ABCB

National Construction Code

Handbook

Energy efficiency

NCC Volume Two

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Attribution

Disclaimer

Version history

Original

Publish date: 2006
Print version: 1.0

This version

Publish date: Jul 2019
Print version: 4.1
Details of amendments: Minor editorial changes.

Preface

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

This Handbook is one of a series produced by the ABCB developed in response to comments and concerns expressed by government, industry and the community that relate to the built environment. The topics of Handbooks expand on areas of existing regulation or relate to topics which have, for a variety of reasons, been deemed inappropriate for regulation. They provide non-mandatory advice and guidance.

This Handbook has been developed to foster an improved understanding of the energy efficiency provisions amongst users of the NCC and where relevant, provide examples. It addresses the issues in generic terms, and is not a document that sets out the specific requirements contained in the NCC, but rather aims to explain their intent. It is expected that this Handbook will be used to guide solutions relevant to specific situations in accordance with the generic principles and criteria contained herein.

This Handbook was first published in 2006 and revised in 2010, 2015 and 2016. Editorial changes were made and new content was added to this document in 2019 to ensure currency with NCC 2019.

Acknowledgements

The ABCB acknowledges and would like to thank all those who assisted in the preparation of previous editions of this Handbook including; industry, academia, and State and Territory Administrations who were kind enough to provide valuable comment on the text and assistance in the provision of diagrams and photos.

Contents

REMINDER

This Handbook is not mandatory or regulatory in nature and compliance with it will not necessarily discharge a user's legal obligations. The Handbook should only be read and used subject to, and in conjunction with, the general disclaimer at page i.

The Handbook also needs to be read in conjunction with the relevant legislation of the appropriate State or Territory. It is written in generic terms and it is not intended that the content of the Handbook counteract or conflict with the legislative requirements, any references in legal documents, any handbooks issued by the *Administration* or any directives by the Appropriate Authority.

1 Introduction

1.1 Background

The Australian Building Codes Board (ABCB) developed this Handbook to assist users with the application and understanding of the National Construction Code (NCC) Volume Two energy efficiency requirements.

The ABCB prepared the original version of this Handbook in conjunction with a wide range of stakeholders, including representatives from State and Territory *Administrations* and many industry organisations.

This revised edition of the 2016 Handbook has been updated to align with NCC 2019, which includes a number of changes to the provisions contained within Volume Two. It is also based on feedback from public consultation and discussions with stakeholders, as well as common technical enquiries received about the energy efficiency measures. This Handbook can be used as a stand-alone information resource on how to work with the energy efficiency requirements.

Reminder:

This document is about the NCC and does not contain State or Territory variations or additions.

1.2 Scope

The objective of this Handbook is to provide details of the current energy efficiency provisions of NCC Volume Two. This Handbook aims to give practitioners sufficient knowledge to successfully apply energy efficiency measures at the design, approval and construction stages of the building process.

The Handbook has a practical focus. In addition to giving adequate theoretical knowledge, it is intended to provide an understanding of the policy context and the technical basis of the NCC requirements. This will enable practitioners to manage a range of situations where different design and assessment tools are needed.

The Handbook is structured to first provide the reader with an understanding of important terms and terminology used in the energy efficiency requirements of NCC Volume Two and an overall introduction to the concept of energy efficiency.

The following chapters will provide the reader with an understanding of the performance based NCC and its position in the overall building regulatory hierarchy.

The remaining chapters of the Handbook are generally focussed on describing the intent of the energy efficiency Deemed-to-Satisfy (DTS) Provisions in Part 3.12 of NCC Volume Two as well as providing examples where relevant.

1.3 Using this document

General information about complying with the NCC and responsibilities for building and plumbing regulation are provided in Appendix A of this document.

Acronyms and symbols used in this document are provided in Appendix B.

Italicised terms are defined terms in this document. They may align with a defined term in the NCC or be defined for the purpose of this document. See Appendix C for further information.

Further reading is also provided.

Different styles are used in this document. Examples of these styles are provided below:

NCC extracts

Examples

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2 Energy Efficiency

2.1 Background

In 2003, energy efficiency requirements for houses were first introduced into the Building Code of Australia (BCA) Volume Two. Since 2006, BCA Volumes One and Two have contained energy efficiency requirements for all building classifications. The inclusion of energy efficiency measures in the NCC was part of a comprehensive strategy undertaken by the Commonwealth, State and Territory Governments to reduce greenhouse gas (GHG) emissions. In 2009 the Council of Australian Governments (COAG) announced that it would ask the ABCB to increase the stringency of all buildings for BCA 2010; with housing increased to a 6 star or equivalent level.

Since 2010 there have only been minor changes to the NCC Volume Two energy efficiency provisions as a result of the Proposal-for-Change (PFC) process and ABCB project work. One of the most significant changes was the consolidation of heated water requirements into NCC Volume Three (Plumbing Code of Australia also known as the PCA) in 2014.

Under the COAG 2015 National Energy Productivity Plan (NEPP), and with endorsement by the Building Ministers' Forum, the ABCB was requested to update the energy efficiency provisions in NCC 2019 Volume One and Two.

The NEPP is a COAG Energy Council agreed package of measures, which aims to improve Australia's energy productivity by 40 per cent by 2030. Measure 31 of the NEPP forecasts strong productivity and emissions reduction benefits from revising the NCC's energy efficiency requirements for residential and commercial buildings. However, it also recognises that there is a need to gather more evidence on the effectiveness of the existing provisions, particularly for residential buildings.

The NEPP was informed by research commissioned by the former Department of Climate Change and Energy Efficiency in 2012.This research was updated in 2016 by the Department of the Environment and Energy. The updated research found that changes to the NCC could achieve energy savings of up to 53 per cent for commercial buildings, but only up to 18 per cent for residential buildings.

On this basis, the ABCB was instructed to focus on increasing the stringency of the energy efficiency provisions for commercial buildings in NCC 2019. For residential buildings (Class 1 buildings, Class 2 sole-occupancy units and Class 4 parts of a building), the ABCB's work involved improving interpretation and compliance with the current requirements, in preparation for potential, future increases in stringency.

There were significant changes consequentially made in 2019 for NCC Volume Two including:

- introducing separate heating and cooling load limits into the Nationwide House Energy Rating Scheme (NatHERS) compliance pathway;
- strengthening the reference building Verification Method;
- including a new Verification Method for building envelope sealing; and
- clarifying building sealing requirements under the DTS Provisions

2.2 What is energy?

For the purpose of the NCC energy efficiency provisions, "energy" is the electricity, gas, oil or other fuels used in buildings for heating, cooling or ventilation, for lighting or heated water supply or to operate other *domestic services*. The NCC addresses operational energy and does not consider the energy embodied in building materials or invested in the construction and recycling of buildings, which is known as a product's 'life cycle'. The NCC requirements for housing do not apply to portable appliances (such as refrigerators, office equipment and the like), which are often subject to separate government schemes such as Minimum Energy Performance Standards (MEPS).

Burning coal, natural gas and other fuels to produce electricity releases GHG's into the atmosphere unless the source is one of the few considered to be renewable sources. Renewable sources include photovoltaic (solar) cells, hydroelectric and wind driven generators. Even these sources will be responsible for emissions at some part of their life cycle. The NCC recognises low-emitting energy sources through its *Performance Requirements*, *Verification Methods* and *DTS Provisions*.

Since most of the energy consumed in buildings comes from GHG emitting sources, reducing energy use will also reduce emissions and their unwanted impacts.

2.3 What is energy efficiency?

Energy efficiency is the prudent, or smart, use of energy resulting from regulatory requirements and voluntary choices in comparison to the amount of energy that would otherwise have been consumed. Reducing energy consumption by making buildings less comfortable and less amenable would result in energy savings but would lead to a lower quality of life, loss of productivity and, possibly poor health. The desired outcome is using less energy for heating, cooling, ventilation, lighting and other *domestic services* whilst maintaining expected standards in these areas. This is the aim of the NCC requirements.

In relation to dwellings, energy efficiency provisions are two-fold: firstly, related to the structure; and secondly related to the fixed services within the structure. This means improving the performance of *domestic services* that directly consume energy (such as lighting, air-conditioning and heating), and having greater control over the way that heat flows into and out of the building through its *fabric*. The dwelling design, material selection, and construction determine the amount of heat flowing in and out of the structure. This heat flow determines how hard the *domestic services* have to work. Better *fabric* thermal performance can mean a smaller air-conditioner, running for less time, as well as reducing the need for heating or cooling in the first instance. A combination of these elements, as well as occupant behaviour, contributes to the total amount of energy consumed.

The stock of buildings grows every year and typical Australian buildings remain in use for many decades. Adding buildings to the stock with poor energy efficiency means that GHG emissions will continue to increase, where their impact will exist for a very long time as well as reduce the opportunity to reduce costs associated with energy consumption. Hence, it is important to have minimum energy efficiency requirements to eliminate poorly performing buildings.

2.4 Philosophy of the NCC requirements

Since 2003, Volume Two has included *Performance Requirements*, *Verification Methods* and *DTS Provisions* with the objective of reducing GHG emissions by efficiently using energy and by using renewable energy or energy from low GHG intensity sources. Housing requirements were introduced first, followed by requirements for Class 2 and 3 buildings (apartments and hotels) and Class 4 parts (e.g. a caretaker's residence) and, finally, other building classifications. The energy efficiency requirements take into account the:

- performance of the house including—
    - building *fabric* e.g. walls, floors and roofs;
    - external *glazing* and shading;
    - sealing of the building;
    - effects of air movement; and
- performance of the house's *domestic services* including—
    - insulation and sealing of ductwork and central heating water *piping*;
    - space heating,
    - artificial lighting; and
    - heated water supply system and the heating and pumping of *swimming pools* and spas.

The philosophy underpinning these provisions is that both economic and human comfort benefits are achieved by having a dwelling designed with greater levels of energy efficiency. The house's interior is likely to stay warmer in cold weather and cooler in hot weather. When the internal environment conditions are tolerable for the occupants, it should minimise the need for artificial cooling and/or heating. This can reduce the size of any equipment needed and reduce the amount of energy the occupants use. Consequently, this can reduce the amount of GHG emissions attributable to a dwelling's artificial heating and cooling.

A common question asked is 'isn't this all about occupant comfort?'. The answer is not directly, because comfort is a perception (i.e. subjective) that varies between individual occupants. However, if we can produce houses that keep conditions inside comfortable, the occupants will be less likely to use heating or cooling services, thereby reducing energy demand and GHG emissions. This may also contribute to reducing incidences of heat stress in extreme weather conditions.

Optimal comfort, however, is not specifically the objective of the NCC. Nor is it directly reflected in the *Performance Requirements* or *DTS Provisions*. Making buildings inherently comfortable and reducing potential heat stress of occupants are by-products of the overall NCC energy efficiency requirements.

2.5 Basis of energy efficiency provisions for differing climates

The energy efficiency requirements are generally based on eight broadly defined climate regions, termed the NCC *climate zones*. The *climate zones* are based on both climate data and local government boundaries, so it may change from time to time in response to changes in those local government boundaries. Please refer to Schedule 3 Definitions in NCC Volume Two for the definition of the NCC *climate zones* and the NCC *climate zone* map.

The energy efficiency requirements will vary from location to location depending upon the *climate zone*. For simplicity, locations with approximately similar climates have been combined.

The eight NCC *climate zones* were based on a list of six zones that were developed by the Bureau of Meteorology (BOM), with the addition of a third temperate zone and the inclusion of the existing BCA alpine areas. The basis of each *climate zone* is shown in Table 2.1.

Table 2.1 Basis of NCC climate zones

Climate zone	Description	Average 3 pm January water vapour pressure	Average January maximum temperature	Average July mean temperature	Average annual heating degree days
1	High humidity summer, warm winter	≥ 2.1 kPa	≥ 30°C	-	-
2	Warm humid summer, mild winter	≥ 2.1 kPa	≥ 30°C	-	-

Climate zone	Description	Average 3 pm January water vapour pressure	Average January maximum temperature	Average July mean temperature	Average annual heating degree days
3	Hot dry summer, warm winter	< 2.1 kPa	> 30°C	≥ 14°C	-
4	Hot dry summer, cool winter	< 2.1 kPa	≥ 30°C	< 14°C	-
5	Warm temperate	< 2.1 kPa	< 30°C	-	≤ 1,000
6	Mild temperate	< 2.1 kPa	< 30°C	-	1,000 to 1,999
7	Cool temperate	< 2.1 kPa	< 30°C	-	≥ 2,000 other than alpine areas
8	BCA alpine areas, determined as per NCC Volume Two definition	-	-	-	-

There were further minor adjustments made to some zones following thermal modelling tests of a typical building around the country. These zones are considered sufficiently accurate for the *DTS Provisions*. More extensive climate data is available when using house energy analysis software to meet the *Performance Requirements*, rather than the elemental *DTS Provisions*.

Where appropriate, the map was then adjusted for ease of administration, by aligning the *climate zone* boundaries with local government areas, where local knowledge identified the impact of topographical features such as an escarpment or significant microclimate variation, and where the type of construction required in another zone was felt to be more appropriate for a particular location.

2.5.1 Approach for energy efficient buildings in warmer climates

For Australia's hotter or warmer climates, *climate zones* 1, 3 and, to a lesser extent, 2, the intent is to limit the need for cooling services, which generally use electricity.

The Volume Two elemental *DTS Provisions* for these locations, such as thermal insulation, favourable orientation and shading of *glazing*, sealing against air infiltration and other requirements, are primarily aimed at reducing unwanted heat gain. Unwanted heat gain may increase discomfort levels in the building to a point where the occupants would want to turn on an air-conditioning system.

External *glazing* can be the main avenue for unwanted heat gain in summer or throughout the year in the hottest climates. Chapter 9 discusses in detail the impact of external *glazing*.

2.5.2 Approach for energy efficient buildings in colder climates

The coldest climates are found in *climate zones* 7 and 8, where *climate zone* 8 is the only strictly alpine climate. For houses in these cold climates, the intent is primarily to reduce the need for heating services although there may still be some use of cooling services during summer. Provisions addressing the thermal insulation of the *envelope*, the size and type of external *glazing* used and the level of air infiltration are mainly aimed at reducing unwanted heat loss through the *envelope,* while making use of wintertime solar gains.

External *glazing* can be the main avenue for heat loss unless the *glazing* has enhanced insulating properties and is appropriately oriented.

Heat loss may cause temperatures in the house to drop to a point where the occupants will turn on the heating system. Reducing heat loss (via the *envelope*) and promoting natural heat gains (via the *glazing* receiving winter sun) can reduce the need for heating services in a house located in a cold climate.

2.5.3 Approach for energy efficient buildings in temperate climates

Many Australians live in areas that have four distinct seasonal changes a year. These areas are found in *climate zones* 4, 5 and 6, with even *climate zone* 2 in this category to some degree. These *climate zones* have warm to hot summers and cool to cold winters. Spring and autumn temperature ranges are generally mild. Air-conditioning systems will, at different times, have a need for both heating and cooling to cater for the extremes of the seasons and, therefore, the NCC measures address both heating and cooling.

Thermal treatment of the building *envelope* is beneficial in both hotter and colder weather. In summer, limiting heat gain can reduce the desire of occupants to run any cooling services installed. In winter, the building *fabric* can reduce the heat loss to the outside and can also promote solar heat gains through good orientation and treatment of *glazing* to offset the conductive heat losses.

Design alert:

Remember, some cooling or heating services are likely to be installed in houses. The NCC Volume Two measures are attempting to minimise their use or how hard they work.

3 Introduction to the performance based NCC

3.1 The Australian Building Codes Board

The ABCB is a joint initiative of all three levels of government in Australia.

The Board was established by an Inter-government Agreement (IGA) signed by the Commonwealth, States and Territories on 1 March 1994. The IGA is periodically updated, with the most recent version was signed on 31 January 2018.

The Board consists of sixteen members including a Chair, the head of each Commonwealth, State and Territory *Administration* responsible for building matters, up to five industry representatives, and a representative of the Australian Local Government Association.

The Board's key objective is to address issues relating to safety, health, amenity, accessibility and sustainability in the design and performance of buildings through the NCC and the development of effective regulatory systems and appropriate non-regulatory solutions.

For further information about the Board and the ABCB office, visit the ABCB website (abcb.gov.au).

3.2 The NCC

The ABCB is, amongst other roles, the building and plumbing code writing body for the States and Territories. The series of construction codes is collectively named the NCC. The NCC is a uniform set of technical provisions for building work and plumbing and drainage installations throughout Australia whilst allowing for variations in climate and geological conditions. The NCC comprises the BCA Volumes One and Two; and the PCA, as Volume Three.

NCC Volume One relates primarily to Class 2 to Class 9 buildings while NCC Volume Two relates primarily to Class 1 and 10 buildings. NCC Volume Three relates primarily to plumbing and drainage associated with all classes of buildings. See Appendix E of this Handbook for further details.

All three volumes are drafted in a performance-based format allowing flexibility to develop *Performance Solutions* based on existing or new innovative building, plumbing and drainage products, systems and designs, or the use of the *DTS Provisions* to develop a *DTS Solution*.

To assist in interpreting the requirements of NCC Volume One, the ABCB also produces a non-mandatory Guide to Volume One. For NCC Volumes Two and Three, clearly identified non-mandatory explanatory information boxes are included in the text to assist users.

This Handbook is primarily concerned with the energy efficiency requirements in NCC Volume Two.

Further information on compliance with the NCC can be found in Appendix A.

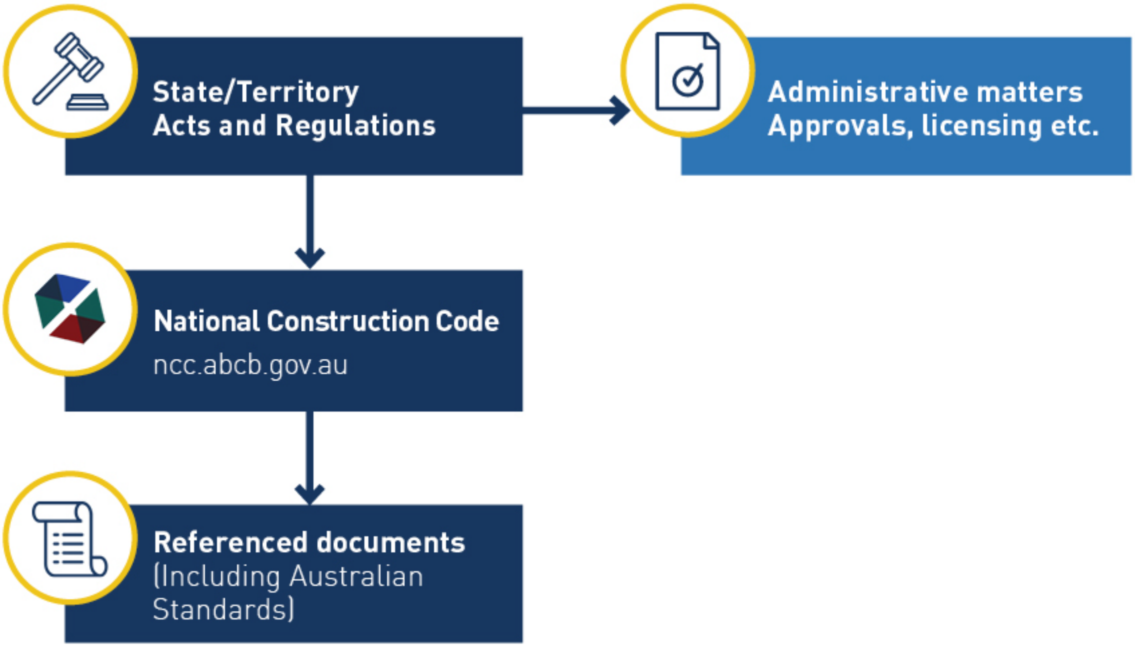
3.2.1 Legislation governing building, plumbing and drainage work

The NCC is given legal effect by building and plumbing legislation in each State and Territory. This legislation prescribes or "calls up" the NCC to fulfil any technical requirements that have to be satisfied when undertaking building work or plumbing and drainage installations.

Each State and Territory's legislation consists of an Act of Parliament and subordinate legislation that empowers the regulation of certain aspects of building work or plumbing and drainage installations, and contains the administrative provisions necessary to give effect to the legislation.

The NCC should be read in conjunction with the legislation under which it is enacted. Any queries on such matters should be referred to the State or Territory authority responsible for building and/or plumbing regulatory matters. Refer to Figure 3.1.

Figure 3.1 Regulatory structure



4 Performance Requirements

4.1 Introduction

The purpose of this Chapter is to explain the energy efficiency *Performance Requirements* in Part 2.6 of NCC Volume Two.

