ABCB

NCC Volume Two Energy Efficiency

DEEMED-TO-SATISFY SOLUTION FOR P2.6.1

CLIMATE ZONE 1

Case Study

NON-MANDATORY DOCUMENT

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Case Study 1

NCC Volume Two Energy Efficiency DtS Elemental Solution for P2.6.1 - climate zone 1

General Information

Compliance Solution	Deemed-to-Satisfy (DtS) Elemental Solution
	NCC 2016, Volume Two DtS Provisions, Clause 3.12.0(a)(ii)
Climate Zone	NCC climate zone 1
Building Classification	Class 1a detached dwelling
Construction Type	Lightweight timber with decorative cement sheet cladding
Design Type	Conditioned

Preface

The Inter-Government Agreement (IGA) that governs the ABCB places a strong emphasis on reducing reliance on regulation, including consideration of non-regulatory alternatives such as non-mandatory guidelines, handbooks, case studies and protocols.

This Case Study is one of a series produced by the ABCB. The series of Case Studies has been developed in response to comments and concerns expressed by government, industry and the community that relate to the built environment. The aim of a Case Study is to provide construction industry participants with non-mandatory advice and guidance on specific topics.

This subject has been identified as an issue that requires consistent uniform guidance. It has been developed to explain the application of the NCC to northern Australia climate responsive designs. This Case Study addresses the issues in generic terms, and is not a document that sets out a specific NCC solution. It is expected that this Case Study will be used to assist practitioners develop solutions relevant to specific situations in accordance with the generic principles and criteria contained herein.

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Introduction

This Case Study describes the development of a DtS Solution which could be used to meet the NCC Volume Two energy efficiency Performance Requirement, P2.6.1.

It is targeted at practitioners with a basic understanding of the NCC energy efficiency provisions and an overall understanding of the NCC performance-based code. For new users, introductory information on the NCC energy efficiency provisions, including their overarching intent, is provided in the Further Reading section and Appendices A to C.

Purpose and Limitations

This Case Study aims to demonstrate the practical application of the NCC when proposing to design a dwelling that takes account of passive design principles with the intention of minimising the need for artificial cooling of the dwelling. Further information on passive design principles for Northern Australian climates is covered in Appendix A.

The Case Study design is responsive to the tropical climate in which the dwelling is to be located. It allows all living/dining and sleeping areas the ability to be air conditioned if the occupant chooses, while also limiting the amount of energy used. This is known as a conditioned design for the purposes of this Case Study and is further explained in Appendix B of this document.

The guidance in this Case Study is limited to the NCC Performance Requirement P2.6.1 and the development of a Deemed-to-Satisfy (DtS) Solution using the associated DtS Provisions. This does not demonstrate full NCC compliance, as all NCC Performance Requirements need to be met. Further information on compliance with the NCC can be found in Appendix C.

In order to achieve the desired outcome in practice, the dwelling and its occupants would need to consider factors not covered by the NCC. These include, but are not limited to:

- the appropriate use of trees, shrubs or alternative shading devices to shade the house and outdoor entertainment areas,
- the appropriate selection and use of air-conditioning systems by occupants to reduce overall energy consumption,
- the adaptive responses used by occupants to reduce overall energy consumption, and
- on-going scheduled building and system maintenance.

The Case Study does not consider other design issues such as construction in cyclone, bushfire or flood prone areas. Diagrams included in the Case Study are only intended to explain issues directly relating to Performance Requirement P2.6.1.

Users of the Case Study are encouraged to check for any relevant State and Territory NCC variations and additions that may apply in their jurisdiction. Furthermore, users should be aware of any applicable legalisation within their jurisdiction that may have a bearing on the content of this Case Study.

The Design

A client has approached a design firm to come up with a passive solar, climate responsive house for a plot of land in the top end of the Northern Territory. The house is to be around 165 square metres and include three bedrooms and open plan living spaces. The living spaces are to have a strong indoor/outdoor relationship, allowing the occupants to open up their living room to an outdoor entertainment area. The building is to be constructed out of lightweight timber construction and be clad in decorative cement sheet cladding. The roof is to be a sloping skillion roof with large overhangs for protection from the sun and rain.

The client would like to minimise the amount of energy used for cooling, for both financial and sustainability reasons, by using passive cooling principles where applicable. This will likely reduce the number of days they will need to rely on air-conditioning for cooling. This means their preference is to be able to open the house up to prevailing breezes in order to cool the house under various weather conditions for the majority of the year, but still have the option of closing up the house to use air-conditioning in all spaces when needed.

The house is situated in NCC climate zone 1, which has a hot, humid climate only requiring cooling, not heating. In designing the building, the designer/architect intends to use several key passive design principles including; orientation, site considerations, shading, ventilation and air movement, and appropriate material selection.

The proposed building design is shown in plan view in Figure 1 and in cross-section view in Figure 2.

Figure 1 Plan view of the design

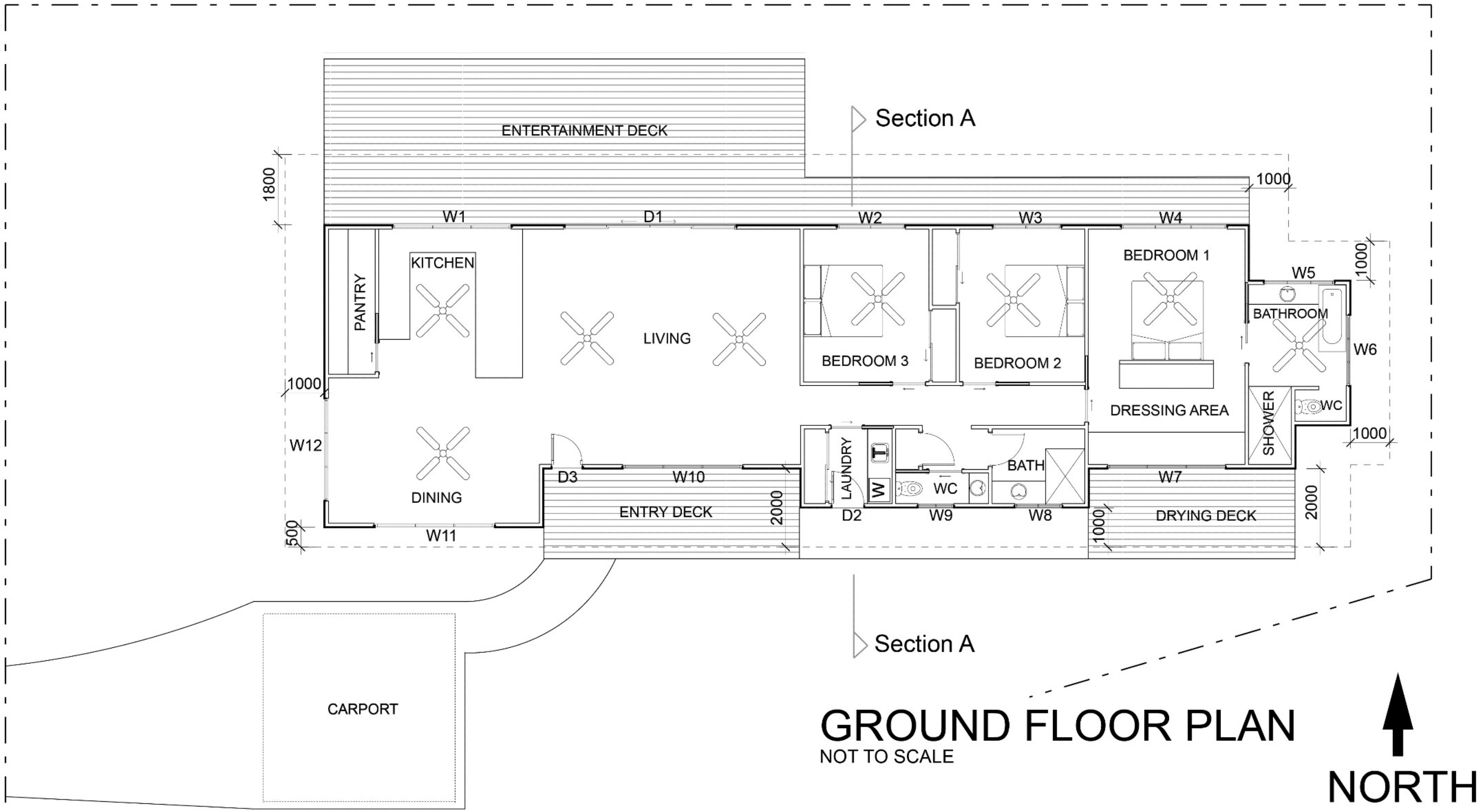
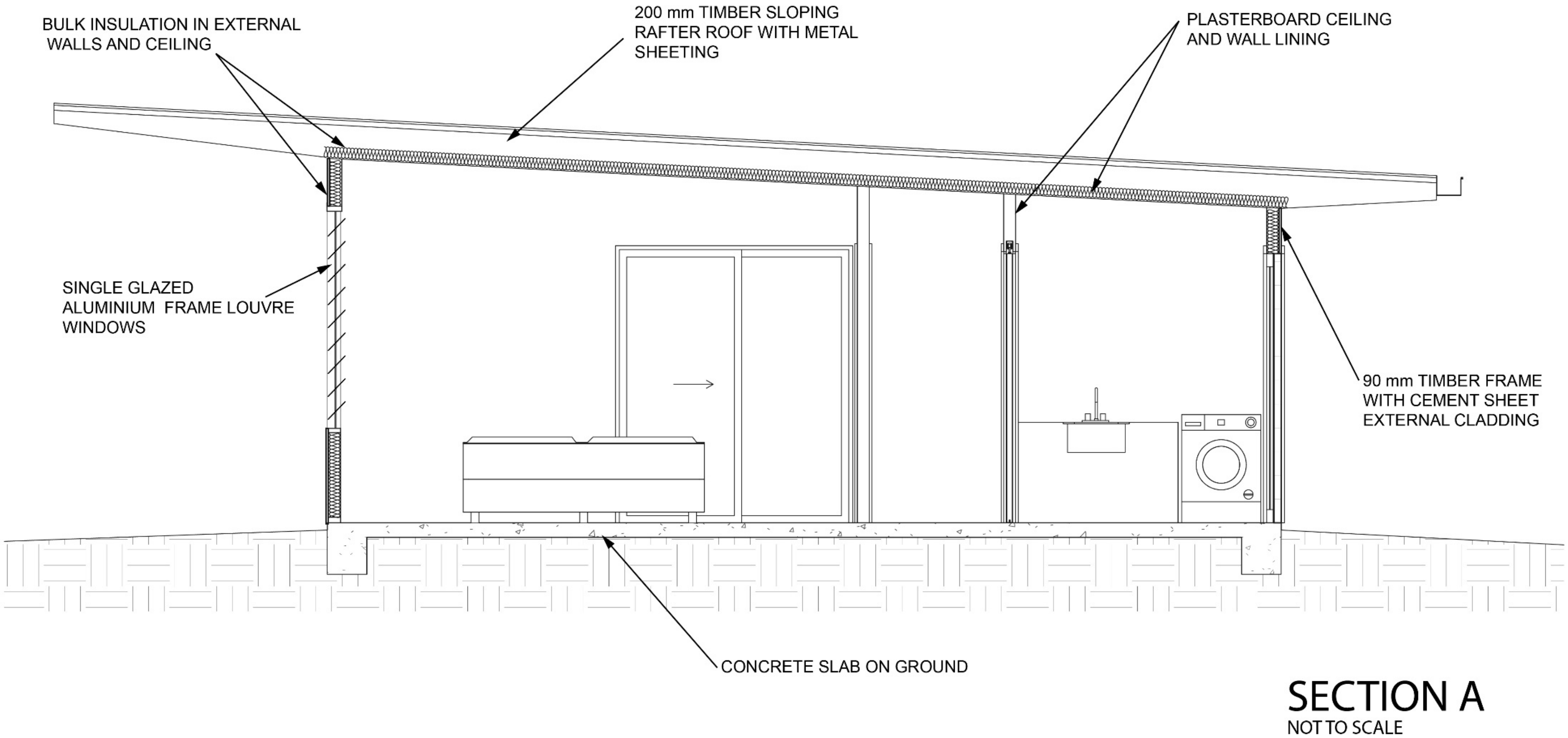


