for more details on this issue: R-Values).

| Recommended Insulation R-Values for Existing Houses | | | | | | |
|---|---|---|---|---|---|---|
| TYPE OF CLIMATE | TYPE OF HEATING SYSTEM [b] | LEVELS OF INSULATION | | | | |
| | | Ceiling | Wood-frame wall | Floor | Basement/ Crawl space walls [d] |
| **Warm with cooling and minimal heating requirements** (i.e., FL & HI; coastal CA; southeast TX; southern LA, AR, MS, AL & GA). | gas/oil or heat pump | R-22 to R-38 | R-11 to R-13 | R-11 to R-13 | R-11 to R-19 |
| | electric resistance | R-38 to R-49 | R-13 to R-25 | R-13 to R-19 | R-11 to R-19 |
| **Mixed with moderate heating and cooling requirements** (i.e., VA, WV, KY, MO, NE, OK, OR, WA & ID; southern IN, KS, NM & AZ; | gas/oil or heat pump | R-38 | R-11 to R-22[c] | R-13 TO R-25 | R-11 to R-19 |

| | | | | | |
|---|---|---|---|---|---|
| northern LA, AR, MS, AL & GA; inland CA & western NV). | electric resistance | | R-11 to R-26[c] | R-25 | R-11 to R-19 |
| **Cold** (i.e., PA, NY, New England, northern Midwest, Great Lakes area, mountainous area (e.g., CO, WV, UT, etc.)). | gas/oil | R-38 to R-49 | R-11 to R-22[c] | R-25 | R-11 to R-19 |
| | heat pump or electric resistance | R-49 | R-11 to R-28[c] | R-25 | R-13 to R-19 |

b. Insulation is also effective at reducing cooling bills. These levels assume your house has electric air-conditioning.

c. R-values may be achieved through a combination of cavity insulation and rigid board insulation and are for insulation only (not whole wall).

d. Do not insulation crawl space walls if crawl space is wet or ventilated with outdoor air.

# R-Values in hot, temperate warm and tropical climates

The recommended values shown below (from the Australian Government Greenhouse) for Australian climates, are also valid to temperate-warm and tropical climates in most other countries. Be aware with those values: pay attention to the 5,67 factor for a non-SI rating (see, for more details on this issue: R-Values).

Pay also attention to the meaning of the zero value, in the table. That zero doesn't mean that no insulation is needed. It just means that insulation to reduce heat loss may not be needed and can cause overheating in houses without a proper sun control. In these cases, you should use a proper type of insulation: one that prevents heat gains without restricting heat losses. In technical terms: you should use insulation with high down r-values and low up r-values.

Note**:** In hot climates insulation should prevent heat gains without restricting heat losses, to avoid overheating. To get it, people use reflective insulation materials, with high down r-value and a low up r-value. Up R values - or winter R-values - describe resistance to heat flow upwards (heat escaping into outdoors through roofs or walls…); Down R – or summer R-values - describe resistance to heat flow downwards (heat entering into the house through roofs or walls…).

| CLIMATE TYPE AND EXAMPLE OF LOCATIONS | RECOMMENDED INSULATION LEVELS (material or system R values) | |
|---|---|---|
| | ROOF/CEILING | WALL |
| **Cool Temperate & Alpine** | | |
| Melbourne, Vic | 3.0 x 5,67 | 1.5 x 5,67 |
| Canberra, ACT | 3.5 x 5,67 | 1.5 - 2.0 x 5,67 |
| Hobart, Tas | 3.5 x 5,67 | 1.5 - 2.0 x 5,67 |
| Mt Gambier, SA | 3.0 x 5,67 | 1.5 - 2.0 x 5,67 |
| Ballarat, Vic | 3.5 x 5,67 | 1.5 - 2.0 x 5,67 |

| | | |
|---|---|---|
| Thredbo, NSW | 4.0 x 5,67 | 1.5 - 2.0 x 5,67 |
| **Hot Humid & Hot Dry** | | |
| Darwin, NT | 0* -4.0 x 5,67 | 0* - 2,0 x 5,67 |
| Cairns, Qld | 0* -3.5 x 5,67 | 0* - 1,5 x 5,67 |
| Broome, WA | 0* -4.0 x 5,67 | 0* - 2,0 x 5,67 |
| Marble Bar, WA | 0* -4.0 x 5,67 | 0* - 2,0 x 5,67 |
| Mt Isa, QLD | 0* -4.0 x 5,67 | 0* - 2,0x 5,67 |
| Tennant Creek, NT | 0* -4.0 x 5,67 | 0* - 2,0x 5,67 |
| Townsville, QLD | 0* -3.5 x 5,67 | 0* -1,5 x 5,67 |
| **Temperate & Warm Humid** | | |
| Brisbane, QLD | 1.5 - 2.5 x 5,67 | 1.0 x 5,67 |
| Perth, WA | 1.5 - 3.0 x 5,67 | 1.5 x 5,67 |
| Alice Springs, NT | 1.5 - 4.0 x 5,67 | 1.5 - 2.0 x 5,67 |
| Bourke, NSW | 1.5 - 4.0 x 5,67 | 1.5 - 2.0 x 5,67 |
| Sydney, NSW | 1.5 - 3.0 x 5,67 | 1.5 x 5,67 |
| Adelaide, SA | 2.0 - 3.0 x 5,67 | 1.5 x 5,67 |
| Katoomba, NSW | 4.0 x 5,67 | 1.5 - 2.0 x 5,67 |

# Reflective insulation (Radiant barriers)

Reflective insulation - mainly applied in roofs with the goal of blocking the sun's heat - is a very specific case. While highly advantageous in hot-warm climates, reflective insulation is often dispensable in colder climates.

See: Reflective Insulation.

See also:

R-Value: Insulation performance
Insulation benefits
Insulation materials
Cellulose insulation
Fiberglass and Mineral Wool insulation
Sprayed foam insulation
Insulation performance
Roof Insulation
Walls Insulation
Floor Insulation
Slab Insulation
Basement insulation
Moisture and insulation
How to deal with Insulation contractors and home builders
Insulation tips

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# INTRODUCTION

The Senate inquiry into the Household Insulation Program took evidence from Dr Richard Aynsley, Director, of Building Energetics Pty Ltd, a former UNESCO Professor or Tropical Architecture, James Cook University in which he outlines the benefits of reflective foil products over bulk insulation products. ICANZ engaged Tony Isaacs Consulting to provide technical comments on this submission.

In general the submission was found to oversimplify the potential benefits of reflective insulation products over bulk insulation products. There is ample evidence to the contrary. This report looks at each of the points raised in turn.

## Law of Diminishing Returns

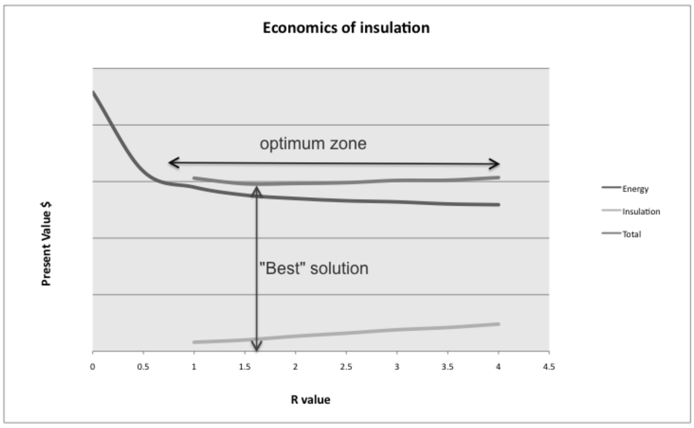
### From the submission:

> To the extent that cooling costs are proportional to cooling loads, a reliable value can be attached to each unit of conductance and if data on conductances are available it is a relatively simple matter to determine how much bulk insulation – such as fibreglass - to use. Increased insulation is subject to diminishing returns.
>
> If 10mm will reduce the U-value (conductance) from 30 W/m2 deg C to 15 W/m2 deg C, it will take 20mm of the insulation material to reduce conductance further to 7.5 W/m2 deg C. The 20mm extra (insulation) will cost roughly twice as much for the extra insulation and will have only half as much effect as the first 10mm. Is this what we should be doing?