This Chapter reviews the intent of the energy efficiency measures in Part 2.6 via the *Objective* and *Functional Statement* of Part 3.12 and the mandatory *Performance Requirements* of P2.6.1 and P2.6.2.

It further explains the wording used within the *Performance Requirements* to provide a clearer understanding of the terminology used as well as provide an enhanced perspective on the intent of Part 2.6.

Reminder:

Objectives and *Functional Statements* are used to provide guidance on the intent and interpretation of the *Performance Requirements*. They are provided as explanatory information with the *Performance Requirements* in Part 2 of NCC Volume Two.

4.2 Objective

The objective of Part 2.6 (from the explanatory information in NCC Volume Two) is O2.6, which states:

O2.6

The *Objective* is to reduce greenhouse gas emissions.

Initially this *Objective* was stated in a COAG Energy Council communiqué following its meeting of 30 April 2009, prior to the BCA 2010 changes.

The Australian Government signed the Paris Climate Agreement in 2015 and, committed to reducing its emissions by 26–28 per cent below 2005 levels by 2030.

The *Objective* to reduce GHG emissions and improve energy efficiency plays a key part in achieving this goal. It should also be noted that the primary goal is not optimal occupant comfort. The measures are based on achieving an internal environment in which conditions are sufficiently moderate for occupants to minimise their use of artificial heating and cooling.

The energy used over the life of a dwelling can be broken into two distinct components: an operational energy component and an embodied energy component. Operational energy is the energy used during occupation/operation of the dwelling and the GHG emissions attributable from the operational component is the focus of the NCC requirements.

The *Objective* also does not have a limitation or application clause, which means that it applies to all buildings covered by NCC Volume Two.

4.3 Functional Statement

The *Functional Statement* relevant to Part 2.6 of NCC Volume Two is F2.6, which states:

F2.6

To reduce greenhouse gas emissions, to the degree necessary—

(a) a building, including its domestic services, is to be capable of efficiently using energy; and

(b) a building's domestic services for heating are to obtain their energy from
   - (i) a low *greenhouse gas intensity* source; or
   - (ii) an on-site renewable energy source; or
   - (iii) another process as reclaimed energy.

The *Functional Statement* recognises that there are two key contributors to GHG emissions from dwellings. The first is the amount of energy the dwelling and its *domestic services* use and the second is the GHG intensity of the energy source.

From an emissions perspective, *renewable energy* is assumed to be better than natural gas, which is better than fuel oil, which is better than electricity generated from coal.

In general terms, *renewable energy* is energy generated from natural resources such as sunlight, wind, tides and geothermal heat, which are renewable (naturally replenished and available).

The *Functional Statement* also clarifies that any *renewable energy* must be on the allotment to gain a concession. GreenPower supplied over the distribution network does not qualify because the dwelling owner might stop using it at any time during the dwelling's lifetime. The Australian Government's requirement for a certain percentage of the electrical energy provided by the grid to be generated from renewable sources also cannot be considered.

Like the Objective, the *Functional Statement* does not have a limitation or application clause and so is relevant to all buildings covered by NCC Volume Two.

4.4 Performance Requirements

The *Performance Requirements* specified in Part 2.6 of the NCC Volume Two are as follows-

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.

P2.6.2 Services

Domestic services, including any associated distribution system and components must, to the degree necessary—

(a) features that facilitate the efficient use of energy appropriate to—
   (i) the *domestic service* and its usage; and
   (ii) the geographic location of the building; and
   (iii) the location of the *domestic service*; and
   (iv) the energy source; and

(b) obtain heating energy from—
   (i) a source that has a greenhouse gas intensity that does not exceed 100 g CO_2-e/MJ of thermal energy load; or
   (ii) an on-site *renewable energy* source; or
   (iii) another process such as reclaimed energy.

Performance Requirement P2.6.1 relates to the thermal performance of a building that is needed in order to *facilitate* the *efficient use of energy* for artificial heating and cooling. This *Performance Requirement* directly corresponds to the *DTS Provisions* of Parts 3.12.0 to 3.12.4.

Performance Requirement P2.6.2 relates to the *domestic services* and considers facilitating the *efficient use of energy* and minimising the GHG emissions from the energy used for heating. The *DTS Provisions* of Part 3.12.5 directly correspond to this *Performance Requirement*.

4.4.1 Performance Requirement P2.6.1

The overarching requirement of P2.6.1 is that the house must have features providing the required level of thermal performance in order to *facilitate* the *efficient use of energy*. This is specific to the elements specified in (a) to (g), which are further explained below.

(a) The function and use of the building and service

Considerations for a dwelling, where the occupant is directly paying the energy costs will be different from those for a commercial building where the individuals are not paying for the energy costs and hence less likely to manage the available facilities such as shading devices.

(b) The internal environment

This relates to the space within a house where the internal environment can be controlled by conditioning or the operation of building elements such as adjustable shading and *ventilation openings.* The internal environment is affected by the occupants' tolerance to temperature as well as outside influences, such as draughts, external temperatures and radiant heat gain or loss through windows.

(c) The geographic location of the building

This reflects the climatic and topographical region where the dwelling is located. The elemental *DTS Provisions* are specific to 8 different *climate zones*. The warmer regions are *climate zones* 1 to 4, the mildest region is *climate zone* 5 and the cooler regions are *climate zones* 6 to 8.

(d) The effects of nearby permanent features such as topography, structures and buildings

The impacts of such *permanent* features, topography and the like are applied in the *Verification Methods* which use computer software packages. In some instances, benefits can be obtained for heavy overshadowing of houses by certain natural or constructed barriers. Advice should be sought from the *Appropriate Authority* as to what features are sufficiently *permanent* to be included in the assessment.

These effects may also be considered as part of the *Performance Solutions* or *Verification Methods* within the NCC.

(e) Solar radiation

Solar radiation can be desirable in winter and undesirable in summer in southern areas of Australia. In the northern parts of the continent, solar radiation is usually undesirable most of the year.

The requirements for solar radiation to be utilised for heating include locating windows in cooler climates towards orientations which offer higher solar heat gains during winter. This will tend to reduce the amount of artificial heating required for the dwelling.

The requirements for solar radiation to be controlled to minimise energy for cooling include reducing the absorption of solar radiation through the building *fabric* and its transmission through *glazing* in hot climates or during the warmer months.

The *DTS Provisions* specify requirements to control the amount of solar radiation through the *glazing* by shading devices, glass toning or coatings, or the type and area of *glazing* facing certain directions. This is to minimise the need for cooling. This is explained further in Chapter 9, which addresses Part 3.12.2 External glazing.

(f) The sealing of the building envelope against air leakage

Sealing the building *envelope* against air infiltration will restrict the leakage of unwanted hot or cold un-conditioned air into a comfortable interior, and the loss of conditioned air from that space. Reducing the need for conditioning to account for unwanted air leakage means lower energy consumption.

(g) The utilisation of air movement to assist cooling

Air movement is especially effective for dwellings in hotter climates. Good design for air movement through the house will assist natural cross flow ventilation. Air movement can also be facilitated by ceiling fans, helping occupants to feel cooler, even when the air temperature has not changed.

Utilising ventilation to purge warm air from the building when outside temperatures are lower (usually overnight) can also reduce the need for air-conditioning. Once again, a reduction in the need for air-conditioning means less energy consumption and a subsequent reduction in GHG emissions.

4.4.2 Performance Requirement P2.6.2

The overarching requirement of P2.6.2 is that the building's *domestic services* must have features that *facilitate* the *efficient use of energy* and minimise greenhouse gas emissions of the energy used for heating. These are specific to the elements specified in (a) and (b) and are further explained below.

The intent of P2.6.2 (b) is to constrain the use of a high GHG intensive source of energy for heating. It does not prevent the use of electricity because the *greenhouse gas intensity* is related to the thermal load rather than the energy consumption which is covered by P2.6.2 (a).

P2.6.2 also contains the qualification that is to be applied "*to the degree necessary*", allowing electricity to be used, even by low efficiency plant where there are no reasonable alternatives available.

(a)(i) The domestic service and its usage

The particular service is a key consideration as the requirement may vary depending on how often it is likely to be used and rate of energy consumption during operation.

(a)(ii) The geographic location of the building

As with P2.6.1 described earlier, this requirement reflects the climatic and topographical region where the building is located.

Example:

Where the dwelling is located will determine the level of insulation on ductwork or water piping. In a more severe climate (e.g. Hobart), more insulation is likely to be needed and provide greater benefit compared to a relatively mild climate (e.g. Sydney).

(a)(iii) The location of the domestic service

The location of the *domestic service* within the dwelling will impact the level of insulation needed to reduce energy consumption. More protected and insulated areas within the dwelling may require less insulation than those exposed to the external environment.

(a)(iv)The energy source

The energy source of the *domestic service* whether it be cooling, heating, ventilation, heated water supply, artificial lighting or heating and pumping for *swimming pools* and spa pools is important as it impacts the amount of annual GHG emissions attributable to that dwelling.

(b)(i) Greenhouse gas intensity of heating energy

Subclause P2.6.2 (b)(i), which sets a limit for the GHG intensity of an energy source, is primarily targeting the use of resistance electricity for heating of spaces, *swimming pools* and spa pools. Since the limit is expressed in terms of emissions per unit of thermal energy load, it allows the energy efficiency of the *domestic services* equipment to be taken into account. Limits calculated on this basis can permit the use of grid distributed electricity as the source for high efficiency plant such as heat pumps.

Note that the energy here is not the energy actually used by the heating service, such as the metered amount of electricity; it is instead, a measure of the amount of energy produced by a source such as coal or gas. The amount of energy consumed to meet a particular *heating load* will vary depending on the efficiencies of different heating appliances and the fuel source.

(b)(ii) Energy from a renewable source

Energy for heating may also be obtained from *renewable energy* sourced on-site such as solar heating, photovoltaic (solar) cells, wind, or geothermal, amongst others, to reduce GHG emissions and potentially reduce energy costs.

(b)(iii) Energy from a reclaimed process

The use of reclaimed energy can come in the form of waste heat from other *domestic services*. Although unlikely for most dwellings, it is possible to reclaim waste heat from the refrigerant chillers of air-conditioners and use it to preheat water for the heated water supply. There are also co-generation units available on the market that utilise the waste heat from generating electricity for re-use in space and water heating.

5 Verification Method V2.6.2.2

5.1 Introduction

A *Verification Method* used to assess a *Performance Solution* and demonstrate that it complies with the mandatory *Performance Requirement* P 2.6.1 for energy efficiency is the *Verification Method* V2.6.2.2, Verification using a *reference building* prescribed in NCC Volume Two.

Verification Method V2.6.2.2 can be used as a *Performance Solution* to meet the *Performance Requirement* P2.6.1 for a proposed design, instead of using the optional energy rating or elemental approach in the *DTS Provisions* of Part 3.12.

It is not mandatory to use a prescribed NCC *Verification Method* as an *Assessment Method*.

Alert:

The *Performance Requirement* P2.6.1 relates to the building *fabric* whilst the *Performance Requirement* P2.6.2 relates to the *domestic services* of the building. To fully satisfy the energy efficiency *Performance Requirements*, the *Performance Requirement* P2.6.2 must also be met.

5.2 Intent

The intent of any *Verification Method* is to demonstrate that a *Performance Solution* meets the appropriate *Performance Requirement(s)*. It is an optional approach to demonstrate compliance to the NCC *Performance Requirements* for energy efficiency.

A *Performance Solution* can provide flexibility where the prescriptive *DTS Provisions* are considered to be too rigid or inappropriate in assessing certain building designs. An *Assessment Method*, such as a *Verification Method*, can allow for innovation and effective use of the building’s *fabric* to make the building more energy efficient.

This flexibility can assist in promoting an innovative built environment. While project home providers have a range of standard house designs, typically no two allotments are exactly the same. The same home, with a different orientation and exposure to the sun, will achieve a different level of energy consumption (unless compensating adjustments are made to the design). Even based on the same design, the dwelling may be painted different colours, have different roof materials or be at a different angle.

V2.6.2.2 is a comparative *Verification Method* because it assesses the *heating load* and/or *cooling load* of the proposed building and compares it to the *heating load* and/or *cooling load* of a *reference building.* The *reference building* characteristics are those of a building modelled using the minimum *DTS Provisions* of NCC Volume Two Parts 3.12.1 to 3.12.4. In using the elemental *DTS Provisions* as the basis for the *reference building*, the thermal performance of the proposed building *fabric* may not be decreased below the minimum required by the *DTS Provisions*.

Reminder:

Verification Methods other than V2.6.2.2 can be used provided they are acceptable to the *Appropriate Authority*.

5.3 Application

The use of V2.6.2.2 is only applicable to Class 1 and enclosed Class 10a buildings attached to a Class 1 building. It is not applicable to detached garages or to open carports and is limited to the *Performance Requirement* P2.6.1.

Alert:

To fully satisfy the energy efficiency *Performance Requirements*, the *Performance Requirement* P2.6.2 must also be met.

5.4 Methodology

The basic approach is that the annual *heating load* and/or *cooling load* (typically measured in MJ/m^2/annum) of the proposed building must not be more than the annual heating load and/or cooling load target of a complying theoretical *reference building* using the *DTS Provisions.*

This establishes the theoretical annual *heating load* and/or *cooling load* that would have been generated by that house's design had it been built to comply with the *DTS Provisions*. This sets a quantified target (benchmark) that must be achieved when modelling the *Performance Solution*.

This approach requires two modelling runs with software (other than *house energy rating software*); the first to set the *heating load* and/or *cooling load* targets (i.e. using the reference building described above) and the second to demonstrate that the proposed building can achieve this minimum target. The same calculation method must be used in both modelling runs to maintain consistency.

Alert:

House energy rating software is defined differently for V2.6.2.2 and Part 3.12 in NCC Volume Two*. House energy rating software,* including software accredited or previously accredited under the NatHERS, as well as the additional functionality provided in non-regulatory mode, is not permitted to be used for complying with V2.6.2.2.

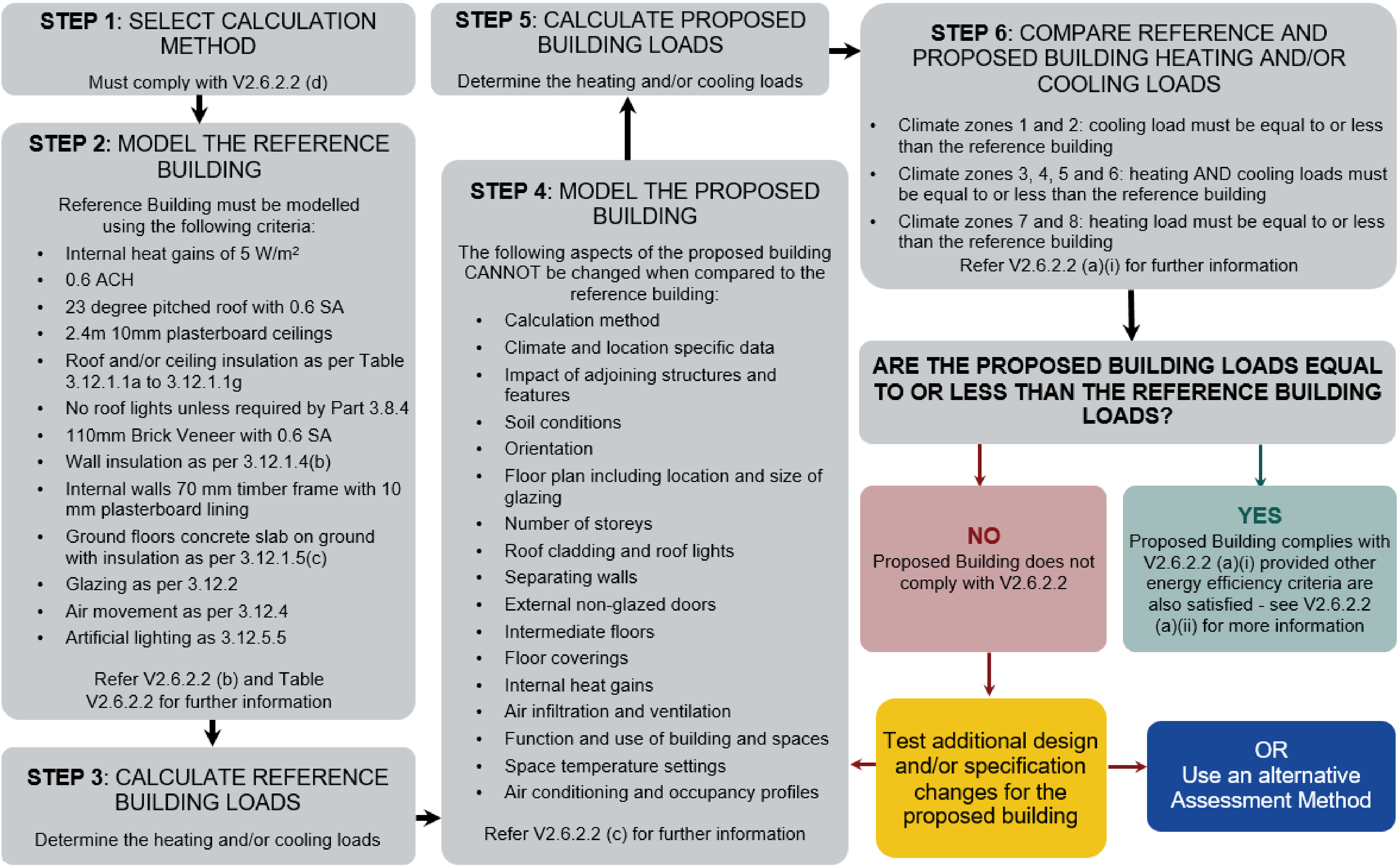
This exclusion is the result of feedback from stakeholders about the misuse of NatHERS software in conjunction with V2.6.2.2 and a number of areas of V2.6.2.2 being gamed.

V2.6.2.2 was first introduced into the NCC to enable the use of non-NatHERS software to assess the energy efficiency of houses. In most instances NatHERS software could not comply with the requirements of V2.6.2.2, specifically in relation to the modelling of temperature settings, and potentially air infiltration and internal heat gains.

The *Verification Method* V2.6.2.2 can *facilitate* certain “trade-offs” between different elements of the building *fabric*, such as a reduction of insulation in the walls whilst increasing the insulation in the roof or improving the thermal performance of the *glazing*. A *reference building* must be modelled using the criteria in Table V2.6.2.2; an infiltration value of 0.6 air changes per hour; and internal heat gains from appliances and equipment of 5 W/m^2 averaged for 24 hours per day, 7 days per week (refer V2.6.2.2(b)). This method also allows for flexibility in the design of *glazing* (openability and thermal performance), shading, and air movement.

The following flowchart demonstrates a procedure that can be used to apply *Verification Method* V2.6.2.2. More complete details regarding the process are documented in the following section.

Figure 5.1 Typical procedure for Verification Method V2.6.2.2



5.4.1 Compliance requirements

The NCC *climate zone* determines whether the annual *heating load* and/or *cooling load* are necessary in determining compliance because the annual energy load of the proposed building must be equal to or less than the energy load of the *reference building*. An extract of the NCC Volume Two requirements are shown below.

V2.6.2.2(a)

(a) Compliance with P2.6.1 is verified when a proposed building—

- (i) compared to a *reference building*, using a calculation method other than *house energy rating software*, has—
  - (A) in *climate zones* 1 and 2, a *cooling load* equal to or less than that of the *reference building;* or
  - (B) in *climate zones* 7 and 8, a *heating load* equal to or less than that of the *reference building;* or
  - (C) in *climate zones* 3, 4, 5 and 6, a *heating load* and a *cooling load* equal to or less than that of the *reference building.*
- (ii) complies with—
  - (A) for building *fabric* thermal insulation, 3.12.1.1; and
  - (B) for thermal break, 3.12.1.2(c) and 3.12.1.4(d); and
  - (C) for compensating for a loss of ceiling insulation, 3.12.1.2(e); and
  - (D) for floor edge insulation, 3.12.1.5(c) and 3.12.1.5(d); and
  - (E) for building sealing, Part 3.12.3 or V2.6.2.3.

A *reference building* is used to determine the maximum annual *heating load* and/or *cooling load* allowed. This is done by applying the *DTS Provisions* outlined in V2.6.2.2(a)(ii), along with certain fixed parameters in accordance with V2.6.2.2(b), to a proposed design (see below). The annual *heating load* and/or *cooling load* calculated then become the target (or benchmark) for the *Performance Solution* as described earlier. Note, the building sealing requirements in V2.6.2.2(a)(ii)(E) can be achieved through the *DTS Provision* of Part 3.12.3 or *Verification Method* V2.6.2.3.

