MODELLING & ANALYSIS REPORT

ICANZ

Review of Insulation Levels for Commercial buildings in BCA

Prepared by

Version 1 Rev 0
January 2005

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Document History and Status

Rev.	Date	Reviewed By	Approved By	Revision Details

Distribution of copies:

Copy No.	Quantity	Issued To

Printed:	03/02/2005 12:39 PM
Last Saved:	3/02/2005
File Name:	ICANZ - Analysis of Insulation Levels in BCA - 4Jan05
Document Version:	1

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Commercial Buildings BCA Review

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APPENDIXES

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1. EXECUTIVE SUMMARY

During 2004, EMET Consultants Pty Limited was commissioned by ICANZ to undertake a review of the insulation provisions proposed to be introduced into the BCA during 2005. The purpose of the analysis was to provide recommendations to ICANZ in relation to:

1. The R values specified in the Draft BCA Energy Efficiency provisions in relation to their compliance with AS4508 (Thermal resistance of insulation for ductwork used in building air conditioning)

2. The building envelope R values specified in the Draft BCA Energy Efficiency provisions in relation to other commercial building energy efficiency models for insulation levels to achieve optimum energy efficiency.

The analysis involved the revision of models previously developed and used by EMET Consultants to arrive at the provisions contained in AS4508 for air conditioning and evaporative cooling ductwork and those used to assess optimum insulation levels for commercial building envelopes (only roof-ceiling insulation was assessed in the latter models); and the application of these models to those listed in the new BCA provisions.

Many of the factors and methodologies used in the original models differ from those used in the BCA work. In many cases insufficient information has been provided in the BCA background notes to enable a direct comparison to be made. However the analysis identified a number of areas which require revision or consideration, as follows:

a) Evaporative Cooling Ductwork Insulation

- Under most circumstances, the optimum levels of insulation calculated by the AS4508 and BCA methodology were in agreement.
- There is justification for the use of climatic zone variations in the selection of evaporative cooler ductwork.
- The specification of different levels of insulation for sheltered (insulated roof space) and exposed locations is justified.
- There is a case to increase the minimum insulation level for the exposed case to R0.9 followed by additional increases by climatic zone.
- The minimum insulation level of R0.6 for the sheltered case is appropriate, also to be followed by additional increases by climatic zone.
- Specific insulation levels for consideration in the analysed climatic zones were made. A further variation for (or a bias towards) cities which have major evaporative cooler applications may be considered for some climatic zones (eg. Adelaide or Perth may be considered more appropriate for Zone 5 rather than Sydney)

b) Air Conditioning Ductwork Insulation

- Discounted energy rates used in the BCA analysis are not representative of the real cost sustained by the consumers, as well as not suitably matching the climatic zone selections (ie. within one climatic zone, variations in energy costs of 100% exist). These lead to lower insulation level selections than would occur in the real case.
- The use of a 10 year payback criteria, which is considerably longer than generally accepted in the industry reduces the effect of the discounted energy rates resulting in reasonable insulation level selections for the milder climatic zones, such as zones 5 & 6.

- In general, the optimum levels of insulation calculated under the AS4508 methodology are above the levels prescribed under the BCA. In particular, those relating to the climatic zones of 2 and 3. It is assumed that this would also apply to zone 1 and to a lesser extent zone 4.
- For the cases evaluated, alternative optimum levels of insulation have been produced.
- The largest discrepancies are found in the figures for Zones 2 and 3 generally; and in the sheltered cases.
- The applications with the closest agreement include Zone 5 generally (except for the sheltered case); and the semi-sheltered cases (excluding zones 2 and 3)

It is considered that a case to review the specified insulation levels for commercial building applications exists.

c) Commercial Buildings – Envelope Insulation Levels

- No envelope (walls and roof) insulation levels are noted for the reference building modelling process (refer to Section & Table JV3). This can lead to the reference building performance option producing a lower standard of design compared to the other compliance methods and therefore lower insulation standards.

- The envelope insulation levels specified in the proposed BCA provisions represent a significant improvement in the treatment of these components, which have largely been ignored to date. However more work should be done on evaluating the true cost of insulation to allow these prescribed levels to be fine-tuned.

- The requirements for shading of external walls in some climatic locations will be impractical, or very costly, for some buildings. An alternative with higher total R-Value or similar option should be considered and included in the provisions. This provision is also not carried across to the reference building modelling process leading to similar issues discussed in the first point above.

- The variation (or lack thereof) of provisions for different climatic zones does not seem to correlate with results achieved for individual cities within those zones. Also, the grouping of major commercial centres in the same climatic zone does not always show the differentiation warranted by their specific climatic patterns. A review of these zones or variations for major centres may be worth considering as more fine-tuning occurs.

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2. INTRODUCTION

2.1. Scope of Work

During 2004, EMET Consultants Pty Limited was commissioned by ICANZ to undertake a review of the insulation provisions proposed to be introduced into the BCA during 2005. More specifically, the analysis included:

3. Re-run the modelling used in AS4508 for:
   - the case of heating and cooling using same duct
   - commercial building only
   - updating parameters for current costs etc
   - climate zones as per BCA or at least main population areas

4. Review the Services (HVAC mainly) R values in the Draft BCA Energy Efficiency Class 2,3,4 and BCA Energy Efficiency Class 5-9 Regulatory Document for compliance with AS4508 and compare with existing commercial building energy efficiency models for insulation levels to achieve optimum energy efficiency.

5. Review the building envelope R values in the Draft BCA Energy Efficiency Class 2-4 and BCA Energy Efficiency Class 5-9 Regulatory Document and compare with existing commercial building energy efficiency models for insulation levels to achieve optimum energy efficiency.

6. Provide recommendations to ICANZ on key assumptions that need to be changed in order to achieve optimum energy efficiency insulation levels if the ABCB/AGO proposals fall below optimum levels.

For the purposes of item 1, the main population areas chosen for the location analysis were:

Darwin – Zone 1
Brisbane – Zone 2
No Zone 3
No zone 4
Adelaide, Sydney and Perth – Zone 5
Melbourne – Zone 6
Canberra and Hobart – Zone 7
No Zone 8

2.2. Qualifications and Assumptions

It should be noted that the analyses and models used in the development of optimum levels of insulation for both ductwork and envelope components were based on adaptations and extensions of previous research undertaken for the insulation industry and/or Standards Australia. The factors used in those models differ to those used in the BCA modelling (where the information and assumptions have been shown) and may lead to alternative optimum solutions for specific cases. The results obtained in this study should not necessarily be used as alternative prescribed values, but rather should be used as a means to identify areas which may require revision or consideration. Refer to other sections of this report, for more specific comparison of assumptions and calculation methods used in different components of this study and the BCA.

3. Analysis of Ductwork Insulation Levels

3.1. Differences in Definitions and Applications

The BCA specifies insulation levels based on location (level of exposure) of ductwork, type of system and element, and climatic zone. Two levels of insulation are specified, depending on the capacity of the systems (ie. Up to 65kW and above 65kW)[1]. The regulation documents do not explain the specific methodology used in arriving at these insulation levels.

The insulation requirements specified in AS4508 were designed to cover those situations where insulation levels in common applications were deficient and causing excessive losses in energy use and costs to users. These were considered to be in residential heating and cooling systems and in commercial applications for air conditioning ductwork in return-air spaces and similar sheltered locations. Ductwork located externally to buildings or in other exposed locations was considered to be reasonably well catered for under standard engineering design practice of the time. The levels specified in AS4508 do not differentiate by climatic zone as the current structure of climatic zones was not formalised at the time of its introduction. The values specified in the standard were derived by evaluating the most cost-effective solution for a number of main cities with varying climatic patterns and selecting a minimum level which ensured that no location was forced to endure a non cost-effective solution. In most cases therefore, the level of insulation specified in the standard was conservative.

In addition, the applications used in the proposed BCA and in the existing standard AS4508 are not identical, resulting in some interpretation issues. For the purposes of this comparison, the following corresponding applications have been used.

Table 3.1 – Comparisons of Applications for Ductwork Insulation – BCA and AS 4508

BCA Application	AS 4508 Equivalent	Comments
System Capacity of no more than 65kW	Residential applications and small commercial, industrial applications not involving ductwork in return-air space or plant rooms.	The distinction for plant capacity needs better clarification in the BCA. Refer to footnote 1.
System capacity of greater than 65kW	Commercial and Industrial applications or central plant in multi-unit residential applications.	The distinction for plant capacity needs better clarification in the BCA. Refer to footnote 1.
Location – Under an enclosed floor; or in a roof space with insulation installed directly beneath the roofing	<65kW - Case 2 – Heating or refrigerative cooling ductwork mounted in unconditioned space for residential applications only. >65kW – Case 1 – Unconditioned space in commercial applications	The BCA should specify bulk insulation at roof level for this case, as sisalation only would not suffice. AS4508 does not differentiate between ductwork in roof space and/or under floor with the exception that under floor ductwork was assumed to be used in heating-only systems and therefore covered under the “heating or cooling” case – see below.
Location – All other locations	AS 4508 does not cover the case	No clear correlation exists

[1] It is assumed that the 65kW refers to the cooling capacity of the system, or equivalent for the evaporative coolers. There is no clear indication as to whether the 65kW refers to the overall cooling/heating capacity of the plant or to each component (air handler or individual component of a modular system)

including – external to the building; or under an unenclosed suspended floor; or in a roof space with insulation installed at the ceiling level	of exposed ductwork, leaving the appropriate insulation level to be determined by the designers for the specific case. Case 2, as described above applies to the roof space and underfloor mounted ductwork.	between the two applications.
Element – Ductwork and Cooling fittings	AS 4508 provides different insulation levels for cooling fittings and ductwork.	The insulation level for fittings was not calculated, but was based on a reduced level to that for ductwork to minimise installation difficulties.
Element – Heating fittings	AS 4508 does not differentiate between cooling and heating fittings. One value is provided for both heating and cooling fittings.	
Location – Within a conditioned space other than where the space is the only space served	Case 2 – commercial applications	
Location – in a plant room	Case 1 – Unconditioned space for Commercial applications	
Application – Evaporative Cooling	All evaporative cooling.	
Application - Heating System or refrigerated cooling system	Residential systems generally.	
Application - Air Conditioning	Commercial systems generally.	