### Comment:

The information presented above is an oversimplification of reality. It has overlooked the cost of installation which is over half the cost of insulation and does not vary significantly with the amount of insulation installed. So in the example given the insulation would not cost twice as much but only around 50% more.

The real issue that these comments are seeking to address is the question of how much insulation is enough. There are diminishing returns to insulation, and the question of how much to install is traditionally to evaluate the Net Present Value (NPV) of insulation and energy costs over the life of a house. This discounts energy savings in future and compares the total cost of insulation and energy savings over the life of a building at various R values to determine an ‘economic optimum’. The NPV evaluation typically produces results like those shown in the graph below:




The majority of the savings are usually obtained in the first R 1, but the additional savings continue to be cost effective up to an economic optimum point. The disbenefits of using much higher levels of insulation are often quite small at R values at up to double the 'optimum' – an optimum zone.

Given the certain higher costs of energy in future due to a carbon price and the increasing cost of meeting peak loads (not included in the chart) it is often sensible to choose a high level of insulation as the disbenefit is so small at today's costs. And there are further benefits of a higher R value at peak air conditioning times as this can reduce the total air conditioning load the house places on the electricity grid.

## Horses for Courses

### From the submission:

> Not all insulation has the same characteristics. Bulk insulation, such as fibreglass, is somewhat effective in reducing heat transfer by conduction and convection. Radiant barriers, such as reflective foil, are highly effective at controlling heat transfer by radiation. More than 80% of heat transfer downward through roof spaces is by radiation. For the hot summer conditions, experienced over virtually the whole of Australia, radiant barriers should be mandatory in all **roof** construction. If bulk insulation, such as fibreglass, is installed directly under metal roofs, which is frequently the case, it will be subjected to temperatures up to 100 deg C, but only rated for R-values for an external temperature of 23 deg C! This needs to change.

### Comment

All three modes of heat flow are present in the heat flow through a roof, and they interact with each other. Simply because a product works primarily on radiation does not make it superior. 80% of heat flow down across a roof cavity may be by radiation on a hot summers day with bright sun and a dark roof surface. Once that heat has cross the roof cavity ***it can only flow into the house by conduction through the ceiling material***. Adding bulk insulation above the ceiling stops most of the heat flow that has crossed the roof cavity from entering the house. Reflective/low emissive insulation (radiant barrier) simply stops the heat flow in a different way. For the same R value at the same temperature conditions R1 provided by any type of insulation has the same effect.

## Diodal Effect of Radiant Barriers

### From the submission:

> It is often overlooked that radiant barriers, while highly efficient at controlling downward heat flow in summer, have a much lower resistance to upward heat transfer after sundown. This has the effect of providing excellent protection from solar heat gain during the day but allowing rapid cooling of the interior of the building after sundown as demonstrated by full-scale studies at The Australian Institute of Tropical Architecture at James Cook University. Relying solely on bulk insulation in roofs will slow down the cooling of buildings in winterless climates after sundown (BCA Climates zones 1 and 2).

### Comment

The key question in deciding what type of insulation is best suited to a house in a winterless climate is not simply that one type allows the house to cool down more quickly. It should also look at how much the house heats up during the day. If a house does not heat up as much during the day the fact that it can't cool down as quickly during the night is not important if it is more comfortable inside because it never got as hot in the first place.

A single radiant barrier has an upper limit on how much resistance to heat flow down it can provide. It does not eliminate heat flow, like all other insulation it reduces heat flow. If a bulk insulation product adds a significantly higher thermal resistance during the day than a radiant barrier it can reduce heat gains by far more than it reduces heat losses.

Furthermore, night ventilation can provide a cooling effect either by replacing warm internal air with cooler outside air or by providing air movement to make the occupant feel cooler. In a well designed house this effect can be an order of magnitude larger than the heat losses through a roof at night. This substantially diminishes the potential disbenefit of lower heat losses through the roof at night.

The diodal effects of radiant barriers have now been built in to the Nationwide House Energy Rating Scheme. All rating tools model horizontal and sloping surfaces with much higher R values for heat flow down than for heat flow up. These tools generally show that the diodal effects of radiant barriers are not sufficient to lead to lower air-conditioning loads when compared to significant levels of bulk insulation. See attachment on the impact of insulation thermal comfort in houses in hot climates.

## Critical Difference between Radiation and other Modes of Heat Transfer

### From the submission:

> Current techniques for calculating heat transfer in buildings avoid the complexities of radiant heat transfer by lumping a crude allowance for radiation together with conductive and convective heat transfer. More precise techniques are available but are generally ignored.
>
> Combining heat transfer, by conduction and convection, with radiation is problematic for the following reasons. Heat transfer by conduction and convection is proportional to temperature, (t1 – t2). Heat transfer by radiation is proportional to (t14 – t24) where t is in degrees Kelvin (deg C + 273).
>
> Long wave (infrared) radiation is an important contributor to heat transfer across cavities in roof and wall construction. For simplicity in building design, resistance to such heat transfer is usually lumped in with resistance to heat transfer by conduction and convection into a single R value (m2.K/W) for the cavity. It is important to note that heat transfer by

conduction and convection is proportional to the difference between surface temperature t1 in degrees Kelvin raised to the 4th power and surface temperature t2 in degrees Kelvin raised to the 4th power. This simplification of lumping radiation with conduction and convection can result in significant error, particularly in countries like Australia where lightweight metal roofing and high intensities of solar radiation often result in metal roof temperatures up to 100° C.

Consider heat transfer across a horizontal cavity in a low pitch metal decked roof. On a comfortable overcast day the zinc/aluminium finish metal roof temperature is likely to be approximately 60° C (333K) and the ceiling temperature is around 25°C (298 K), a temperature difference of 35° C (35K). The AIRAH Handbook suggests an R value of 0.17m2.K/W for a 100 mm horizontal cavity with high emittance surfaces when heat flow is downwards. For a temperature difference of 35K the heat transfer per square metre would be 206 Watts (35/0.17). Now consider downward heat transfer across the same horizontal roof on a hot day when the metal roof is around 90° C (363K) and the ceiling temperature is around 55° C (328K), a temperature difference of 35° C (35K). The R value of 0.17 m2.K/W and temperature difference of 35K remain the same the heat transfer per square metre would be the same 206 Watts (35/0.17).

The equation for the net radiant heat transfer across a cavity between two large parallel plates can be derived (Geankoplis, 1983) using Plank's law, Kirchhoff's law and the Stefan-Boltzmann law as:

Q = A (σ [t14 - t24] / [1/ε1 + 1/ε2 -1] ) W

Where:

Q = Net radiant heat exchange in Watts

A = Sample surface area of each of the large parallel plates taken as 1 m2

σ = A constant for blackbody radiation taken as 5.676 x 10-8,W/m2•K4

t1 = Surface temperature of plate 1 in degrees Kelvin

t2 = Surface temperature of plate 2 in degrees Kelvin

ε1 = Long wave emissivity of surface of plate 1

ε2 = Long wave emissivity of surface of plate 2

Using this equation and assuming both surfaces have an emissivity of 0.9, the net radiant heat transfer across the cavity in the first example with surface temperatures of 298 K and 333 K is 205 Watts/m2. The net radiant heat transfer across the cavity in the second example with surface temperatures of 328 K and 363 K is 269 W/m2 for the second example.

***This is a 31% increase in net radiant heat transfer across the cavity even though the temperature difference is the same, but higher on the temperature scale, or mean temperature of surfaces.***

Heat transfer by conduction in building materials such as concrete, masonry, timber etc is assumed to be directly proportional to the temperature difference across them.