Figure 2 Section view of the design



The Solution

NCC Climate Zone

The DtS Elemental Provisions use ‘climate zones’ to specify the technical requirements for energy efficiency. The climate zones group together parts of Australia with broadly similar climatic conditions. The first step in developing a DtS Elemental Solution is to determine the NCC climate zone.

Alert

‘Climate zone’ is a defined term in the NCC. An explanation of this term is contained within Part 1.1.1 of Volume Two. There is also a map of Australia showing the extent of each zone. It is accompanied by a table detailing the applicable climate zone for common locations. For locations that are more difficult to determine, a suite of State and Territory climate zone maps may also be viewed on the ABCB website.

As the house is to be constructed on the coast of the Northern Territory, the building falls within NCC climate zone 1. The main characteristics of this climate zone are:

- high humidity with a degree of ‘dry season’,
- moderate to high temperatures year round,
- low to moderate seasonal temperature variation, and
- minimal diurnal (day–night) temperature range.

Climate zone 1 is the only NCC climate zone in Australia that is regarded as not needing heating during winter. As a result, the provisions are only concerned with the efficient cooling of the building.

For a passive designed house in climate zone 1, the following may need to be considered:

- Maximise the indoor−outdoor relationship by providing outdoor living spaces that are screened, shaded and rain protected.
- Maximise convective ventilation with high-level windows and ceiling or roof space vents.
- Zone living and sleeping areas appropriately for climate — vertically and horizontally.
- Design ceilings and position furniture for optimum efficiency of fans, cool breezes and convective ventilation.

- Locate mechanically cooled rooms in thermally protected areas (i.e. highly insulated, shaded and well-sealed).

Climate zone 1 climatic characteristics are diverse and cover a vast amount of Australia's land mass. With this being the case, it is important to consider the local or 'microclimate' conditions that a house will be subject to. For example, dominant wind patterns used to naturally cool a house in climate zone 1 differ depending on the specific location of the house. As a result, to make the most of these microclimate conditions, it may be necessary to undertake a site analysis of the building allotment to better understand the site conditions.

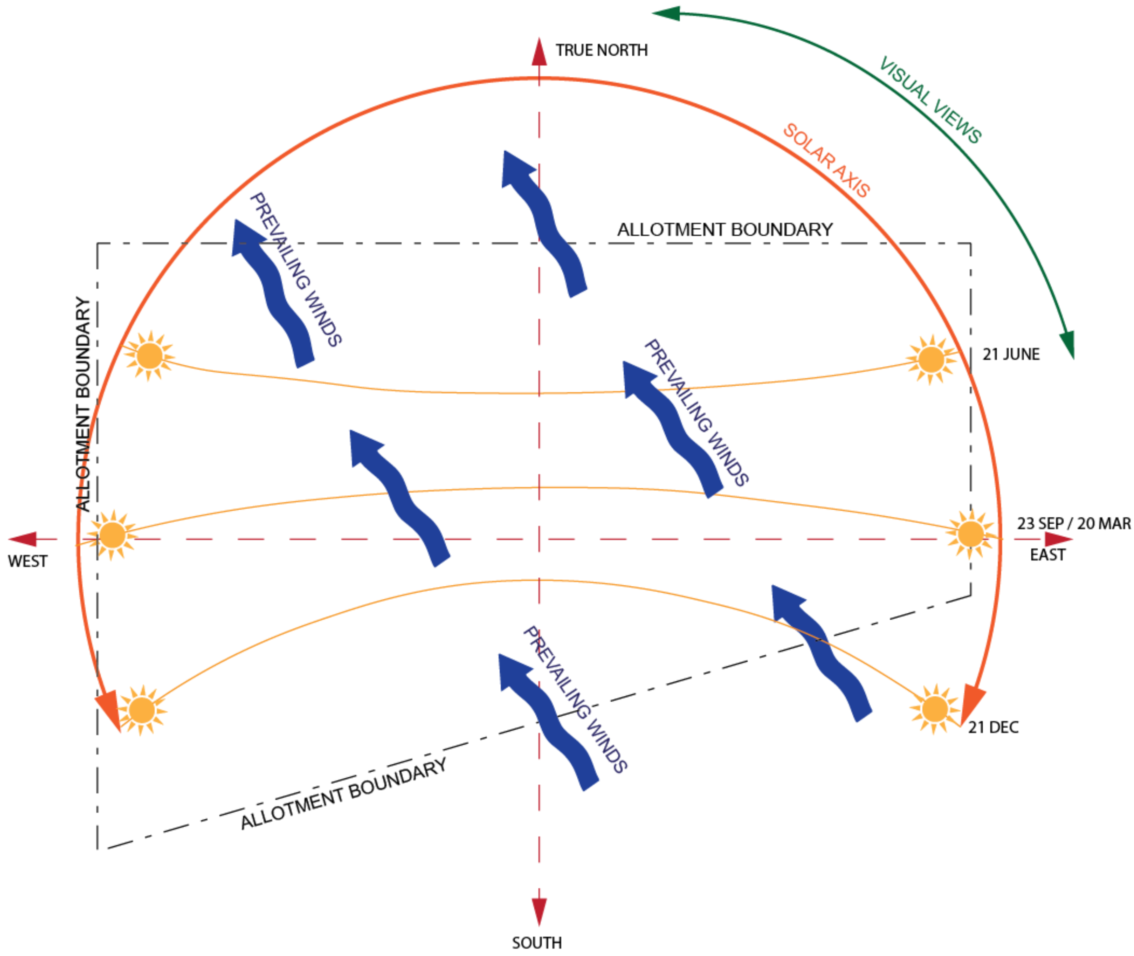
A site analysis plays a critical role in the holistic planning of the house, including the location of windows and openings, breezeways and external shading.

For this Case Study, a site analysis was undertaken to better understand how a house situated on the allotment could make the most of factors such as:

- allotment size, shape and gradient,
- orientation,
- solar axis and shading, including orientating the long axis of the building running east to west to minimise the amount of east and west wall exposure,
- prevailing wind directions, and
- other non-passive design considerations such as views and vistas.

The site analysis for the Case Study allotment is shown in Figure 3.

Figure 3 Site analysis of the allotment



The site analysis can then be used to help meet and build upon the minimum necessary energy efficiency requirements of the NCC. Notably, the site analysis plays a critical role in the holistic planning of the house, including the location of windows and openings, breeze ways and external shading.

Building Fabric

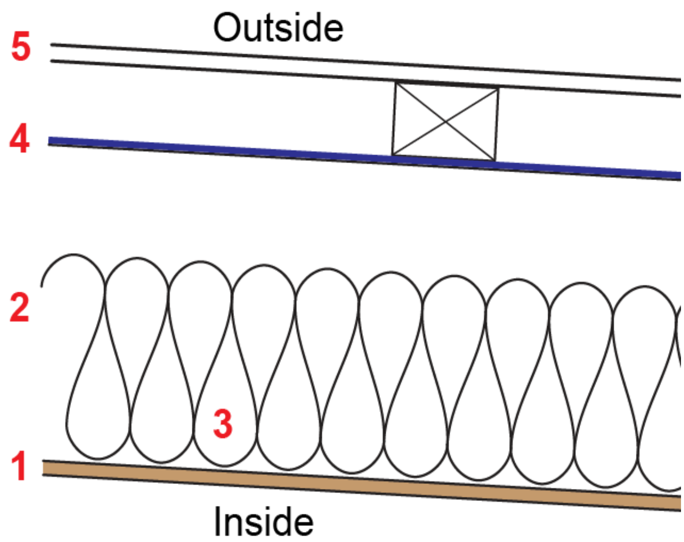
The building fabric comprises of the building's external construction, being the external walls, floor and roof. The provisions contained in Part 3.12.1 determine what thermal performance is required for the fabric of the house.