3.2. Differences in Economic Evaluation Methodologies

The levels of insulation specified under AS 4508 were determined using the following economic criteria:

- Lowest Nett Present Value cost option for different climatic zones (represented by selected main cities) comprising the marginal cost of the insulation and the resultant reduction in energy costs.
- No allowance was made for the reduction in the cost of the primary cooling/heating plant resulting from the increase in insulation levels.
- Electricity rates used were 10c/kWh (residential) and 13c/kWh (commercial) and gas rates were assumed to be $9/GJ. These represented average costs paid by consumers at the time of the analysis.
- A range of discount rates were used in the economic evaluations to assess the sensitivity of the solutions identified. The final factors used were: 15% rate of return; 33% tax rate; 2.5% inflation factor; 15 years life of plant, resulting in a discount rate of 10.05%.
- Sensitivity analyses were also carried out for energy costs to test out the firmness of the solutions.
- The lowest derived optimum level of insulation (based on climatic variations, energy prices, discount rates etc) was selected representing a conservative minimum level.

The BCA provisions for ductwork insulation do not specifically indicate the criteria used in determining the insulation level specified. However it is stated that all measures specified produced a payback period of 10 years or less. This is a much longer term than those resulting from the NPV calculations in AS4508.

Energy costs used in the BCA calculations were based on the findings of a separate report[2] and are quoted as being “avoidable charges”. No distinction between residential and commercial pricing was made.

[2] Atech Group (Jul 2003) Financial Analysis Procedure for Energy Efficiency in Buildings Class 5-9 – Final Report

Comparison of these charges with typical rates paid by consumers shows them to vary between 60% and 90% of the true costs for electricity; and around 50% of the true cost of gas.

The effect of the lower energy costs used in the BCA tend to be diminished by the longer payback period used compared to AS4508, bringing the two criteria closer to alignment.

Further to the above effects, the BCA calculations may be expected to result in reduced insulation levels as they are based on the reduced heating and cooling requirements of a building which has been optimised for energy efficiency in its overall design, whereas AS4508 was based on typical building and plant efficiencies of the time.

The comparison of corresponding insulation levels between the proposed BCA provisions and AS4508 are shown in Table 3.2. The key characteristics of this comparison are:

- The recommended evaporative cooling ductwork insulation is equal for all applications in both cases, however the original AS4508 analysis showed considerable variation with climatic zones and it may be appropriate to use a climate based insulation level for this system for this case (refer to section 4.1).
- The insulation levels for heating or refrigerative cooling ductwork and fittings are higher than the value of R0.9 and R0.4 respectively as called up in AS4508, however the insulation level for the heating fittings is specified as R0.1 in BCA whereas AS 4508 uses the same level as cooling fittings (R0.4). There is no reason for fittings to have any lower level of insulation than the ductwork they are attached to, except one of practicality of installation/application. Therefore, the increase of this insulation level to one equivalent to the cooling systems should be considered.
- AS 4508 does not apply to exposed locations as described above and therefore cannot be compared directly for those cases.
- AS 4508 calls for R0.9 and R0.4 for insulation to ductwork and fittings located within air conditioned space (excluding the area solely served by the duct) respectively. In the BCA, this application ranges from R0.75 for climatic zones 1 to 5, to R1.0 for climatic zone 5 and 7 and R1.25 for climatic zone 8.
- The insulation levels for air conditioning ductwork and fittings in conditioned space in commercial buildings were specified as R1.5 and R0.6 respectively in AS4508. The BCA calls for a range of levels of insulation, based on climatic zoning, being R1.0 for climatic zones 1 to 4; R1.25 for climatic zone 5; and R1.5 for climatic zones 6 to 8. No separate allowance for fittings is made.

Table 3.2 – Comparisons of Ductwork Insulation Levels specified in BCA and AS 4508

Type of location	*Application - BCA*	*Capacity of System*	*Application*	*Components*	*Climatic Zones*	*BCA Insulation Level - R*	*AS4508 Equivalent - Description*	*AS 4508 Insulation Level - R*	*AS 4508 Insulation for Fittings - R*
			Evap Cooling	Ductwork & Cooling Fittings	All zones	0.6	All evap cooling in unconditioned space	0.6	0.6
			Heat or Ref Cooling	Ductwork & Cooling Fittings	1,2,3 & 4	1.0	Case 2 -Heating or Cooling for Residential and conditioned space for commercial (for air conditioning in commercial see below >65kW)	0.9	0.4
			" " " " "	" " " " "	5	1.0	" " " " "	0.9	0.4
			" " " " "	" " " " "	6 & 7	1.0	" " " " "	0.9	0.4
	Under an enclosed suspended floor; or in a roofspace with insulation installed directly beneath the		" " " " "	" " " " "	8	1.5	" " " " "	0.9	0.4
			" " " " "	Heating Fittings	1,2,3 & 4	0.1	" " " " "	N/A	0.4
			" " " " "	" " " " "	5	0.1	" " " " "	N/A	0.4
			" " " " "	" " " " "	6 & 7	0.1	" " " " "	N/A	0.4
Semi sheltered	roof	=<65kW	" " " " "	" " " " "	8	0.1	" " " " "	N/A	0.4
			Evap Cooling	Ductwork & Cooling Fittings	All zones	0.6	All evap cooling in unconditioned space	0.6	0.6
			Heat or Ref Cooling	Ductwork, cooling & heating fittings	1,2,3 & 4	1.5	Not specifically covered by AS4508 – left to designers to determine the appropriate level based on the actual exposure		
			" " " " "	" " " " "	5	1.0			
			" " " " "	" " " " "	6 & 7	1.5			
			" " " " "	" " " " "	8	1.5			
Exposed	All other locations	=<65kW							
Sheltered	Within a conditioned space other than where the space is the only space served	>65kW	Evap Cooling	All components	All zones	Nil	Evap cooling in conditioned space	Nil	
			Air Conditioning	" " " " "	1,2,3 & 4	0.75	Return air space in commercial buildings only (corresponds to heating & cooling case)	0.9	0.4
			" " " " "	" " " " "	5	0.75	" " " " "	0.9	0.4

			" " " " "	" " " " "	6 & 7	1.0	" " " " "	0.9	0.4
			" " " " "	" " " " "	8	1.25	" " " " "	0.9	0.4
Semi sheltered	Under an enclosed suspended floor; or in a roofspace with insulation installed directly beneath the roof; or in a plant room	>65kW	Evap Cooling	All components	All zones	0.6	All evap cooling in unconditioned space	0.6	0.6
			Air Conditioning	" " " " "	1,2,3 & 4	1.0	Heating and Cooling - Residential and conditioned space for commercial	1.5	0.6
			" " " " "	" " " " "	5	1.25	" " " " "	1.5	0.6
			" " " " "	" " " " "	6 & 7	1.5	" " " " "	1.5	0.6
			" " " " "	" " " " "	8	1.5	" " " " "	1.5	0.6
Exposed	All other locations	>65kW	Evap Cooling	All components	All zones	0.6	All evap cooling in unconditioned space	0.6	0.6
			Air Conditioning	" " " " "	1,2,3 & 4	1.5	Not covered in AS4508 as the commercial case only relates to return-air space and residential is assumed to be smaller than 65kW	N/A	N/A
			" " " " "	" " " " "	5	1.25	" " " " "	N/A	N/A
			" " " " "	" " " " "	6 & 7	1.5	" " " " "	N/A	N/A
			" " " " "	" " " " "	8	1.75	" " " " "	N/A	N/A

4. Review of AS4508 Calculations in line with BCA

4.1. Evaporative Cooling Ductwork

The following comparisons are provided for evaporative cooling ductwork insulation levels:

- The original calculated optimum levels based on the original AS4508 criteria and climatic locations;
- The updated optimum levels based on the updated AS4508 criteria and the original climatic locations (refer to the updated criteria below);
- The corresponding BCA level of insulation.

These are summarised in Table 4.1.

Table 4.1 – Economic Analysis Criteria for Evaporative Cooling Ductwork

Criteria	Original AS4508 Value	Revised AS4508 Value	BCA Equivalent
Energy Costs Electricity	10.2 c/kWh	12 c/kWh	Location dependent. As per BCA
Rate of Return	15%	10%	N/A
Tax Rate	33%	30%	N/A
Inflation	2.5%	4.5%	N/A
Life of Plant	15 yrs	15 yrs	N/A
Resulting discount factor	10.05%	7.00%	N/A
Payback period yrs	N/A	N/A	10 yrs max

Further assumptions used in the modelling process are as follows:

1. The cooler would be used for ventilation and/or cooling whenever the O/A temperature is greater than or equal to 26 deg C
2. The internal comfort temperature is – 26DegC
3. A 95 percentile design condition is chosen for each city as per standard air conditioning design process.
4. A 75% efficiency has been used for the evaporative cooler operation.
5. The internal load assumed for the spaces is fixed at 100 W/m2.
6. Temperature loss in duct is calculated assuming 20 metres of .35m dia duct in roof space whose temperature is 15Deg C above dry bulb (for the uninsulated roof case) and 8DegC above dry bulb (for the insulated roof case).
7. Air velocity in duct is assumed to be 5 m/sec.
8. A typical installation will use 60 metres of ductwork.
9. The capital cost of the evaporative cooler is based on a pro-rata price of the Braemar range of coolers with allowance for installation etc.

4.1.1. Results – Evaporative Cooler Analysis

Figures 4.1 and 4.2 show the optimum levels of insulation calculated under the original AS4508 methodology; the AS4508 methodology using updated factors; and the BCA criteria and factors for a range of main cities and climatic zones. These are compared to the levels of insulation specified in AS4508 and the proposed BCA provisions. A detailed work-sheet is shown in Appendix 1.

The following observations may be made from the evaporative cooler ductwork analysis:

- The principal advantage in providing insulation in evaporative cooling ductwork is in reducing the total air quantity required to produce a specific cooling effect. This reduces the

total size of the installation and therefore its total capital cost. Savings in energy costs follow from the selection of smaller units and reduction in operating speeds of fans.