## Comment

This description of how radiation flows from the underside of a roof surface to the ceiling across an air space again overlooks the crucial last step in the passage of the heat from outside to inside the house: the heat transfer through the ceiling material – all of which is by conduction (unless there are holes in the ceiling in which case there will be convection too). Furthermore, if bulk insulation is sitting on top of the ceiling material the upper side of the insulation will be close to the effective radiant temperature of the roof so the temperature difference, and thus the amount of radiant heat flow, will be substantially less. And the bulk insulation provides thermal resistance to this heat flow substantially reducing the total heat flow. As stated above, it doesn't matter what mode of heat flow the thermal resistance is reduces. If the heat flow through a roof is reduced by providing thermal resistance to radiant or conducted heat flow, all other factors being equal, if the resistance is the same the heat flow will be also. Radiant barriers are not a magic solution to reducing heat flows in roofs in hot climates and bulk insulation is not unsuitable for use in these climates.

While the AIRAH handbook may give misleading R values for heat flow across air spaces at the temperature levels that occur in peak conditions inside a roof in summer because it does not adequately consider the magnitude of temperatures, the NatHERS simulation does not oversimplify this calculation for the most common roofs in Australia: roofs with attic spaces. These tools calculate radiant heat flow from the underside of a roof surface to the top of the ceiling using the appropriate $4^{th}$ power equations. And these tools generally show that bulk insulation (at, say R3.5) leads to much lower air conditioning use than installing foil under a roof surface.

# REPORT ON THE IMPACT OF CEILING INSULATION ON THE THERMAL COMFORT OF HOUSES IN HOT CLIMATES

PREPARED BY TONY ISAACS CONSULTING PTY LTD

MONDAY, JUNE 18, 2007

# INTRODUCTION

The following information is drawn from various reports prepared for ICANZ by Tony Isaacs Consulting which evaluated whether the installation of insulation creates 'hot box' problems in hot climates. Traditionally building designers have been fearful of heavily insulating houses because they believe that this will trap any heat gain during the day and make the house impossible to cool down at night. Using AccuRate simulations to predict temperatures in houses without heating and cooling I have found that high levels of insulation will not create a hot box when ventilation is adequate (not perfect) and heat gains through windows are moderated (but not eliminated). The following sections explain that:

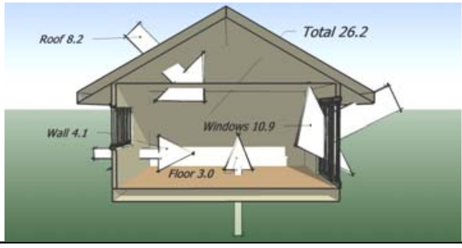
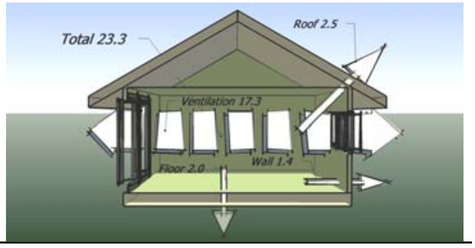
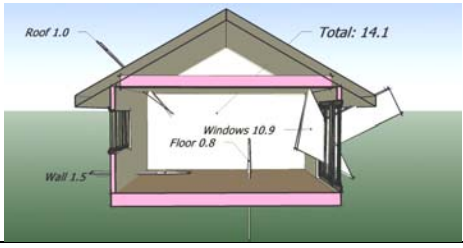
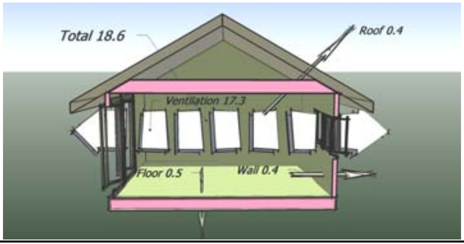
1. Using simple heat flow theory that insulating reduces heat gains by more than is slows night time heat loss,

2. Thermal simulation using AccuRate reveals that using high insulation levels in new housing reduces peak temperatures and only slightly reduces the ability of the house to cool down. Using higher star ratings in Queensland which require higher levels of insulation should not create a hot box.

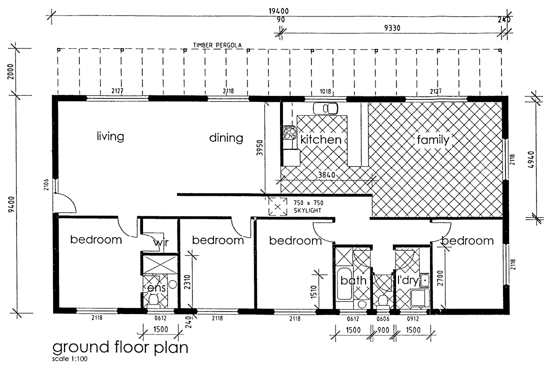
3. Thermal simulation using AccuRate also shows that insulating the ceilings of existing houses does not hamper their ability to cool down and in fact makes houses more comfortable. Insulation of existing ceilings will therefore not create a hot box.

## INSULATION REDUCES HEAT GAINS BY MORE THANIT REDUCES HEAT LOSSES

As shown below insulation cuts heat gains by more than it cuts heat losses. The heat gains take into account the effect of the sun in creating higher heat gains during the day.

| | Day Gains | Night Losses |
|---|---|---|
| Uninsulated |  |  |
| Insulated |  |  |
| Difference | Insulated 12.1 less gain | Insulated 4.7 less loss |

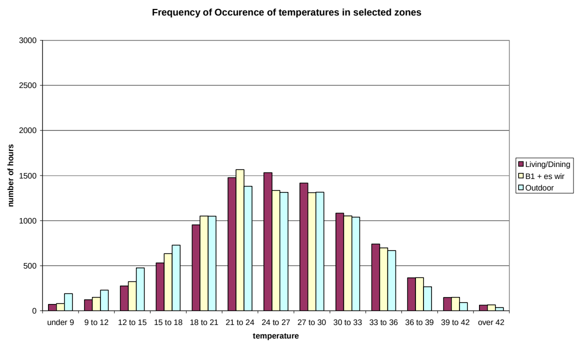
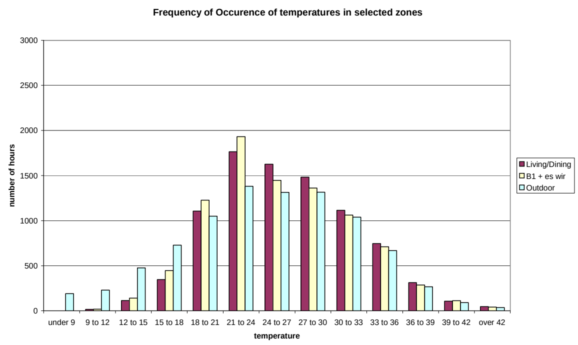
## HIGH LEVELS OF INSULATION DO NOT STOP A HOUSE IN LONGREACH FROM COOLING DOWN OVERNIGHT




Two AccuRate simulations of the house shown opposite 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 BCA 2006 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.

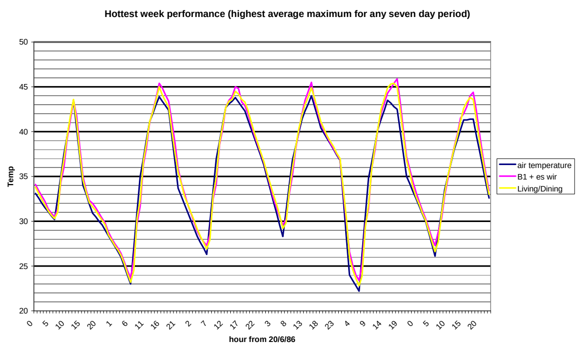
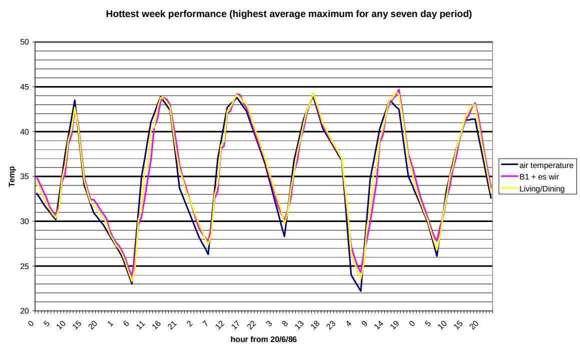
## Temperature frequency over the year

| Low insulation level | High Insulation level |
| --- | --- |
|  |  |



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

## Temperature over a hot 7 day period

| Low insulation level | High Insulation level |
| --- | --- |
|  |  |



The graphs above show that the highly insulated house has lower maximum temperatures than the house with minimal insulation 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.