Roof

The roof system has been designed to consist of the following:

1. plasterboard on the internal face of the ceiling,
2. 200 mm timber rafter and batten system,
3. bulk insulation to be installed within the cavity created by the timber rafters,
4. reflective insulation (pliable building membrane) fixed between the rafters and battens, and
5. metal roof sheeting (light grey) (solar absorptance value: 0.4 > 0.6).

Figure 4 Roof system cross section



Recessed downlights are to be located in various rooms throughout the house without insulation placed over them. The overall insulation R-Value throughout the ceiling must therefore be increased in accordance with 3.12.1.2(e).

The DtS Elemental Provision 3.12.1.2 specifies the minimum Total R-Value for roofing systems. For climate zone 1 the required Total R-Value is **4.1** in the downwards direction when the solar absorptance value of the upper roof surface is of more than 0.4 but not more than 0.6 in accordance with Table 3.12.1.1a.

Table 3.12.1.1a Roof and Ceiling – Minimum Total R-Value

Table 3.12.1.1a ROOF AND CEILING—MINIMUM TOTAL R-VALUE

Climate zone	1	2 Altitude less than 300 m	2 Altitude 300 m or more	3	4 and 5	6 and 7	8
Direction of heat flow	Downwards		Downwards and upwards		Upwards		
Minimum *Total R-Value* for a roof with an upper surface solar absorptance value of not more than 0.4	3.1	4.1	4.1		4.1	4.6	6.3
Minimum *Total R-Value* for a roof with an upper surface solar absorptance value of more than 0.4 but not more than 0.6	4.1	4.6	4.6		4.6	5.1	6.3

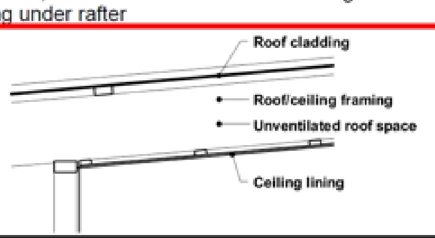
To determine the R-Value of the insulation needed to meet the minimum Total R-Value for the roofing system, the contribution of the roofing materials and any pliable building membranes needs to be accounted for. This calculation process is outlined in Table 1.

Table 1 Roof insulation R-Value calculation steps

Step	*Calculation*	*R-Value*
1	Determine the **required Total R-Value** by the Provision 3.12.1.2 (from Table 3.12.1.1a). This is the minimum R-Value that the total roof system must achieve.	**4.1**
2	Determine the **Total R-Value for the roof construction** (from Figure 3.12.1.1). This is the R-Value of the roof construction without insulation added. As per Figure 3.12.1.1(a) the roof construction is deemed to be: Flat roof, skillion roof and cathedral ceiling – ceiling lining under rafter and unventilated. This has a system R-Value of **0.48.**	**0.48**

Figure 3.12.1.1 TOTAL R-VALUE FOR TYPICAL ROOF AND CEILING CONSTRUCTION

Roof construction description		*Total R-Value*	
(a) Flat roof, skillion roof and cathedral ceiling — Ceiling lining under rafter	Unventilated	Down	0.48
		Up	0.36



<table>
<tr><th>Step</th><th>Calculation</th><th>R-Value</th></tr>
<tr><td>3</td><td>Determine the R-Value of any added pliable building membranes (from explanatory information after the Provision 3.12.1.2(d)).

A reflective insulation with an emittance of 0.2 outer, 0.05 inner is to be added to the roof. The Total R-Value of this reflective insulation 1.28.

<table>
<tr><th rowspan="3">Emittance of added reflective insulation</th><th rowspan="3">Direction of heat flow</th><th colspan="6">R-Value added by reflective insulation</th></tr>
<tr><th colspan="2">Pitched roof (>10°) with horizontal ceiling</th><th rowspan="2">Flat skillion or pitched roof (≤10°) with horizontal ceiling</th><th colspan="3">Pitched roof with cathedral ceilings</th></tr>
<tr><th>Unventilated roof space</th><th>Ventilated roof space</th><th>15° to not more than 25° pitch</th><th>more than 25° to not more than 35° pitch</th><th>more than 35° to 45° pitch</th></tr>
<tr><td>0.2 outer
0.05 inner</td><td>Downwards</td><td>1.12</td><td>1.21</td><td>1.28</td><td>0.96</td><td>0.86</td><td>0.66</td></tr>
</table>
</td><td>1.28</td></tr>
<tr><td>4</td><td>Determine the Total R-Value of the roof system by adding the R-Value of the roof construction (from Step 2) and the pliable building membrane (from Step 3) (i.e. 0.48 + 1.28 = 1.76).</td><td>1.76</td></tr>
<tr><td>5</td><td>Determine the R-value of insulation required to be added by subtracting the roof system Total R-Value (Step 4) from the required Total R-Value (Step 1) (i.e. 4.1 – 1.76 = 2.34).</td><td>2.34</td></tr>
</table>

This means that a minimum R-value of **R 2.34** insulation is required to be added to the roof cavity.

However, as recessed downlights are to be installed throughout the house, an adjustment to the minimum R-Value to account for the loss of ceiling insulation must be taken into consideration. This is outlined in the Provision 3.12.1.2(e).

3.12.1.2(e)

(e) Where, for operational or safety reasons associated with exhaust fans, flues or recessed downlights, the area of *required* ceiling insulation is reduced, the loss of insulation must be compensated for by increasing the *R-Value* of insulation in the remainder of the ceiling in accordance with **Table 3.12.1.1b**.

The calculation of this adjustment is outlined in the table below. This calculation follows on from the previous table.

Table 2 Roof insulation R-Value calculation steps accounting for recessed downlights

Step	*Calculation*	*R-Value*
6	Determine the **R-Value of insulation required to be added** that requires adjustment to satisfy 3.12.1.2(e) (from Step 5).	**2.34**
7	Determine the **percentage of ceiling area uninsulated.** It is assessed as being greater than 0.5% but less than 1.0%.	n/a
8	Determine the **adjustment of the minimum R-Value of ceiling insulation** (using Table 3.12.1.1b). The required adjustment (i.e. increased insulation R-Value) is calculated by interpolation. The total minimum R-Value required for the roof system is increased to **2.56**.	**2.60**

Table 3.12.1.1b ADJUSTMENT OF MINIMUM R-VALUE FOR LOSS OF CEILING INSULATION

Percentage of ceiling area uninsulated	Minimum *R-Value* of ceiling insulation *required* to satisfy 3.12.1.2(a)										
	1.0	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**	**5.5**	**6.0**
	Adjusted minimum *R-Value* of ceiling insulation *required* to compensate for loss of ceiling insulation area										
0.5% to less than 1.0%	1.0	1.6	2.2	2.8	3.4	4.0	4.7	5.4	6.2	6.9	
1.0% to less than 1.5%	1.1	1.7	2.3	2.9	3.6	4.4	5.2	6.1	7.0		
1.5% to less than 2.0%	1.1	1.7	2.4	3.1	3.9	4.8	5.8	6.8			
2.0% to less than 2.5%	1.1	1.8	2.5	3.3	4.2	5.3	6.5				
2.5% to less than 3.0%	1.2	1.9	2.6	3.6	4.6	5.9					
3.0% to less than 4.0%	1.2	2.0	3.0	4.2	5.7		Not permitted				
4.0% to less than 5.0%	1.3	2.2	3.4	5.0							
5.0% or more											

Note: Where the minimum *R-Value* of ceiling insulation *required* to satisfy **3.12.1.2(a)** is between the values stated, interpolation may be used to determine the adjusted minimum *R-Value*.

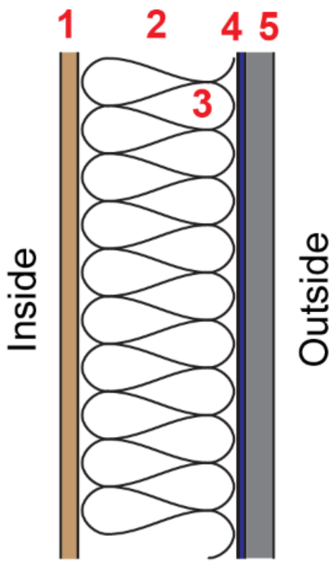
The minimum amount of insulation that must be added to the roof system is **R 2.6**.

External walls

The external wall system has been designed to consist of the following:

1. plasterboard on the internal face of the wall,
2. 90 mm timber frame load bearing construction,
3. bulk insulation to be installed within the cavity created by the timber frame,
4. pliable building membrane, and
5. cement sheet external cladding.

Figure 5 External wall cross section



The DtS Elemental Provision 3.12.1.4 specifies the minimum Total R-Value for external wall systems. Table 3.12.1.3a provides two options in climate zone 1. The required Total R-Value is **2.4** when option (b) in this table is satisfied.

Table 3.12.1.3a

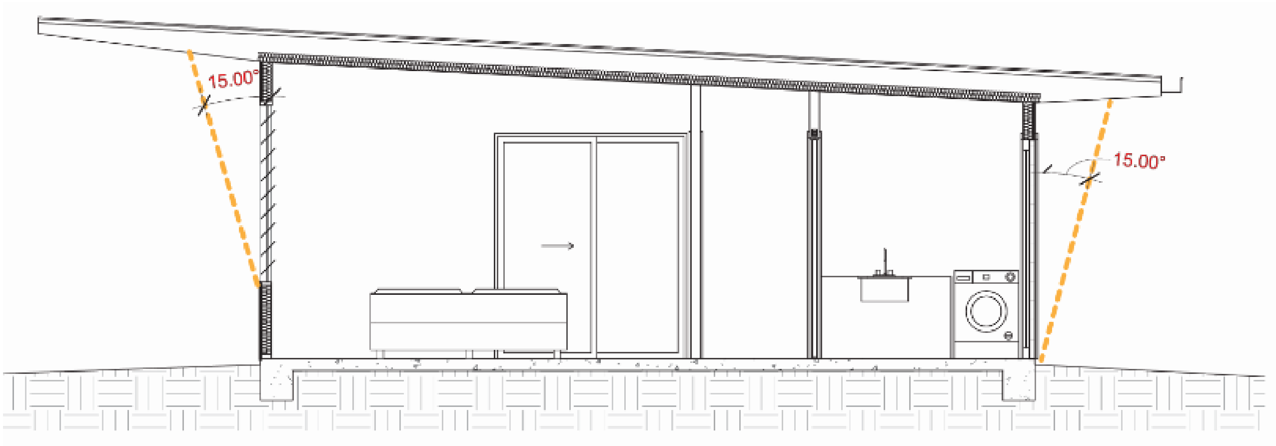
Table 3.12.1.3a — OPTIONS FOR EACH PART OF AN EXTERNAL WALL

Climate Zone	Options
1, 2, 3, 4 and 5	(a) Achieve a minimum *Total R-Value* of 2.8.
	(b) (i) Achieve a minimum *Total R-Value* of 2.4; and (ii) shade the *external wall* of the storey with a verandah, balcony, eaves, carport or the like, which projects at a minimum angle of 15 degrees in accordance with **Figure 3.12.1.2**.