5.4.2 Parameters for the reference building

Besides V2.6.2.2(a)(ii), there are several parameters that must be used when calculating the *heating load* and *cooling load* in (a) of a *reference building*.

V2.6.2.2(b)

(b) The *heating loads* and *cooling loads* in (a) must be calculated for the reference building using—

(i) internal heat gains from appliances and equipment of 5 W/m^2 averaged for 24 hours per day, 7 days per week; and

(ii) an infiltration value of 0.6 air changes per hour; and

(iii) the modelling criteria in Table V2.6.2.2.

(i) Internal heat gains from appliances and equipment of 5W/m^2 averaged for 24 hours per day, 7 days per week

This includes lighting, appliances, cooking and other power loads, but does not include heating equipment. V2.6.2.2(b)(i) limits the average internal heat gains to 5 W/m^2 regardless of the source. Although equipment and appliances may change over the life of the house, they should remain consistent when calculating the energy consumption of the *reference building.*

(ii) An infiltration value of 0.6 air changes per hour

The air change rate is an indication of the air-tightness of a building. Air changes per hour measures how quickly the air in an interior space is replaced by outside air through infiltration. For example, if the amount of air that enters and exits a house in one hour equals the total volume of the conditioned part of the house, the house is said to have undergone one air change per hour.

(iii) The modelling criteria in Table V2.6.2.2

Table V2.6.2.2 is shown below. It lists the requirements for the reference building, which are based on the DTS requirements of Part 3.12.

Table V2.6.2.2

Item	Description	Criteria to be modelled
1	Roof	Pitched roof (23 degrees) with solar absorptance of 0.6
2	Ceiling	2.4 m high horizontal, 10 mm plasterboard ceiling
3	Roof and ceiling insulation	In accordance with Tables 3.12.1.1a to 3.12.1.1g
4	Roof lights	No roof light, unless required by Part 3.8.4
5	External walls	Masonry veneer with 110 mm thick masonry with a solar absorptance of 0.6
6	Wall insulation	The minimum Total R-Value specified in 3.12.1.4(b)
7	Internal walls	70 mm timber frame with 10 mm internal plaster lining
8	Ground floor	Concrete slab-on-ground, insulated in accordance with 3.12.1.5(c)
9	Glazing	In accordance with Part 3.12.2
10	Air movement	In accordance with Part 3.12.4
11	Artificial lighting	In accordance with the maximum illumination power density allowed by 3.12.5.5 without any increase for a control device illumination power density adjustment factor

5.4.3 Parameters for both buildings (reference building & proposed building)

There are several parameters that must be the same in both the *reference building* and the proposed building. This is to avoid using energy efficiency criteria or calculations that could result in a more generous target for the *reference building* and then criteria or calculations that result in a lower annual *heating load* and/or *cooling load* values for the proposed building. A fair and equal comparison of parameters between the two building models is required.

The requirements that must be the same in both modelling runs are:

(i) The calculation method

Using the same software program, including its version, in all modelling runs, and the same operator considerably diminishes the software differences and the operator interpretations.

As previously discussed, *house energy rating software* (including accredited or previously accredited NatHERS software as well as any functionality provided by these tools in non-regulatory mode) is not permitted to be used.

(ii) Location specific data

This is either the location where the dwelling is to be constructed, if climatic data is available, or the nearest location with similar climatic conditions for which climatic data is available. For instance, it would not be appropriate to use Wagga Wagga for the reference building and Mildura for the proposed building even though they are both within the same defined NCC *climate zone*. This clause requires that the same climatic file that is used for the reference building also needs to be used for the proposed building.

(iii) Adjoining structures and features

It would not be appropriate to treat the *reference building* as a greenfield site but the proposed building as part of a townhouse development with other proposed buildings providing shade. Likewise, in one modelling run it would not be appropriate to anticipate the demolition of a building or the growth of vegetation, without doing the same for both modelling runs.

(iv) The soil conditions

These are part of the environmental conditions which need to be the same for both modelling runs.

(v) The building orientation

It would not be appropriate to model the *reference building* along the east-west axis or with its façade facing east, and then re-orientate it so that it is located along the north-south axis, or the façade is facing north for the proposed building.

(vi) The floor plan, including the location and size of glazing

To change the configuration of the building, including its floor plan and room types, could significantly change the energy consumption. This particularly applies to the location of *glazing*. The location of *glazing* is to remain constant between the *reference building* and the proposed building, which includes the orientation that the *glazing* faces.

The thermal performance of the glazing (*Total System U-Value* and *Total System SHGC*), ability to open and the degree of shading over the *glazing* may be varied between the modelling runs. This enables improvements to be made to the thermal performance of the *glazing* so that the proposed building achieves compliance. Further consideration should also be given to the requirements of NCC Volume Two Part 2.4 (and the related *DTS Provisions* of Part 3.8) which contain the minimum requirements for natural lighting and ventilation commonly achieved using *glazing*.

Reminder:

The principle of the *reference building* is that it represents the proposed building had it been designed to comply with the *DTS Provisions*.

(vii) Number of storeys

Further to the building floor plan remaining the same, the number of *storeys* present in the design must be the same for both modelling runs.

(viii) Roof cladding and roof lights

Given the large impact roofing may have on a home's *heating load* and *cooling load*, it is important to keep the roof design constant between both runs. The roof cladding influences the roofs capacity to absorb or reflect heat, thus impacting on the potential heat gain and loss within the dwelling. The inclusion of *roof lights* can also influence this heat gain or loss.

(ix) Separating walls

Separating walls are those that are common to adjoining Class 1 buildings. These walls are typically required to be of a fire-resisting construction. When undertaking a comparative assessment for energy efficiency, the construction used for the *separating walls* needs to remain consistent between the two modelling runs.

(x) The external non-glazed doors

The number and type of doors must be the same even if the calculation method used has the ability to distinguish between types of doors and the degree of air infiltration.

(xi) The intermediate floors

Further to the building floor plan remaining the same, any intermediate floors present in the design have to be modelled the same for both modelling runs.

(xii) Floor coverings

The type of floor coverings need to be kept constant for both modelling runs as they have different thermal properties. Changing floor coverings between the *reference building* and the proposed building can result in a change in *heating loads* and/or *cooling loads*.

(xiii) The internal heat gains including equipment and appliances

This includes lighting, appliances, cooking and other power loads. Although equipment and appliances may change over the life of the house, they should remain consistent when comparing the energy consumption of the *reference building* and the proposed building to allow for a fair comparison of internal heat loads that influence the thermal performance of the building *fabric*. The internal heat gains from equipment and appliances must be modelled 5 W/m^2 averaged for 24 hours per day, 7 days per week for the reference building as specified in V2.6.2.2(b)(i), therefore the proposed building must use the same value based on V2.6.2.2(c).

(xiv) Air infiltration and ventilation

Air movement must be determined as specified in Part 3.12.4 and modelled consistently when comparing the reference building and the proposed building. As air infiltration must be modelled at 0.6 air changes per hour for the reference building as specified in V2.6.2.2(b)(ii), therefore the proposed building must use the same value based on V2.6.2.2(c) (xiv).

(xv) Function and use of the building including zoning, hours of occupation, hours of heating and cooling availability

Each internal building zone should be considered separately to ensure that all conditioned and non-conditioned spaces are calculated appropriately for both the reference building and the proposed building. For example a non-conditioned space such as a hallway that it not compartmentalised from an open kitchen/living should be classified as a *conditioned space*. Where the dwelling is complex, and making each room a separate zone would require the creation of more zones than can be modelled by the tool, some combining of zones may be allowed providing these zones have a similar occupancy e.g. day time, night time or unconditioned zones.

The internal zones need to remain consistent between both modelling runs in order to avoid the calculations being manipulated by how the conditioned and unconditioned zones (or rooms) within the house's design are defined. Different zones tend to have different heating and cooling requirements based on their occupancy and use. If the zones are configured differently for the *reference building* and the proposed building, there may be an unintended increase in the energy target(s) that is not related to the thermal performance of the building *fabric*.

Generally the hours of occupation affect the hours of heating and cooling, so the same occupancy profiles should be used for both calculations to ensure consistency.

(xvi) Space temperature settings within the ranges of 20°C to 21°C for heating and 25°C to 28°C for cooling

Although these temperature ranges may change to suit the individual or the climate, they should remain consistent when comparing the reference building and the proposed building to allow for a fair comparison of internal heating and cooling loads that influence the thermal performance of the building envelope.

(xvii) Profiles for occupancy and air-conditioning

Occupancy profiles (OP) and air-conditioning used for both the reference building and the proposed building should be the same. For example it is not possible to use an OP of a household size of 2 people – ‘actively working couple’ for the reference building, and then use OP of a household size of 2 people – ‘retired couple’, as the heating and cooling load for an actively working couple would be less than a stay at home retired couple. Similarly you cannot use an OP of 4 people for the reference building and then an OP of 2 people for the proposed building.

5.4.4 Calculation method

Clause V2.6.2.2(d) outlines the requirements of the calculation method itself (i.e. the requirements of the energy rating software where used as the calculation method and its compliance with ANSI/ASHRAE Standard 140). This is to ensure that sufficient parameters are able to be taken into account when undertaking the calculation of *heating loads* and *cooling loads*. The number of hours per day which heating and cooling is available (as identified in V2.6.2.2(c)(xv)), is likely to lie between 8 and 17 hours. Hours outside of this duration are considered unlikely, other than in exceptional circumstances.

ANSI/ASHRAE Standard 140 Is a standard method of test for the evaluation of building analysis computer programs, used in calculating the thermal performance of a building and its heating, ventilation and air-conditioning (HVAC) system. ASHRAE 140 can be used to identify and diagnose differences from building energy simulation software that may be caused by modelling limitations, input errors, algorithmic differences, faulty coding, or inadequate documentation.

The requirements of V2.6.2.2(d) are shown in the extract from NCC Volume Two below.

V2.6.2.2(d)

(d) The calculation method used must comply with ANSI/ASHRAE Standard 140 and be capable of assessing the *heating load* and *cooling load* by modelling—

- (i) the building *fabric*; and
- (ii) *glazin*g and shading; and
- (iii) air infiltration and ventilation; and
- (iv) the function and use of the building including zoning, hours of occupation, hours of heating and cooling availability and internal heat gains; and
- (v) relevant built-environment and topographical features; and
- (vi) the sensible heat component of the *cooling load* and *heating load*.

5.4.5 Climatic data

The climatic data heavily influences the *heating loads* and *cooling loads* calculated for the house design. Data from a reliable source should be used and be representative of hourly data over a typical year. Suitable climatic data which includes dry-bulb temperature, direct and diffuse solar radiation, wind speed, wind direction and cloud cover may be obtained from the BOM website (bom.gov.au). An extract of this sub-clause is shown below.

V2.6.2.2(e)

Climatic data employed in the calculation method must be based on hourly recorded values and be representative of a typical year for the proposed location.

5.5 Examples

5.5.1 Lightweight construction in Brisbane

Using the Verification Method V2.6.2.2

A *Performance Solution* to satisfy P2.6.1, assessed using the *Verification Method* V2.6.2.2 is proposed for a single-storey house located in Brisbane (See floor plan in Appendix E). Since Brisbane is located in NCC *climate zone* 2, only the *cooling load* must be verified as being equal to, or less than that of the reference building. To apply the *Verification Method* V2.6.2.2 in this scenario, the following steps are needed.

Step 1: Determine the suitability of proposed calculation method.

The calculation method used to assess the heating and cooling loads under V2.6.2.2 must be validated using the 2007 version of ANSI/ASHRAE Standard 140 (see V2.6.2.2(d)). More information about this standard can found at the ASHARE bookstore website (techstreet.com)[1]. The same calculation method must be used for determining *heating load* and *cooling loads* of both the reference building and the proposed building.

In addition to complying with this standard, the calculation method used must also be *capable* of modelling the following components that can affect the heating and cooling loads of a building – see V2.6.2.2(d) for details:

- Elements that make up the building envelope such as floors, walls and roofs
- Glazed elements such as windows and doors
- Shading elements such as awnings or eaves overhangs
- Air movement due to leakage and natural ventilation

[1] The software or methodology that is used for the calculation method should be documented. Also evidence of suitability demonstrating it has been validated using ANSI/ASHRAE Standard 140 can be provided as part of the documentation submitted to the relevant authority.

- The operation of the building, such as hours of occupancy, conditioned/unconditioned zones, operating times for heating & cooling systems and heat gains from equipment & people within the building
- External features such as neighbouring buildings, dense vegetation or other topographical features
- The sensible heat component of the cooling load and heating load.

The proposed calculation method must also use hourly climate data that is representative of the building's proposed location (see V2.6.2.2(e) for further details). Suitable climate data should be made available by the developer of the calculation method or will need to be sourced from a third party.

Additionally, the proposed calculation method must not be the same method as used for *house energy rating software* – see V2.6.2.2(a)(i). *House energy rating software* cannot be used with this *Verification Method*. That means current and previous accredited software under NatHERS (AccuRate Sustainability, BERS Pro and FirstRate 5) cannot be used for V2.6.2.2. Non-regulatory functions included in the NatHERS software cannot be applied under V2.6.2.2 either.

Step 2: Model the reference building

V2.6.2.2(b) outlines the required settings that must be used when modelling the heating and cooling loads for the reference building. For this example, the required settings are summarised in the following table:

Table 5.1 Reference building modelling settings

Description	Required settings
Internal heat gains	**5 W/m^2** (averaged over 24 hours a day 7 days a week)
Air infiltration	**0.6 Air Changes per Hour (ACH)**
Roof	**23 degree** pitched roof **0.6 *solar absorptance* (SA)**
Ceiling and height	**2.4 m** with 10 mm plasterboard
Roof and ceiling *insulation*	**R4.6** (see Table 3.12.1.1b)
Roof lights	**None** (unless required by NCC Volume Two Part 3.8.4)
External walls	110 mm masonry veneer with **0.6 SA**

Description	Required settings
Wall *insulation*	**R2.8** (see 3.12.1.4(b)(i)(A))
Internal walls	**70 mm timber frame with 10 mm internal plaster lining**
Ground floor	**Concrete slab on ground 100mm** **No insulation** (no in-slab or in-screed heating or cooling system)
Glazing	***Total U-Value* (U-Value): 7.9 W/m^2.K & *Total Solar Heat Gain Coefficient* (SHGC): 0.48** (see below)
Air movement	**10% minimum** (as percentage of floor area – see below)
Artificial lighting	**5 W/m^2** (for Class 1 – see 3.12.5.5(a)(i))

For *glazing* in the reference building, performance values need to be determined using the methodology outlined in Part 3.12.2. In this example, the windows require a U-Value of 7.9 W/m^2.K and a SHGC of 0.48. The ABCB Glazing Calculator NCC 2014 Volume Two (available at the ABCB website (abcb.gov.au)) can be used to assist in determining the required performance values. Documentary evidence for the reference building *glazing* can be included as part of this *Verification Method*.

It is also necessary to calculate the air movement within *habitable rooms* of the reference building to ensure they comply with Part 3.12.4.1. For NCC *climate zone* 2, the air movement in *habitable rooms* must comply with Table 3.12.4.1, being a ventilation open area of 10% of the floor area. The following table provides a summary of the air movement calculations used for the *reference building*:

Table 5.2 Air movement calculations for reference building

Habitable room	Floor area (m^2)	Ventilation area (m^2)	Window/floor percentage
Living	18	4.7	26%
Dining/kitchen	25	8.6	34%
Office/gallery	14	5	36%
Study	5.5	1.4	25%
Bed 1	14.2	3.9	27%
Bed 2	14.3	2.3	16%
Entry/passage	17.7	2.2	12%

Air movement setting for glazing calculator in this example is high.

Step 3: Assess the heating load and/or cooling load for the reference building using the calculation method.

Using the specifications determined in Step 2, calculate the *heating load* and/or *cooling load* for the reference building. The calculation method used to determine these loads must comply with V2.6.2.2(d) as outlined in Step 1.

In this example for Brisbane (NCC *climate zone* 2), only the *cooling load* need be determined, as required by V2.6.2.2(a)(i)(A). The calculated *cooling load* for the reference building in this example is 13,096 kWh/year. These results establish the reference building benchmark load.

Step 4: Model the proposed building

It is recommended that the reference building modelling and calculation results be recorded separately and tested one change at a time, for easy comparison with the proposed building.

Using the same calculation method for both the reference and proposed buildings satisfies the requirements outlined in V2.6.2.2(c)(i). There are also restrictions as to what changes can be made between the reference building and the proposed building. Some of the elements and modelling assumptions in the building design that **cannot** be changed between the reference and proposed building include:

- the orientation, location and/or position of the building;
- the floor plan and the number of *storeys*;
- the location and size of *glazing* and external non-glazed doors;
- materials used for the roof cladding, *separating walls*, floors between *storeys* and floor coverings;
- the infiltration, zoning, internal gains, occupation, function and use of the building and the spaces within; and
- the temperature and air conditioning settings used for heating and/or cooling.

Other restrictions may also apply to the reference and proposed buildings - refer V2.6.2.2(c) for detailed requirements.

The *reference building* assumes brick veneer for the *external wall* construction. The clients' preference is for the *external walls* to have less thermal mass using only a framed construction with weatherboard cladding (i.e. no brickwork). They would also prefer all rooms to have a minimum ceiling height of 2.7 m:

Table 5.3 Design parameters for reference building and proposed building

Design parameter	Reference building	Proposed building
External wall construction	Brick veneer R2.8	Framed weatherboard R2.8
Ceiling height	2.4 m	2.7 m

Step 5: Calculate proposed building loads

Changing the *external wall* construction and ceiling heights of the proposed building results in a *cooling load* of 10,621 kWh/year, as shown in the table below:

Step 6: Compare the heating load and/or cooling load of the reference building and the proposed building and test further changes if required.

For a building located in NCC *climate zone* 2 as in this example, V2.6.2.2(a)(i)(A) states that only the *cooling load* of the proposed building must be equal to or less than that of the *reference building*. By comparing the *cooling load* of the reference and proposed buildings it is now possible to determine whether the design complies with *Verification Method* V2.6.2.2.

Table 5.4 Comparison of cooling load results

Model	Cooling load (kWh/year)
Reference building	13,096
Proposed building	**10,621**
Satisfies V2.6.2.2(a)(i)	**Yes**

The *cooling load* of the proposed building is less than the *reference building* by 2,475 kWh/year. This means the proposed building would satisfy the criteria in V2.6.2.2(a)(i).

Design options:

There are other options that can be adjusted for the proposed building. For example, the clients may also wish to change the roof of the proposed building to a lighter colour, which would in turn change the *solar absorptance*:

Table 5.5 Adjustment to solar absorptance

Design parameter	Reference building	Proposed building
Solar absorptance	0.6*	0.4

* As required by Item 1 in Table V2.6.2.2.

Changing the *solar absorptance* of the roof results in a cooling load for the proposed building of 7,268 kWh/year.

Table 5.6 Cooling loads for proposed building

Model	Cooling load (kWh/year)
Reference building	13,096
Proposed building	**7,268**

Since the *cooling load* of the proposed building is still less than the *reference building* (5,828 kWh/year lower), the proposed building still satisfies the criteria in V2.6.2.2(a)(i). In some cases to achieve a compliant design, it may be necessary to revert to a previous iteration, or undertake further modifications to other building elements. Alternatively, a different *Assessment Method* could be used.

Notes:

In addition to satisfying the *reference building cooling loads*, the construction of the proposed building must also meet the following DTS requirements of NCC Volume Two for the proposed building to comply with the Performance Requirement P2.6.1 using Verification Method V2.6.2.2:

- Part 3.12.1.1 building fabric thermal insulation
- Part 3.12.1.2(c) and 3.12.1.4(d) for thermal breaks
- Part 3.12.1.2(e) for compensation for loss of ceiling *insulation*
- Part 3.12.1.5(c) and 3.12.1.5(d) for floor edge *insulation*

- Part 3.12.3 or V2.6.2.3 for building sealing.

Outcome:

The design and specification changes tested in the various iterations of the proposed building design will comply with *Performance Requirement* P2.6.1 using *Verification Method* V2.6.2.2, provided the above DTS requirements are also met.

To comply with *Performance Requirement* P2.6.2 Services, the proposed building would also need to comply with the deemed to satisfy provisions of Part 3.12.5 for services in the building including central heating pipework, heating and cooling ductwork, electric resistance space heating, artificial lighting, water heating and pumping & heating of pools & spas.

5.5.2 Double brick construction in Perth

Using the Verification Method V2.6.2.2

A *Performance Solution* to satisfy P2.6.1, assessed using *Verification Method* V2.6.2.2 is proposed for a single *storey* house located in Perth (see floor plan in Appendix E). Since Perth is located in NCC *climate zone* 5, both the *heating load* and *cooling load* must be verified as being equal to or less than that of the *reference building*. To apply the *Verification Method* V2.6.2.2 in this scenario, the following steps are needed.