# IMPACT OF CEILING INSULATION ON TEMPERATURES IN A HOUSE IN BRISBANE

To test whether insulation creates a 'hot box' AccuRate was used to simulate a house with and without insulation in the ceiling in Brisbane.

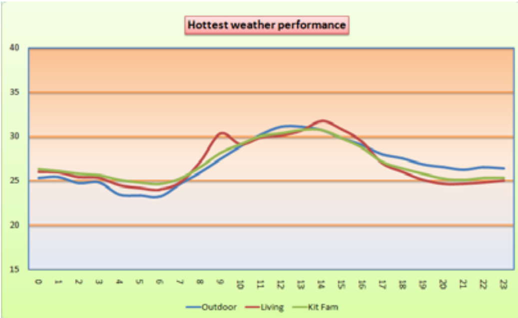
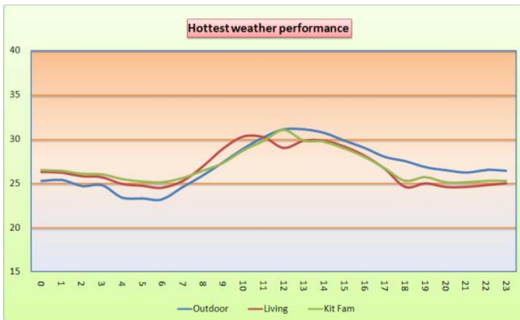
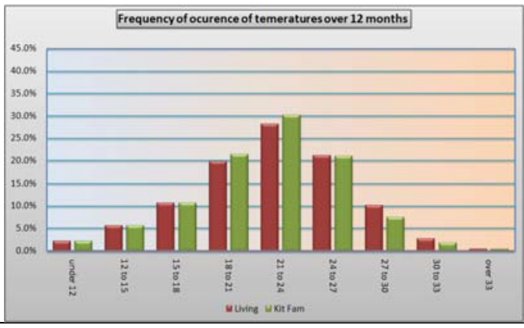
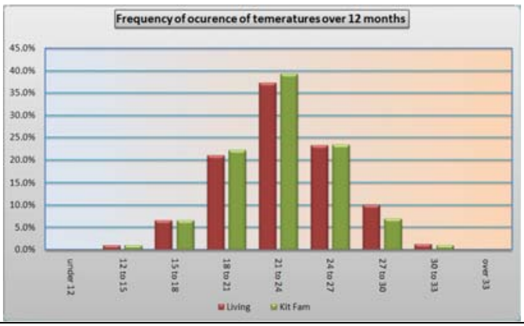
The house Plan and appearance from the street are shown in the table below.

| | |
|---|---|
| View from street |  |
| Plan |  |

The house has uninsulated Brick Veneer walls and a concrete slab floor. Windows are aluminium sliding and the house has no special provision for cross ventilation. Shading from the summer sun is minimal and the largest area of windows face east and west. The roof is a dark colour. The thermal mass of the slab relatively high solar gain and the poor cross ventilation mean that if a hot box effect is to be seen it should be evident in this house.

The charts below compare the temperatures predicted by AccuRate without heating or cooling in the house on the hottest day of the year (highest 24 hour average temperature) and the frequency distribution of temperatures over the year. The temperatures include the cooling effect of breezes when windows are opened and the radiant temperature of surfaces as well as the air temperature. The charts show that the house with an insulated ceiling is cooler than the house with an uninsulated ceiling both on the hottest day of the year and over the year as a whole.

## Temperature frequency over the year

| | Low insulation level | High Insulation level |
|---|---|---|
| **Hot day temps** |  |  |
| **Yearly temps** |  |  |









Without insulation, on the day with the highest average temperatures over the year the temperature inside the house reaches 32 in the living room by 3 pm, while the insulated house is three degrees cooler. Overnight the insulation does not stop the house cooling down as minimum temperatures are the same or slightly lower in the insulated house.

The temperature frequency charts show that the insulated house has reduced the number of hours where the temperature inside exceeds 27 by 131 hours per year. It has also reduced the number of hours under 15 degrees by 569 hours per year. The house with insulation is not only

# EVALUATING THE BENEFITS AND COSTS OF 5 STAR BUILDING FABRIC REGULATIONS AS DESCRIBED IN THE REGULATORY IMPACT STATEMENT

BY TONY ISAACS CONSULTING PTY LTD

THURSDAY, 13 MARCH 2008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# 1 EXECUTIVE SUMMARY

The Regulatory Impact Statement (RIS) for the 5 star national residential building fabric regulations shows that benefits in Queensland, and particularly in Brisbane, are marginal. Benefit to cost ratios are, on average, around 1 i.e. costs and benefits around the same. In some cases ratios are below 1 i.e. costs exceed benefits. Due to time limitations this project only looked at benefits and costs in climate zone 2 i.e. Brisbane where the benefit cost ratio was lowest. Many of the conclusions for Brisbane will apply across other climates.

This report finds that there are many factors which will lead to better benefit cost ratios than those reported in the RIS. In a number of cases these factors were not known at the time the RIS was produced:

- Policy changes such as higher renewable energy targets for power generation or the introduction of carbon trading will increase future energy prices and significantly improve cost benefit ratios. In the short term rises of over 20% have been discussed, while in the longer term some analysts have said cost will double.
- AccuRate has been found to under predict cooling loads when compared to monitored houses. Adjusting AccuRate to match monitored energy use would lead to substantial increases in the cooling energy predictions in Brisbane in particular.

The report also finds some methodological problems with the RIS itself:

- Energy savings for one of the four houses evaluated seem to be far too low (House 2 – 2 storey),
- Compliance costs for one of the houses seems far too high (House 4), and
- Benefit cost ratios included only 10 years of energy savings when they will clearly extend well beyond that time.

It was the poor benefit cost ratios of house 2 and 8 that led to the poor overall result in climate zone 2 yet the costs and benefits for these houses appear to be incorrect. Benefit cost ratios for the other houses easily exceeded 1.

There are also a number of issues which were outside the brief for the project but which will have a substantial impact on benefit cost ratios:

- Aging of the population will lead to higher cooling requirements and therefore better cost benefit ratios,
- Global warming will occur to some extent and will significantly increase cooling energy requirements,
- While reductions in appliance size for zone 2 were found to offer appliance cost savings they will also deliver avoided electricity generation and distribution costs in the order of $1,500 per house but this was not evaluated, and
- Economic growth can be stimulated through regulations which transfer resources from capital intensive sectors (energy) into more labour intensive sectors (building construction and products). In Victoria these benefits were of a

greater size than the energy savings themselves. Growth impacts were not evaluated for the RIS.

For cost benefit ratios to improve to those found in zone 5 (Adelaide and Perth) only one or two of the factors discussed above would need to be applied to the RIS. A number of them would appear to be quite reasonable adjustments to the RIS methodology. It is therefore likely that 5 star benefit cost ratios are much higher than shown in the RIS.

The RIS cost benefit evaluation for Queensland climates may have caused the state government to question whether the standards should be introduced. This report shows that benefit cost ratios are likely to be significantly higher and this should give confidence to the government that the implementation of the regulations in Queensland will provide significant benefits.