Table 3.12.1.3a(b)(ii) is satisfied when the external walls are shaded by a shading device which projects at an angle of 15 degrees in accordance with Figure 3.12.1.2. This is because the thermal performance of the wall improves when less direct sunlight falls on it.

The required 15 degree shading for the Case Study design is demonstrated in Figure 6.

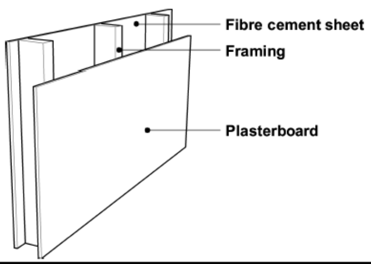
Figure 6 Shading of external walls



The Total R-Value for the external wall system is calculated as follows:

Table 3 External wall insulation R-Value calculation steps

<table>
<tr><th>Step</th><th>Calculation</th><th>R-Value</th></tr>
<tr><td>1</td><td>Determine the required Total R-Value using Table 3.12.1.3a.
This is the minimum R-Value that the total wall system must achieve.</td><td>2.4</td></tr>
<tr><td>2</td><td>Determine the Total R-Value of the external wall construction (from Figure 3.12.1.3(b)). This is the R-value of the wall construction without insulation added.
As per Figure 3.12.1.3(b) the external wall construction is deemed to be fibre-cement sheet on timber frame which has a Total R-Value of 0.42.
Figure 3.12.1.3 TOTAL R-VALUE FOR TYPICAL WALL CONSTRUCTION
<table>
<tr><th>External wall construction description</th><th>Total R-Value</th></tr>
<tr><td>(b) Fibre-cement sheet



</td><td>0.42</td></tr>
</table>
</td><td>0.42</td></tr>
<tr><td>3</td><td>Determine the R-Value of the wall cavity that is to be filled with insulation.
The wall cavity is deemed to have an R-Value of 0.17.
This value is found in the explanatory information following Figure 3.12.1.3 (point 1).</td><td>0.17</td></tr>
</table>

Step	*Calculation*	*R-Value*
4	The Total R-Value for the external wall is calculated by subtracting the Total R-Value for the wall cavity that is to be filled with insulation from the Total R-Value for the external wall construction (i.e. 0.42 – 0.17 = 0.25).	**0.25**
5	The Total R-Value for the external wall then needs to be subtracted from the required Total R-Value from Table 3.12.1.3a, which equals the **minimum R-Value of the insulation required to be installed** (i.e. 2.4 - 0.25 = 2.15).	**2.15**

The minimum amount of insulation required to be added to the external wall system is **R 2.15**.

Note that as the wall cavity is to be filled with insulation, in this instance, no additional R-Value is achieved by adding a pliable building membrane.

Pliable building membranes

A pliable building membrane such as reflective insulation is not required in this Case Study to achieve the minimum required R-Value of the roof or external wall system. However, it may be required by other provisions in NCC Volume Two. Installing a pliable building membrane may have benefits including shielding from radiant heat, reducing air infiltration, managing condensation risk, reducing draughts and can act as a water barrier for certain external wall claddings.

Floor

The building design includes a slab-on-ground floor with exposed concrete finish throughout the whole house. There will be no in-slab or in-screed heating or cooling installed anywhere in the house. Consequently, no insulation is required to be installed in the floor as per Provision 3.12.1.5(c).

Installation of insulation

Where insulation is installed throughout the building, it must be installed so that it performs to its intended performance level. The Provision 3.12.1.1 sets out a range of requirements for the appropriate installation of building fabric thermal insulation. These requirements apply to both reflective and bulk insulation installed throughout the building's fabric.

Glazing

Glazing in the building serves several purposes including allowing natural light, natural ventilation through openable windows, and access to views and vistas. Glazing plays an important role in the building design and function. However, glazing is the main source of unwanted heat gain via direct radiation and conduction.

The Case Study house includes significant amounts of glazing. All windows are louvre windows, which allow 80%[1] of the total window to open to breezes. Louvres can provide flexibility in that the angle of the glazed panels can be adjusted when it is raining or excessively windy. Cross ventilation and breezes are then likely to be utilised to cool the dwelling all year round.

Aluminium window frames with clear glass have been selected in this Case Study. The use of speciality glass and frame types such as tinted glass, glass with low emittance films, double glazing or timber framing may provide additional benefits in terms of reducing the window conductance and solar heat gain.

The provisions of 3.12.2 consider two major thermodynamic effects on glazing, namely:

- Heat conduction through the glass and frame by virtue of a temperature difference between inside and outside; and
- Solar radiation transmitted through the glass and frame into the building.

The Provisions consider the thermal performance of glazing (glass and frame) depending on the glazed area, building orientation and the extent of any shading. This approach attempts to limit unwanted heat gain into the house for climate zone 1.

The external glazing provisions set separate maximum allowances for conductance and for solar heat gain. Two equations are then used to calculate the performance of the proposed glazing layout for comparison with those allowances. For the purposes of the DtS Elemental Provisions, glazing refers to windows, glazed doors and other transparent or translucent elements located in the building fabric.

Table 4 outlines the schedule of external glazing components as specified in the Case Study design. Total System U-Value and Total System SHGC values have been sourced from the proposed window manufacturer. These values were calculated in

[1] Refer to the AFRC procedures and protocols (http://www.afrc.org.au/TechDocs.htm)

accordance with the Australian Fenestration Rating Council (AFRC) protocols and procedures.

The glazing calculations can be done long hand, or automated by using a spreadsheet calculator. For this Case Study, the calculations have been undertaken by using the ABCB Glazing Calculator, as shown in Figure 7. Further details concerning the use of the glazing calculator can be found in Chapter 9 of the *NCC Volume Two Energy Efficiency Provisions Handbook.*

Table 4 Glazing Schedule

Plan Reference Number	*Type/ Description*	*Specification*	*Facing Sector[2]*	*Height (m)*	*Width (m)*	*Total System U Value ($W/m^2.K$)*	*Total System SHGC*	*Shading - Projection[3] (m)*	*Shading - Height (m)*
W1	Window - Louvre - Aluminium frame	Clear glass	N	1.2	2.3	6.0	0.55	1.8	1.8
D1	Door - Hinged - Aluminium frame	Clear glass	N	2.1	4.0	6.0	0.66	1.8	2.8
W2	Window - Louvre - Aluminium frame	Clear glass	N	2.0	1.5	6.0	0.55	1.8	2.4
W3	Window - Louvre - Aluminium frame	Clear glass	N	2.0	1.5	6.0	0.55	1.8	2.4
W4	Window - Louvre - Aluminium frame	Clear glass	N	2.0	1.5	6.0	0.55	1.8	2.4
W5	Window - Louvre - Aluminium frame	Clear glass	N	1.2	1.6	6.0	0.55	1	1.6
W6	Window - Louvre - Aluminium frame	Clear glass	E	1.2	2.0	6.0	0.55	1	1.6
W7	Window - Louvre - Aluminium frame	Clear glass	S	0.6	3.0	6.0	0.55	2	0.7
W8	Window - Louvre - Aluminium frame	Clear glass	S	0.6	1.2	6.0	0.55	1	0.85
W9	Window - Louvre - Aluminium frame	Clear glass	S	0.6	1.0	6.0	0.55	1	0.85
D2	Door - Hinged - Aluminium frame	Clear glass	S	2.1	0.8	5.9	0.56	1	2.3
W10	Window - Louvre - Aluminium frame	Clear glass	S	2.1	2.4	6.0	0.55	2	2.3
D3	Door - Hinged - Aluminium frame	Clear glass	S	2.1	0.8	5.9	0.56	2	2.3
W11	Window - Louvre - Aluminium frame	Clear glass	S	2.1	2.4	6.0	0.55	0.57	2.3
W12	Window - Louvre - Aluminium frame	Clear glass	W	1.0	2.0	6.0	0.55	1	1.2

[2] Refer to Figure 3.12.2.1 of NCC Volume Two for determining orientation sectors.
[3] Refer to Figure 3.12.2.2 of NCC Volume Two for the method of determining shading projection.