- Due to the limited operating temperature band available to evaporative cooling, this system is particularly sensitive to duct heat gains, requiring large increases in air quantity to make up for the lost cooling effect.
- In the majority of cases there is reasonable agreement in the optimum level of insulation calculated from the three methodologies used (the original AS4508, the original AS4508 methodology with updated factors, and the BCA methodology).
- There is substantial variation of insulation levels between the sheltered case and the exposed case for each location and between climatic zones.
- Climatic Zone 5, incorporates a number of major cities which have been grouped due to similar air conditioning requirements, however due to variation in the humidity patterns of the 3 cities evaluated, some variation in the optimum insulation levels for these is evident (refer to Figures 4.1 and 4.2.
- The specified levels of insulation under the both the BCA and AS4508 are lower than the optimum levels for most climatic zones for all evaluation criteria used.
- The minimum level of insulation for the exposed case as specified under both documents is inadequate and should be raised to R0.9. The minimum level for the sheltered case agrees with the results of this analysis (ignoring additional variations due to climatic zone/location)

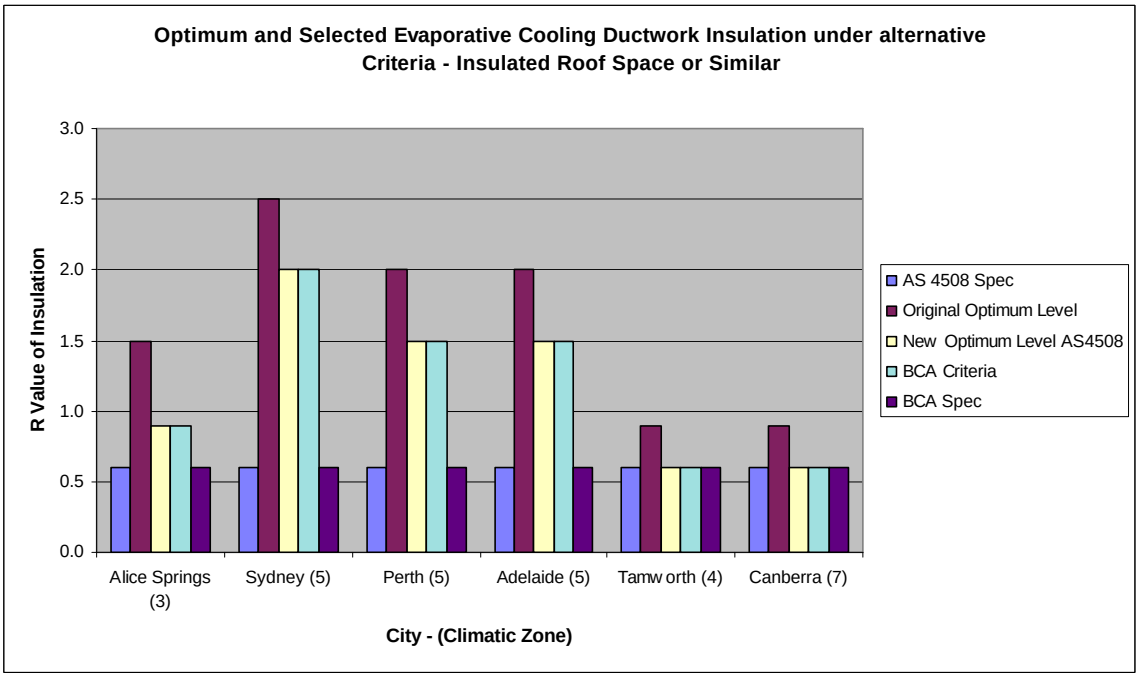

Figure 4.1 – Evaporative Cooling Ductwork Insulation – Comparison of Optimum Levels – Sheltered Case

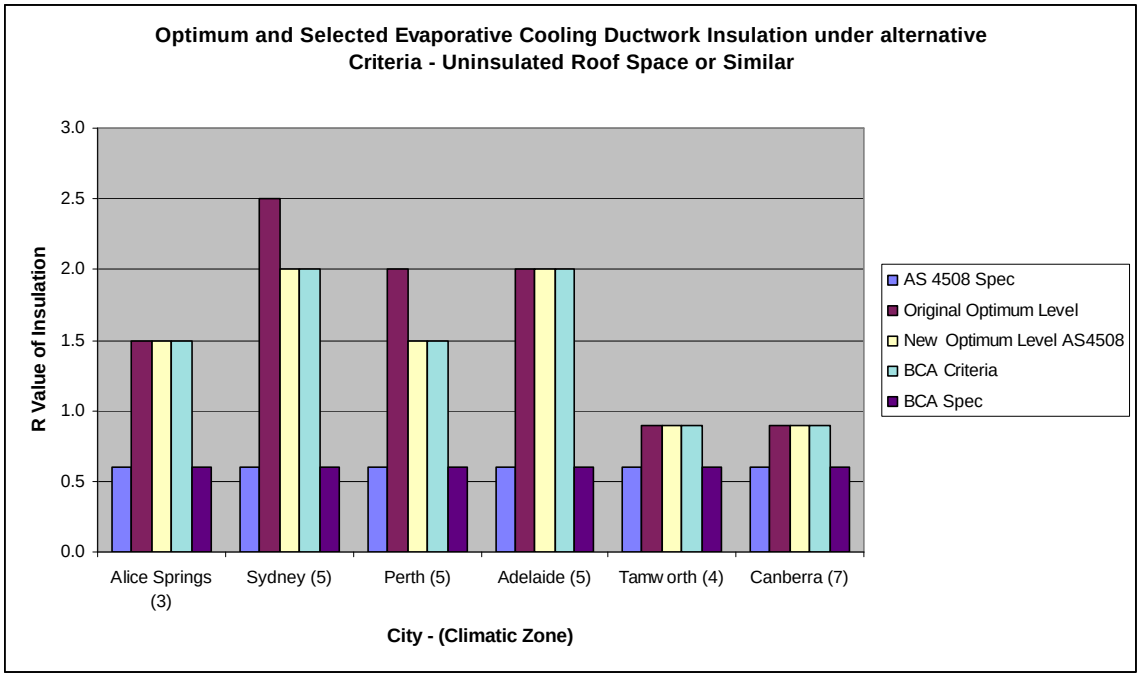

Figure 4.2 – Evaporative Cooling Ductwork Insulation – Comparison of Optimum Levels – Exposed Case

4.1.2. Conclusions – Evaporative Cooling Ductwork

The analysis into the evaporative cooling ductwork leads to the following conclusions:

- Under most circumstances, the optimum levels of insulation calculated by the AS4508 and BCA methodology were in agreement.
- There is justification for the use of climatic zone variations in the selection of evaporative cooler ductwork.
- The specification of different levels of insulation for sheltered (insulated roof space) and exposed locations is justified.
- There is a case to increase the minimum insulation level for the exposed case to R0.9 followed by additional increases by climatic zone.
- The minimum insulation level of R0.6 for the sheltered case is appropriate, also to be followed by additional increases by climatic zone.
- For the cases evaluated, the following levels of insulation should be considered. A further variation for (or a bias towards) cities which have major evaporative cooler applications may be considered for some climatic zones (eg. Adelaide or Perth may be considered more appropriate for Zone 5 rather than Sydney)

Table 4.2 – Economic Analysis Solutions for Evaporative Cooling Ductwork

Climatic Zone	Sheltered Case	Exposed Case
Zone 3	R0.9	R1.5
Zone 5	R1.5	R1.5
Zone 7	R0.9	R0.6

* Note: optimum values are subject to selected economic criteria and modelling assumptions

4.2. Commercial Buildings – Air Conditioning Applications

AS 4508 specifies optimum insulation levels for commercial buildings in the following applications (refer also to Table 3.2):

- Air conditioning ductwork in return air space (Sheltered); and
- Air conditioning ductwork in plant rooms (Semi-sheltered)

The above applications do not provide a corresponding case for the BCA "Exposed" case (refer to Table 3.2). To provide a better comparison with the BCA levels of insulation, a corresponding level of insulation for the "Exposed" case was calculated, using the AS4508 methodology.

The insulation levels specified in AS4508 were based on conditions and operating patterns generally applicable to multistorey office buildings. The model used in the analysis consisted of [3]a 14 storey building with square shaped floor plan with 50% glazed area, double glazing and shading coefficient of 0.57 and 100mm concrete and plaster curtain wall. This model provides a fair representation of this type of commercial building however, it is does not incorporate the higher energy efficiency measures used in the BCA modelling process. This does not affect the losses from ductwork in either of the above applications however, it does reduce the total time and intensity with which heating and cooling plant may be operating thus resulting in lower savings than those produced by this model.

The following comparisons are provided for commercial building ductwork insulation levels:

- The original level of insulation specified in AS4508;
- The original calculated optimum levels based on the original AS4508 criteria and climatic locations;
- Revised optimum levels based the AS4508 methodology with updated economic evaluation factors and the original climatic locations (refer to the updated criteria below);
- The optimum levels based on the AS4508 methodology using the BCA energy rates;
- The corresponding level of insulation for a 10 year payback (or lowest payback case where no option is below 10 years) as per the BCA limiting conditions, using the AS4508 costings and BCA energy rates.
- The corresponding level of insulation specified in the BCA.

These are summarised in Table 4.3.

Table 4.3 – Economic Analysis Criteria for Commercial Building Ductwork

Criteria	Original AS4508 Value	Revised AS4508 Value	Revised AS4508 Methodology with BCA Energy Rates	BCA Equivalent
Energy Costs Electricity Gas	13 c/kWh (15c/kWh for Alice Springs) $9/GJ ($16/GJ for Alice Springs)	12 c/kWh (14c/kWh for Alice Springs) $9/GJ ($15/GJ for Alice Springs)	Location dependent. As per BCA	Location dependent. As per BCA
COP	2.5	3	3	3
Improved building efficiency	N/A	15% reduction in heating and cooling	15% reduction in heating and cooling	15% reduction in heating and cooling
Gas appliance efficiency	80%	80%	80%	80%
Rate of Return	15%	10%	10%	N/A
Tax Rate	33%	30%	30%	N/A
Inflation	2.5%	4.5%	4.5%	N/A
Life of Plant	15 yrs	15 yrs	15 yrs	N/A
Resulting discount factor	10.05%	7.00%	7.00%	N/A
Payback period yrs	N/A	N/A	N/A	10 yrs

[3] Refer to AS4508 for further details of the model and analysis criteria

Although AS4508 only covered the "Sheltered" and "Semi-Sheltered" applications for commercial building ductwork (refer to Table 3.2), the above analysis was extended to provide an equivalent solution for the "Exposed" application for each of the above cases, for comparison against the proposed BCA levels.