A summary of the factors that would lead to better cost benefit ratios and comment on their likely impact are shown in the table on the next page.

| Factor leading to improved benefit Cost rations in Brisbane climate | Extent of effect |
|---|---|
| **RIS uses hours of use of air conditioners found by ABS in 1986** | Increase in air con. installation from 17% to 68% over equivalent time. Benefit cost ratios for higher occupancy patterns likely to apply (up to 1.36 from 1.09.) |
| **AccuRate found to under-predict actual cooling in SA monitoring project** | Changing AccuRate thermostat and air con trigger lead to 280% increase in cooling in Brisbane in preliminary research. Unlikely to be this high in final version but shows RIS savings could easily be 50% higher. |
| **Aging population** | Higher home occupancy and less tolerance to heat leads to higher cooling use and greater energy savings. Greater proportion of high use households in future which have better benefit cost ratios. |
| **Global Warming** | AGO shows worst case scenario is a 400% increase in cooling loads in Brisbane. Action to reduce emissions will help to avoid this but some significant increase is inevitable. |
| **Using rating tools reduces costs/increases savings** | Cost benefit ratios for compliance using a rating tool are 30% better. Growing experience with rating tools and their benefits means the market will use this rather than the Deemed to Satisfy. |
| **Reductions in Peak load** | Costed in RIS as appliance purchase savings they imply a 1kW load reduction. This is worth at least $1500 in avoided generation and distribution costs but is not included in RIS |
| **Energy Price will increase faster than inflation due to need for clean coal and renewables to meet government targets** | There is some talk of a 20% increase in the next 5 years. This will improve benefit cost ratios by the same amount |
| **Construction costs for House 8 overestimated** | Rather than $4,000 for the timber floor option a cost of under $1,000 is more likely. This house had the worst benefit cost ratio |
| **Energy savings for house 2 look too low** | 30 larger than house 1, 3 times more spent to reduce energy use but savings are lower than house 1. There may be an error in the calculation. This house also has benefit cost ratios under 1 and is the main reason for the overall benefit cost ratio being low. |
| **Benefit Cost ratios use only 10 year life, a real 6% discount rate with no energy cost escalation above inflation** | Using the mortgage rate as the discount rate, assuming a 40 year life and a modest energy cost escalation of 1.5% increased benefits by 240% |

TABLE 1 FACTORS THAT WOULD IMPROVE 5 STAR BENEFIT COST RATIOS IN BRISBANE

# 2 INTRODUCTION

The Regulatory Impact Statement (RIS) for the national 5 star energy efficiency regulations[1] showed that the cost benefit of the regulations was smallest in the Brisbane climate. In all other climates the benefits clearly exceeded costs, however in Brisbane:

*"Overall, the financial benefits are about equal to financial costs. That is, the benefit/cost ratio is close to 1.0.[2]"*

In two of the four houses evaluated in the RIS the costs exceeded the benefits, and on average costs exceeded benefits if the Deemed to Satisfy (DtS) regulations were used and in those houses which are unoccupied during the day. In the face of significant resistance from the building industry it is therefore not surprising that 5 stars has not been adopted in Queensland.

This report revisits the RIS to determine whether the evaluation of costs and benefits is realistic from a number of perspectives:

1. Are the predicted energy savings correct?
2. Are the cost evaluations correct?
3. Are the lifetime savings adequately valued?

In the time available for this project not all aspects of the issues above were able to be quantified with accuracy and some further work would be required if this needs to be done.

> ICANZ engaged Tony Isaacs Consulting (TIC) to revisit the RIS and examine the benefit to cost ratios. Tony oversaw the development of Victoria's 5 star RIS in 2002, developed cross ventilation allowances for the Deemed to Satisfy for the ABCB in 2004 and worked with ATECH (the authors of the RIS) to develop energy savings estimates on the first draft of the RIS in 2005. Tony is therefore perfectly placed to give an unbiased and objective view of the benefit to cost ratios.

[1] Regulatory Impact Statement 2006-01, "Proposal to amend the Building Code of Australia to increase the energy efficiency requirements for houses, prepared by ATECH for the Australian Building Codes Board, Canberra, 2006

[2] RIS 2006-01, p 23

# 3 PREDICTION OF ENERGY SAVINGS

AccuRate was specifically designed to better evaluate residential energy loads in Hot Humid climates by taking into account the physiological cooling effect of air movement induced either though opening windows or by the operation of ceiling fans. The predictions of cooling load should therefore be far more reliable than its predecessor NatHERS. However, energy savings will still be highly dependent on the hours of use and thermostat settings assumed.

## 3.1 HOURS OF USE

The RIS sets the average hours of use for air conditioning in AccuRate simulations to match the average hours of use of cooling equipment reported by the ABS. This information was published in 1986[3]. In 1986 the ABS reported ownership of airconditioners in Queensland was around 17% while in 2005 it was reported as 68%. Anecdotal evidence suggests that the extent of use and size of air conditioners has also grown with the ownership of airconditioners. Cost benefit ratios were significantly improved for more intensive user patterns and it is logical to assume that using a more up to date user pattern would improve the cost benefit ratios.

## 3.2 THERMOSTAT SETTINGS

The thermostat settings used by AccuRate for energy ratings (25.5 in Brisbane) were not used for the RIS but a day time thermostat of 24 and night time thermostat of 23 were selected. This results in a 16% increase to cooling loads in a typical 5 star house compared to the standard AccuRate thermostat. In recent times the Australian Greenhouse Office (AGO) has compared the AccuRate predicted loads in houses in South Australia with actual air conditioning energy use and AccuRate was found to significantly under-predict actual cooling by around 50%[4]. This research found that AccuRate's predictions could be brought into line with monitored results if lower thermostat settings were used together with adjustments to the way in which cooling was triggered.

AccuRate delays the onset of cooling till internal temperatures are quite uncomfortable e.g. in Brisbane AccuRate will wait till internal temperatures are as high as 28 degrees plus any allowance for air movement before the air conditioner is switched on. By lowering this upper threshold the air conditioning will be used more frequently. Preliminary research conducted by Tony Isaacs Consulting for the AGO evaluated the impact of the revised user behaviour settings suggested by the monitoring in various climates around Australia. It found that while the changed user pattern increased cooling energy load by only 40 to 80% in climates like Adelaide – as consistent with

[3] ABS Cat. 8218.0 *National Energy Survey*, 1986

[4] Wasam W, Oliphant M., and Mudge L., "Study Of The Effect of Temperature Settings On AccuRate Cooling Energy Requirements And Validation Using Monitored Data" prepared for the Australian Greenhouse Office, Dec 2007, unpublished.

monitored energy use - cooling loads in Brisbane were increased by 232%. This was the largest increase in any of the climates studied[5].

This is only preliminary research and it will be some time before it produces a change to the AccuRate software in use for rating houses. Further, the extent of change could well be significantly less than found in this first test. It does suggest, however, that AccuRate's predictions of cooling loads could easily increase by 50% which would be enough to increase the cost-benefit ratios in Brisbane to be equivalent to those in zone 5(Adelaide, Perth, Sydney).

## 3.3 IMPACT OF DEMOGRAPHIC CHANGES

Australia's society is aging due to the "baby boom bubble' reaching retirement age and the lower fertility rate. Older people are at home more often than those in full time employment or at school and are more sensitive to heat stress than younger people. In future this change to Australia's demographic is likely to see a greater number of households using air conditioning for a greater number of hours at lower temperatures. This trend will lead to higher cooling energy use and will therefore improve the cost benefit ratio of the regulations.

## 3.4 POTECTING LOW INCOME FAMILIES

Later sections explain that energy prices are certain to rise significantly in coming years. The recent international meeting on climate change at Bali aimed to keep climate change under 2 degrees, so further warming will occur and this will increase the need for cooling. Low income families in poor quality homes will be at risk of either large increases in bills or substantial discomfort (and the related health issues that overheating can cause). Buildings with a higher performance building fabric will maintain better comfort without air conditioning and have lower requirements for air conditioning itself. 5 star fabric regulations will therefore help protect low income families from the impacts of both climate change and the policies we need to pursue to reduce greenhouse gas emissions.