Figure 7 Glazing Calculation using the Glazing Calculator

NCC VOLUME TWO GLAZING CALCULATOR (first issued with NCC 2014)

Building name/description: **Case Study House 1**

Climate zone: **1**

	C_U	C_{SHGC}
CONSTANTS	1.650	0.069

Storey: **1**

Air Movement: **High**

Floor Construction	Area
Direct contact	165m²
Suspended	
Area of storey	165m²
Area of glazing	*45.0m² (27% of area of storey)*

Wall insulation option chosen for 3.12.1.4: ***No wall insulation concession used***

	C_U x Area	C_{SHGC} x Area
ALLOWANCES	272.3	11.4

Number of rows for table below **15** *(as currently displayed)*

GLAZING ELEMENTS, ORIENTATION SECTOR, SIZE and PERFORMANCE CHARACTERISTICS								SHADING		CALCULATION DATA			CALCULATED OUTCOMES - OK (if inputs are valid)			
Glazing element		Orientation	Size			Performance		P&H or device		Exposure		Size	Conductance - PASSED		Solar heat gain - PASSED	
ID	Description (optional)	Facing sector	Height (m)	Width (m)	Area (m²)	Total System U-Value (AFRC)	Total System SHGC (AFRC)	P (m)	H (m)	P/H	Es	Area used (m²)	U x area	Element share of % of allowance used	SHGC x Es x area	Element share of % of allowance used
1	W1	N	1.20	2.30		6.00	0.55	*1.80*	1.80	0.50	0.28	2.76	16.56	6% of 99%	0.4	5% of 75%
2	D1	N	2.10	4.00		6.00	0.66	*1.80*	2.80	0.32	0.33	8.40	50.40	19% of 99%	1.8	21% of 75%
3	W2	N	2.00	1.50		6.00	0.55	1.80	2.40	0.75	0.23	3.00	18.00	7% of 99%	0.4	4% of 75%
4	W3	N	2.00	1.50		6.00	0.55	1.80	2.40	0.75	0.23	3.00	18.00	7% of 99%	0.4	4% of 75%
5	W4	N	2.00	2.50		6.00	0.55	1.80	2.40	0.75	0.23	5.00	30.00	11% of 99%	0.6	7% of 75%
6	W5	N	1.20	1.60		6.00	0.55	1.00	1.60	0.63	0.25	1.92	11.52	4% of 99%	0.3	3% of 75%
7	W6	E	1.20	2.00		6.00	0.55	1.00	1.60	0.63	0.64	2.40	14.40	5% of 99%	0.8	10% of 75%
8	W7	S	0.60	3.00		6.00	0.55	2.00	0.70	2.86	0.16	1.80	10.80	4% of 99%	0.2	2% of 75%
9	W8	S	0.60	1.20		6.00	0.55	1.00	0.85	1.18	0.22	0.72	4.32	2% of 99%	0.1	1% of 75%
10	W9	S	0.60	1.00		6.00	0.55	1.00	0.85	1.18	0.22	0.60	3.60	1% of 99%	0.1	1% of 75%
11	D2	S	2.10	0.80		5.90	0.56	1.00	2.30	0.43	0.41	1.68	9.91	4% of 99%	0.4	4% of 75%
12	W10	S	2.10	2.40		6.00	0.55	2.00	2.30	0.87	0.28	5.04	30.24	11% of 99%	0.8	9% of 75%
13	D3	S	2.10	0.80		5.90	0.56	2.00	2.30	0.87	0.28	1.68	9.91	4% of 99%	0.3	3% of 75%
14	W11	S	2.10	2.40		6.00	0.55	0.57	2.30	0.25	0.52	5.04	30.24	11% of 99%	1.4	17% of 75%
15	W12	W	1.00	2.00		6.00	0.55	1.00	1.20	0.83	0.56	2.00	12.00	4% of 99%	0.6	7% of 75%

If inputs (including air movement levels) are valid ✓

Note: Refer to the Air Movement section for an explanation as to why air movement in the house is considered “High”.

Shading

The Case Study's design includes large roof eaves and overhangs, as these features allow for shading and protection of indoor and outdoor spaces, and shading of external walls and glazing. This is achieved by varying the roof overhangs depending on the glazing orientation and the need to protect outdoor spaces such as the drying deck, entry deck and entertainment deck. Additional shading is intended to be used to shade the entertainment deck by using native trees and shrubs.

The depth of the roof eaves also takes into consideration the winter and summer solstice sun angles. Figure 8 demonstrates the severity of the sun angles and relationship they have with shading of the building created by the roof overhangs.

Figure 8 Winter and summer solstice sun angles

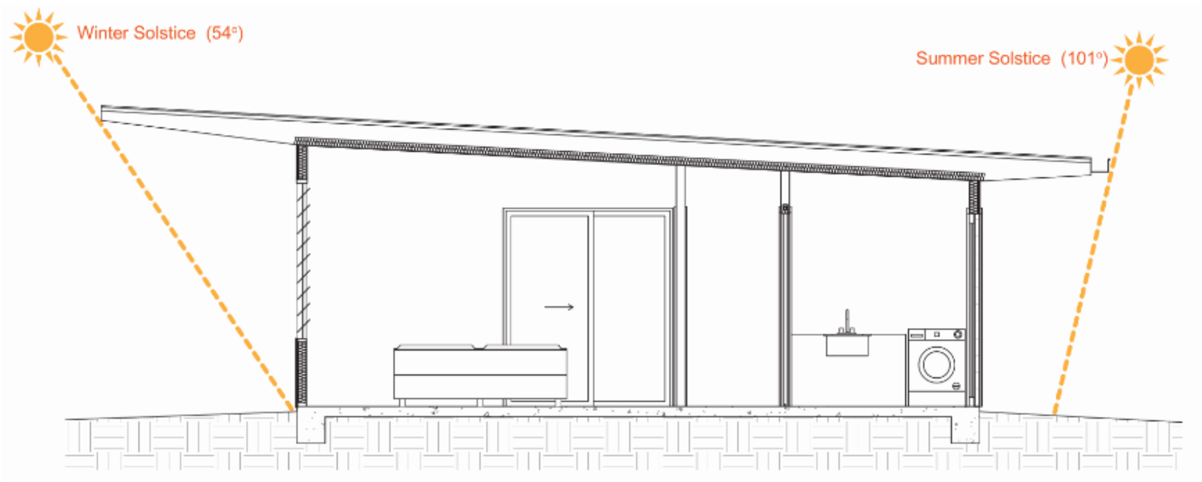
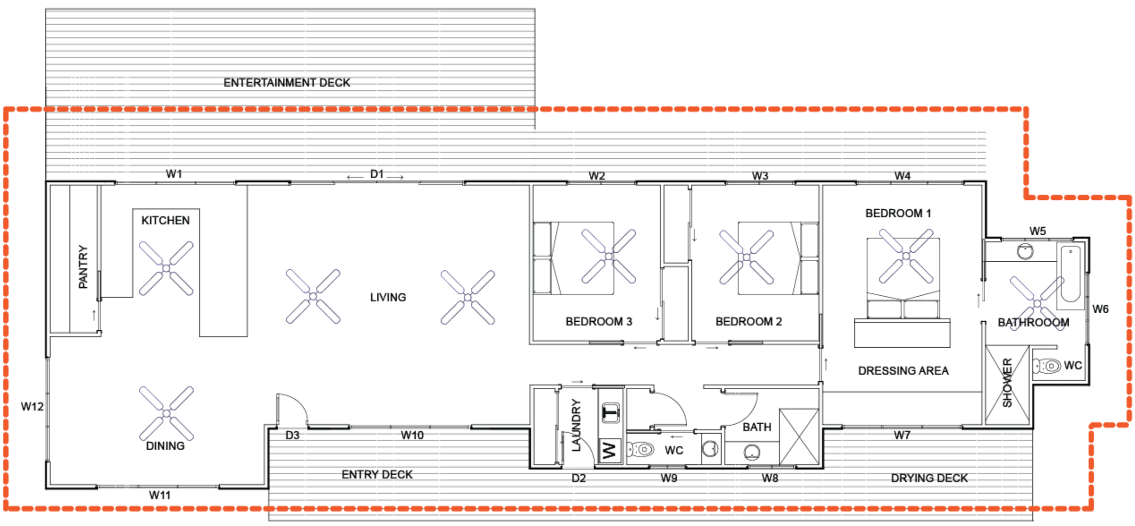


Figure 9 The orange dotted line shows the external footprint of the roofs eave lines around the building.



As previously mentioned, the use of external shading with an angle not less than 15 degrees is in reference to the total amount of insulation required in the wall. Better thermal performance may be achieved by reducing the amount of direct sunlight falling onto the walls.

The extent of glazing allowed under Provision 3.12.2.1 is influenced by several factors including the amount of shading provided. Shading of windows has the potential to minimise unwanted heat gains in hotter seasons lessening the need for cooling. As solar heating is not considered necessary in climate zone 1, shading of external glazing should be maximised. In this example, the designer has opted to use the roof eaves as projected shading devices, varying the depth of the eaves depending on the orientation.

Building Sealing

As part of the DtS Elemental Provisions, Part 3.12.3 sets out requirements to determine whether the subject house is required to be sealed to control unwanted air leakage. For a house located in climate zone 1, air leakage in and/or out of an air conditioned space can allow cool indoor air to escape and allow hot unwanted outdoor air to enter. The provisions for building sealing are generally concerned with keeping conditioned cool air inside the house when appropriate, such as when natural cooling from openings and windows is not being utilised by the occupant.

In the Case Study house, building sealing applies to the external windows and doors, exhaust fans from the bathrooms and kitchen, as well as the overall sealing of the building's external fabric.

External windows and doors

For external windows and doors, where they serve a conditioned space, seals are required to restrict air infiltration as per Provision 3.12.3.3.

3.12.3.3 External windows and doors

(a) A seal to restrict air infiltration must be fitted to each edge of an external door, openable *window* and other such opening—
  (i) when serving a *conditioned space*; or
  (ii) in *climate zones* 4, 5, 6, 7 and 8, when serving a *habitable room*.

(b) A *window* complying with the maximum air infiltration rates specified in AS 2047 need not comply with **(a)**.

(c) A seal *required* by **(a)**—
  (i) for the bottom edge of an external swing door, must be a draft protection device; and

(ii) for the other edges of an external swing door or the edges of an openable *window* or other such opening, may be a foam or rubber compressible strip, fibrous seal or the like.

In this Case Study—

- All external swinging doors have draft seals placed on the bottom edge of the door.
- All other edges of external swinging doors and all edges of openable windows have a rubber compressible strip installed to form a tight seal with the door and window frame.

Exhaust fans

For exhaust fans, where they serve a conditioned space, they must be fitted with a sealing device such as a self-closing damper, filter or the like, in accordance with Provision 3.12.3.4.

3.12.3.4 Exhaust fans

An exhaust fan must be fitted with a sealing device such as a self-closing damper, filter or the like when serving—

(a) A *conditioned space*; or

(b) A *habitable room* in *climate zones* 4, 5, 6, 7 and 8.