One major difference between the evaporative cooling and the commercial building analyses is that the impact of the ductwork on the overall cooling/heating systems within the buildings is ignored in the latter. This results in conservative solutions for the optimum levels of insulation compared to those shown in the BCA specifications, which it is assumed incorporate the effect on system sizing in the overall analysis.

4.2.1. Results – Commercial Buildings Air Conditioning Ductwork

Figures 4.3, 4.4 and 4.5 show comparisons of the optimum levels of insulation calculated for the "Sheltered", "Semi-Sheltered" and "Exposed" applications of ductwork under each of the economic criteria detailed in Table 4.3, for a number of selected cities/climatic zones. These are also tabulated in Appendix 2.

The following observations are made from the commercial buildings ductwork analysis:

a) General

- The discounted electricity rates used in the BCA analyses provide major variations in the optimum solutions within individual climatic zones. In the analysis carried out for commercial buildings, this is particularly noted for Alice Springs, where the discounted rate for electricity used in the BCA is 9.3 c/kWh and is up to 50% higher than the rate used in other cities in the same climatic zone. Similar major variations exist in the rates presented in the BCA for zone 1 (Cairns 6.1 c/kWh & Darwin 9.8 c/kWh); zone 4 (Kalgoorlie-Boulder 10.2 c/kWh and Wagga Wagga 5.9 c/kWh); etc.

- The discounted gas rates used in the BCA analyses are not very representative of the prices paid by consumers. In the case of a large consumer in Victoria, the rates used may as close as 80% of the actual rate paid, but for all other States and smaller commercial building applications, the rates are 50% or less than actual.

The above situation puts into question the overall principle of using discounted energy rates and/or climatic zones for the financial evaluation of the BCA options. The full energy rate used in the AS4508 evaluation is considered to better represent the impact sustained on the consumer.

a) Sheltered Case (ductwork in air conditioned and return air space or similar)

- The original level of insulation specified in AS4508 represented the minimum level identified across all climatic zones/locations and therefore is lower level than the original optimum for all locations except Sydney. The above difference is further increased in the revised AS4508 methodology.
- The 10 year payback case is more directly affected by the omission of capital cost influences noted above in section 4.2 and may therefore be considered as providing a low solution.
- The levels of insulation specified in the BCA do not appear to reflect the variations applicable to climatic factors for locations such as Brisbane, Alice Sprigs and Canberra.
- Using an optimum level of insulation being between the two AS4508 criteria (original and revised), the levels of insulation considered to be applicable to the locations/climatic zones shown, compared to the BCA provisions are shown in Table 4.4.

Table 4.4 – Economic Analysis Solutions for Commercial Buildings Ductwork – Sheltered Case

Climatic Zone	Optimum Insulation Level*	BCA Specification
Zone 2	R1.5	R0.75
Zone 3	R1.8	R0.75
Zone 5	R1.2	R0.75
Zone 6	R1.3	R1.0
Zone 7	R1.4	R1.0

* Note: optimum values are subject to selected economic criteria and modelling assumptions

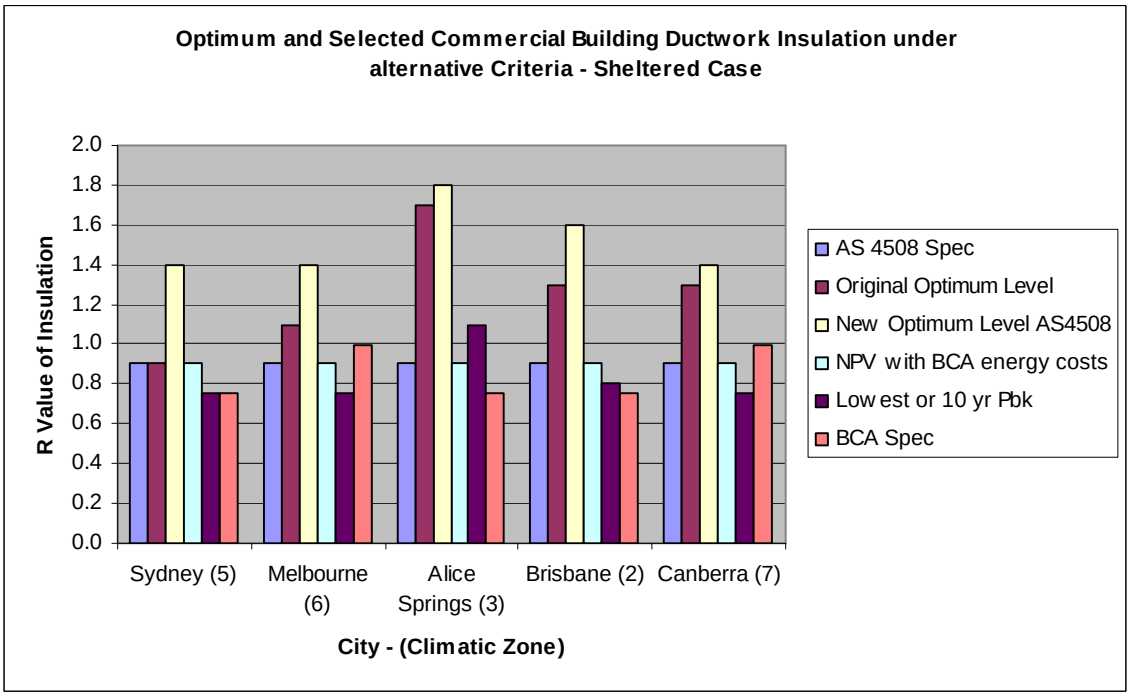

Figure 4.3 – Commercial Building Ductwork Insulation – Comparison of Optimum Levels Sheltered Case

b) Semi-Sheltered Case (ductwork in plant rooms or similar)

- The original level of insulation specified in AS4508 represented an average level of economic performance across all climatic zones/locations. Under the revised AS4508 methodology, the specified level tends towards the minimum optimum level of insulation across the locations analysed.
- As for the sheltered case, the 10 year payback case is more directly affected by the omission of capital cost influences noted above in section 4.2 and may therefore be considered as providing a low solution.
- There is a better level of consistency, in some locations between the levels of insulation specified in the BCA and those calculated using the AS4508 methodology however the effect of climatic influences for locations such as Brisbane and Alice Sprigs still appear to be underestimated.
- Using an optimum level of insulation being between the two AS4508 criteria (original and revised), the levels of insulation considered to be applicable to the locations/climatic zones shown, compared to the BCA provisions are shown in Table 4.5.

Table 4.5 – Economic Analysis Solutions for Commercial Buildings Ductwork - Semi-Sheltered Case

Climatic Zone	Optimum Insulation Level*	BCA Specification
Zone 2	R1.6	R1.0
Zone 3	R2.0	R1.0
Zone 5	R1.3	R1.25
Zone 6	R1.5	R1.5
Zone 7	R1.7	R1.5

* Note: optimum values are subject to selected economic criteria and modelling assumptions

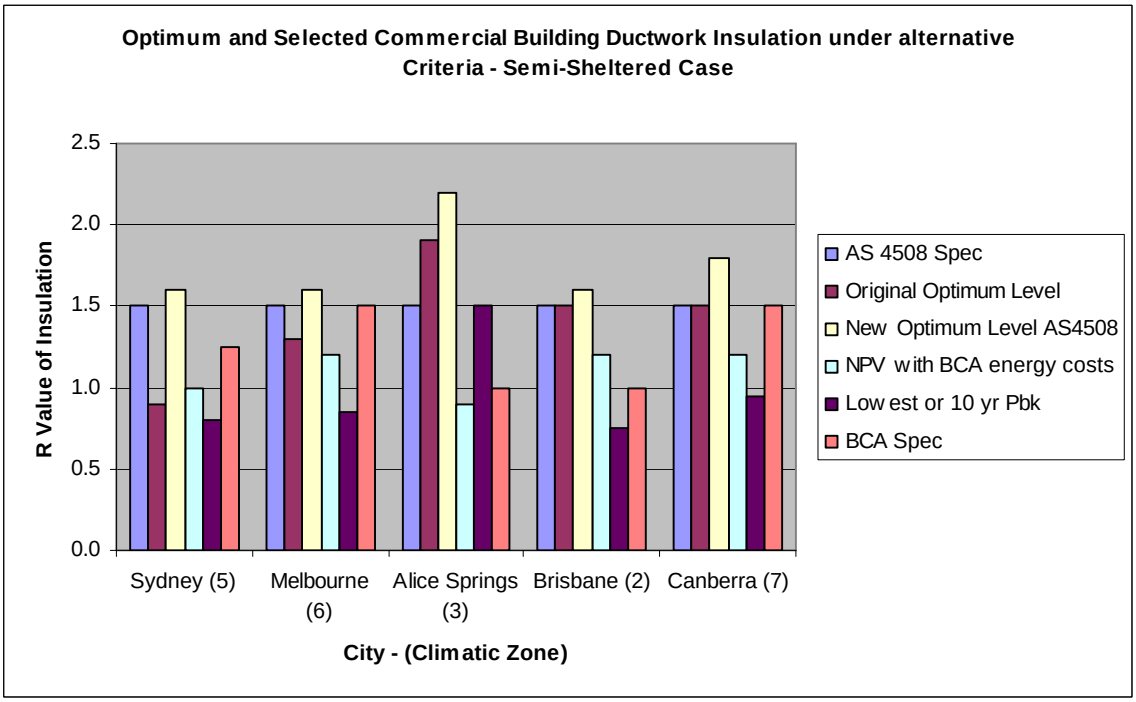

Figure 4.4 – Commercial Building Ductwork Insulation – Comparison of Optimum Levels Semi-Sheltered Case

b) Exposed Case

- AS4508 does not provide an insulation level for exposed ductwork, as it was assumed that this would be calculated by the designers for each case, as was current practice at the time of the standard's development.
- Using a similar relationship with the calculated optimum levels, as for the Sheltered and Semi-sheltered cases, the levels of insulation considered applicable to the locations/climatic zones shown, compared to the BCA provisions are shown in Table 4.6.