## 3.5 IMPACT OF GLOBAL WARMING

A project by the Building Research Association of New Zealand (BRANZ) for the AGO evaluated the impact of global warming on heating and cooling loads in residential buildings[6]. It took projections by the International Panel on Climate Change (IPCC) to 2070 assuming that global efforts to reduce greenhouse emissions had only limited success. The CSIRO used these projections to predict average temperature, solar radiation, windspeed and cloud cover in 2070. This data was used to modify current AccuRate weather data files to reflect global warming by 2070 and a series of houses

[5] Note that while AccuRate may predict higher energy use the star rating i.e. or relative ranking of performance of one house over the other, would not change. Even if AccuRate is changed to predict higher loads a 5 star house will still get 5 stars.

[6] BRANZ, **AN ASSESSMENT OF THE NEED TO ADAPT BUILDINGS FOR THE UNAVOIDABLE CONSEQUENCES OF CLIMATE CHANGE,** prepared fo r the AGO, Canberra , 2007.

were simulated using the new weather data. The chart below is extracted from the report and shows that Brisbane will have fourfold increase in cooling loads.

There are some methodological issues with the report in that it is based on older projections and the translation to weather data files was not ideal, but the overall thrust – that there will be a substantial increase to cooling energy use - would not changed by methodological improvements. Hopefully we will be better able to deal with greenhouse emissions and this warming scenario will not eventuate. However, some warming will occur and with each revision to climate projections it seems that minimum temperature increases are revised upward. Even if the benefits of 5 stars in Brisbane are marginal today it is certain that there will be higher temperatures in future – even if it is not as bad as shown in the BRANZ report. Benefits in future will certainly increase so cost benefit ratios for 5 star can only improve.

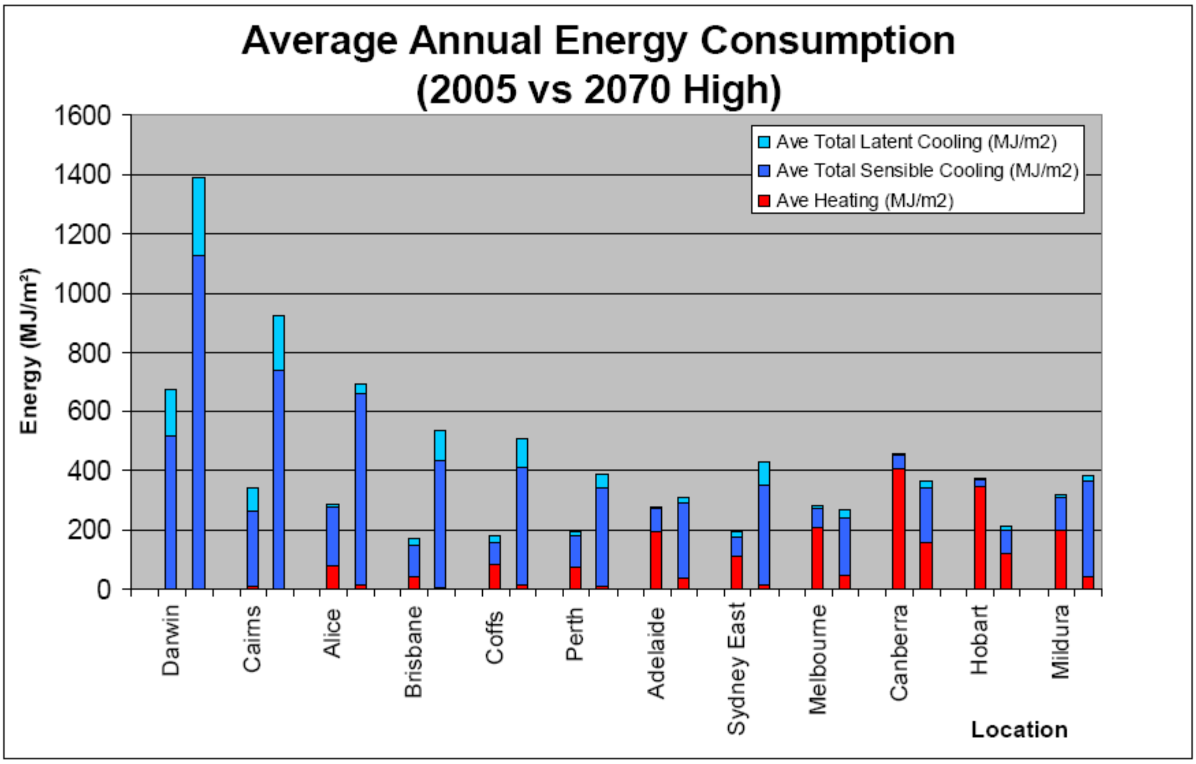


FIGURE 1 IMPACT OF GLOBAL WARMING ON HEATING AND COOLING LOADS IN 2070

# 4 PREDICTION OF COSTS AND BENEFITS

## 4.1 COST SAVINGS AVAILABLE FOR RATINGS OVER DTS

The RIS demonstrates that greater savings in both energy use and reduced appliance size are available where the house is rated at 5 stars rather than modified to meet the DtS. This was also found in Victoria's cost benefit analysis of 5 stars undertaken in 2002[7]. Energy ratings allow the user to tailor the modifications to the specific house design and in so doing provides greater energy savings. In Victoria it was also found to reduce construction costs as the ability to hone in on problem areas avoids the whole building prescriptions of a DtS regulation. Builders in Victoria who were first to change to 5 stars found that construction costs for 5 stars decreased as they gained experience with the rating. In radio interviews before 5 stars was introduced in Victoria Henley Properties boss Peter Hayes reported that the initial cost of achieving 5 stars was around $3,000 per house, but when designed from scratch to meet five stars the cost was only $1,500. As experience grows with rating techniques in Queensland it is likely that the regulation will produce greater energy savings and lower construction costs.

There are already hundreds of energy raters in Queensland and there are several hundred more available to the industry in other states through the Association of Building Sustainability Assessors (ABSA). While the uptake of 2nd generation tools has been slow experience in the industry with these tools is growing. The significant benefits to the industry of using rating tools will mean that market forces should ultimately see most houses use ratings over DtS. This will ensure that the cost effectiveness of the regulation improves over time.

## 4.2 BENEFITS OF REDUCED APPLIANCE SIZE

The RIS estimates that improved building fabric performance will allow a significant reduction in the size of air conditioners (and heaters). This allows a smaller size air conditioner to be installed and therefore saves money on appliance purchase. The extent of saving in Brisbane represents about a 1 kW reduction in appliance size and therefore in peak load. In terms of avoided generation and transmission costs for a gas peaking plant this saving alone is worth around $1,500. These benefits exceed the average construction cost and were not reported in the RIS.

The RIS average and high use occupancy patterns assumed some cooling during the day. The largest reduction to peak load will occur when the house has been left closed up during the day and air conditioning is turned on when the occupants arrive home after work/school. The low use occupancy assumes the house is vacant during the day and should produce significantly greater peak load savings. The RIS simply did not evaluate these savings in each case but applied the same value to each occupancy. The 'home

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[7] Sustainable Energy Authority of Victoria, **COMPARATIVE COST BENEFIT STUDY OF ENERGY EFFICIENCY MEASURES FOR** Prepared by Energy Efficient Strategies- 2002

vacant during day' occupancy had the worst cost benefit ratio, but is likely to produce the greatest saving in peak load and air conditioner capacity.

Appendix A shows extracts from information sheets developed by ICANZ on the benefits of insulation in hot climates. They show that AccuRate hourly load profiles indicate that 5 stars produces 20 – 40% reductions peak loads compared to the previous energy efficiency standards in two houses in Townsville. The savings predicted by the RIS therefore appear to be quite conservative.

## 4.3 COST OF ENERGY

The RIS was published in 2006. Since that time Australia has signed the Kyoto protocol, committed to 60% reductions by 2050, increased the Minimum Renewable Energy Target and has announced plans to set up a Carbon Trading scheme that will cap Australia's greenhouse gas emissions. The Garnaut review has already signalled that targets may need to be as high as a 90% reduction in emissions. This will certainly increase the cost of electricity generation and the price of energy in future. It is not clear how much this will be but estimates have ranged from 20% to 100%. It has been suggested that a 20% increase could occur in as little time as 5 years, while in the long term some analysts have suggested that energy prices will double. Again, this will significantly improve the cost benefit ratios for 5 stars in Queensland.