In this Case Study, the exhaust fan in the kitchen is fitted with a self-closing damper.

Construction of roofs, walls and floors

For construction of roofs, walls and floors, where they serve a conditioned space, they must be constructed to minimise air leakage in accordance with Provision 3.12.3.5.

3.12.3.5 Construction of roofs, walls and floors

(a) Roofs, external walls, external floors and any opening such as a *window* frame, door frame or the like must be constructed to minimise air leakage in accordance with **(b)** when forming part of the external fabric of—

  (i) a *conditioned space*; or

  (ii) a *habitable room* in *climate zones* 4, 5, 6, 7 and 8.

(b) Construction required by **(a)** must be--

  (i) enclosed by internal lining systems that are close fitting at ceiling, wall and floor junctions; or

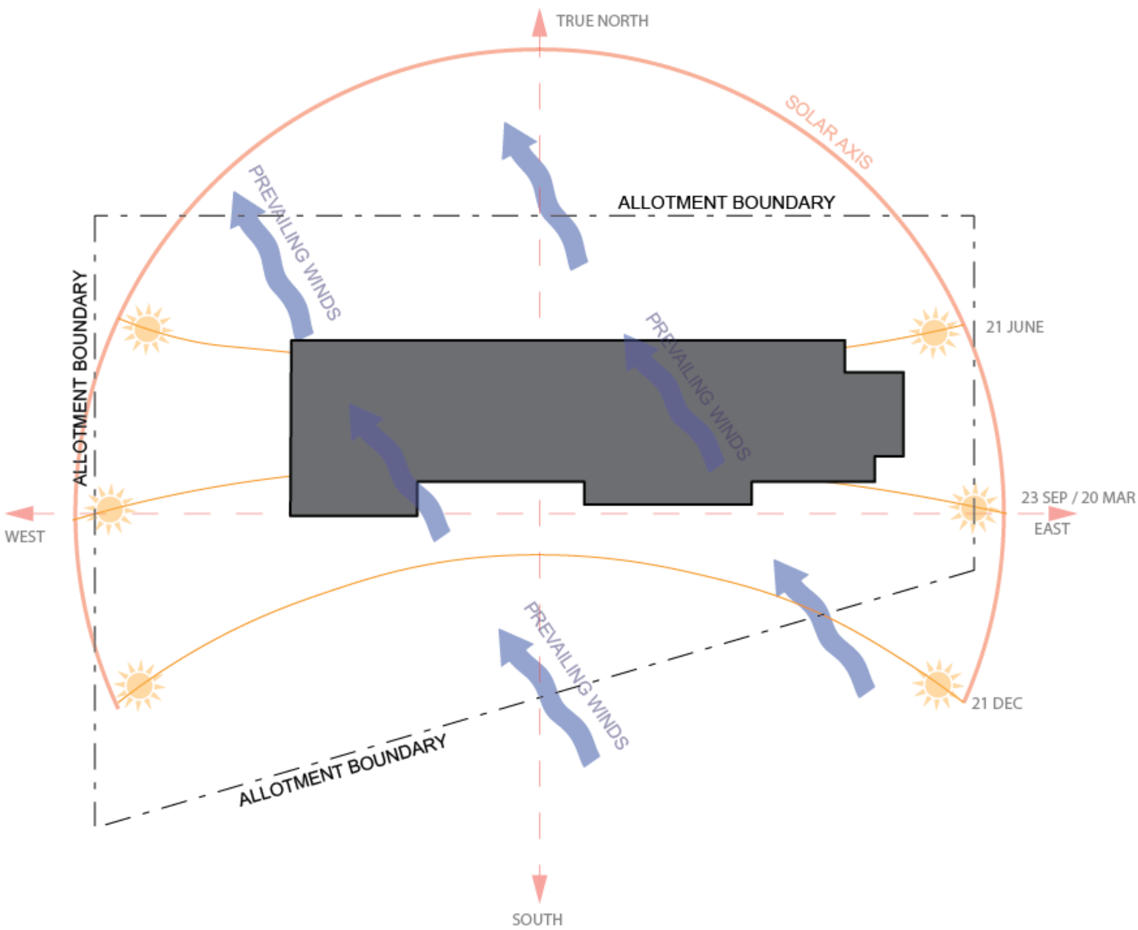
(ii) sealed by caulking, skirting, architraves, cornices or the like.

All the internal linings associated with external walls, floors and openings are to be sealed with a combination of expanded foam caulking, skirting and architraves.

Air movement

For a climate zone 1 passively designed house, the relationship between building orientation and air movement is critical to achieving the desired outcome. The site analysis of the allotment demonstrated that there are south easterly winds that sweep across the site that can be used to aid in the passive cooling of the building. As shown in Figure 10, the building footprint is long and thin promoting the ability for cooling winds to pass through the building.

Figure 10 Site analysis overlayed with the building footprint



Aside from being a functional layout for the building's occupants, the orientation of the building is designed to make use of cross ventilation to penetrate through the building, which will naturally cool the internal and external spaces. Internal rooms, including the living and master bedroom spaces, allow cross ventilation through louvre windows on both the north and south elevations. This is intended to reduce the likelihood of needing to use air-conditioning in these spaces.

Provision 3.12.4 for air movement requires the building to have a minimum total ventilation opening of not less than 7.5% to habitable rooms where ceiling fans are installed. This is achieved by having large louvre windows, slender room depths of less than 20 meters, and large bladed ceiling fans located centrally within the room. Table 5 shows whether the minimum total ventilation opening area, as a percentage of the floor area, is achieved for each habitable room.

Table 5 Minimum total ventilation opening area, as a percentage of the floor area, for each habitable room

Habitable rooms	*Floor area (m^2)*	*Area of openings[1] (m^2)*	*Area of openings (%)*	*Area of openings required[2] (%)*
Bedroom 1	23.8	3.8	16	7.5
Bedroom 2	12.5	2.4	19.2	7.5
Bedroom 3	12.5	2.4	19.2	7.5
Living area	75	17	22.6	7.5

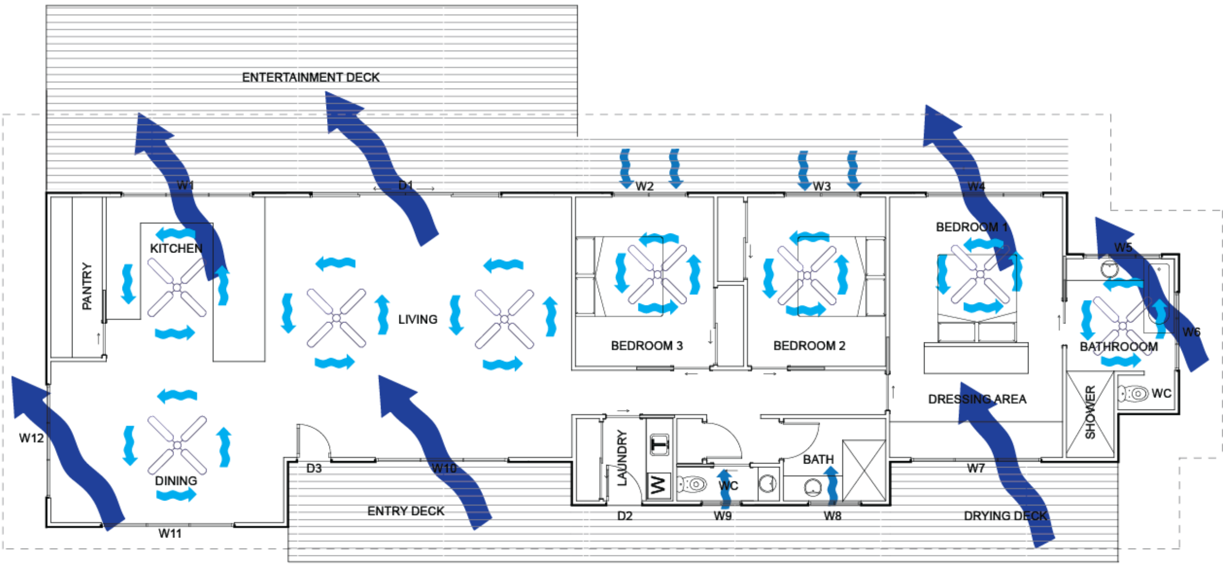
Notes:

1. The area of the openings (in square meters) takes into account that only 80% of the louvre windows and 45% of the doors are effectively “openable”.
2. Reference: Table 3.12.2.1, Note 2 High air movement.

For the purpose of determining the glazing requirements, the air movement is deemed to be “High” in accordance with Table 3.12.2.1. This is determined by noting the achieved air movement is greater than the required “Standard” air movement (10%) with the addition of ceiling fans. Ceiling mounted fans are located in the living and master bedroom spaces to help increase air movement on still air days.

The dividing wall between Bedroom 1 and the Dressing Area is to be 1400 mm high to allow for cross ventilation through the space.

Figure 11 Natural and artificial ventilation paths through the building



Summary

This Case Study provides a detailed understanding of the DtS Elemental Provisions in Volume Two of the NCC. It shows how a lightweight constructed house in climate zone 1 can use this method to comply with the Performance Requirement P2.6.1.

Within the Case Study, connections have been established between tropical climate responsive design techniques and using the DtS Elemental Provisions contained in NCC Volume Two.

Glossary

Climate zone means an area defined in Figure 1.1.4 and in Table 1.1.2 of NCC Volume Two for specific locations, having energy efficiency provisions based on a range of similar climatic characteristics.

A climate zone is defined as part of Australia with broadly similar climatic conditions. The zones have been adjusted to simplify use of the NCC provisions. The definition includes a map of Australia indicating the various climate zones together with a table specifying the zones for major cities and towns. Refer to the ABCB website for the current NCC climate zone map.

Compliance Solution means a Performance Solution or a Deemed-to-Satisfy Solution that meets the Performance Requirements.

Conditioned space means a space within a building that is heated or cooled by the building's domestic services, excluding a non-habitable room in which a heater with a capacity of not more than 1.2 kW or 4.3 MJ/hour is installed.