Step 1: Determine the suitability of proposed calculation method

The calculation method used to assess the heating and cooling loads under V2.6.2.2 must be validated using the 2007 version of ANSI/ASHRAE Standard 140. The calculation method used must also be *capable* of modelling a suite of components that can affect the heating and cooling loads of a building required under V2.6.2.2(d). The calculation method must be the same for both the reference and proposed building.

As stated in V2.6.2.2(e), the proposed calculation method must also use hourly climate data that is representative of the building's proposed location. Suitable climate data should be made available by the developer of the calculation method or will need to be sourced from a third party.

V2.6.2.2(a)(i) prohibits the use of *house energy rating software* as the proposed calculation method.

Step 2: Model the reference building

V2.6.2.2(b) outlines the required settings that must be used when modelling the *heating load* and *cooling loads* for the *reference building*. For this example, the required settings are summarised in the following table:

Table 5.7 Reference building modelling settings

Description	Required settings
Internal heat gains	**5 W/m²** (averaged over 24 hours a day 7 days a week)
Air infiltration	**0.6 ACH**
Roof	**23 degree** pitched roof **0.6 SA**
Ceiling and height	**2.4 m** with 10 mm plasterboard
Roof and ceiling *insulation*	**R5.1** (see Table 3.12.1.1f)
Roof lights	**None** (unless required by NCC Volume Two Part 3.8.4)
External walls	**110 mm masonry veneer with 0.6 SA**
Wall *insulation*	**R2.8** (see 3.12.1.4(b)(ii))
Internal walls	**70 mm timber frame with 10 mm internal plaster lining**
Ground floor	**Concrete slab on ground 100mm** thick **No insulation** (no in-slab or in-screed heating or cooling system)
Glazing	**U-Value: 7.9 W/m².K and SHGC: 0.61**
Air movement	**7.5% minimum** (as percentage of floor area – see below)
Artificial lighting	**5 W/m²** (for Class 1 – see 3.12.5.5(a)(i))

For *glazing* in the *reference building,* performance values need to be determined using the methodology outlined in Part 3.12.2. In this example, the glazed doors and windows require a U-value of 7.9 W/m^2.K and a SHGC of 0.61 to comply with the Glazing Calculator.

Documentary evidence for the *reference building glazing* can be included as part of this *Verification Method*.

It is also necessary to calculate the air movement within *habitable rooms* of the *reference building* to ensure they comply with Part 3.12.4.1. For NCC *climate zone* 5, the air movement in *habitable rooms* must comply with Table 3.12.4.1 being a ventilated area of 7.5% of the floor area (for a room without ceiling fans and/or an evaporative cooler). The following table provides a summary the air movement calculations used for the *reference building*:

Table 5.8 Air movement calculations for reference building

Habitable room	Floor area (m^2)	Ventilation area (m^2)	Window/floor percentage
Bed 1	13	2	15%
Bed 3	13	2	15%
Main suite/WIR	20.7	2.5	12%
Bed 2	11.8	0.9	8%
Living/dining/kitchen	57.7	19.5	34%

Air movement setting for glazing calculator in this example is high.

Step 3: Assess the heating load and/or cooling load for the reference building using the appropriate calculation method.

Using the specifications determined in Step 2, calculate the *heating load* and/or *cooling load* for the *reference building*. The calculation method used to determine these loads must comply with V2.6.2.2(d) as outlined in Step 1.

In this example for Perth (NCC *climate zone* 5), both the *heating load* and *cooling load* need to be determined, as required by V2.6.2.2(a)(i)(C). The *heating load* and *cooling load* for the *reference building* in this example are 7,365 kWh/year and 8,027 kWh/year, respectively. These results establish the *reference building* benchmark loads.

Step 4: Model the proposed building

By using the same calculation method, this satisfies the requirements outlined in V2.6.2.2(c)(i). There are also restrictions as to what changes can be made between the *reference building* and the proposed building. For a list of elements and modelling assumptions in the building design that **cannot** be changed between the reference and proposed building (see V2.6.2.2(c)).

In this example, the first iteration would be to change the external and internal walls to the intended construction types, being *cavity* brick for the *external walls* and single brick for the *internal walls*:

Table 5.9 Adjustment to wall construction

Design parameter	Reference building	Proposed building
External wall construction	Brick veneer R2.8	250 mm double brick (no *insulation*)
Internal wall construction	7 0mm timber frame with 10 mm internal plaster lining	90 mm masonry with 10 mm wet plaster lining

Step 5: Calculate proposed building loads

The heating and cooling loads are then recalculated for the first iteration of the proposed building, resulting in a *heating load* of 7,677 kWh/year and a *cooling load* of 7,405 kWh/year.

Step 6: Compare the heating load and/or cooling load of the reference building and the proposed building and test further changes if required.

By comparing the heating and cooling loads of the reference and proposed buildings it is now possible to determine whether the design complies with *Verification Method* V2.6.2.2. For a building located in NCC *climate zone* 5, V2.6.2.2(a)(i)(C) states that the *heating load* and *cooling load* of the proposed building must be equal to or less than that of the *reference building*.

Table 5.10 Comparison of load results

Model	Heating load (kWh/year)	Cooling load (kWh/year)
Reference building	7,365	8,027
Proposed building	**7,677**	**7,405**

Referring to the table shown above, while the *cooling load* of the proposed building is less than the *reference building* (622 kWh/year lower), the *heating load* of the proposed building is higher than the *reference building* (312 kWh/year higher).

This means the proposed building does not currently comply with *Verification Method* V2.6.2.2.

Further changes to the proposed building will need to be tested in comparison to the *reference building*. For example, selecting higher performance windows with a lower U-value may help to reduce the proposed building's *heating load*:

Table 5.11 Adjustment to window U-Value

Design parameter	Reference building	Proposed building
Window U-Value ($W/m^2.K$)	7.9*	5.6

* As required by Item 1 in Table V2.6.2.2.

The heating and cooling loads for the proposed building are now recalculated based on the lower U-Value for the windows. This results in a *heating load* of 7,229 kWh/year and a *cooling load* of 7,265 kWh/year as shown in the following table:

Table 5.12 Comparison of results after adjustment to U-Value

Model	Heating load (kWh/year)	Cooling load (kWh/year)
Reference building	7,365	8,027
Proposed building	**7,229**	**7,265**
Satisfies V2.6.2.2(a)(i)	**Yes**	**Yes**

By improving the U-Value of the windows, the proposed building *heating load* is now less than the *reference building heating load* (136 kWh/year lower). The proposed building *cooling load* is also further reduced compared to the *reference building* (762 kWh/year lower).

Design options

Instead of specifying higher performance windows, other changes could be investigated to help reduce the *heating load* for the proposed building, such as:

- Increasing the ceiling and/or roof *insulation*
- Adding external wall insulation

Alternatively, a different *Assessment Method* could be used.

Notes

As long as the proposed buildings *heating load* AND *cooling load* continue to be equal to or less than the *reference building*s established limits, the proposed building will comply with V2.6.2.2(a)(i). The proposed building must also meet the additional DTS requirements listed in V2.6.2.2(a)(ii).

Outcome

The design and specification changes tested in the various iterations of the proposed building design will comply with *Performance Requirement* P2.6.1 using *Verification Method* V2.6.2.2, provided requirements of V2.6.2.2(a)(ii) are also met. In addition to the *Performance Requirement* P2.6.1, the design also needs to be satisfy with the *Performance Requirement* P2.6.2 Services. P2.6.2 can be achieved by complying *DTS Provisions* under 3.12.5.

5.5.3 Brick veneer construction in Albany

Using the Verification Method V2.6.2.2

A *Performance Solution* to satisfy P2.6.1, assessed using *Verification Method* V2.6.2.2 for a two-*storey* house located in Albany is proposed (see floor plan in

Appendix E). Since Albany is located in NCC *climate zone* 6, both the *heating load* and *cooling load* must be verified as being equal to, or less than that of the *reference building*. To apply the *Verification Method* V2.6.2.2 in this scenario, the following steps are needed.

Step 1: Determine the suitability of proposed calculation method.

As with the previous two worked examples, the calculation method applied to both the reference and proposed buildings needs to comply with V2.6.2.2(d).

Step 2: Model the energy efficiency specifications of the reference building.

V2.6.2.2(b) outlines the required settings that must be used when modelling the heating and cooling loads for the *reference building*. For this example, the required settings are summarised in the following table:

Table 5.13 Reference building modelling settings

Description	Required settings
Internal heat gains	**5 W/m²** (averaged over 24 hours a day 7 days a week)
Air infiltration	**0.6 ACH**
Roof	**23 degree** pitched roof **with 0.6 SA**
Ceiling and height	**2.4 m** with 10 mm plasterboard
Roof and ceiling *insulation*	**R5.1** (see Table 3.12.1.1f)
Roof lights	**None** (unless required by NCC Volume Two Part 3.8.4)
External walls	**110mm masonry veneer** **0.6 SA**
Wall *insulation*	**R2.8** (see 3.12.1.4(b)(ii))
Internal walls	**70 mm timber frame with 10 mm internal plaster lining**
Ground floor	**Concrete slab on ground 100 mm** **No *insulation*** (no in-slab or in-screed heating or cooling system)
Glazing	**U-Value: 5.3-6.7 W/m².K** **SHGC: 0.81-0.85** (see below)
Air movement	**5% minimum** (as percentage of floor area – see below)
Artificial lighting	**5 W/m²** (for Class 1 – see 3.12.5.5(a)(i)) **3 W/m²** (for Class 10a – see 3.12.5.5(a)(iii))

In this example, windows on the ground floor require a **U-value of 6.7 W/m^2.K** and a **SHGC of 0.81** while the upper floor windows require a **U-value of 3.4 W/m^2.K** and a **SHGC of 0.85** to comply with the Part 3.12.2.

It is also necessary to calculate the air movement within *habitable rooms* of the *reference building* for compliance with Part 3.12.4.1. For NCC *climate zone* 6, the air movement in *habitable rooms* must comply with Part 3.8.5, being a ventilated area of 5% of the floor area. The following table provides a summary the air movement calculations used for the *reference building*:

Table 5.14 Air movement calculations for reference building-ground level

Habitable room	Floor area (m^2)	Ventilation area (m^2)	Window/floor percentage
Entry/hall	13	2.0	15%
Master bed	20	2.0	10%
WIR	7.0	0.4	5%
Living/dining/kitchen	58	14.3	25%
Total ground level:	**98**	**18.7**	**19%**

*Air movement setting for glazing calculator at the ground is high.

Table 5.15 Air movement calculations for reference building-upper level

Habitable room	Floor area (m^2)	Ventilation area (m^2)	Window/floor percentage
Retreat/study/hall	34	2.5	7%
Bed 2	17	2.5	15%
Bed 3	11	0.7	6%
Bed 4	12	1.6	13%
Total upper level:	**74**	**7.3**	**10%**

*Air movement setting for *glazing* calculator at the upper floor is high.

Step 3: Assess the heating load and/or cooling load for the reference building using the calculation method.

Using the specifications determined in Step 2, calculate the *heating load* and/or *cooling load* for the *reference building*. The calculation method used to determine these loads must comply with V2.6.2.2(d) as outlined in Step 1.

In this example for Albany (NCC *climate zone* 6), both the *heating load* and *cooling load* need to be determined, as required by V2.6.2.2(a)(i)(C). The *heating load* and *cooling loads* for the *reference building* in this example are 1,440 kWh/year and 570 kWh/year, respectively. These results establish the *reference building* benchmark loads.

Step 4: Model proposed building

The clients may wish to change the roof of the proposed building to a lighter colour, which would in turn change the *solar absorptance*:

Table 5.16 Adjustment to solar absorptance

Design parameter	Reference building	Proposed building
Solar absorptance	0.6*	0.4

* As required by item 1 in Table V2.6.2.2.

Step 5: Calculate proposed building loads

Changing the *solar absorptance* of the roof results in *heating load* and *cooling load* for the proposed building of 1,462 kWh/year and 555 kWh/year respectively.

Step 6: Compare the heating load and/or cooling load of the reference building and the proposed building and test further changes if required.

By comparing the heating and cooling loads of the reference and proposed buildings it is now possible to determine whether the design complies with *Verification Method* V2.6.2.2(a)(i). For a building located in NCC *climate zone* 6, V2.6.2.2(a)(i)(C) states that the *heating load* AND *cooling load* of the proposed building must be equal to or less than that of the *reference building*.

Table 5.17 Comparison of load results

Model	Heating load (kWh/year)	Cooling load (kWh/year)
Reference building	1,440	570
Proposed building	**1,462**	**555**

Referring to the table above, while the cooling load of the proposed building is less than the reference building (15 kWh/year lower), the heating load of the proposed building is higher than the reference building (22 kWh/year higher). This means the proposed building does not currently comply with *Verification Method* V2.6.2.2(a)(i).

Further changes to the proposed building will need to be tested in comparison to the *reference building*. For example, increasing the total ceiling *insulation* in the proposed building may help to offset the additional *heating load* that results from a roof with a lower *solar absorptance*:

Table 5.18 Adjustment to ceiling insulation

Design parameter	Reference building	Proposed building
Total ceiling *insulation*	R5.1	R6.4

The heating and cooling loads for the proposed building are now recalculated to also include the increased ceiling *insulation*. This results in a *heating load* of 1,412 kWh/year and a *cooling load* of 554 kWh/year.

Because the updated *heating load* and *cooling loads* for the proposed building are now equal to or less than the *reference building*, the proposed building design would satisfy the criteria in V2.6.2.2(a)(i).

Table 5.19 Comparison of load results after adjustment to ceiling insulation

Model	Heating load (kWh/year)	Cooling load (kWh/year)
Reference building	1,440	570
Proposed building	**1,412**	**554**
Satisfies V2.6.2.2(a)(i)	**Yes**	**Yes**

Design options

Other changes could be investigated to reducing the proposed design's *heating load*. For example, changing the *external wall* construction from brick veneer to reverse brick veneer would improve the thermal performance of the proposed building:

Table 5.20 Adjustment to external wall construction

Design parameter	Reference building	Proposed building
External wall construction	Brick veneer R2.8	Reverse brick veneer R2.8

The heating and cooling loads are then recalculated:

Table 5.21 Table Comparison of load results after adjustment to external wall

Model	Heating load (kWh/year)	Cooling load (kWh/year)
Reference building	1,440	570
Proposed building	1,316	490

As both the heating and cooling loads are still less than the *reference building*, the third iteration of the proposed building also still satisfies V2.6.2.2(a)(i).

The client may then wish to test further design changes to the proposed building. If further testing of changes results in either the heating and/or cooling loads being greater than the *reference building* loads, this will mean that particular iteration of the proposed building will not comply with *Performance Requirement* P2.6.1 using *Verification Method* V2.6.2.2.

To achieve a compliant design, it may be necessary to revert to a previous iteration that complies, or further modifications to other building elements could be also tested. Alternatively, a different *Assessment Method* could be used.

Note

The proposed building must also meet the DTS requirements outlined under V2.6.2.2(a)(ii).

Outcome

The design and specification changes tested in the various iterations of the proposed building design will comply with *Performance Requirement* P2.6.1 using *Verification Method* V2.6.2.2, provided the DTS requirements listed in V2.6.2.2(a)(ii) are also met. To fully compliant with the energy efficiency requirements in NCC Volume Two, the design also needs to comply with the *Performance Requirement* P2.6.2 Services. This can be achieved by complying *DTS Provisions* in Part 3.12.5.

6 Verification Method V2.6.2.3

6.1 Introduction

Verification Method V2.6.2.3, Verification of building envelope sealing as prescribed in the NCC Volume Two is a *Verification Method* used to assess if a *Performance Solution,* it complies with the mandatory *Performance Requirement* P2.6.1(f) for energy efficiency.

Verification Method V2.6.2.3 can be used as a *Performance Solution* to meet the *Performance Requirement* P2.6.1(f) for a proposed design, instead of using the prescriptive approach of the *DTS Provisions* contained within Part 3.12.

It is not mandatory to use a particular NCC *Verification Method* as an *Assessment Method*.

Alert:

The *Performance Requirement* P2.6.1 relates to the building *fabric*, whilst the *Performance Requirement* P2.6.2 relates to the *domestic services* of the building. V2.6.2.3 can only meet P2.6.1(f).To fully satisfy the energy efficiency *Performance Requirements*, other requirements under P2.6.1 and the *Performance Requirement* P2.6.2 must also be met.

6.2 Intent

The intent of this *Verification Method* is to demonstrate that a *Performance Solution* meets the associated *Performance Requirement* (i.e. P2.6.1(f)). It is an optional approach to demonstrating compliance with the NCC *Performance Requirement* for building sealing.

A *Performance Solution* can provide flexibility where the prescriptive *DTS Solution* is considered too rigid or inappropriate for the particular building design. An *Assessment Method*, such as this *Verification Method*, provides a pathway that can be followed to achieve a *Performance Solution*.

The flexibility offered by this *Verification Method* can assist in creating an innovative built environment. Many builders and industry groups are recognising the energy savings which result from a more tightly sealed building, and tools like Green Star are encouraging practical testing. This *Verification Method* allows the results of such testing to demonstrate compliance with *Performance Requirement* P2.6.1(f). As such, it provides an alternative compliance pathway to the prescriptive *DTS Solution* for building *envelope* sealing.

As it is not mandatory, building designers should consider whether the *Verification Method*, the prescriptive *DTS Provisions*, or another *Performance Solution* is most appropriate for their project.

6.3 Application

The use of *Verification Method* V2.6.2.3 is limited to Class 1 buildings and enclosed Class 10a buildings attached to Class 1 buildings. It is not intended to apply to detached garages or open carports. *Verification Method* V2.6.2.3 is limited to *Performance Requirement* P2.6.1(f), and cannot verify compliance with any other components of P2.6.1.

6.4 Methodology

The approach of the *Verification Method* is to demonstrate compliance with the *Performance Requirement* P2.6.1(f) through practical testing. The requirements have been set based upon consultation with industry, to match the performance level of 10 $m^3/hr.m^2$ at 50 Pa achieved by typical construction in accordance with the prescriptive *DTS Provisions*. Although this will approximate 10 air changes per hour at 50 Pa in typical constructions, the requirement in $m^3/hr.m^2$ is both more practical to test and more appropriate to confirm the performance of the building *envelope*.

In the NCC, 10 air changes per hour at 50 Pa in the explanatory information accompanying *Verification Method* V2.6.2.3 is only advisory, but aims to assist in clarifying the intent of the code. It should also be noted that this figure is indicated at a 50 Pa pressure difference, and should not be confused with the 0.6 air changes per hour (at atmospheric pressure) required in the modelling for *Verification Method* V2.6.2.2.

With a quantified goal and standardised testing conditions, *Verification Method* V2.6.2.3 offers designers flexibility in how they meet the *Performance Requirement*.