Table 4.6 – Economic Analysis Solutions for Commercial Buildings Ductwork – Exposed Case

Climatic Zone	Optimum Insulation Level*	BCA Specification
Zone 2	R1.7	R1.0
Zone 3	R2.0^{+}	R1.5
Zone 5	R1.3	R1.25
Zone 6	R1.8	R1.5
Zone 7	R1.8	R1.5

* Note: optimum values are subject to selected economic criteria and modelling assumptions

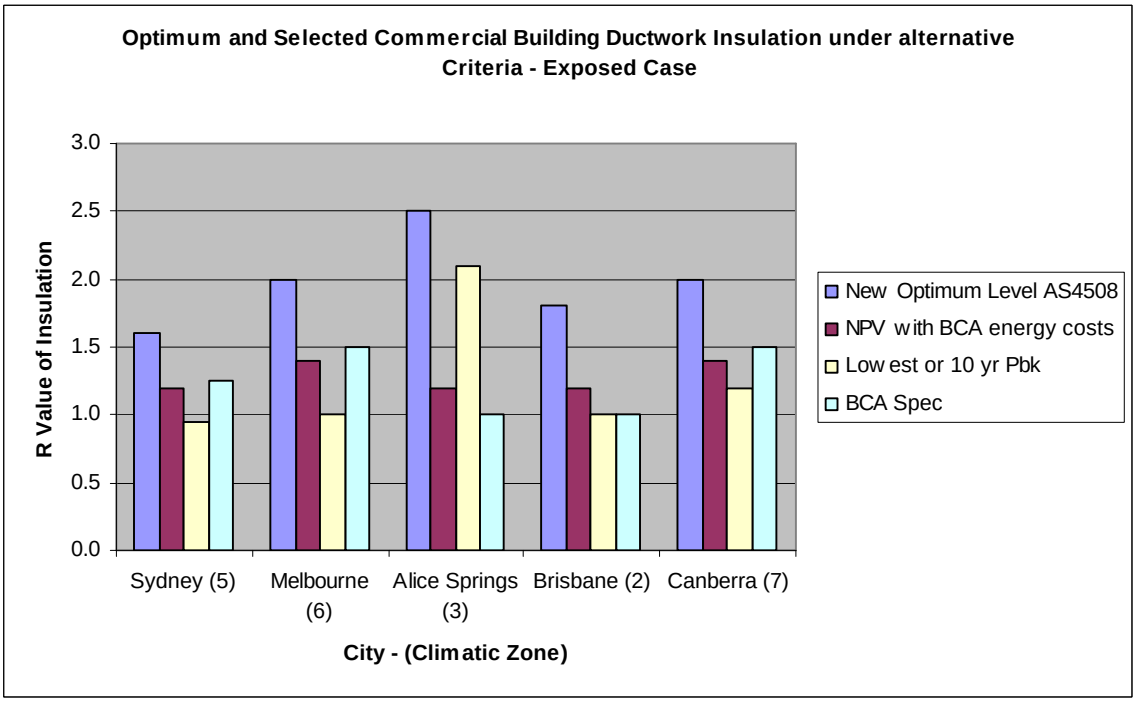

Figure 4.5 – Commercial Building Ductwork Insulation – Comparison of Optimum Levels Exposed Case

4.2.2. Conclusions – Commercial Buildings Ductwork

The analysis into the commercial building ductwork leads to the following conclusions:

- Discounted energy rates used in the BCA analysis are not representative of the real cost sustained by the consumers, as well as not suitably matching the climatic zone selections (ie. within one climatic zone, variations in energy costs of 100% exist). These lead to lower insulation level selections than would occur in the real case.
- The use of a 10 year payback criteria, which is considerably longer than generally accepted in the industry reduces the effect of the discounted energy rates resulting in reasonable insulation level selections for the milder climatic zones, such as zones 5 & 6.
- In general, the optimum levels of insulation calculated under the AS4508 methodology are above the levels prescribed under the BCA. In particular, those relating to the climatic zones of 2 and 3. It is assumed that this would also apply to zone 1 and to a lesser extent zone 4.
- For the cases evaluated, the optimum levels of insulation shown in Table 4.7 should be considered. The respective level of insulation prescribed in the BCA is included in parentheses.

- The largest discrepancies noted in Table 4.7 are found in the figures for Zones 2 and 3 generally; and in the sheltered cases generally.
- The applications with the closest agreement include Zone 5 generally (except for the sheltered case); and the semi-sheltered cases (excluding zones 2 and 3)

Table 4.7 – Economic Analysis Solutions for Commercial Buildings Air Conditioning Ductwork
(BCA specified level shown in parentheses)

Climatic Zone	Sheltered Case	Semi-Sheltered Case	Exposed Case
Zone 2	R1.5 (R0.75)	R1.6 (R1.0)	R1.7 (R1.0)
Zone 3	R1.8 (R0.75)	R2.0 (R1.0)	$R2.0^{+}$ (R1.5)
Zone 5	R1.2 (R0.75)	R1.3 (R1.25)	R1.3 (R1.25)
Zone 6	R1.3 (R1.0)	R1.5 (R1.5)	R1.8 (R1.5)
Zone 7	R1.4 (R1.0)	R1.7 (R1.5)	R1.8 (R1.5)

It is considered that a case to review the specified insulation levels for commercial building applications exists.

5. Insulation of Building Envelope Components

5.1. Differences in Definitions and Applications to existing Standards

The provisions for commercial buildings represent a significant increase in the minimum insulation requirements for commercial building envelopes, which to date has been largely ignored in existing standards and in general construction practice.

The BCA provides for two methods of achieving the minimum energy standards in Commercial Buildings. One involves the verification of performance against a "stated value" of energy consumption (based on building class and location) or against a reference building for which minimum modelling requirements are provided. The other method involves "Deemed-to-Satisfy" provisions, which include total R-Values[4] for all envelope components (roof/ceiling, walls and floors – both exterior and to adjoining non-conditioned spaces).

This review primarily involves itself with the "Deemed-to-Satisfy" provisions, which are presumed to have been reflected in the performance requirements specified. In saying this however, it is noted that Section JV3 and its related table, which specify the modelling requirements of the "reference building", do not include a reference to the minimum insulation levels to be included in the envelope model. This point should be clarified in the BCA to ensure that the required performance of the reference model is achieved and that this method of compliance provides comparable results against the others.

5.2. Economic Evaluation Methodologies and Assumptions

In general, the insulation levels specified in the BCA have initially been calculated using simple payback criteria, and then reviewed on the basis of practicality of installation.

The economic criteria were based on:

- Discounted energy rates which are substantially lower than the actual rates paid by consumers (refer to earlier discussion on this issue in the ductwork analysis).
- Reduction in the cost of the primary cooling/heating plant resulting from the increase in insulation levels is included in the global methodology used and is assumed to be have been reflected in the figures shown.
- Limiting payback periods of 10 years, which is more generous than normally accepted in the marketplace, however this essentially eliminates the effect of using the low energy rates referred to above and produces results achieved with more conventional economic criteria.
- Two sets of insulation costs which are substantially different and are further discussed below.

Individual analyses were conducted for walls (each side of the building reviewed independently), roof/ceiling structures and floors.

The resulting R-Values based on the above criteria were reported to be generally impractical and did not reflect the true cost of installation of the insulation (refer to the discussion below). This lead to the selected total insulation values having payback periods closer to 3 years, based on the above criteria.

5.2.1. Cost of Insulation

It is clear from the analysis of the RD that the actual cost of insulation has not been identified and the final levels of insulation used in the BCA represent discounted optimum levels, based on issues of practicality and ease of installation, which could not be reflected in the figures used.

[4] Total R-Values relate to the entire envelope component including the properties of the construction materials, air gaps, insulation materials, film coefficients etc.

Two sets of cost figures were used for the supply and installation of insulation to walls, roof/ceilings and floors. One set was sourced from the "Insulation Industry" and the other was calculated from Rawlinsons Construction Handbook. A comparison of these figures is shown in Figure 5.1, which shows discrepancies in the order of up to 260%.

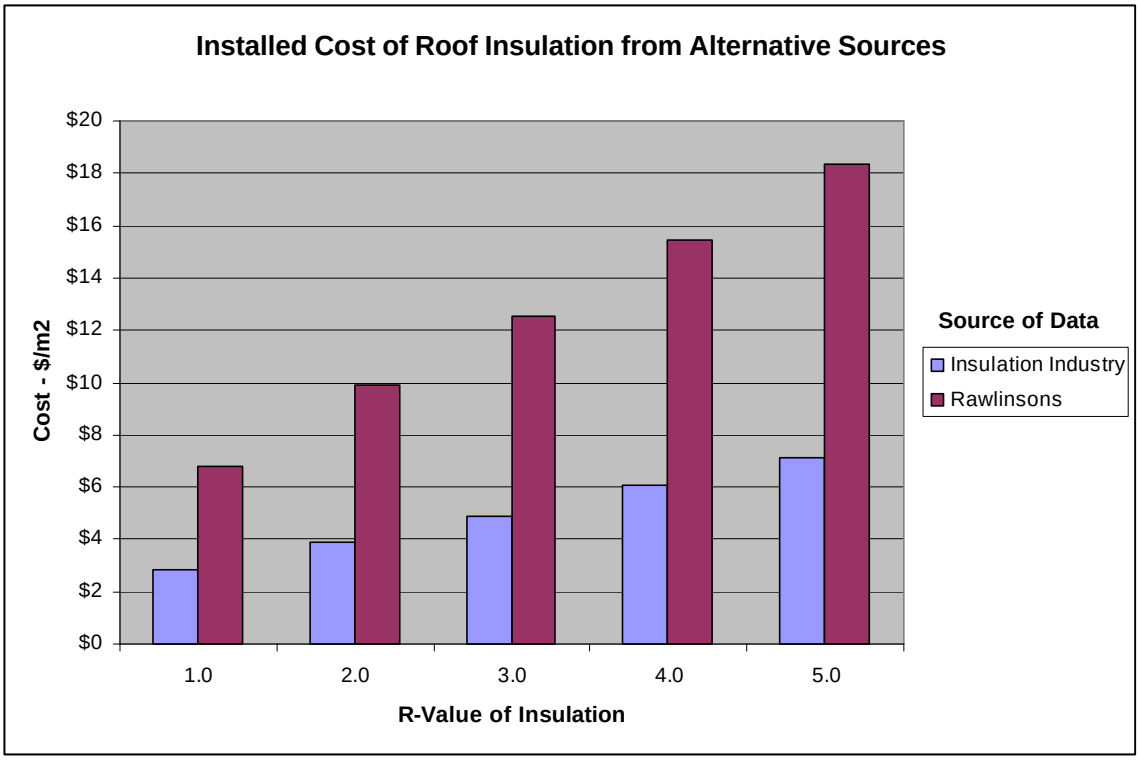

Figure 5.1 – Installed Cost of Roof Insulation from Alternative Sources

Cost factors which still need to be incorporated into the above cost figures include:

- Additional support requirements needed as the insulation increases.
- The loss of floor space as the thickness of insulation increases (or the additional cost of construction required for accommodating this).
- New products which may be developed to offset practical issues and minimise the cost.