Envelope, for the purposes of Part 3.12, means the parts of a building's fabric that separate artificially heated or cooled spaces from—

(a) the exterior of the building; or

(b) other spaces that are not artificially heated or cooled.

This term was developed to describe the location of the thermal barrier to prevent unnecessary energy loss or gain between a conditioned space (including a potentially conditioned space) and a non-conditioned space. The defined term conditioned space should be read in conjunction with the term envelope.

Expert Judgement means the judgement of an expert who has the qualifications and experience to determine whether a building solution complies with the Performance Requirements.

Fabric means the basic building structural elements and components of a building including the roof, ceilings, walls and floors.

Glazing, for the purposes of energy efficiency, means a transparent or translucent element and its supporting frame located in the envelope, and includes a window other than a roof light. This means windows, glazed doors or other transparent and translucent elements (such as glass bricks) including their frames, located in the building fabric.

Habitable room means a room used for normal domestic activities, and—

(a) includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom but;
(b) excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes-drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.

Lightweight construction means construction which incorporates or comprises—

(a) sheet or board material, plaster, render, sprayed application, or other material similarly susceptible to damage by impact, pressure or abrasion; or
(b) concrete and concrete products containing pumice, perlite, vermiculite, or other soft material similarly susceptible to damage by impact, pressure or abrasion; or
(c) masonry having a thickness less than 70 mm.

Microclimate means the climate of a very small or restricted topographical area, especially when this differs from the climate of the surrounding area.

NatHERS is the Nationwide House Energy Rating Scheme, which provides a framework that allows accredited computer software tools to rate the potential energy efficiency of Australian homes, by assessing the thermal performance of the building's design.

Passive solar design means the building design, windows, walls, and floors are made to collect, store, and distribute solar energy in the form of heat in the winter, and reject solar heat in the summer.

Performance Requirement means a requirement which states the level of performance which a Performance Solution or Deemed-to-Satisfy Solution must meet.

Performance Solution (Alternative Solution) means a method of complying with the Performance Requirements other than by a Deemed-to-Satisfy Solution.

R-Value (m^2.K/W) means the thermal resistance of a component calculated by dividing its thickness by its thermal conductivity.

Reflective insulation means a building membrane with a reflective surface such as a reflective foil laminate, reflective barrier, foil batt or the like capable of reducing radiant heat flow.

This means a material with a reflective surface capable of reducing radiant heat flow across an adjacent airspace. It may be a sarking-type material that has specific reflective qualities, such as reflective foil laminate or it may be combined with other insulation material.

Site analysis is the study of allotment size, shape and gradient, orientation, solar axis and shading, prevailing wind directions, and other non-passive design considerations such as views and vistas of an associated topographical location.

Solar absorptance is the classification of colours based on solar absorptance. A value of 0 indicates that a roof absorbs none and a value of 1 indicates that a roof absorbs 100% of the incoming solar radiation.

Total R-Value (m^2.K/W) means the sum of the R-Values of the individual component layers in a composite element including any building material, insulating material, airspace and associated surface resistances.

Total System Solar Heat Gain Coefficient (SHGC) means the fraction of incident irradiance on glazing or a roof light that adds heat to a building's space.

Total system U-Value (W/m^2.K) means the thermal transmittance of the composite element allowing for the effect of any airspaces and associated surface resistances. In simple terms, the Total System U-Value is the opposite of the Total R-Value as an expression. That is, Total System U-Value is the ability of a composite element, such as glazing, to conduct heat, while the Total R-Value measures the ability of a composite element, such as a wall construction, to resist heat flow.

Ventilation opening means an opening within the building envelope that permits the movement of air through a building.

Window includes a roof light, glass panel, glass block or brick, glass louvre, glazed sash, glazed door, or other device which transmits natural light directly from outside a building to the room concerned when in the closed position.

Further Reading

The following references are recommended if further information is required regarding the tropical house design, passive solar design and NCC energy efficiency requirements:

- *NCC Volume Two Energy Efficiency Provisions* non-mandatory handbook. The handbook provides details of the energy efficiency requirements of NCC Volume Two. It aims to provide practitioners with sufficient knowledge to successfully apply the energy efficiency requirements for residential dwellings and can be downloaded for the ABCB website.

- *Your Home: Australia's guide to environmentally sustainable homes* is published by the Commonwealth of Australia, Department of Industry, Innovation and Science. Your Home is a comprehensive guide to environmentally sustainable homes including information on passive designed homes. The guide can be accessed from the Your Home website.

- The Cairns Regional Council has produced a number of resources on their website concerning smart design for the tropics and sustainable tropical building design.

- The Tropical Green Building Network and James Cook University has produced a number of case studies of tropical house design projects in Cairns and Far North Queensland. The case studies feature constructed examples of tropical house design and can be accessed from their website.

- *Warm House Cool House, Inspirational Designs for Low-Energy Housing* by Nick Hollo. This book contains useful information about sustainable Australian house design incorporating information on passive solar design and energy efficiency.

- WoodSolutions Australia has produced a number of technical design guides on the thermal performance in timber-framed buildings which include guidance on NCC energy efficiency compliance and passive solar design principles. They can be accessed from the WoodSolutions website.

Appendix A Passive design principles

Passive design uses a building's local environment, climate, specific design techniques and appropriate material selection to reduce, or in some instances eliminate, reliance on artificial heating and cooling, whilst allowing reasonable occupant comfort, and reducing energy consumption.

Passive design can facilitate heating, cooling, or both by maximising the effect of beneficial climate conditions and minimising the impact of unfavourable climate conditions. The design techniques used depend on the climate, and the heating or cooling requirements for a specific dwelling.

In tropical climates of Australia, cooling is typically the dominant requirement for dwellings, with little or no need for heating throughout the year. Passive cooling involves minimising unwanted heat gain by a dwelling, maximising the ability of the dwelling to expel heat to the outside, and facilitating natural cooling of the occupants.

These principles, in relation to passive cooling, are utilised in the design described in this Case Study, and are explained in the following sections.

A.1 Orientation and site considerations

In a tropical climate, orientation and site considerations can contribute to passive cooling by minimising solar gains and maximising exposure to prevailing cooling breezes.

The angle of the sun in the sky changes throughout the year and as a result, the solar heat gains experienced by a building differ throughout the day and during different seasons. Solar radiation is greater when the sun strikes a surface at a more direct angle. This means that eastern and western walls are typically exposed to greater solar radiation as the sun angle is low around sunrise and sunset.

Northern and southern walls in northern Australian climates receive less radiation due to the sun being higher in the sky. As a result, a dwelling should aim to be oriented along the east-west axis to minimise the solar gains. While consideration of the orientation to minimise solar gains is important, precise solar orientation is not critical for reducing solar gain. Effective solar heat gain reduction can usually be achieved by orienting a building within 20^{o} west and 30^{o} east of north.

Orientation should be balanced with access to prevailing cooling breezes to determine the most effective dwelling orientation. Minimising the exposure of the dwelling to warm breezes and utilising prevailing cooling winds can greatly assist with providing occupant comfort in hot, humid climates.

The microclimates and other features of the site can also impact on the ideal orientation of the building and should also be taken into consideration. Surrounding structures, landscape features, and vegetation can impact on radiation heat gains and the prevailing cooling breezes.

Other features of the individual site can also assist with orienting a dwelling to maximise passive cooling potential. This could include utilising a south facing slope to assist with shading, or situating the dwelling in order to access cooling breezes channelled down a valley. Each site will have a different microclimate that will necessitate careful consideration of the building orientation.

A.2 Shading

The primary source of heat gain for buildings in tropical climates is solar heat gain through solar radiation and conduction. This can be reduced by appropriate shading.

Sunlight is a broad spectrum of radiation from very short ultraviolet wavelengths to long infrared wavelengths. The wavelength emitted from a surface depends on the surface temperature. Short wavelengths typically hit a building surface, and are partially absorbed. As the surface is relatively cool, longer infrared wavelengths are re-emitted.

Conduction is the process of energy transfer through building parts caused by a temperature difference between the parts. An example may be heat conduction through windows, where the temperature on one side is greater than the other, and where heat is passed from the hotter side to the cooler side.

Glazing, external walls and the roof all facilitate heat gain, however, glazing is usually the greatest source of unwanted heat gain when not correctly shaded. In tropical climates all walls, and in particular glazing, should be shaded. This assists greatly in reducing unwanted heat gain.

Shading can be achieved through roof overhangs and eaves, screens, and also supplemented with appropriate planting and vegetation. The most effective shading techniques for minimising heat gain will involve external shading of the entire surface of the building. This will also involve shading of southern elevation in buildings located north of the Tropic of Capricorn where the sun travels through the southern part of the sky in summer.

While external shading is the most effective method for reducing solar heat gain, full external shading may not be possible on eastern and western orientations. Low Solar Heat Gain Coefficient (SHGC) glazing may assist with reducing solar heat gain in these instances, which can also be paired with internal shading devices.

Where possible, shading the roof of the building will also assist with reducing solar heat gains and can be achieved by utilising shade from trees and other buildings.

A.3 Ventilation and air movement

Ventilation can assist with removing heat that accumulates in a building, as well as cooling the building occupants. Heat accumulates in a building due to solar gains, and from heat generated by appliances, lights, and occupants. Orientation, shading, and materials can assist with reducing the amount of heat entering a building, and ventilation can help to remove the accumulated heat, and cool the building occupants.

Natural ventilation for passive cooling is most effective when the building is long, narrow, and oriented towards prevailing cooling breezes. To maximise cross ventilation, the building should be single room depth, open plan, have openings on the cooling breeze side of the building, and larger openings on the leeward side. The positioning of the openings and the use of external devices can be adjusted to suit the desired air flow pattern for a particular room. For example, a louvre or canopy over a window has the potential to deflect the airflow upward or downwards inside the room.

Cross ventilation is achieved by a pressure differential. When the windward side is exposed to a cooling breeze, the lower pressure on the leeward side draws the cool breeze through the building. The size and positioning of the openings on the windward side can also vary the speed of the airflow through a building. Generally openings positioned near the centre of walls on the windward side experience the greatest pressure and will offer the greatest cross ventilation. Planting and vegetation can also assist with directing and channelling breezes, and ceiling fans can be used to supplement natural ventilation during still periods to ensure that air movement is sufficient.