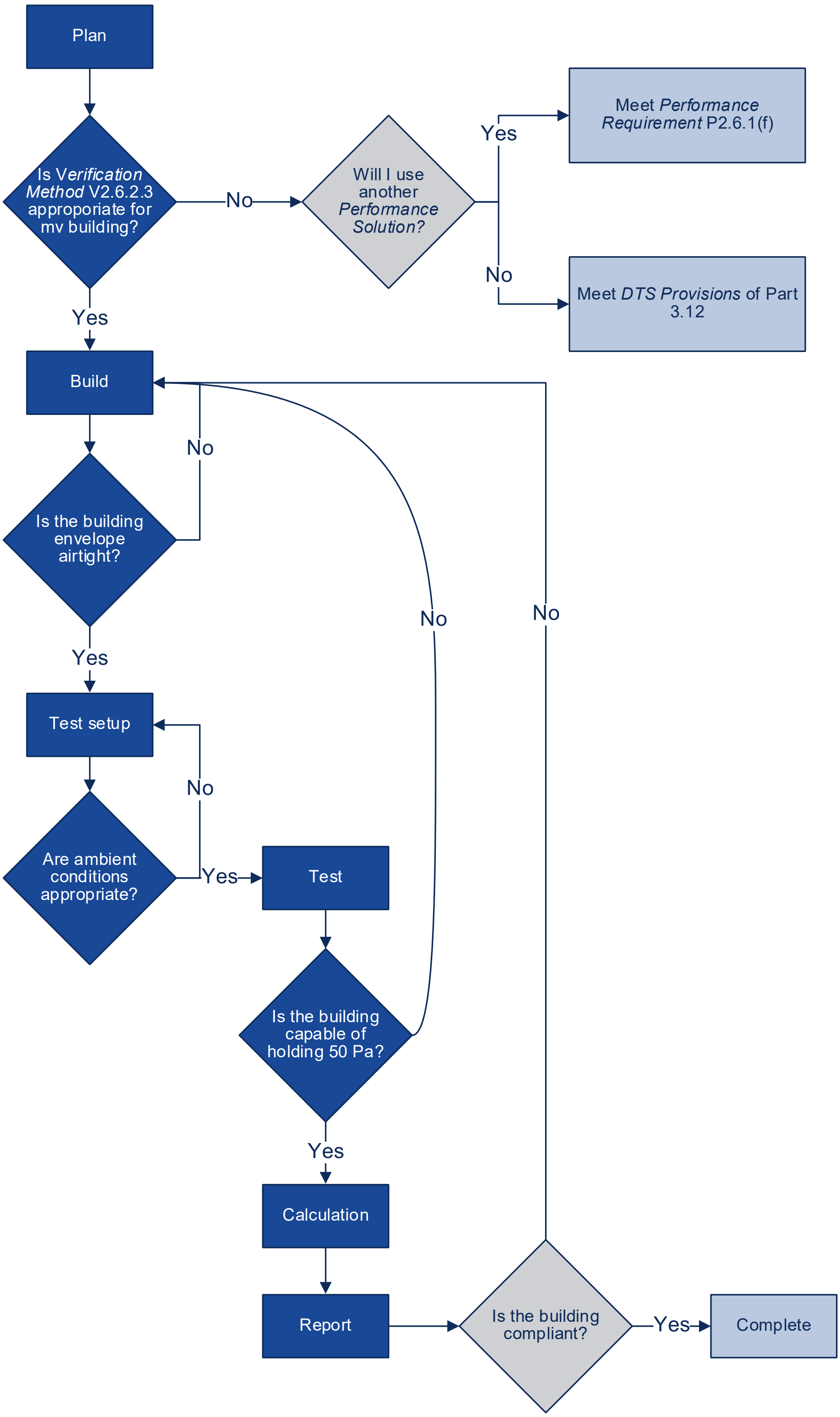
Specifying that tests must be undertaken under Method 1 of AS/NZS ISO 9972 ensures that testing conditions are standardised and hence that tests can be compared across different buildings. This ensures that the intent of the *Performance Requirement* is met, and that the requirement of this *Verification Method* can be quantified. Other testing methods could be considered as *Performance Solutions*, although this would require further amendment of whether they satisfied the *Performance Requirement*.

Alert:

AS/NZS ISO 9972 is the Australian/New Zealand standard, “Thermal performance of buildings – Determination of air permeability of buildings – Fan pressurization method”. It contains requirements for testing the air permeability of buildings using the fan pressurisation method, including the apparatus, measurement procedures, expression of results and the standardised format of testing reports. There are three different methods contained within the standard which are suitable for different test purposes, but Method 1 must be used for the purposes of *Verification Method* V2.6.2.3.

The following flowchart demonstrates a procedure that can be used to apply *Verification Method* V2.6.2.3. More complete details regarding the process are documented in the following section.

Figure 6.1 Typical procedure for Verification Method V2.6.2.3



6.4.1 Compliance requirements

As previously discussed, the building *envelope* must be sealed at an air permeability of not more than 10 $m^3/hr.m^2$ at 50 Pa reference pressure, verified through testing. The test must comply with the requirements of Method 1 described within AS/NZS ISO 9972.

V2.6.2.3

Compliance with P2.6.1(f) is verified when a building *envelope* is sealed at an air permeability of not more than 10 $m^3/hr.m^2$ at 50 Pa reference pressure when tested in accordance with AS/NZS ISO 9972 Method 1.

The first task of building designers is to define their building's *envelope*. The *envelope* is a defined term within the NCC, so this definition must be adhered to.

Envelope, for the purposes of Part 2.6 and Part 3.12 in Volume Two, means the parts of the 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

The *envelope* is the parts of the building's *fabric* that separates the artificially heated or cooled space from either the outside or from spaces that are not artificially heated or cooled. This means that the wall between a Class 1 house and its Class 10a garage would form part of the house's envelope, unless the garage was artificially heated or cooled. As the permeability through the *envelope* is the requirement, defining the building's *envelope* is critically important for both design and testing.

There are a variety of testing options within the Standard to determine the envelope's permeability, but all will require the building *envelope* to be functionally airtight and seals to be in place. If a building's construction is appropriately programmed, this should be the case well before completion. Temporary *envelope* sealing (except for that within the testing procedure) is not appropriate, as the tested scenario must represent the final building.

Ideally, this verification testing should be planned in the program of a build, to ensure both that the requirement can be demonstrated, and that there is still the capability to make improvements after testing if required. The cost required to go back, resolve poor sealing and retest is a risk which would be managed through appropriate scheduling and quality assurance (QA), if this *Verification Method* is chosen.

At this planning stage, the air barrier layer should ideally be designated and indicated on the building's drawings. This air barrier should be continuous, whether as plasterboard, a dedicated membrane, sheathing or another material. Where discontinuities occur, there is a risk of *envelope* leakage. Particular care should be taken in sealing this air barrier during construction.

Method 1 within AS/NZS ISO 9972 precisely defines the testing requirements, of which components are summarised here to aid in reference. Please refer to the Standard to confirm the requirements for your project.

The testing required for this measurement is commonly done using a blower door, but other methods are equally applicable. However the pressure difference between inside and outside the building is achieved, it must be at least 50 Pa to provide reliable results.

The following actions must be taken per the requirements of AS/NZS ISO 9972 Method 1 to ensure that the results of testing are consistent and reliable:

- Close all windows, doors and trapdoors in the *envelope*.
- Ventilation openings in the *envelope* for natural ventilation shall be closed.
- Openings for whole building mechanical ventilation and air conditioning shall be sealed.
- Other intentional openings in the *envelope*, including intermittent use mechanical ventilation, shall be closed.
- Fire-guards and smoke-guards shall be in their normal position of use.
- Openings not intended for ventilation in the envelope shall be closed.
- No further measures can be taken to improve the air-tightness of the building *envelope*.

The test results should be clearly communicated and documented in a test report confirming that the procedure was in compliance with AS/NZS ISO 9972 Method 1, together with the other reporting information specified within the Standard. This should be provided as part of the certification process.

Using a *Verification Method* which requires testing after the *envelope* is complete does introduce the risk that testing results will fall short of the requirement. Builders should ensure that sufficient time is allowed for a retest and remediation if required, as well as planning to retest as early as practicable. The nomination and documentation of the air barrier material during the design phase may be of considerable benefit in achieving the target. The particular remediation actions required will be dependent upon the observations from the testing process, but might include checking and improvement of seals around windows and doors, improved sealing around HVAC systems, or fixing gaps in subfloor systems.

Although tighter building sealing above that required by the *Verification Method* can improve energy efficiency, care must also be taken to avoid any potential *condensation* or indoor air quality issues. Designers should take these factors into account if targeting an especially well sealed building.

Particular care should be taken if the building is sealed tightly and the ventilation strategy requires the action of occupants. A building sealed beyond the level required by the *Verification Method* can introduce indoor air quality and/or the possibility of *condensation* issues. In cases where the building is sealed particularly tightly, the introduction of mechanical ventilation may be necessary to ensure indoor air quality. In such cases, consideration should be given to whether existing ventilation (bathroom or kitchen exhaust for instance) can be dual-purposed to run constantly and thus induce the required ventilation.

An occupant's reluctance to use natural ventilation openings when outside conditions are adverse should be taken into consideration. Therefore, a mechanical exhaust may be a better option, particularly if a building's tight *envelope* limits relief through leakage. Designers should consider the particular circumstances of the building and its existing systems, but provide an indicative guide to the requirements which may be induced through sealing a building tighter than that required by the *Verification Method*. Designers should note that where either supply or exhaust is suggested, this does not preclude the addition of the other to form a balanced system.

In all cases, any mechanical ventilation introduced must comply with the requirements of *Performance Requirements* P2.4.5 and P2.4.7 (and thus likely AS 1668.2 as an Acceptable Construction Manual, unless another solution is proposed). Mechanical ventilation to account for sealing should be considered and sized for the whole building. In cases where exhaust is used to induce outside air infiltration, designers should ensure that the induced infiltration rates are sufficient to meet the outside air demand.

Alert:

AS 1668.2 is the Australian Standard – “The use of ventilation and air conditioning in buildings - Part 2: Mechanical ventilation in buildings”. It contains requirements for the mechanical ventilation of buildings, including procedures for calculating suitable outside airflow rates and other requirements surrounding mechanical ventilation.

Table 6.1 Relationship between building sealing and ventilation

Leakage class	q_{E50} ($m^3/hr.m^2$)	Mechanical ventilation	Ventilation type in climate zones 1 & 2	Ventilation type in climate zones 3, 4, 5, 6, 7 & 8
A	$0 \leq 2$	Yes	Supply & Exhaust	Supply & Exhaust
B	>2, ≤7	Yes	Supply	Exhaust
C	>7, ≤10	Optional	Supply &/or Exhaust	Supply &/or Exhaust

Building designers should consider these potential impacts at the planning stage, and examine what options are available if such results are found in testing. The dual-purposing of existing systems is often the most effective way of dealing with these issues.

6.5 Example

6.5.1 Blower door testing

Procedure for applying Verification Method V2.6.2.3

Let's consider an example of a house (Class 1), whose designers are keen to use *Verification Method* V2.6.2.3 to suit their design.

Step 1: Plan ahead

As the *Verification Method* V2.6.2.3 requires verification through testing, the building and/or design professionals need to ensure that their program of work accounts for the associated risks. Testing will be needed immediately after the building *envelope* is complete to ensure that if improvements are required, the staff are available to complete them. Several days may be needed for testing, to account for adverse weather conditions. A month between testing and handover of the building; and a second test during this period, so that if the building fails to meet the 10 $m^3/hr.m^2$ requirement, may be needed so it can be improved and retested. The air barrier is continuous, and needs to be clearly defined and marked on the building's drawings.

Step 2: Quality construction

Although using *Verification Method* V2.6.2.3 means that the *DTS Provisions* are not mandatory, they can still be used as guidelines. In some areas, departures from the *DTS Provisions* may be used as they suit an innovative method, so long as the *Performance Requirement* is satisfied.

Step 3: Prepare for the test

After the building *envelope* is complete, the building needs to be made suitable for testing. To follow the requirements of AS/NZS ISO 9972 Method 1, closing the house's windows, doors, trapdoors, ventilation openings and other openings in the building's *envelope* is needed. The air terminal devices in the house's ducted air conditioning system is also sealed so the whole building is treated as a whole system. Openings in the building's *envelope* for the kitchen and toilet exhaust systems are closed, but not specifically sealed, as these systems are intermittent. The blower door testing experts will then mount a blower door assembly at the house's front door and connect pressure measuring devices to the inside and outside of the building.

Step 4: Test

The blower door testing experts follow the procedures listed in AS/NZS ISO 9972. They check for large leaks and failures of temporarily sealed openings. They record the temperature inside and outside the building, as well as the wind speed. They also measure the pressure difference between the inside and outside of the building without the blower door providing any airflow, to ensure that this can be accounted for.

The blower door testing experts then turn on the blower door. The test is carried out by taking measurements of blower door air flow rate and indoor/outdoor pressure difference over a range of applied pressure differences in 10 Pa increments. They repeat this up to 60 Pa, as their attempt to test at 70 Pa proves beyond the capability of their equipment. When pressure differences above 50 Pa can be achieved like this, the accuracy of the test is enhanced, so they should be attempted to improve accuracy, but are not required by AS/NZS ISO 9972. They repeat this process for both positive and negative pressures.

Step 5: Calculation

The blower door testing experts still need to convert their recordings into an air flow rate at 50 Pa, to verify the results. As part of this process, they refer again to AS/NZS ISO 9972 which sets out the calculations required. They account for the base pressure difference, convert airflow readings into airflow through the *envelope* and plot the results to determine the relationship between the airflow through the *envelope* and induced pressure difference.

By synthesising data from the series of tests as required by the Standard, they reduce the error in measurement. The final result is calculated as the average result of both positive and negative test results. Corrections for the environmental conditions universalise the results, so that they can be compared with the requirement of the *Verification Method*.

Step 6: Test Reporting

The blower door testing experts then produce a test report with all the information specified by AS/NZS ISO 9972. This includes that the test was undertaken using Method 1 of AS/NZS ISO 9972, the status of all building openings, testing apparatus, data, calculations, and results.

Step 7: Check

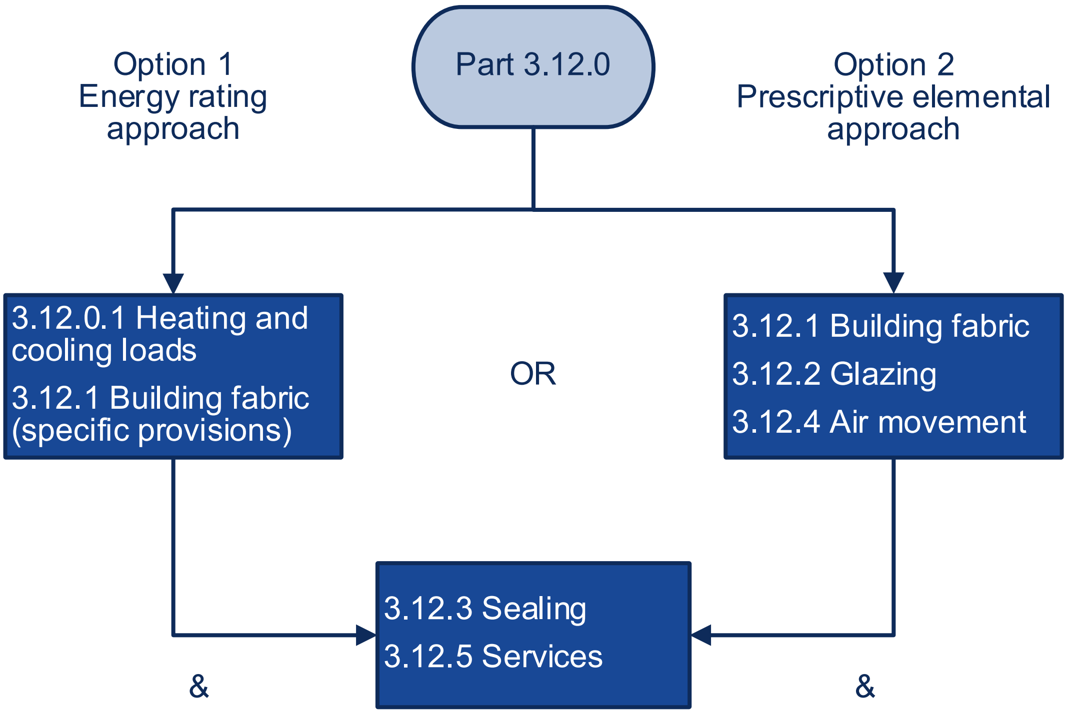
The building and/or design professionals check the results of the test against the 10 $m^3/hr.m^2$ requirement. Due to the attention paid to construction and quality assurance, their test results show that the building meets the requirement. If they fell short, then they would return to Step 2, rectify any defects and test again.

7 Part 3.12.0 - Application of Part 3.12

7.1 Introduction

Part 3.12.0 provides a roadmap for practitioners to demonstrate compliance to the *DTS Provisions*. There are two approaches provided for the thermal performance of the building, the energy rating approach (using *house energy rating software*) or the prescriptive elemental approach. Either approach fulfils the *Performance Requirement* P2.6.1. The *Performance Requirement* P2.6.2 (for *domestic services*) may be satisfied using the *DTS Provisions* of Part 3.12.5. This is further represented in Figure 7.1 where Option 1 relates to the energy rating approach and Option 2 the elemental approach.

Figure 7.1 Basic flowchart showing the two options for complying with the DTS Provisions



7.2 Scope

The *DTS Provisions* for energy efficiency address the following:

- Part 3.12.1 Building *fabric*;

- Part 3.12.2 External glazing;
- Part 3.12.3 Building sealing;
- Part 3.12.4 Air movement; and
- Part 3.12.5 Services.

When using the *DTS Provisions*, to comply with the relevant *Performance Requirements* of Part 2.6, all of the above must be met.

7.3 Application of Part 3.12

The energy efficiency requirements in Part 3.12 apply to the thermal performance of the building and its *domestic services*.

3.12.0 Application of Part 3.12

(a) *Performance Requirement* P2.6.1 for the thermal performance of the building is satisfied by—

(i) complying with—

(A) 3.12.0.1, for reducing the heating or cooling loads; and

(B) 3.12.1.1, for building *fabric* thermal insulation; and

(C) 3.12.1.2(c) and 3.12.1.4(b), for thermal breaks; and

(D) 3.12.1.2(e), for compensating for a loss of ceiling insulation, other than where the *house energy rating software* used can automatically compensate for a loss of ceiling insulation; and

(E) 3.12.1.5(c) and 3.12.1.5(d), for floor edge insulation; and

(F) Part 3.12.3, for building sealing; or

(ii) complying with—

(A) Part 3.12.1, for the building *fabric*; and

(B) Part 3.12.2, for the external *glazing* and shading; and

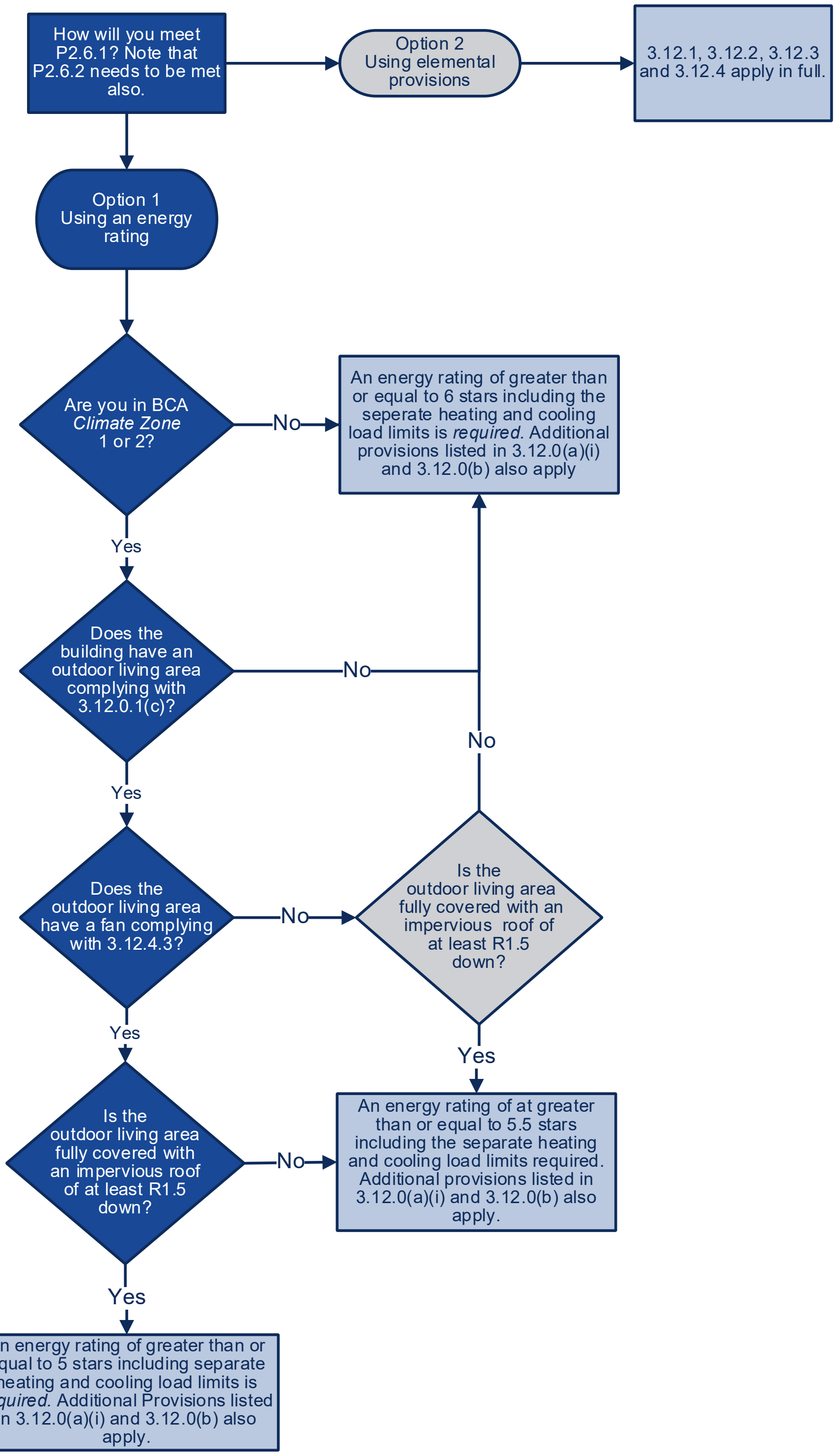
(C) Part 3.12.3, for building sealing; and

(D) Part 3.12.4, for air movement.