The above factors are sensitive to the performance and qualities of insulation materials, such as their conductivity (ie. determining the installed thickness) and stiffness (internal or self-supporting) and are likely to change as product specifications change.

Even with slight variation of the installed cost of insulation, the return on investment on insulation is very positive, as also indicated in the BCA working papers.

5.3. Specified Minimum Levels of Total R-Value and Comparison with Previous Works

5.3.1. BCA Requirements

The total R-Values specified in the BCA for commercial buildings (Classes 5 to 8, 9a and 9b) are shown in Table 5.1. Climatic variations have generally been eliminated for simplification with all climatic zones (1 to 7) having equal R-Value requirements, with the exception of exposed floor slabs where buildings in climatic zones 2 and 5 are given exemptions and for non-exterior walls, where buildings in climatic zones 1, 2, 3 and 5 are given exemptions.

Table 5.1 – Minimum Total R-Value of Building Envelope Elements for Commercial Buildings (Classes 5 to 8, 9a and 9b

Envelope Element	Climate Zone 1	2	3	4	5	6	7	8	Comment
ROOF - CEILINGS									
Principal heat flow direction for roof/ceiling	downwards							upwards	
Roof or Ceiling Generally	3.2	3.2	3.2	3.2	3.2	3.2	3.2	4.3	
Ceiling below non-conditioned space	1.6	1.6	1.6	1.6	1.6	1.6	1.6	2.15	
WALLS									
Exterior Walls (all directions)	1.9	1.9	1.9	1.9	1.9	1.9	1.9	2.8	1. specific options to satisfy these conditions are provided 2. Zones 2, 4 and 5 also require shading to exterior walls 3. provisions for combination with window treatment if the specified level cannot be achieved
Non-exterior wall	n/a	n/a	n/a	0.95	n/a	0.95	0.95	1.4	Equivalent treatment to an external wall is acceptable Zones 4, 7 and 8 - requires that each element bounding the non-conditioned space be similarly treated
FLOORS									
Suspended Floors with unenclosed perimeter	1.5	Nil	1.5	1.5	Nil	1.5	1.5	2.5	Floors with in-slab heating to be insulated with R1.0 around perimeter and underneath the slab

In the case of roof-ceilings and floors, the designer is left free to achieve the required minimum R-Value by whatever combination of construction material/insulation is desired.
In the case of walls, a number of options and additional requirements are made and a minimum component of insulation is often specified. Typically the options include combinations of:

- A minimum density and maximum level of conductivity (normally 0.8) for the construction materials;
- Options with and without air gaps
- Minimum levels of insulation required in the wall for alternative options
- Various requirements for shading[5] of exterior walls for buildings in selected climatic zones

[5] The provision of shading to the exterior walls of many commercial buildings is considered impractical or very costly, resulting in many buildings in climatic zones 2, 4 and 5 bypassing the deemed-to-satisfy provisions for the performance options, or otherwise seeking exemptions

Specific minimum levels of insulation materials included in the provisions are summarised in Table 5.2. It should be noted that the total R-Values are not achieved by many of the combinations shown, requiring designers to increase the level of insulation or reduce the conductivity of the construction materials, as necessary for those cases.

Table 5.2 – Options for external wall for Commercial Buildings (Classes 5 to 8, 9a and 9b

Climatic Zone	Surface density	Masonry maximum conductivity	Air Gap	Minimum R-Value	Further requirements
1, 3 & 7	220 kg/m2	0.8	N	1	Minimum total R-Value of 1.9
	220 kg/m2	0.8	Y	0.5	
	220 kg/m2	>0.8	Y	1	
2 & 5	220 kg/m2	0.8	Y	n/a	Minimum total R-Value of 1.9
	220 kg/m2	0.8	N	0.5	
	220 kg/m2	>0.8	Y	1	External shading to walls
4	220 kg/m2	0.8	N	1	Minimum total R-Value of 1.9
	220 kg/m2	0.8	Y	0.5	
	220 kg/m2	>0.8	Y	1	External shading to walls
6	220 kg/m2	0.8	Y	n/a	Minimum total R-Value of 1.9
	220 kg/m2	0.8	N	0.5	
	220 kg/m2	>0.8	Y	1	
8	Minimum total R-Value of 2.8				

5.3.2. Previous Studies on Commercial Buildings Insulation Levels

Previous studies conducted by EMET Consultants for FARIMA looked into optimum levels of insulation for roof-ceiling structures in commercial buildings. This analysis has been reviewed and extended to provide a limiting value for optimum insulation levels for this application. It should be noted that due to the differing assumptions used in this analysis to those used in the BCA, the results can only be compared notionally. Some of these differences consist of:

- The use of NPV on marginal increases in insulation levels instead of simple payback methodology;
- Differing costs of insulation and energy rates (refer also to the discussion on ductwork insulation);
- Differing costs for primary heating and cooling plant and associated equipment;
- The isolation of roof-ceiling only without changes to the remainder of the building;
- Existing levels of energy use compared to the improved levels of energy use used in the BCA modelling;
- Other specific modelling assumptions for items such as equipment operations, efficiencies of plant, etc.

Figure 5.2 illustrates the results of the updated economic evaluation of roof-ceiling insulation levels for commercial buildings. The key features of the chart are:

- The NPV value tends to flatten out after about R2.0 for all cases.
- The NPV for various cities which are in the same climatic zone in the BCA are often quite different (eg. Sydney, Melbourne, Perth) again putting to question some of the climatic zone groupings.
- The optimum figures obtained are in the range of R2.0 (Adelaide) to R3.0 (Melbourne) although the flatness of the curve results in high sensitivity to other influencing factors.

The above values are comparable to the BCA total R-Value requirements for roof-ceiling elements, of R3.2 although there may be more scope for variation based on climatic zones and within climatic zones for major cities. In particular, the combination of the major commercial centres of Sydney, Adelaide and Perth into one climatic zone results in the reduction of stringency for the cities of Adelaide and Perth. Similarly, climatic zone 2 is often classified as a minor intensity zone and provided with various dispensations. This result is not evident when comparing the results for Brisbane, which is the major commercial centre in this zone.

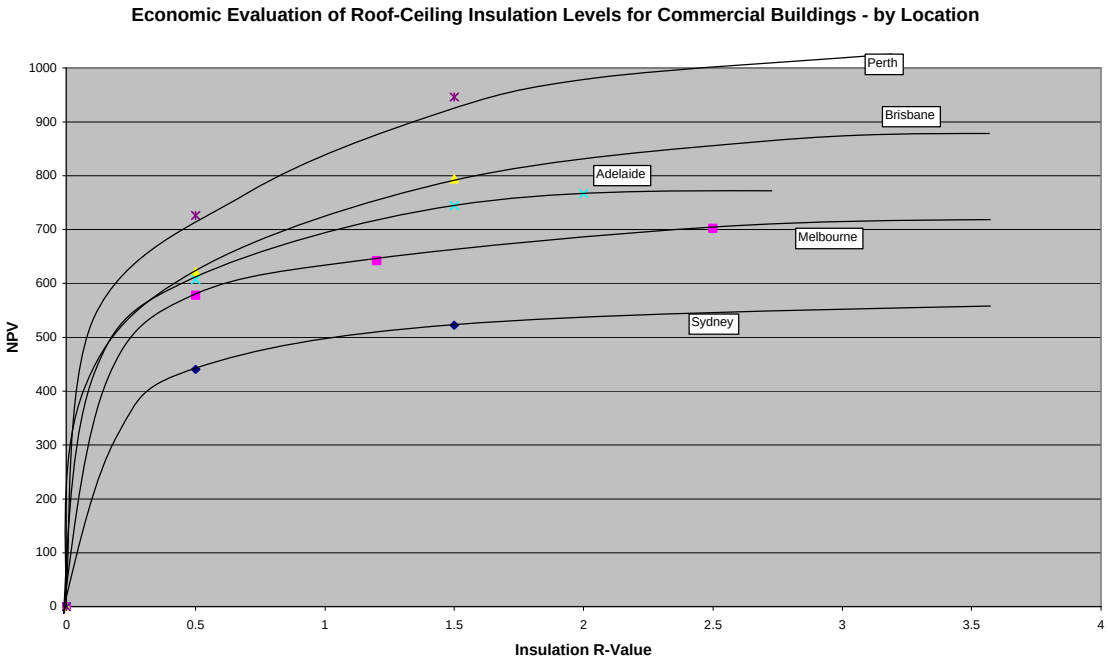

Figure 5.2 – Economic Evaluation of Roof-Ceiling insulation Levels for Commercial Buildings – by Location

5.4. Conclusions – Envelope Insulation Levels

The analysis into the envelope Insulation components of the proposed BCA provisions for commercial buildings leads to the following conclusions:

- No envelope (walls and roof) insulation levels are noted for the reference building modelling process (refer to Section & Table JV3). This can lead to the reference building performance option producing a lower standard of design compared to the other compliance methods and therefore lower insulation standards.