In regions with low relative humidity, evaporative cooling can be used as a method of passive cooling. Positioning a pond, water feature, or other water source outside a window and in the path of a cooling breeze can reduce the apparent temperature of the air before it enters the building. Water sources with a large surface area are most effective – particularly mists and fountains.

A.4 Material selection

Selecting appropriate building materials and internal finishes will help to reduce initial heat gain, and allow the building and its occupants to reject heat quickly to the outside. Lightweight materials are generally preferred where cooling is the dominant requirement. Lightweight materials don't store heat in periods of high temperature, and respond quickly to temperature changes - rejecting heat quickly when temperatures drop. They also respond faster to cooling breezes and cooler night time temperatures. Light, low mass materials also assist with occupants rejecting heat to their surroundings. These materials should be used for roofs, walls, shading devices, and internal surfaces. Thermal mass is generally not effective in tropical areas with a limited diurnal range. In these climates, thermal mass may reradiate absorbed heat, and may limit the ability of a dwelling to shed heat overnight.

The construction of the roof is a key consideration for effective passive cooling. Roofs can be difficult to shade so the materials selected should minimise heat gain. A highly reflective roof surface will assist with reflecting heat, as will the use of reflective insulation. Reflective insulation reduces radiant day time heat gains, and allows for effective discharge of heat at night time when the outside temperature cools. Bulk insulation should be used carefully in passive cooling applications in cooling dominated climates as it does not allow effective night time heat loss. A well ventilated roof space can also contribute to the passive cooling of a building.

Appendix B Types of designs used in hot and tropical climates

B.1 Free-running Design

Free-running designs rely entirely upon passive heating and/or cooling. Free-running dwellings require careful consideration and balancing of passive design features. There should be no intention to include air-conditioning at a future date unless major renovation works are completed – for example adding insulation, altering the amount of glazing, and improving the building sealing to contain air that has been cooled using an air conditioner.

B.2 Conditioned Design

A conditioned design means the building is designed to contain an air-conditioning system that artificially heats and cools. Air-conditioning is the process of altering the properties of air (primarily temperature and humidity) to more thermally comfortable conditions. To achieve this efficiently, the building needs to be well sealed and insulated to stop internal conditioned air loss and unwanted external temperatures impacting upon internal conditions.

B.3 Hybrid Design

Passive design can also include a hybrid design – a combination of free-running and conditioned spaces. The conditioned space may be a living area that can be used during periods of extreme heat and humidity. The envelope of the conditioned space should be well sealed and insulated from the external environment and the free-running spaces to achieve maximum efficiency of the air-conditioning system. The conditioned space(s) may be able to be opened up and utilise passive cooling when not in use.

The conditioned space(s) should be protected from excess exposure to heat. This could include positioning the conditioned space in the centre of a building with the remaining part of the building providing a buffer, and ensuring that the conditioned space is not positioned in an area that would receive large solar gains.

Appendix C The National Construction Code

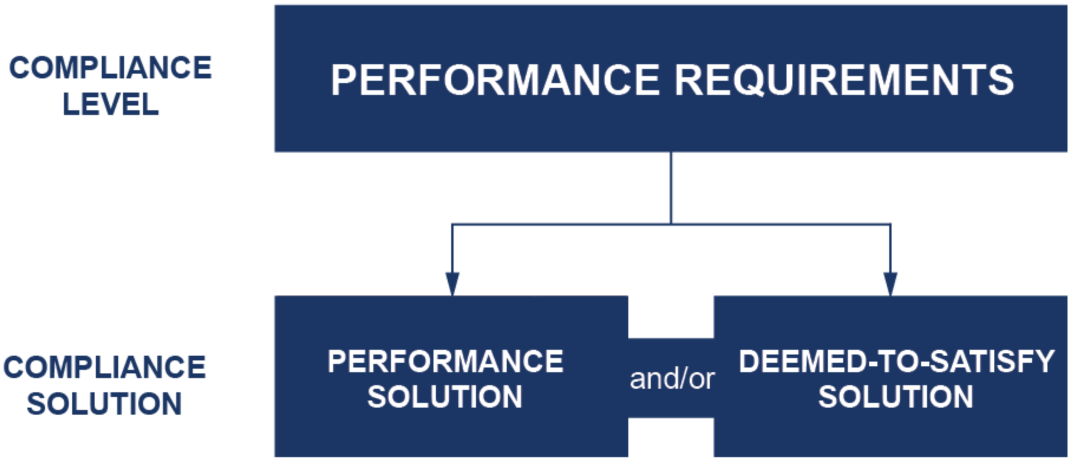
The NCC contains a set of technical provisions for building, and plumbing and drainage work undertaken in Australia.

The mandatory requirements of the NCC are the Performance Requirements. Demonstrating compliance with the Performance Requirements can be achieved by:

- Developing a Performance Solution
- Developing a DtS Solution or
- A combination of the two.

This is shown in Figure 12 below.

Figure 12 NCC Compliance Structure



C.1 NCC Volume Two

Volume Two of the NCC is primarily concerned with the design and construction of Class 1 and 10 buildings. They are typically houses, garages, sheds, carports, and swimming pools.

C.2 Performance Requirement P2.6.1

The Performance Requirement in NCC Volume Two related to the energy efficiency of a house is P2.6.1. It requires the performance of the house to allow for the efficient use of energy for artificial heating and cooling. This Performance Requirement is shown below.

P2.6.1 Building

A building must have, to the degree necessary, a level of thermal performance to facilitate the efficient use of energy for artificial heating and cooling appropriate to—

(a) the function and use of the building; and
(b) the internal environment; and
(c) the geographic location of the building; and
(d) the effects of nearby permanent features such as topography, structures and buildings; and
(e) solar radiation being—
  (i) utilised for heating; and
  (ii) controlled to minimise energy for cooling; and
(f) the sealing of the building *envelope* against air leakage; and
(g) the utilisation of air movement to assist cooling.

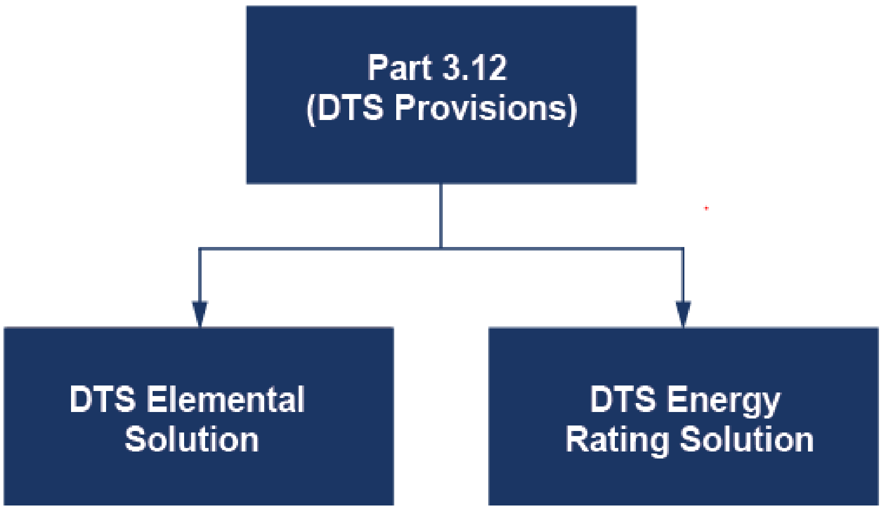
There is a second Performance Requirement related to energy efficiency in NCC Volume Two. Performance Requirement P2.6.2 relates to the domestic services associated with a house and is not covered by this Case Study.

C.3 Compliance Solutions

C.3.1 DtS Solution

There are two DtS Solutions outlined in NCC Volume Two in Part 3.12; the DtS Elemental Solution and DtS Energy Rating Solution. The use of either of these solutions is deemed to comply with Performance Requirement P2.6.1.

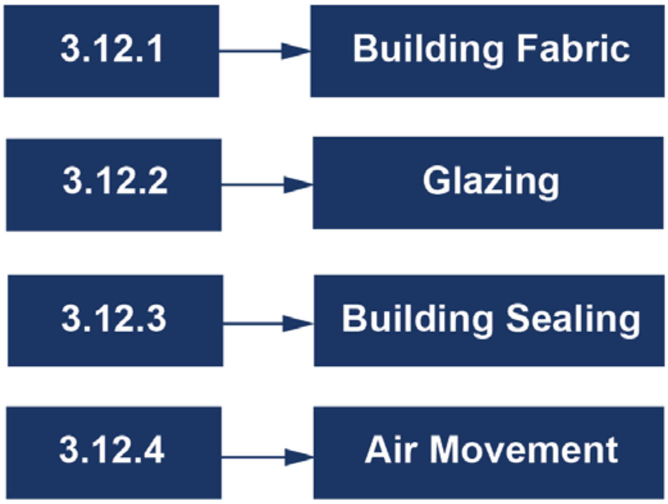
Figure 13 DtS Solutions in NCC Volume Two for P2.6.1



DtS Elemental Solution

A DtS Elemental Solution for meeting the Performance Requirement P2.6.1 uses the DtS Provisions that are specified in the Parts 3.12.1 to 3.12.4 of NCC Volume Two. These provisions are shown in the following figure.

Figure 14 Relevant DtS Provisions for an Elemental Solution



DtS Energy Rating Solution

The DtS Energy Rating Solution of meeting the Performance Requirement P2.6.1 is a method of satisfying the DtS Provisions using software accredited under the NatHERS to work out the relevant energy rating. The method also requires compliance with certain additional requirements in the DtS Elemental Provisions to achieve full compliance.

C.4 Performance Solution

Performance Solution means a method of complying with the Performance Requirements other than by a DtS Solution. A Performance Solution addresses the individual relevant Performance Requirements using one or more of the NCC's Assessment Methods.

Further information on developing a Performance Solution can be found at www.abcb.gov.au.