(b) *Performance Requirement* P2.6.2 for reducing greenhouse gas emissions is satisfied by complying with Part 3.12.5.

Two approaches using the *DTS Provisions* to satisfy the *Performance Requirement* P2.6.1 are provided in 3.12.0. These approaches are referred to as: the energy rating approach and the elemental provisions. The following flow chart from NCC Volume Two (Figure 7.2) shows the compliance pathway for these approaches.

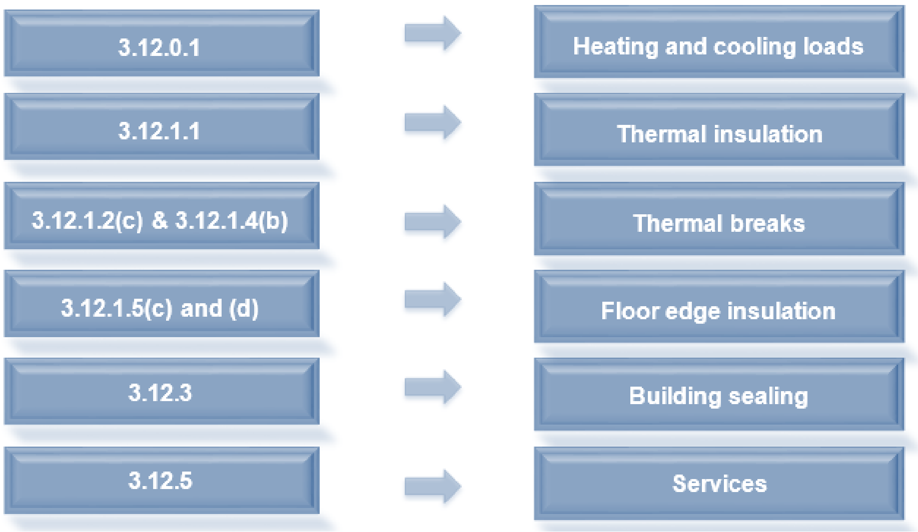
Figure 7.2 Flowchart to demonstrate compliance to the Performance Requirement P2.6.1 using the DTS Provisions



7.3.1 Energy rating approach

The energy rating approach requires a building to achieve an energy rating using *house energy rating software*, being software accredited under NatHERS. To achieve compliance to P2.6.1, the requirements in 3.12.0(a)(i) need to be satisfied. Full compliance to the energy efficiency *DTS Provisions* is achieved by also satisfying P2.6.2 through meeting the requirements of Part 3.12.5. Figure 7.3 outlines the relevant *DTS Provisions* for this approach.

Figure 7.3 DTS Provisions relevant to the energy rating approach



The energy rating approach aids in the development of unique building solutions, however it is limited to assessing the thermal efficiency of the building *envelope* only. For this reason, when undertaking a rating using *house energy rating software*, there are additional requirements that must be satisfied to achieve full compliance to the *DTS Provisions*.

Alert:

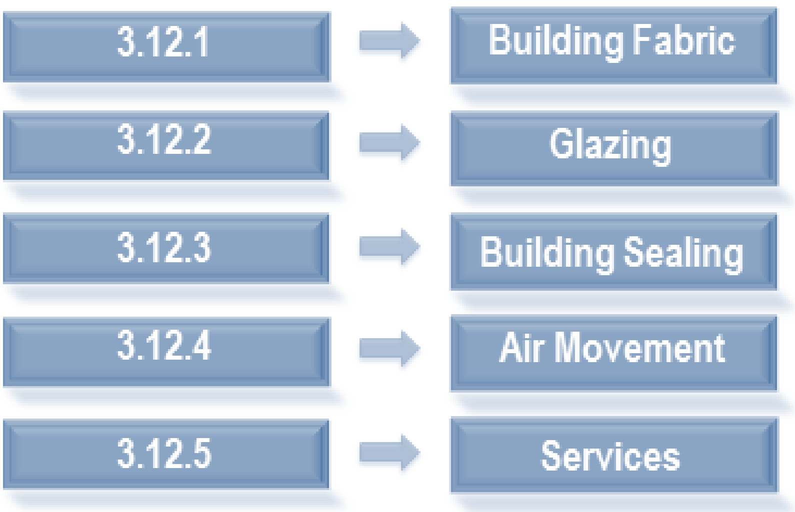
House energy rating software is defined differently for V2.6.2.2 and Part 3.12 in NCC Volume Two. *House energy rating software* used for Part 3.12 must be accredited under the NatHERS. Further information on NatHERS is available at the NatHERS website (nathers.gov.au).

Where an energy rating approach is taken by using accredited software under NatHERS, other relevant *DTS Provisions* outlined in 3.12.0(a)(i) will also need to be satisfied to demonstrate compliance as a *DTS Solution*.

7.3.2 Elemental provisions

The elemental provisions approach requires the building to meet the requirements of the *DTS Provisions* of Parts 3.12.1, 3.12.2, 3.12.3 and 3.12.4 to satisfy the *Performance Requirement* P2.6.1. Full compliance to the energy efficiency *DTS Provisions* is achieved by also satisfying *Performance Requirement* P2.6.2 through meeting the requirements of Part 3.12.5. Figure 7.4 outlines the relevant *DTS Provisions* for this approach.

Figure 7.4 DTS Provisions relevant to the elemental approach



7.4 Heating and cooling loads

The energy rating approach is mostly based on a computer simulation of the annual demand for heating and cooling, measured as a total heating and cooling load in mega *joules* per square metre of conditioned floor area per annum (MJ/m^2.annum). Using the *DTS Provisions*, software accredited under NatHERS must be used to determine the energy rating. NatHERS accredited software currently recognises 69 distinct climates in Australia, compared to the NCC elemental approach which is based on 8 *climate zones*. Clause 3.12.0.1 contains the requirements for energy ratings as well as the separate heating load and cooling load limits that must be achieved by the building. Heating load and cooling load limits are specified in the ABCB Standard for NatHERS Heating Load and Cooling Load Limits.

7.4.1 Energy ratings

According to 3.12.0.1, energy ratings must be generated using *house energy rating software* that is software accredited under NatHERS. A minimum energy rating of 6 stars must be achieved unless an allowance is used for buildings in *climate zones* 1 or 2 where a compliant outdoor living area and/or ceiling fan is provided. Depending on the design of the outdoor living area, the minimum energy rating is 5.5 or 5 stars and must-

- be fully covered with an impervious roof having a *Total R-Value* of at least 1.5 (for downward heat flow); or
- have at least one permanently installed ceiling fan (complying with 3.12.4.3 as per 3.12.0.1(d)).

Starting with the minimum requirement of 6 stars, a credit of 0.5 stars is given for meeting each of above conditions. If one condition is met, a minimum energy rating of 5.5 stars is required. If both conditions are met, a 1 star credit is given, resulting in the design being required to achieve a minimum energy rating of 5 stars.

7.4.2 Heating and cooling load limits

The NCC requires dwelling designs to appropriately manage solar radiation to separately minimise *heating load* and *cooling load*. However, the star ratings determined by *house energy rating software (*software that must be accredited under NatHERS) are based on a dwelling's total annual energy load (i.e. the combined heating and cooling loads). Consequently, a dwelling may perform poorly in either winter or summer despite meeting the total energy load for the required star rating.

In 2016, the ABCB was requested to investigate having separate load limits, in addition to the existing energy rating, as part of the energy efficiency project under Measure 31 of the National Energy Productivity Plan. Introducing heating and cooling load limits is one of the key elements of the proposed energy efficiency changes for residential buildings in the NCC 2019.

The introduction of heating load and cooling load limits as a mandatory requirement to NCC 2019 does not change the stringency of current regulations. The heating load and cooling load limits are intended to improve the five per cent worst performing houses in terms of *heating load* and the five per cent worst performing houses in terms of cooling load. The addition of the heating and cooling load limits ensures greater occupant comfort year round. This will address houses that could potentially be comfortable in winter, but overly hot in summer, or vice versa.

Separate heating load and cooling load limits are not required to be applied in all 69 NatHERS climate zones. This is because some climates are dominated by either hot or cold weather, for example *climate zones* in the Northern Territory (NT), Tasmania (Tas) and some *climates zones* in Queensland (Qld) and Western Australia (WA).

New South Wales (NSW) already has separate heating and cooling load limits (or “caps”) covered in its Building Sustainability Index (BASIX) Thermal Comfort requirements.

Hence, heating load and cooling load limits do not apply in NSW, NT, Tas and parts of Qld and WA. The heating load and cooling load limits are detailed in the ABCB Standard for Heating Load and Cooling Load Limits, which can be download from the ABCB website (abcb.gov.au).

7.5 Outdoor living area and celling fan

There is some evidence that suggests that the majority of home owners turn off their air-conditioners when using an outdoor living area. When an air-conditioner is not being used, the total energy use is significantly reduced, hence the concession. The *breeze path* created by the outdoor living area may also *facilitate* ventilation and provide passive cooling.

Subclause 3.12.0.1(c) and (d) provide the requirements for an outdoor living space. These must be met to use the allowance. The extract of this clause from NCC Volume Two is provided below.

3.12.0.1(c) & (d)

(c) An outdoor living area in (a)(ii) and (a)(iii) is a space that—

(i) is directly adjoining, and directly accessible from, a general purpose living area of a Class 1 building such as a lounge, kitchen, dining or family room, which is not a room for sleeping or specialist tasks such as a study or home theatre; and

(ii) has a *floor area* greater than or equal to 12.0 m^2; and

(iii) has length and width dimensions greater than or equal to 2.5 m each; and

(iv) has an opening height above floor level greater than or equal to 2.1 m; and

(v) has one side permanently open with a second side either—

(A) permanently open; or

(B) readily openable.

(d) The sides referred to in (c)(v) must be greater than or equal to 900 mm from an allotment boundary or 900 mm from an obstruction to the breeze path such as a building, fence or other structure.

Design alert:

For NatHERS assessments required using the energy rating approach, 'Holland blinds' are considered as the default for modelling windows. No other internal window coverings are permitted. Further details can be found in the *NatHERS Technical Note* available from the NatHERS website (nathers.gov.au).

7.6 Examples – Heating and cooling load limits

7.6.1 A house with suspended floor in Brisbane

Applying Part 3.12.0.1(a)

A *DTS Solution* using the *DTS Provisions* listed in 3.12.0(a)(i) (Option 1 energy rating) is proposed to assess a single *storey* house (Class 1a) located in Brisbane (See floor plan in Appendix E).

Part 3.12.0.1 (a) requires that the house design does not exceed three separate load limits – the existing total load limit corresponding to the applicable star rating, and the new *heating load* limit and *cooling load* limit.

Step 1: Identify the required energy rating

The suburb of Brisbane is located in NatHERS climate zone 10 (NCC *climate zone* 2). Houses located in NCC *climate zone* 2 have the option under Part 3.12.0.1 (a) to use a lower energy rating requirement to achieve compliance if the building includes an outdoor living area that satisfies certain design criteria:

- 5.5 stars: if the outdoor living area has an impervious roof with a total R-value equal to or greater than R1.5 (for downward heat flow) OR at least one permanently installed ceiling fan that complies with Part 3.12.4.3; or
- 5.0 stars: if the outdoor living area has an impervious roof with a total R-value equal to or greater than R1.5 (for downward heat flow) AND at least one permanently installed ceiling fan that complies with Part 3.12.4.3

See Part 3.12.0.1(a)(ii) and (iii) for further information about when the energy rating allowance can be applied. The design and dimensions of the outdoor living area also have to comply with the requirements outlined in Parts 3.12.0.1(c) and 3.12.0.1(d).

In this example, the house's design includes a 21 m² outdoor living area with a permanently installed ceiling fan that complies with 3.12.0.1(a)(iii), 3.12.0.1(c) and 3.12.0.1(d). Consequently, the house design only needs to achieve an energy rating greater than or equal to 5 stars. To achieve the required energy rating for this *climate* *zone* (NatHERS climate zone 10), the total load limit for the house design must not exceed 55 MJ/m^2.annum.

Step 2: Identify heating and cooling load limits

In addition, 3.12.0.1(a) requires the house to not exceed the *heating load* limits and *cooling load* limits as specified in the ABCB Standard for NatHERS Heating and Cooling Load Limits (the Standard) available from the ABCB website (abcb.gov.au).

Clause 2.3(a) of this Standard sets the heating and cooling load limits based on the floor type of the lowest living area.

The house design has a suspended timber floor 600 mm above the ground.

Referring to Table 6 in the Standard (Class 1 Suspended Floor (SF)–for NatHERS 5 star in NCC *climate zones* 1 and 2, NatHERS climate zone 10), it shows the house design must also not exceed a *heating load* limit of 40 MJ/m^2.annum and a *cooling load* limit of 37 MJ/m^2.annum.

The total load limit corresponding to the applicable energy rating, and the new heating and cooling load limits are summarised in the following table:

Table 7.1 Total load limit and heating & cooling load limits

NatHERS climate zone	Total load limit (MJ/m^2.annum)	Heating load limit (MJ/m^2.annum)	Cooling load limit (MJ/m^2.annum)
10	55	40	37

Step 3: Calculate three energy loads of the proposed house design

The house design is assessed using *house energy rating software* (software accredited under NatHERS) and achieves a total load limit of 50.9 MJ/m^2.annum which equals a 5.1 star rating. *House energy rating software* also shows that the *heating load* for the house's design is 21.6 MJ/m^2.annum while the *cooling load* is 29.3 MJ/m^2.annum.

The load limits for the total load, *heating load* and *cooling load* for NatHERS climate zone 10 along with the calculated loads of the proposed house design, are summarised in the following table:

Table 7.2 Comparison of load results

Model	Total load limit (MJ/m^2.annum)	Heating load limit (MJ/m^2.annum)	Cooling load limit (MJ/m^2.annum)
Load limits for NatHERS climate zone 10	55	40	37
Calculated loads of house	**50.9**	**21.6**	**29.3**
Compliant	**Yes**	**Yes**	**Yes**

Outcome

The individual heating, cooling and total loads do not exceed the respective load limits defined for NatHERS climate zone 10, therefore the house's design complies with Part 3.12.0.1(a). Note the other elements listed in 3.12.0(a)(i)(B)-(F) must also be complied with.

7.6.2 A house with a concrete slab-on-ground floor in Perth

Applying Part 3.12.0.1(a)

A *DTS Solution* using the *DTS Provisions* listed in 3.12.0(a)(i) (Option 1 energy rating) is proposed to assess a single *storey* house (Class 1a) located in Perth (see floor plan in Appendix E).

Part 3.12.0.1 (a) requires that the house design does not exceed three separate load limits – the total load limit corresponding to the applicable star rating, the *heating load* limit and the *cooling load* limit.

Step 1: Identify the required energy rating

Perth is located in NatHERS climate zone 13 (NCC *climate zone* 5).
Part 3.12.0.1(a)(i) requires an energy rating greater than or equal to 6 stars using NatHERS accredited software tools. To achieve the required energy rating for this

climate zone, the total load limit for the house design must not exceed 70 MJ/m^2.annum.

Step 2: Identify heating and cooling load limits

In addition, 3.12.0.1(a) requires the house not exceed the *heating load* limits and *cooling load* limits as specified in the ABCB Standard for NatHERS Heating and Cooling Load Limits. The Standard is available at the ABCB website (abcb.gov.au).

Clause 2.3(a) of this Standard sets the heating and cooling load limits based on the floor type of the lowest living area, which means if the floor is a concrete slab-on-ground (CSOG), the heating and cooling load limits for CSOG should be applied.

The floor of this house is proposed to be concrete slab on ground. Referring to Table 1 (Class 1 CSOG) in the Standard, the house design in NatHERS climate zone 13 must not exceed a *heating load* limit of 57 MJ/m^2.annum and a *cooling load* limit of 39 MJ/m^2.annum.

Step 3: Calculate three energy loads of the proposed house design

The house design is assessed using *house energy rating software* (software accredited under NatHERS). It achieves a total load limit of 65.8 MJ/m^2.annum, which equals a 6.2 star rating. *House energy rating software* also shows that the *heating load* is 26.5 MJ/m^2/year, however the *cooling load* is 39.3 MJ/m^2.annum. The load limits for the total load, *heating load* and *cooling load* for NatHERS climate zone 13, along with the calculated loads of the proposed house design, are summarised in the following table:

Table 7.3 Comparison of load results

Model	Total load limit (MJ/m^2.annum)	Heating load limit (MJ/m^2.annum)	Cooling load limit (MJ/m^2.annum)
Load limits for NatHERS climate zone 13	70	57	39
Calculated loads of the house	**65.8**	**26.5**	**39.3**

Result

Because the *cooling load* exceeds the limit defined for NatHERS climate zone 13, the house's design does not comply with Part 3.12.0.1, even though the house energy rating is greater than 6 stars.

Design options

Changes to the house design will need to be considered in order to reduce the *cooling load*, such adding ceiling fans to *habitable rooms* and/or changing the opening type for windows to increase the amount of available ventilation.

Outcome

Following design adjustments, the energy loads are re-calculated for the house and are shown in the table below.

Table 7.4 Comparison of load results after design change

Model	Total load limit (MJ/m^2.annum)	Heating load limit (MJ/m^2.annum)	Cooling load limit (MJ/m^2.annum)
Load limits for NatHERS climate zone 13	70	57	39
Calculated loads of the house	**58.3**	**26.5**	**31.8**
Compliant	**Yes**	**Yes**	**Yes**

The individual heating, cooling and total loads of the revised design does not exceed the respective load limits defined for NatHERS climate zone 13, therefore the house design complies with Part 3.12.0.1(a). Note the other elements listed in 3.12.0(a)(i)(B)-(F) must also be complied with.

7.6.3 A house with mixed floor type in Albany

Applying Part 3.12.0.1(a)

A *DTS Solution* using the *DTS Provisions* listed in 3.12.0(a)(i) (Option 1 energy rating) is proposed to assess a two *storey* house (Class 1a) located in Albany (see floor plan in Appendix E).

Part 3.12.0.1 (a) requires the house's design not exceed three separate load limits – the existing total load limit corresponding to the applicable star rating, and the *heating* load limit and *cooling* load limit.

Step 1: Find the required energy rating

The suburb of Albany is located in NatHERS climate zone 58 (NCC *climate zone* 6). Part 3.12.0.1(a)(i) requires an energy rating greater than or equal to 6 stars. To achieve the required energy rating for this *climate zone*, the total load limit for the house design must not exceed 83 MJ/m^2.annum.

Step 2: Identify heating and cooling load limits

In addition, Part 3.12.0.1(a) requires the house design does not exceed the *heating load* limits and *cooling load* limits as specified in the ABCB Standard for NatHERS Heating and Cooling Load Limits available from the ABCB website (abcb.gov.au).

Clause 2.3(a) of this Standard sets the heating and cooling load limits based on the floor type of the lowest living area.

The house design consists of a number of different floor types:

- Ground floor: CSOG to garage and the kitchen, living, dining and pantry areas;
- Ground floor: suspended timber floor above an enclosed sub-floor to the remainder of the ground floor; and
- First floor: suspended timber floor

Because the ground floor, being the lowest living area of the house which consists of a combination of CSOG and suspended floor (SF) construction, the heating and cooling load limits shown in Table 2 Class 1 SF in the Standard would apply. See

Section 2.3 (a)(iv)(B) of the Standard and its explanatory information for further information.

Referring to Table 2 of the Standard, for NatHERS climate zone 58 the house design must also not exceed a *heating load* limit of 77 MJ/m^2.annum and a *cooling load* limit of 18 MJ/m^2.annum.

The total, heating and cooling load limits are summarised in the following table.

Table 7.5 Total load limit and heating & cooling load limits

Climate zone	Total load limit (MJ/m^2.annum)	Heating load limit (MJ/m^2.annum)	Cooling load limit (MJ/m^2.annum)
58	83	77	18

Step 3: Calculate three energy loads of the proposed house design

The house design is assessed using *house energy rating software* (software accredited under NatHERS). It achieves a total load limit of 85.6 MJ/m^2.annum which equals a 5.9 star rating. The *heating load* is 76.6 MJ/m^2.annum and the *cooling load* is 9 MJ/m^2.annum.

Table 7.6 Comparison of load results

Model	Total load limit (MJ/m^2.annum)	Heating load limit (MJ/m^2.annum)	Cooling load limit (MJ/m^2.annum)
Load limits for NatHERS climate zone 58	83	77	18
Calculated loads of house	85.6	76.6	9
Compliant	No	Yes	Yes

Result

Even though both the heating and cooling loads are less than the load limits specified in the Standard for a Class 1a building with a suspended floor in NatHERS climate zone 58, the house design does not comply with Part 3.12.0.1, because the total load exceeds 83 MJ/m^2.annum.