- The envelope insulation levels specified in the proposed BCA provisions represent a significant improvement in the treatment of these components, which have largely been ignored to date. However more work should be done on evaluating the true cost of insulation to allow these prescribed levels to be fine-tuned.

- The requirements for shading of external walls in some climatic locations will be impractical, or very costly, for some buildings. An alternative with higher total R-Value or similar option should be considered and included in the provisions. This provision is also not carried across to the reference building modelling process leading to similar issues discussed in the first point above.

- The variation (or lack thereof) of provisions for different climatic zones does not seem to correlate with results achieved for individual cities within those zones. Also, the grouping of major

commercial centres in the same climatic zone does not always show the differentiation warranted by their specific climatic patterns. A review of these zones or variations for major centres may be worth considering as more fine-tuning occurs.

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Appendix 1

Evaporative Cooling Analysis Worksheet

Table A1.1 – Evaporative Cooler Insulation Evaluation Work-sheet (single case only shown)

Case	City	Number operating hrs pa	Dry bulb temp at 95%'le	Wet bulb temp at 95%'le	Duct Insulation R Value	Heat gain in Duct W	Temp Gain in Duct (K)	Temp Range available for Cooling (K)	Air Quantity Needed (l/sec/m2)	Equiv Air Change Rate	Duct Dia	Total Capital Cost ($/m run)	Energy Use kWh pa	Annual Energy Saving $ pa	Capital Cost based on 60 M	NPV over 15 years
1a	Alice Springs	2824	33.2	16.5	0	3027	5.19	0.14	596.0	794.61	1.89	1227.95	13978.80	0.00	84477	-84477
1b	Alice Springs	2824	33.2	16.5	0.6	757	1.30	4.03	20.5	27.29	0.35	50.68	1044.88	1552.07	3541	49549
1c	Alice Springs	2824	33.2	16.5	0.9	550	0.94	4.38	18.8	25.08	0.34	48.04	960.56	1562.19	3382	50054
1d	Alice Springs	2824	33.2	16.5	1.5	356	0.61	4.71	17.5	23.31	0.32	47.86	706.00	1592.74	3222	51259
1e	Alice Springs	2824	33.2	16.5	2	275	0.47	4.85	17.0	22.65	0.32	49.15	685.83	1595.16	3299	51265
1f	Alice Springs	2824	33.2	16.5	2.5	224	0.38	4.94	16.7	22.25	0.32	51.02	673.71	1596.61	3411	51203
2a	Sydney	541	38.3	17.8	0	3340	5.72	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
2b	Sydney	541	38.3	17.8	0.6	835	1.43	1.64	50.1	66.86	0.47	113.61	297.55	0.00	8017	-8017
2c	Sydney	541	38.3	17.8	0.9	607	1.04	2.03	40.5	54.03	0.43	94.19	240.47	6.85	6851	-6617
2d	Sydney	541	38.3	17.8	1.5	393	0.67	2.40	34.3	45.77	0.39	83.96	200.17	11.69	5537	-5138
2e	Sydney	541	38.3	17.8	2	304	0.52	2.55	32.3	43.03	0.38	82.12	188.18	13.12	5427	-4979
2f	Sydney	541	38.3	17.8	2.5	247	0.42	2.65	31.1	41.46	0.37	82.31	181.34	13.95	5438	-4961
3a	Perth	1218	36.3	16.6	0	3274	5.61	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
3b	Perth	1218	36.3	16.6	0.6	818	1.40	3.07	26.8	35.78	0.30	62.66	450.66	0.00	4260	-4260
3c	Perth	1218	36.3	16.6	0.9	595	1.02	3.45	23.9	31.82	0.28	57.22	400.76	5.99	3933	-3728
3d	Perth	1218	36.3	16.6	1.5	385	0.66	3.81	21.6	28.81	0.27	54.86	362.94	10.53	3792	-3432
3e	Perth *	1218	36.3	16.6	2	298	0.51	3.96	20.8	27.72	0.26	55.28	349.21	12.17	3817	-3400
3f	Perth	1218	36.3	16.6	2.5	243	0.42	4.06	20.3	27.08	0.26	56.56	341.08	13.15	3893	-3444
4a	Adelaide	793	35.7	17.9	0	3120	5.35	N/A	N/A	N/A	N/A	N/A	N/A	N/A		
4b	Adelaide	793	35.7	17.9	0.6	780	1.34	2.34	35.2	46.99	0.30	79.74	293.41	0.00	5284	-5284
4c	Adelaide	793	35.7	17.9	0.9	567	0.97	2.70	30.5	40.65	0.28	70.59	253.85	4.75	4735	-4573
4d	Adelaide *	793	35.7	17.9	1.5	367	0.63	3.05	27.1	36.08	0.26	65.74	225.27	8.18	4444	-4165
4e	Adelaide	793	35.7	17.9	2	284	0.49	3.19	25.8	34.46	0.26	65.30	215.17	9.39	4418	-4097
4f	Adelaide	793	35.7	17.9	2.5	231	0.40	3.28	25.1	33.51	0.25	66.06	209.27	10.10	4464	-4119

Case	City	Number operating hrs pa	Dry bulb temp at 95%'le	Wet bulb temp at 95%'le	Duct Insulation R Value	Heat gain in Duct W	Temp Gain in Duct (K)	Temp Range available for Cooling (K)	Air Quantity Needed (l/sec/m2)	Equiv Air Change Rate	Duct Dia	Total Capital Cost ($/m run)	Energy Use kWh pa	Annual Energy Saving $ pa	Capital Cost based on 60 M	NPV over 15 years
5a	Tamworth	1439	29.9	11.6	0	3156	5.41	4.39	18.8	25.03	0.34	43.11	532.43	0.00	3087	-3087
5b	Tamworth	1439	29.9	11.6	0.6	789	1.35	8.45	9.8	13.01	0.24	26.71	359.75	20.72	1953	-1244
5c	Tamworth *	1439	29.9	11.6	0.9	574	0.98	8.82	9.4	12.47	0.24	26.67	344.70	22.53	1950	-1180
5d	Tamworth	1439	29.9	11.6	1.5	371	0.64	9.16	9.0	12.00	0.23	28.20	331.65	24.09	2042	-1218
5e	Tamworth	1439	29.9	11.6	2	287	0.49	9.31	8.9	11.81	0.23	29.95	326.50	24.71	2147	-1302
5f	Tamworth	1439	29.9	11.6	2.5	234	0.40	9.40	8.8	11.69	0.23	31.97	323.34	25.09	2268	-1410
6a	Canberra	465	29.5	13.7	0	2958	5.07	3.33	24.7	33.00	0.38	55.58	172.05	0.00	3835	-3835
6b	Canberra	465	29.5	13.7	0.6	739	1.27	7.13	11.6	15.41	0.26	30.80	116.25	6.70	2198	-1969
6c	Canberra *	465	29.5	13.7	0.9	538	0.92	7.48	11.0	14.70	0.26	30.51	110.88	7.34	2180	-1929
6d	Canberra	465	29.5	13.7	1.5	348	0.60	7.80	10.6	14.09	0.25	31.89	106.26	7.90	2264	-1994
6e	Canberra	465	29.5	13.7	2	269	0.46	7.94	10.4	13.85	0.25	33.63	104.44	8.11	2368	-2090
6f	Canberra	465	29.5	13.7	2.5	219	0.38	8.02	10.3	13.70	0.25	35.67	103.33	8.25	2490	-2208

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Appendix 2

Commercial Buildings Ductwork Insulation Solutions using alternative Evaluation Methods

Table A2.1 – Sheltered Case

Location/Clim Zone	Sydney (5)	Melbourne (6)	Alice Springs (3)	Brisbane (2)	Canberra (7)
AS 4508 Spec	0.9	0.9	0.9	0.9	0.9
Original Optimum Level	0.9	1.1	1.7	1.3	1.3
New Optimum Level AS4508	1.4	1.4	1.8	1.6	1.4
NPV with BCA energy costs	0.9	0.9	0.9	0.9	0.9
Lowest or 10 yr Pbk	0.75	0.75	1.1	0.8	0.75
BCA Spec	0.75	1	0.75	0.75	1

Table A2.2 – Semi-Sheltered Case

Location/Clim Zone	Sydney (5)	Melbourne (6)	Alice Springs (3)	Brisbane (2)	Canberra (7)
AS 4508 Spec	1.5	1.5	1.5	1.5	1.5
Original Optimum Level	0.9	1.3	1.9	1.5	1.5
New Optimum Level AS4508	1.6	1.6	2.2	1.6	1.8
NPV with BCA energy costs	1	1.2	0.9	1.2	1.2
Lowest or 10 yr Pbk	0.8	0.85	1.5	0.75	0.95
BCA Spec	1.25	1.5	1	1	1.5

Table A2.3 – Exposed Case

Location/Clim Zone	Sydney (5)	Melbourne (6)	Alice Springs (3)	Brisbane (2)	Canberra (7)
AS 4508 Spec	N/A	N/A	N/A	N/A	N/A
Original Optimum Level	N/A	N/A	N/A	N/A	N/A
New Optimum Level AS4508	1.6	2	2.5	1.8	2.0
NPV with BCA energy costs	1.2	1.4	1.2	1.2	1.4
Lowest or 10 yr Pbk	0.95	1	2.1	1	1.2
BCA Spec	1.25	1.5	1	1	1.5