## 4.4 CONSTRUCTION COSTS & ENERGY SAVINGS

The RIS shows that additional construction costs for two of the houses were under $400 and had benefit/cost ratios well over 1. The other two houses were considerably more expensive: $1,500to $1,700 for the House 2, a two storey house, and $2,000 to $4,000 for house 8. The RIS explains the low benefit cost ratios found in Brisbane are:

*"sensitive to the weights assigned to house 3 (large two storey) and house 8 (passive solar design). For both houses, the cost of the measures is disproportionate to the expected benefits."*

Note that house 8 is described as 'passive solar', but it is nothing like a passive solar building[8]. It has no thermal mass and the largest area of glazing faces south west with deep overhangs. This was one of the houses used by Tony Isaacs Consulting to develop the ventilation correction for the DtS and was selected as an example of a well ventilated house. The changes required to meet the DtS on a timber floor for this house would be minimal and it is hard to see how the high construction costs have been found:

- The house has deep eaves and high level cross ventilation so compliance with glazing requirements can be met with clear glazing and trimming areas by around 10%,
- Ceiling insulation would be only need to be R1.5 with a light coloured ventilated roof, and
- many of the walls would not need to be insulated due to the deep shade.

The two storey house (house 2) is expensive to improve to meet 5 stars as the building has virtually no shading. It is typical of spec homes designed for cooler climates which are unfortunately being transplanted to northern climates with little thought for

[8] See RIS 2006-01 page 115

climatic conditions. While the cost does not seem unreasonable, the energy savings that are produced are surprisingly low. This house is 30% larger than the single storey house, has had 3 times more money spent to improve its performance and yet achieves only 60% of the energy savings. This is counter intuitive and may be an error in the RIS.

Houses like house 2 perform poorly in Brisbane and are therefore far more likely touse either central air conditioning (10.1% of houses, ABS 4602.0, 2005) or use more than one airconditioner(28% of houses, ABS 4602.0, 2005). As shown in the RIS[9], higher use of air conditioning significantly increases the savings. The 'average' occupancy and areas cooled may not apply to this house and the benefits could be reasonably be expected to be even larger in the field.

As explained above the Cost benefits are very sensitive to the findings for house 2 and 8, yet costs seem to be significantly overestimated for house 8 and benefits seem to be underestimated for house 2. These anomalies need to be investigated further as they would change the cost benefit of the regulation in Brisbane substantially.

[9] See RIS 2006-01, page 22 table 5.2

# 5 VALUING LIFE TIME ENERGY SAVINGS & FINANCIAL ASSUMPTIONS

## 5.1 FINANCIAL ASSUMPTIONS

Benefit cost ratios in the RIS were based on a Net Present Value of annual energy savings. These ratios are highly sensitive to assumption about the life of investment, discount rate and assumptions about energy price rises. The RIS used the following assumptions:

| Parameter | Value |
|---|---|
| **Discount Rate:** | 6% (real) *"In this case the discount rate is a weighted average cost of capital, combining debt-financing at 4.5% and equity financing at 8.3%, both expressed in real terms that excludes the allowance for inflation. The return on equity is somewhat less than the average market return on equity, reflecting below-average exposure of the proposed investment to general market risks."* RIS 2006-01, p 39 |
| **Energy Cost escalation over inflation:** | 0%. The 6% discount is in effect is a real rate i.e. it allows for 2.5% general inflation. It does not take account of any higher rise in energy prices over and above the inflation rate. |
| **Life of investment:** | 10 years. *"Chapter 5 reports the expected impacts of the proposed measures on owner-occupiers, with impacts expressed as dollar amounts per representative house. ... While the regulation is notionally assigned a life of 10 years (from 2007 to 2016), the measures that are implemented have a life of up to 40 years, with the result that impacts extend to 2050 and beyond."* RIS 2006-01, p 38 |

FIGURE 2 FINANCIAL MODELLING OF 5 STAR IN RIS SECTION 5

The values were set according to the processes outlined in ABCB's *Financial Analysis Procedure*[10]. The RIS explains the basis for this approach:
*"Essentially, the investment is viewed as a business proposal to be funded on normal commercial terms, including a reasonable allowance for risk and notional payment of normal business taxes." RIS 2006-01, p39*

Using the values above will result in the Net Present Value of future savings being discounted to 7.4 times the annual saving.

There are difficulties applying this methodology to the home building sector:

- the cost of money for home buyers is simply the mortgage interest rate,
- unlike investments where the return is taxed the energy savings are tax free,

[10] Atech (2003), *Financial Analysis Procedure for Energy Efficiency in Buildings.*

- the benefits of the energy savings continue for the life of the building and not just the 10 year life of the regulation,
- as explained in section 4.3 it is certain that energy price rises will exceed general inflation, though the amount is not clear, yet this has not been allowed for.

If assumptions were changed to better take account of the differences between the residential and commercial sector the following values are reasonable:

| Parameter | Value |
|---|---|
| **Discount Rate:** | 9.3 % - ANZ standard variable mortgage interest rate |
| **Energy Cost escalation over inflation:** | 3% inflation, 1.5% additional energy inflation i.e. a 20% increase in energy costs by 2020 |
| **Life of investment:** | 40 years – the life of the house may be even longer. |

FIGURE 3 ALTERNATE PARAMETERS FOR FINANCIAL MODELLING OF 5 STAR IN RIS SECTION 5

Using these parameter value produces a Net Present Value multiplier of 17.9 i.e. the value of savings would be increased by a factor of 2.4 dramatically improving the cost benefit ratios. At a 2.5% energy cost escalation above inflation i.e. doubling the price over 40 years the NPV multiplier is 20.8 increasing benefits by a factor of 2.8. This assumes that costs escalate gradually over time and benefits would be larger if costs increase more quickly.

Note that the Victorian Treasury endorsed a real discount rate of 3.5% and a life of 40 years for the analysis of the Victorian 5 star on the basis of advice from the Allan Consulting group.

It is understood that setting these parameters is the matter of some debate among economists and there are several schools of thought. Even with a discount rate of 6% and a life of only 20 years the benefits double. Housing is a long life asset that will often last over 70 years and it is appropriate to use a longer life for the benefits than 10 years. A longer life substantially improves the benefit cost ratios.

## 5.2 ECONOMIC GROWTH

The economic modelling for the Victorian 5 star regulations and for the National Framework for Energy Efficiency showed that energy saving programs stimulate mild economic growth. The same basic principles were observed in each study:

- Resources are transferred away from the capital intensive energy sector (lower bills) into the more labour intensive building construction and materials sectors. This creates more jobs.
- Reduced demand for energy reduces results in greater downward pressure on prices. This flows through to all sectors lowering costs.

These two factors provide a small stimulus to economic growth, but a small stimulus is quite large compared to the energy bills and construction costs. In Victoria the NPV over 40 years of costs was 107 million and energy savings was 159 million. The NPV of economic growth generated over 15 years was predicted to be 500 million. It is worth noting that while 4 stars in Victoria had a superior benefit cost ratio it only produced half the economic growth predicted for 5 stars. Of course simply because the Victorian regulation was predicted to generate growth does not mean that similar benefits are available in all locations. However the Victorian and NFEE projects do show that the RIS did not even evaluate all potential benefits.