Design options

Changes to the house design will need to be considered in order to reduce either the heating and/or cooling loads. In this example, reducing *heating load* can be achieved through increasing *insulation* to *external walls,* ceiling and/or suspended floors, or improving the performance of the windows.

Outcome

Following design adjustments, the energy loads are re-calculated for the house and are shown in the table below:

Table 7.7 Comparison of load results after design change

Model	Total load limit (MJ/m^2.annum)	Heating load limit (MJ/m^2.annum)	Cooling load limit (MJ/m^2.annum)
Load limits for NatHERS climate zone 58	83	77	18
Calculated loads of house	82.9	74.1	8.8
Compliant	Yes	Yes	Yes

Because the individual heating, cooling and total loads do not exceed the respective load limits defined for NatHERS climate zone 58, therefore the house's design complies with Part 3.12.0.1(a). Note the other elements listed in 3.12.0(a)(i)(B)-(F) must also be complied with.

8 Part 3.12.1 - Building fabric

8.1 Introduction

The NCC Volume Two building *fabric DTS Provisions* for energy efficiency have been developed to provide a minimum acceptable level of thermal efficiency for the *opaque* elements and *roof lights* of the building *envelope*.

As with all aspects of the *DTS Provisions*, each element within Part 3.12.1 is designed to work as part of a system approach to ensure the building *fabric* achieves the desired level of thermal performance.

Compliance with the requirements of Part 3.12.1, Building *Fabric*, is accepted as complying with the *Performance Requirement* P2.6.1. As with all *DTS Provisions*, compliance is not mandatory as a *Performance Solution* can be developed to comply with the *Performance Requirements* if desired.

8.2 Scope

The building *fabric* requirements address the following:

(a) General requirements for the thermal construction of a building such as the testing, installation and compression of bulk *insulation*;

(b) Roof and ceiling construction including the avoidance of thermal bridging, which occurs when metal elements provide a bridge for heat flow around the insulation. With some forms of construction this can reduce the effectiveness of the *insulation* by half;

(c) *Roof lights* installed at an angle of between 0 and 70 degrees measured from the horizontal plane (*roof lights* that fall outside this range are considered to be *windows* and are addressed under Part 3.12.2 External glazing);

(d) *External walls* (with separate categories for those with a surface density above and below 220 kg/m^2), again including the avoidance of thermal bridging;

(e) Floors (including any subfloor enclosures); and

(f) Class 10a buildings attached to a Class 1 building so that the thermal performance of the dwelling is not compromised.

As previously discussed, the elemental *DTS Provisions* are based on eight *climate zones*. They divide Australia into broad regional areas with similar climatic conditions allowing the requirements to be applied on a national basis as each *climate zone* will have similar thermal requirements irrespective of the State or Territory where the house is located.

8.3 Intent

Although occupant comfort is not the primary goal of these requirements, an essential aspect of energy efficiency in a residential building is to ensure that the building is constructed in a manner that provides a sufficient level of comfort for the occupants, to the extent that they have less need for artificial heating or cooling. This can be achieved by creating a thermally effective building *envelope*. Creating a thermally effective building *envelope* also means that when artificial heating or cooling is needed, the *envelope* will be more effective at retaining the conditioned air due to the barrier between the internal and external environment.

The intent of the building *fabric* elemental *DTS Provisions* in Part 3.12.1 is to ensure that the construction around *conditioned spaces* has sufficient levels of thermal performance to ensure energy is not used unnecessarily. The measures in Part 3.12.1 are intended to achieve this outcome by requiring certain elements to have minimum levels of *insulation*, either through adding *insulation*, such as batts or *reflective insulation*, or through the inherent thermal qualities of the building material, for instance the thermal mass of a masonry wall.

The *fabric* requirements are based on the occupant's likely response to the annual external climatic conditions. For example, in Hobart, this would be heating due to the long cooler winters and night time use, therefore, the energy used for winter heating exceeds the energy used for summer cooling. Accordingly, the NCC Volume Two *DTS Provisions* are designed to ensure that the house uses the least amount of energy to heat.

This is often achieved by installing *insulation* or by otherwise increasing the capacity of the building elements to resist heat flow.

For Darwin, the opposite is the case and the prevailing mode is cooling so the underlying philosophy is that, by applying measures to the external *fabric*, the internal environment will be more comfortable for the occupants of residences without excessive use of air-conditioning.

8.4 Application

Part 3.12.1 states that the requirements of 3.12.1.1 to 3.12.1.5 (*insulation*, roofs, *roof lights external walls* and floors) apply to:

- a Class 1 building; and
- a Class 10 building if it has a *conditioned space*.

Part 3.12.1 also states that 3.12.1.6 only applies to a Class 1 building with an attached Class 10a building, such as a garage.

8.5 Building fabric thermal insulation

Clause 3.12.1.1 contains a broad range of general requirements that apply to the *insulation* in the building *fabric*, so that the required thermal performance is achieved.

In order to ensure the performance of materials is correctly validated, test reports complying with AS/NZS 4859.1 should be provided in accordance with Part A5 of NCC Governing Requirements and this documentation forms an integral part of the *building approval*.

8.5.1 Integrity of the insulation

Subclause 3.12.1.1(a) requires any mandatory *insulation*, when installed in a building, to form a consistent and continuous barrier other than at supporting members. This is important as any gaps in the barrier will allow heat to bypass the *insulation* and undermine the effectiveness of the overall energy efficiency requirements.

However, it is recognised that certain gaps are essential, particularly adjoining *domestic services* and light fittings, where the close proximity of insulation may create a fire or smoke hazard. Refer to Figure 8.5 for further explanation in relation to roof *insulation*.

A key aspect of these requirements is the recognition that certain elements of the building contribute to achieving the required levels of thermal efficiency without any added insulation. For instance, wall *insulation* must closely fit within a wall frame to achieve the desired level of performance for the wall. The wall elements in conjunction with the *insulation* are deemed to achieve the required level of performance, so calculating the proportion of timber studs to bulk *insulation* in a wall for example, isn't necessary when using the elemental *DTS Provisions*.

The reference standard for *insulation* is AS/NZS 4859.1 – Materials for the thermal *insulation* of buildings: General criteria and technical provisions. This Standard specifies the testing criteria for *insulation*, including both reflective and bulk *insulation*. In broad terms, the Standard requires the manufacturer test its products using a specified method and then provide a data sheet which explains the thermal performance and the installation requirements for the product.

The manufacturer's data sheet should be utilised by both building designers and building certifiers as documentary evidence of the performance of the *insulation* and may be required to form part of the *building approval* documentation.

8.5.2 **Installation of reflective insulation**

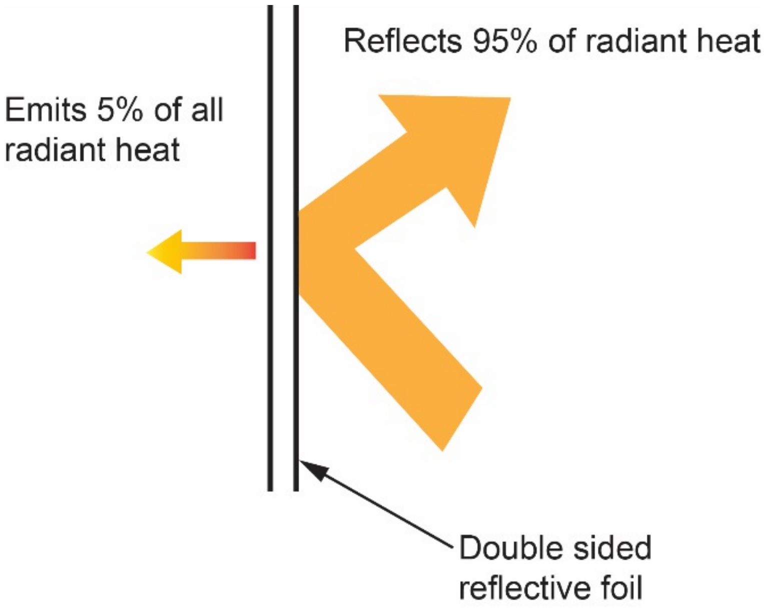
Subclause 3.12.1.1(b) provides a list of requirements for *reflective insulation*.

In order to appreciate the requirements of this subclause, it is worthwhile understanding how *reflective insulation* works.

Insulating performance is achieved by the ability of the *reflective insulation* to "reflect" heat at one surface and not transmit it at another, combined with the insulating qualities of the thin air films adjacent to the *reflective insulation*. Some *reflective insulation* is also bonded to bulk or board *insulation* providing enhanced performance of the composite system.

Accordingly, the reflectivity (emissivity) value and the presence of an airspace at the reflective surface are critical because, without this airspace the reflection will not occur. Refer to Figure 8.1 for an illustration of how *reflective insulation* works.

Figure 8.1 Reflective insulation



The other issue to consider is that *reflective insulation* generally has a dull or anti-glare (painted) side and a shiny silver side. Both sides will achieve a degree of reflectivity. However, the shiny side is far more effective.

Wearing appropriate eye protection when installing reflective *insulation* is necessary as it can give off significant glare. The reflective properties of *reflective insulation* can also increase the risk of sunburn. 3.12.1.1(b)(i) outlines the requirement for the *reflective insulation* to be installed with the necessary airspace so that the required *R-Value* can be achieved. The width of the airspace will vary depending on the particular type of *reflective insulation* and the *R-Value* to be achieved.

Note that overlapping of *reflective insulation* should be not less than 150 mm. This matches the requirement of AS/NZS 4200, the Standard covering the installation of pliable building membranes. The overlap provides a degree of water proofing which is suited to typical housing construction.

Design Alert:

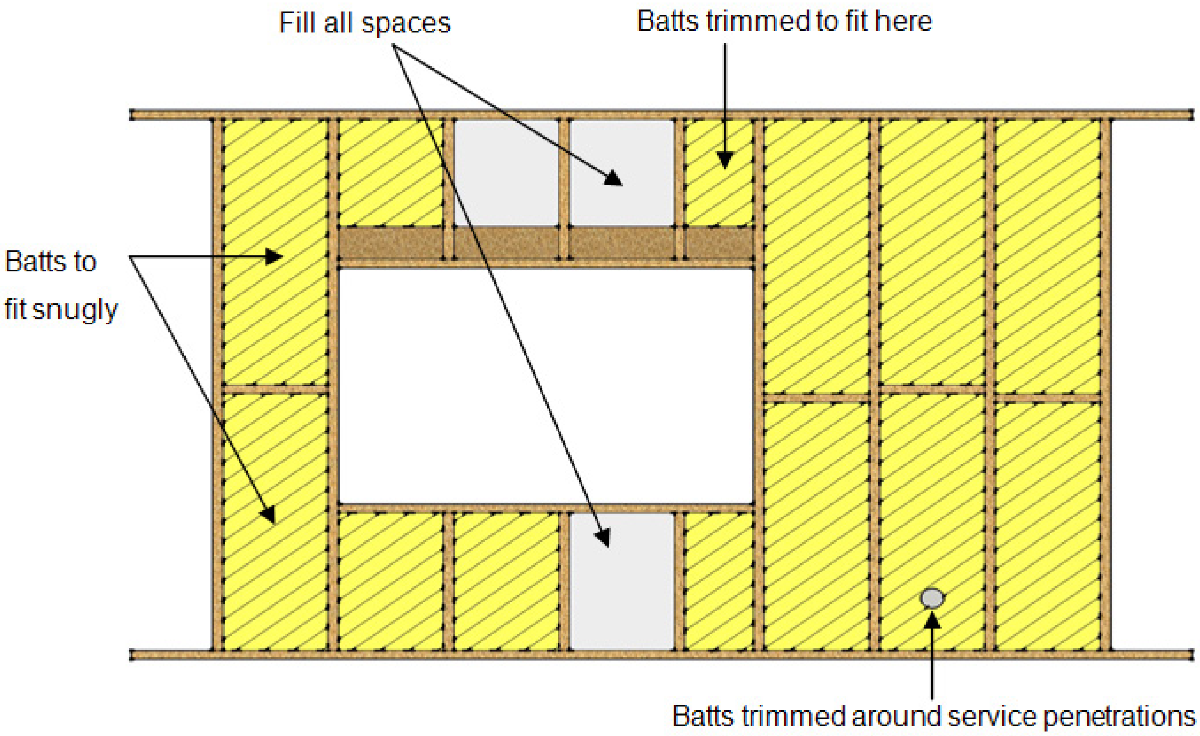
Beyond the NCC requirements, the need to install *reflective insulation* as a vapour barrier should also be considered and the additional lapping and sealing measures of AS/NZS 4200.2 applied if necessary. In cases where the *reflective insulation* is to act as both a vapour barrier and sarking, both the minimum overlap and taping may be necessary.

8.5.3 Installation of bulk insulation

Subclause 3.12.1.1(c) provides requirements specifically for bulk *insulation*. The term “bulk *insulation*” includes glass fibre, wool, cellulose fibre, polyester and polystyrene foam. These materials tend to have a high percentage of air voids that are fundamental to their ability to limit heat flow.

The thermal performance of bulk *insulation* is dependent on the material retaining the depth specified by the manufacturer, in accordance with the required test results. The depth of the *insulation* is critical because of the need to retain the air pockets within the material. If the *insulation* is compressed, it will lose some of these air gaps as the fibre contact increases, which, in turn, will reduce its capacity to achieve the tested *R-Value*. Refer to Figure 8.2 for installation of bulk *insulation* in walls.

Figure 8.2 Installing bulk insulation in framed walls



A cathedral ceiling is one instance where the thickness of the roof framing dictates the thickness of the bulk *insulation* that can be installed, otherwise compression of bulk *insulation* may occur. In these instances larger framing members or a thinner, higher performing *insulation* may be required.

Design Alert:

An important issue for roof design, especially in cooler climates where *insulation* with higher *R-Values* is required, will be to ensure that the roof structure has sufficient space to accommodate the *insulation* without the *insulation* being compressed. Any compression of the *insulation* will reduce its *R-Value* and consequently the effectiveness of the *insulation*.

When determining the location of the bulk and *reflective insulation*, careful consideration should be given to avoid possible *condensation* forming inside the layers of the building *envelope* particularly in certain climates and where there are high concentrations of water vapour. The ABCB has produced a non-mandatory handbook, *Condensation* in Buildings, to assist in understanding *condensation* risk and to detail measures that can be taken to help keep buildings dry. This handbook is available for free download from the ABCB website (abcb.gov.au).

8.6 Roofs

8.6.1 Total R-Value required

Subclause 3.12.1.2(a) specifies that a roof, in order to achieve acceptable levels of thermal efficiency, must–

3.12.1.2

(a) …

(i) achieve the *Total R-Value* specified in Tables 3.12.1.1a to 3.12.1.1g as appropriate, for the direction of heat flow; and

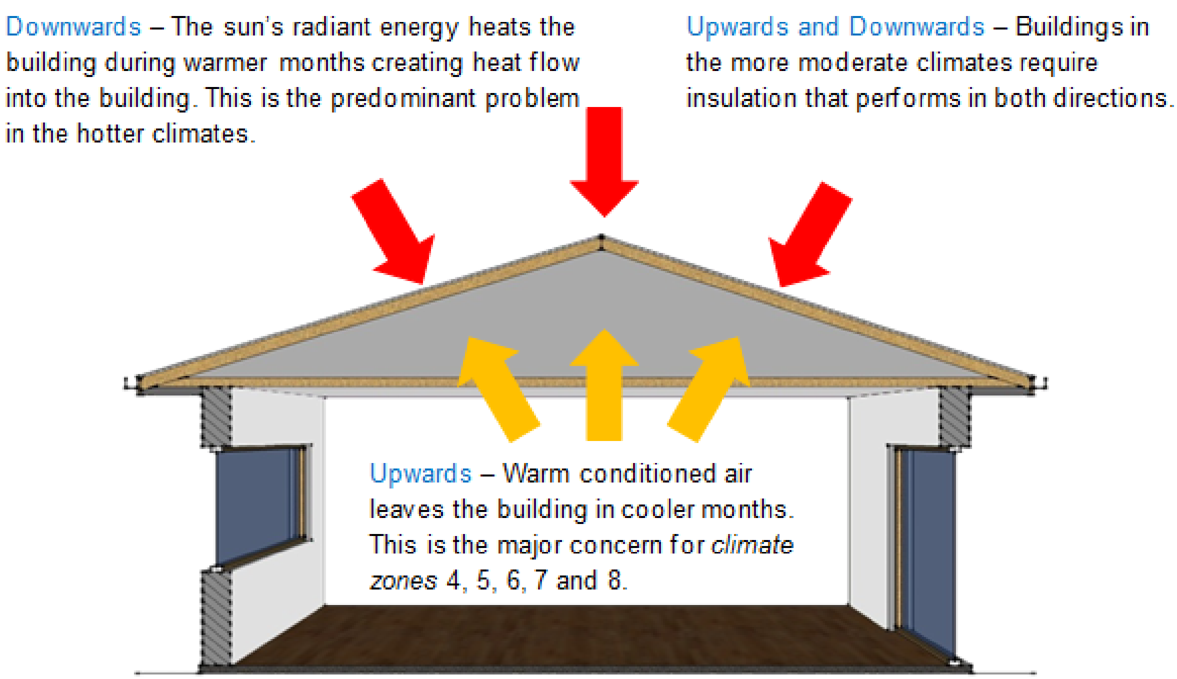
(ii) where a pitched roof has a flat ceiling, have greater than or equal to 50% of the added *insulation* laid on the ceiling.

The *Total R-Values* specified in Tables 3.12.1.1a to 3.12.1.1g vary depending on *climate zone*, altitude, direction of heat flow and the *solar absorptance* of the roof colour and material.

The reason for specifying heat flow direction is that the performance of *insulation* varies with the direction of heat flow, which varies with the dominant character of the climate.

In reading Tables 3.12.1.1a to 3.12.1.1g “downwards” indicates that summer heat (a downwards heat flow into the building) is the major concern. A combined “downwards” and “upwards” requirement means that summer cooling and winter have a roughly similar level of impact on an annual basis, while an “upwards” flow indicates that heat loss from the building during winter is the major concern (corresponding to warm conditioned air rising up through the roof space). The direction of heat flow is therefore dominated by the *climate zone* in which the building is located, and forms the first step in reading Tables 3.12.1.1a to 3.12.1.1g. Note that when *insulation* is tested, its performance is assessed against both upwards and downwards heat flow and should be selected and installed as per the test criteria. This concept of upwards and downwards heat flow is explained further in Figure 8.3.

Figure 8.3 Downwards and upwards heat f low for residential buildings



While there has been some debate about the direction in *climate zone* 5; these directions have been confirmed using computer simulation modelling. It should also be remembered that the highest energy usage and occupancy rate generally occurs in a dwelling in the evening, when heating will be the predominant use of energy.

The colour of the roof expressed as the surface *solar absorptance* value can also affect the flow of heat from solar radiation and hence, the thermal performance of the dwelling. The higher the surface *solar absorptance* value the darker the colour and the more easily the roof is able to absorb heat and possibly transmit it into the dwelling. For instance, a dark grey slate colour can have a *solar absorptance* value of 0.90 while an off white or cream colour will be in the region of 0.35. This is the reason why for lighter coloured roofs the minimum *Total R-Value* in Tables 3.12.1.1a to 3.12.1.1g of NCC Volume Two is reduced.

It is important to select the appropriate roof *solar absorptance* value for use with Tables 3.12.1.1a to 3.12.1.1g. The explanatory information box below Tables

3.12.1.1a to 3.12.1.1g contains typical absorptance values and this information is reproduced below in Table 8.1 Typical absorptance values.

Table 8.1 Typical absorptance values

Colour	Value
Slate (dark grey)	0.90
Red, green	0.75
Yellow, buff	0.60
Zinc aluminium - dull	0.55
Galvanised steel - dull	0.55
Light grey	0.45
Off white	0.35
Light cream	0.30

8.6.2 Concessions

Subclause 3.12.1.2(b) allows the *Total R-Value* specified in Tables 3.12.1.1a to 3.12.1.1g to be reduced by R0.5 in *climate zones* 1 to 5 if all the required *insulation* is laid on the ceiling and the roof space is sufficiently ventilated. To obtain the concession, ventilation requirements can be met either passively or with wind-driven roof ventilators as specified by subclause 3.12.1.2(b)(i) and (ii) respectively.