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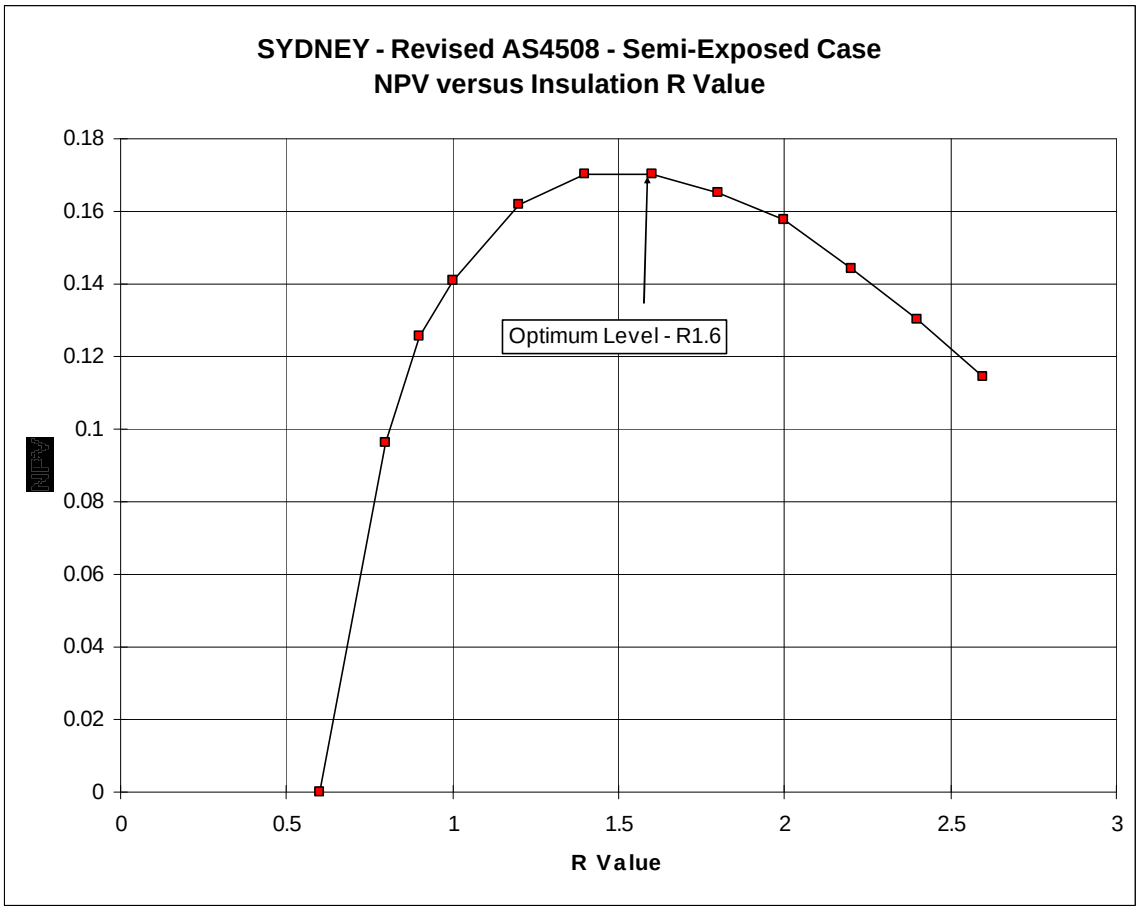
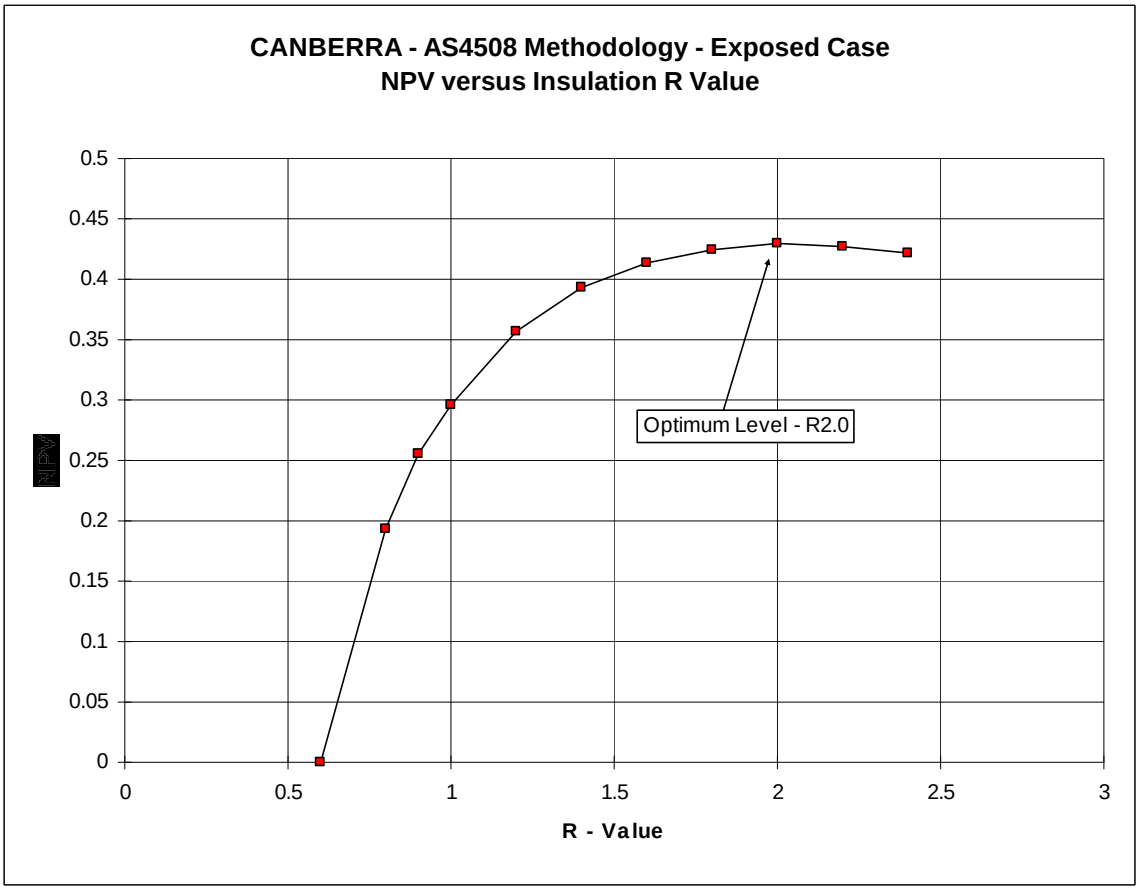
Commercial Builidngs BCA Review

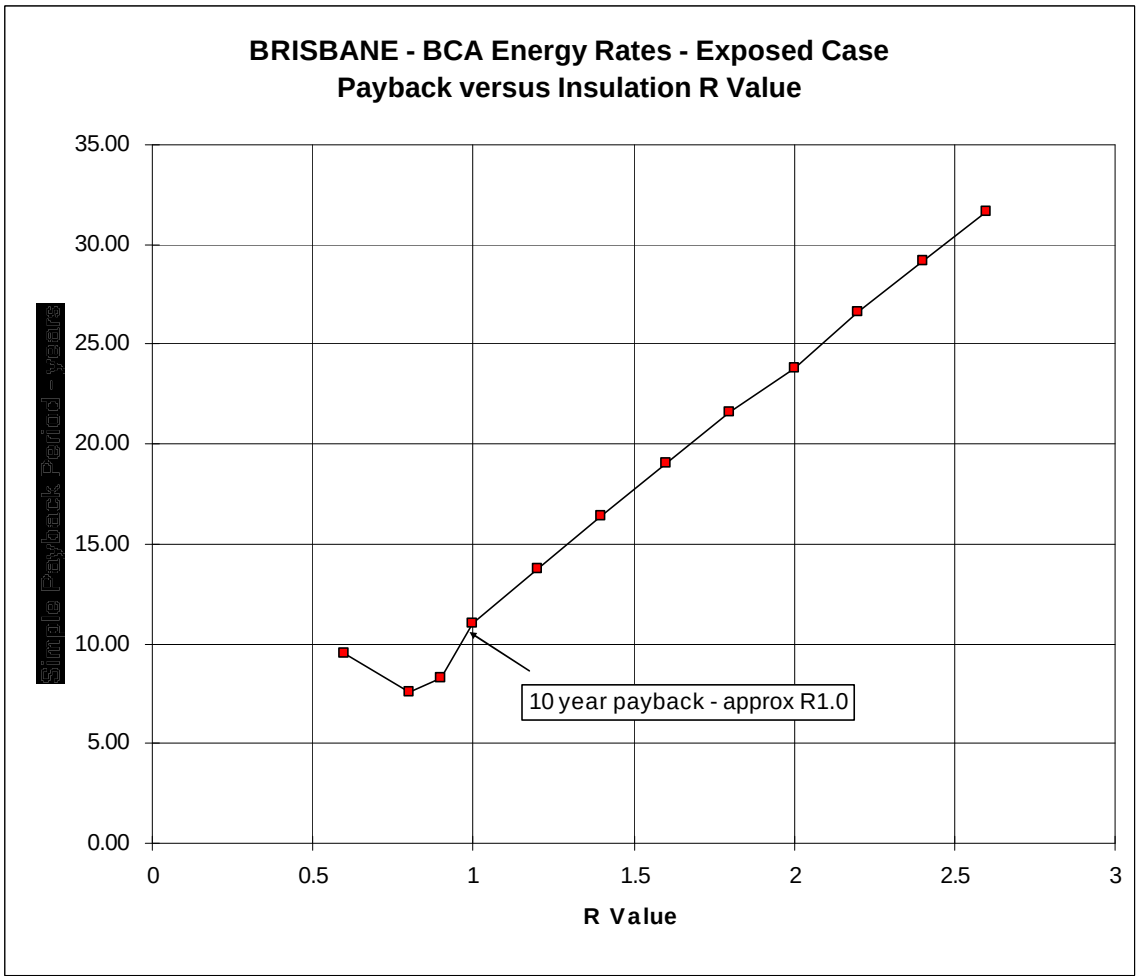
Appendix 3

Commercial Buildings Ductwork

Evaluation Results for a selected sample of Locations, Applications and Methodologies




CANBERRA - AS4508 Methodology - Exposed Case
NPV versus Insulation R Value
NPV
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
0.5
1
1.5
2
2.5
3
R - Value
Optimum Level - R2.0


BRISBANE - BCA Energy Rates - Exposed Case
Payback versus Insulation R Value
Simple Payback Period - years
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
0.5
1
1.5
2
2.5
3
R Value
10 year payback - approx R1.0