# 6 APPENDIX A: INSULATION NEED NOT CREATE A HOT BOX IN HOT CLIMATES

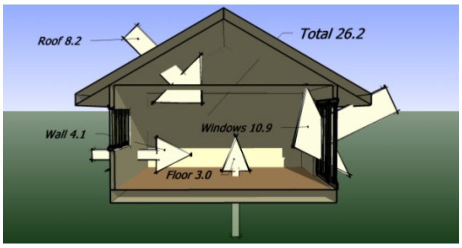
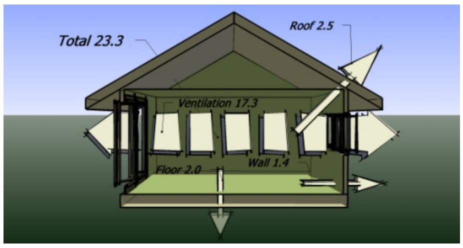
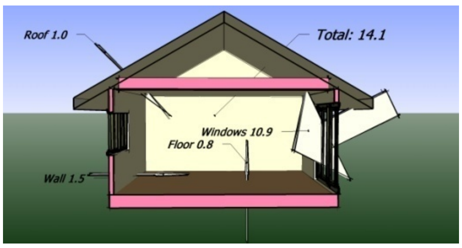
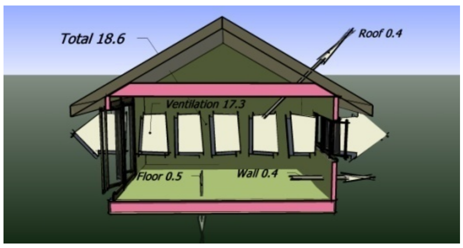
## 6.1 INSULATION OFFERS CONSIDERABLE ADVANTAGE IN ACHIEVING 5 STARS IN WARM CLIMATES

AccuRate shows that a ventilated house is far better suited to warm climates and that insulation will improve comfort levels. It also shows that significant improvements can still be made to houses of a concrete block design.

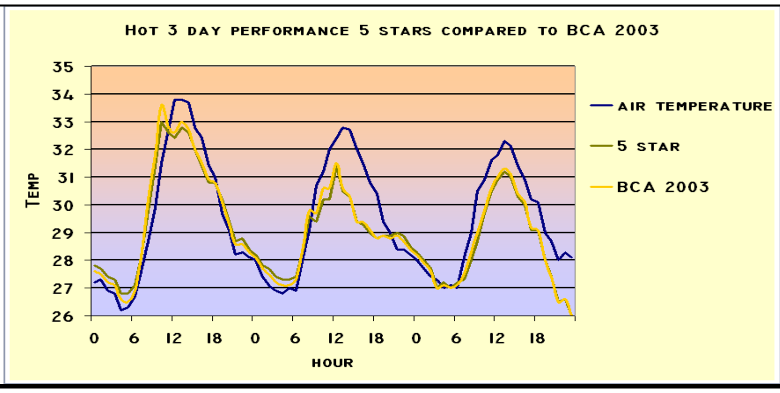
With poor ventilation and uncontrolled sun penetration insulated houses can become hot boxes. However, the new regulations ensure that sun penetration is controlled and that the house can achieve minimum levels of ventilation.

In these circumstances insulation should not create a hot box, even at very high levels of insulation. As shown in Figure 2 insulation cuts heat gains by more than it cuts heat losses where good levels of ventilation are provided.

FIGURE 2. HOW THE HEAT GAINS AND LOSSES UNDER PEAK CONDITIONS ARE AFFECTED BY INSULATION.

| | Day Gains | Night Losses |
|---|---|---|
| Uninsulated |   |   |
| Insulated |   |   |
| Difference | Insulated 12.1 less gain | Insulated 4.7 less loss |

In the Townsville case studies that follow, AccuRate is used to predict unconditioned temperatures to show whether high levels of insulation do create a hot box. In all cases wall and floor insulation does not significantly affect summer comfort, while ceiling insulation is always beneficial.

| ***House:*** | **Well ventilated light weight house in Townsville** |
|---|---|
| ***Plan*** |  |
| ***Elevation facing south*** |  |
| ***5 Star: energy savings*** | ***30%*** |
| ***5 star: reduction in appliance size/utility load*** | ***20%*** |
| ***Impact on Comfort*** High insulation slightly improves comfort. No hot box effect because ventilation is excellent. |  |

### 6.2.1 HOUSE CONSTRUCTION

The house has a light coloured metal deck roof with foil underneath and R1.5 insulation on the ceiling. Walls are constructed from weatherboard and are uninsulated except for east and west walls which contain R1.0 insulation. The floor is assumed to be particleboard with timber veneer sheet over. Windows are constructed from lightly tinted louvres in an aluminium frame. Cross ventilation is excellent with one room deep plan and windows on either side. This house is similar to the classic well ventilated houses constructed in the northern territory such as the C19*.

### 6.2.2 HIGH INSULATION LEVELS WON'T CREATE A HOT BOX IN TOWNSVILLE

The graph shows temperatures in the living room without air conditioning over a three-day hot period in Townsville. It compares the house constructed to the specifications of the BCA 2003 DtS and using high insulation levels to achieve the new 5 star requirements.

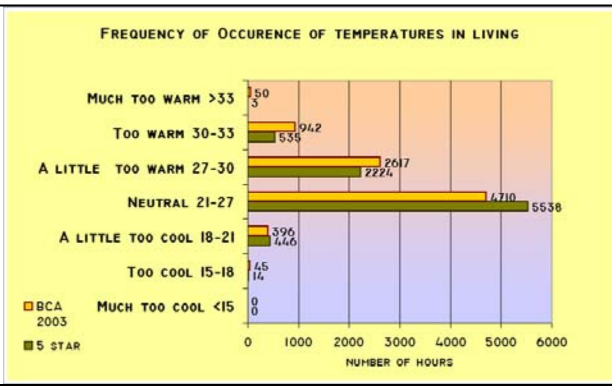
The graph shows virtually no difference between temperatures on the hottest three days period of the year. The 5 star houses are slightly cooler during the day and slightly warmer overnight (less than a degree). Over the whole year the 5 star houses reaches a temperature of over 30 degrees around 50 hours less than the house specified to BCA 2003 level.

### 6.2.3 WHY DOES INSULATION REDUCES THE ENERGY REQUIRED FOR COOLING ENERGY BUT NOT AFFECT COMFORT?

In a well-ventilated well shaded house without air conditioning the temperature inside is about the same as outside air temperature, though it may feel cooler if there is air movement. If there is no temperature difference between inside and outside there is no heat flow, so the insulation has little effect in walls and floor. Insulation in the roof will improve comfort even though there is no air temperature difference because the sun shining on the roof can have an effect equivalent to a 40 degrees air temperature difference.

When the house is air conditioned the temperature in the house is reduced. This creates a temperature difference between the inside and outside temperature. This temperature difference creates a heat gain through the walls and floor during the day. Under these circumstances adding insulation makes a difference because there is now a heat flow which insulation can reduce.

## 6.3 CONCRETE BLOCK HOUSE IN TOWNSVILLE

<table>
<tr><th>House:</th><th>Concrete block house in Townsville</th></tr>
<tr><td>Plan</td><td>
</td></tr>
<tr><td>Elevation facing west</td><td></td></tr>
<tr><td>5 Star: energy savings</td><td>50%</td></tr>
<tr><td>5 star: reduction in appliance size/utility load</td><td>40%</td></tr>
<tr><td>Impact on Comfort<br>5 stars provides: 400 fewer hours over 27, 450 fewer over 30 compared to BCA 2003</td><td>
</td></tr>
</table>

### 6.3.1 HOUSE CONSTRUCTION

This house is typical of the concrete block houses spec homes constructed on a slab in northern Australia. While insulation can only help heat flows through the ceiling in this house, using higher levels of insulation can still provide enough performance boost to reduce the cost of achieving 5 stars.

To meet BCA 2003, minimal upgrade is required because walls are shaded with eaves and are not required to be insulated. The glass area is also low enough to use standard aluminium frame clear glass. Only a R1 reflective backed blanket under the roof deck was required. It only achieves 1.5 stars. While insulating the wall would help, the cost is very high so it will not be considered for the 5 star solution.

### 6.3.2 CONCRETE SLAB HOMES COMPARED TO WELL VENTILATED HOMES

It is far easier to achieve 5 stars with high set, lightweight houses than in the concrete block wall and slab floor in this house. This is particularly seen in the extent of glazing.

The well ventilated lightweight house is able to achieve 5 stars at a 40% glass to floor area ratio (GFR) while the concrete house must cut glass areas back to 20% GFR and use external blinds to reduce heat gains. The ventilated style allows the house to achieve comfort with more than double the heat gains through windows.