The roof space ventilation concession in 3.12.1.2(b) applies to a pitched roof with a flat ceiling to ensure that efficient cross ventilation is achieved in the roof space to remove hot air. Roof space ventilation is generally not suitable for most flat, skillion, cathedral ceiling and similar roof types because of the lack of space between the ceiling and roof. Care should be taken to ensure that the roof ventilation openings do not allow rain penetration and that they comply with appropriate bushfire requirements if applicable.

Note that compliance with 3.12.1.2(b)(ii) may result in the ingress of wind driven rain, fine dust, corrosive aerosols, or stimulate the growth of mould or fungus in the roof enclosure. Therefore consideration should be given to the surrounding environmental features, prior to adopting a particular design.

8.6.3 **Thermal breaks**

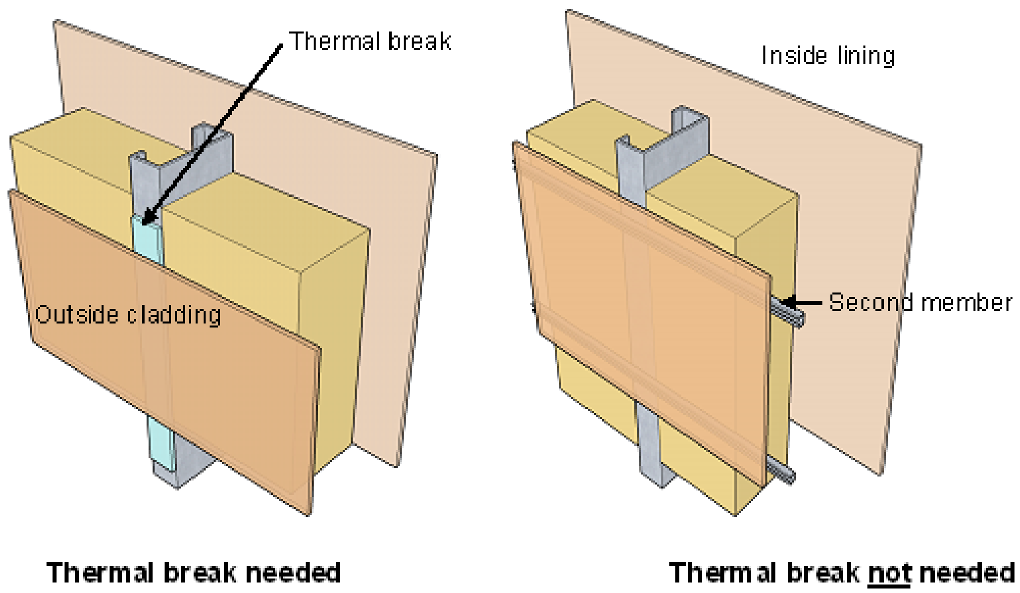
In addition to the minimum *Total R-Value* requirements, subclause 3.12.1.2(c) contains the requirements for thermal breaks and recognises that heat can bypass *insulation* travelling along metal framing systems. A thermal break is required in roofing systems where a metal framing member connects the outer roof cladding with the inner lining, or where there is no inner lining. Without this thermal break, the *insulation*'s effectiveness can be reduced by as much as half, thereby requiring more *insulation* to achieve the same *Total R-Value*.

The purpose of the thermal break is to ensure that the thermal performance of this form of roof construction is comparable to that of a similar roof with timber purlins or timber battens. *Reflective insulation* alone is not suitable for use as a thermal break because it requires an adjoining airspace to achieve its specified *R-Value*.

The thermal break must be a material with an *R-Value* of greater than or equal to 0.2. A 20 mm thick piece of timber or 12 mm thick expanded polystyrene strips, plywood or bulk *insulation* are deemed to have an *R-Value* of 0.2.

Refer to Figure 8.4 below for an illustration of the thermal break requirements for *external walls*.

Figure 8.4 Thermal break



8.6.4 R-Values for typical roof constructions

Subclause 3.1.2.1.1(d) outlines that a roof, or roof and associated ceiling, is deemed to have the *Total R-Value* in Figure 3.12.1.1 of NCC Volume Two, which provides the *Total R-Value* associated with typical roof and ceiling constructions. The *R-Value* of the required *insulation* is calculated by subtracting the inherent *Total R-Value* for the roof or ceiling construction in Figure 3.12.1.1 from the *Total R-Value* specified in Tables 3.12.1.1a to 3.12.1.1g.

The explanatory information presented immediately after Figure 3.12.1.1 provides guidance on the added *R-Value* provided by any *reflective insulation* installed for various roof and ceiling constructions. Refer to the NCC extract below.

Figure 8.5 Extract of Figure 3.12.1.1 explanatory information

R-Value added by reflective insulation—Pitched roof (>10°) with horizontal ceiling

Emittance of added *reflective insulation*	Direction of heat flow Note 1	*R-Value* added—unventilated roof space	*R-Value* added—ventilated roof space
0.2 outer / 0.05 inner	Down	1.12	1.21
0.2 outer / 0.05 inner	Up	0.75	0.59
0.9 outer / 0.05 inner	Down	0.92	1.01
0.9 outer / 0.05 inner	Up	0.55	0.40

R-Value added by reflective insulation—Flat skillion or pitched roof (≤10°) with horizontal ceiling

Emittance of added *reflective insulation*	Direction of heat flow Note 1	*R-Value* added
0.2 outer / 0.05 inner	Down	1.28
0.2 outer / 0.05 inner	Up	0.68
0.9 outer / 0.05 inner	Down	1.06
0.9 outer / 0.05 inner	Up	0.49

R-Value added by reflective insulation—Pitched roof with cathedral ceilings

Emittance of added *reflective insulation*	Direction of heat flow Note 1	*R-Value* added — pitch ≥ 15° to ≤ 25°	*R-Value* added — pitch > 25° to ≤ 35°	*R-Value* added — pitch > 35° to ≤ 45°
0.2 outer / 0.05 inner	Down	0.96	0.86	0.66
0.2 outer / 0.05 inner	Up	0.72	0.74	0.77
0.9 outer / 0.05 inner	Down	0.74	0.64	0.44
0.9 outer / 0.05 inner	Up	0.51	0.52	0.53

Notes:

1. The *required* direction of heat flow applicable in each of the *climate zones* specified in Tables 3.12.1.1a to 3.12.1.1g.
2. Ventilated roof space means ventilated in accordance with 3.12.1.2(b).

The added *R-Values* in the explanatory information table are considered typical provided the emittance values, as listed in the first column of the table, are achieved by the *reflective insulation* and the airspace is as stated.

The actual *R-Value* added by *reflective insulation* and its adjoining airspace should be determined for each product in accordance with AS/NZS 4859.1, which takes into consideration factors such as the number of adjacent airspaces, dimensions of the adjacent airspace and whether the space is ventilated.

The lower the emittance value, the more reflective the material and therefore the greater the *insulation* performance; as less heat passes through the *reflective insulation*.

The explanatory information table refers to “inner" and “outer" for *reflective insulation*. In this instance, “inner" means facing in towards the inside of the building, while “outer” means facing externally or outwards from the building.

To gain further insight into the thermal characteristics of materials, air gaps and reflective surfaces, reference could be made to Specifications J1.2 and J1.3 of NCC Volume One.

Example: Determining the Total R-Value specified in Tables 3.12.1.1a to 3.12.1.1g

Consider a dwelling with a light cream, pitched, metal roof and a flat ceiling, located in *climate zone* 6. The roof construction is not ventilated; and both reflective and bulk *insulation* will be used.

Step 1: Find the upper solar absorptance of the roof

For a light cream roof this is 0.30. The typical absorptance values are located in the explanatory information under Table 3.12.1.1g in NCC Volume Two.

Step 2: Determine the minimum Total R-Value required

This is found in Table 3.12.1.1a to Table 3.12.1.1g of NCC Volume Two. Since the roof *solar absorptance* was determined to be 0.30 (from Step 1), the minimum *Total R-Value* required for *climate zone* 6 is **4.6**, noting that the direction of heat flow is upwards.

Step 3: Work out the minimum R-Value of the ceiling insulation to satisfy 3.12.1.2(a)

This value can be calculated by referring to Figure 3.12.1.1 of NCC Volume Two which contains the inherent *Total R-Values* for typical roof and ceiling constructions.

For this example, which has a pitched metal roof with a flat ceiling and is unventilated, the inherent *Total R-Value* for the construction with upwards heat flow is **0.39** (refer to (d) in Figure 3.12.1.1).

Since this roof construction will also have *reflective insulation* installed under the roof cladding, this is considered in calculating the *required R-Value* of the ceiling *insulation*. Using *reflective insulation* which has an emittance of 0.2 (outer reflective surface) and 0.05 (inner reflective surface), the *R-Value* for this type of *reflective insulation* for an upwards heat flow direction in a pitched roof with a flat ceiling construction is **0.75**. This R-Value is obtained from the explanatory information table below Figure 3.12.1.1 in NCC Volume Two.

To calculate the *required* added *R-Value* of the ceiling *insulation*, the inherent *Total R-Value* of the roof and ceiling construction, including the *reflective insulation* is subtracted from minimum *Total R-Value* required (from Step 2).

Added *R-Value* of ceiling *insulation* = minimum *Total R-Value* – (inherent *Total R-Value* for the construction + *R-Value* of the *reflective insulation*)

$$= 4.6 - (0.39 + 0.75)$$

$$= 4.6 - (1.14)$$

$$= 3.46$$

This means that the *minimum R-Value* of ceiling *insulation required* to satisfy 3.12.1.2(a) must have an *R-Value* of 3.46, or 3.5 for simplicity.

8.6.5 Compensating for ceiling penetrations

Subclause 3.12.1.2(e) of NCC Volume Two requires that where an insulated ceiling has a significant number of penetrations for exhaust fans, flues or recessed downlights, the amount of *insulation* must be increased to account for this loss in thermal performance.

The subclause refers to Table 3.12.1.1h of NCC Volume Two which helps calculate the revised *insulation R-Value* depending on the initially required *R-Value* and the percentage of uninsulated ceiling area. A small area of ceiling penetrations (up to 0.5%) is allowed before the *R-Value* of the ceiling *insulation* is adjusted to account for heat loss/gain through penetrations in the *insulation*.

Roof lights (skylights) are exempt from this requirement as their performance is covered by clause 3.12.1.3 of NCC Volume Two.

Australian Standard AS/NZS 3000 – Electrical installations (known as the Australian/New Zealand wiring rules) outlines requirements for the safe installation of downlights, such as keeping *insulation* at safe distances. Note that this Standard is not referenced by NCC Volume Two.

Reminder

The requirements in subclause 3.12.1.2(e) of NCC Volume Two does not apply to Class 1 dwellings where the house energy rating approach has been used and the *house energy rating software* used can automatically compensate for a loss of ceiling *insulation*. Refer to Chapter 7 for more information.

Design Alert:

Consideration should be given to air leakage effects when installing downlights, exhaust fans and other openings in ceilings that previously had no openings to the roof space as they may break down deliberate protection against air leakage. Sealed light fittings should be used wherever their installation cannot be avoided.

Example: Adjustment of minimum R-Value for a loss of ceiling insulation

This example will build on the previous example and look at how to adjust the minimum *R-value* for ceiling *insulation* required to satisfy 3.12.1.2(a).

Step 1: Work out the adjustment of the minimum R-Value for loss of ceiling insulation.

This is based on the area of the ceiling that will be uninsulated for safety reasons due to the recessed luminaries, exhaust fans etc.

The required clearance of each lamp from building elements can be found in AS/NZS 3000.

The total area of penetrations in *insulation* required for clearance is summed for all lamps and exhaust fans.

Step 2: Calculate the uninsulated ceiling as a percentage of the ceiling area and then determine the adjusted minimum R-Value required for the ceiling insulation.

Percentage of ceiling area uninsulated = uninsulated ceiling area/ceiling area

$$= \frac{\text{total cut– out of insulation}}{\text{Ceiling area}} \times 100\ \%$$

Step 3: Determine the 'new' adjusted minimum R-Value for the ceiling insulation by referring to Table 3.12.1.1b of NCC Volume Two.

For example, the ceiling *insulation* has an *R-Value* of 3.5 (from the previous example), if the calculated percentage falls into the '0.5% to less than 1.0%' band, the adjusted minimum *R-Value* for the ceiling *insulation* is 4.0 as can be seen in an excerpt of Table 3.12.1.1h of NCC Volume Two in Figure 8.6.

Figure 8.6 Table 3.12.1.1h of NCC Volume Two

Table 3.12.1.1h 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	X
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	X	X

Outcome

This means that to satisfy 3.12.1.2, the adjusted minimum *R-Value* of the *insulation* would be R4.0 for the ceiling and the *reflective insulation*, which has an emittance of 0.2 (outer reflective surface) and 0.05 (inner reflective surface), as specified in the previous example.

8.7 Roof lights

The *DTS Provisions* control the area and thermal performance of *roof lights* in order to limit heat transfer. From a thermal design perspective, a *roof light* can be considered as a large opening in the insulated roof space that allows energy (heat) to either enter or leave the building in an uncontrolled manner. Accordingly, that opening must be protected to reduce the energy (heat) loss or gain.

A *roof light* has a specific meaning within NCC Volume Two as follows:

Schedule 3

Roof light, for the purposes of **Part 2.6**, **Part 3.8.4** and **Part 3.12**, means a skylight, *window* or the like installed in a roof—

(a) to permit natural light to enter the room below; and

(b) at an angle between 0 and 70 degrees measured from the horizontal plane.

This means that a *roof light* will include elaborately manufactured units through to simple sheets of glass or polycarbonate roof cladding. The allowed area will depend upon the performance of the *roof light* and the geometry of any light shaft. To keep the clause simple, the impacts of *climate zones* and *roof light* orientation have not been included. Instead the provisions are based maximum areas of *roof lights* as a percentage of the *floor area* of the room or space the *roof lights* serve and the thermal performance of the *roof lights*. The thermal performance of *roof lights* is expressed in terms of *Total System U-Value* and *Total System SHGC*.

The approach adopted also recognises the ability of *roof light* domes and diffusers to slow the loss of heat and that a *roof light* with a long shaft will allow less heat to enter the room below, than the same *roof light* with no shaft.

The requirements of 3.12.1.3 are broken into two separate categories; *roof lights* that are **not required** for compliance with Part 3.8 and *roof lights* that are **required** for compliance with Part 3.8 of NCC Volume Two; which covers minimum health and amenity requirements.

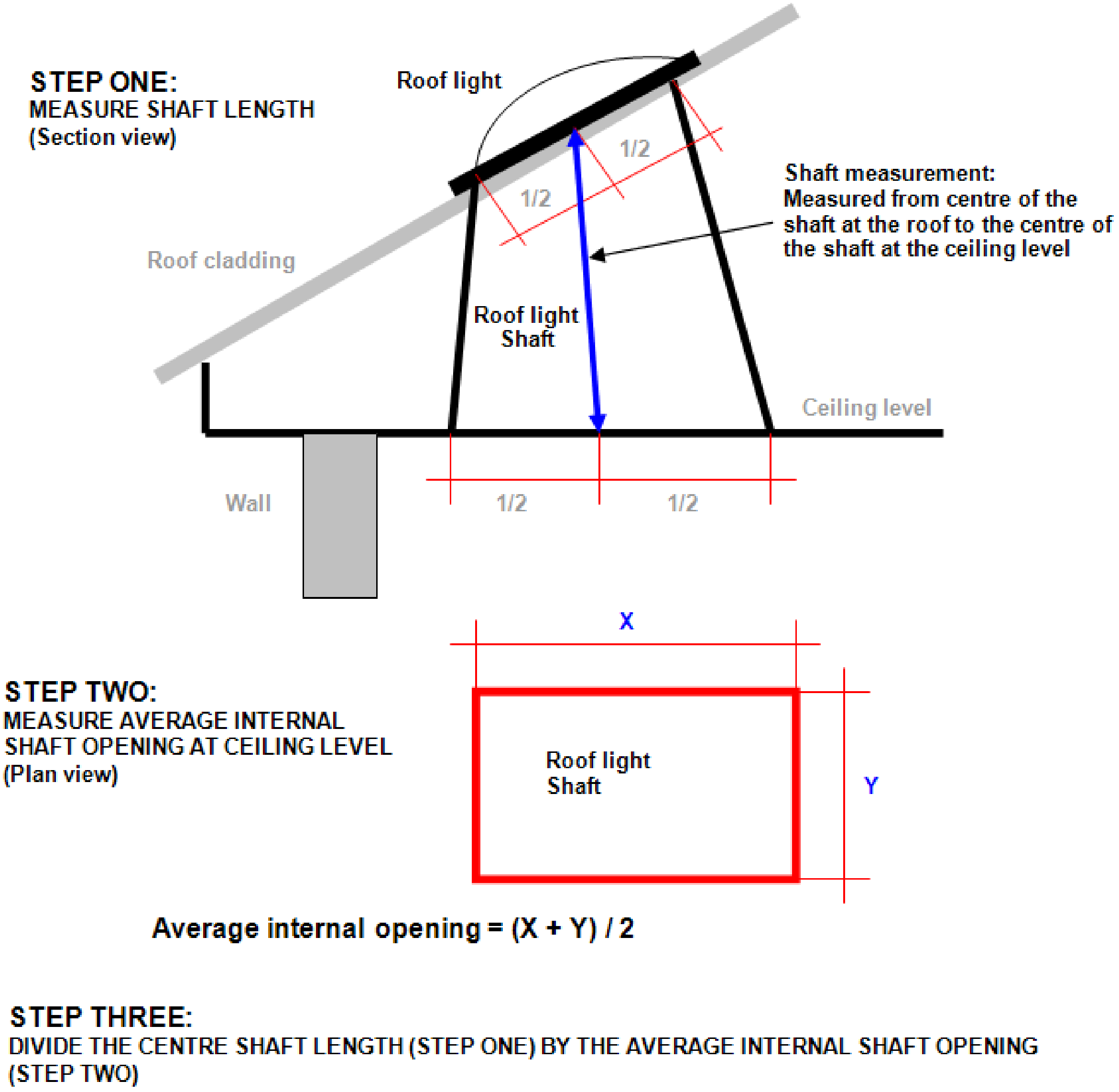
Design Alert:

Roof lights are not captured by the defined term *glazing* and therefore cannot be entered into the ABCB's Glazing Calculator, which will be discussed in the next chapter. The energy efficiency requirements for *roof lights* are contained within 3.12.1.3 of NCC Volume Two and are considered as part of the building's *fabric*.

3.12.1.3(a)(i) requires that where *roof lights* are **not required** for compliance with Part 3.8, Table 3.12.1.2 and a maximum aggregate area of not more than 3% of the total *floor area* of the *storey* served applies. Table 3.12.1.2 covers *roof lights* up to 5% of the *floor area* of the room or space they serve and are applied according to the shaft index of the *roof light*. This, in turn is based on the size of the *roof light* opening and the length of the shaft. The steps required to determine a *roof light* shaft index are explained in Chapter 7.

Another point worth noting in Table 3.12.1.2 is that the calculation of *floor area* is based on the *floor area* of the space the *roof lights* serve. In multi *storey* areas, this would relate only to the top *storey* immediately below the *roof lights*. Accordingly, the area of other floors is not taken into consideration.

Figure 8.7 Determining roof light shaft index



3.12.1.3(a)(ii) specifies the maximum size and required performance of *roof lights* if they are the only means of satisfying Part 3.8.4. In these circumstances, the *roof lights* will need to achieve a more stringent *Total System SHGC* and *Total System U-Value* while being limited to an area up to 50% more than that required by Part 3.8.5.

8.8 External walls

The construction of *external walls* is a major contributing factor in the overall thermal performance of the dwelling. Clause 3.12.1.4 states the requirements for the *opaque* (or non-transparent) elements of the walls. *Glazing* in the *external walls* is addressed in Part 3.12.2 of NCC Volume Two and is discussed in the next chapter of this Handbook.

8.8.1 Application

Part 3.12.1.4(a)

(a) Each part of an *external wall* must satisfy the requirements —

(i) (b) for all walls; or

(ii) (c) for walls with a surface density greater than or equal to 220 kg/m^2,

except for—

(iii) opaque non-glazed openings such as doors (including garage doors), vents, penetrations, shutters and the like; and

(iv) glazing unless covered by (c).

3.12.1.4(a) addresses the thermal performance of *external walls* by requiring each part of an *external wall* to comply with a minimum *Total R-Value* outlined in 3.12.1.4(b); however for *external walls* with a high surface density (i.e. not less than 220 kg/m^2), 3.12.1.4(c) can also be used.

External walls that achieve a surface density greater than 220 kg/m^2 are considered to be high mass, which slows heat movement into and out of the dwelling and can act to moderate temperatures inside the house.

Reminder:

Surface density is the mass of one vertical square metre of wall.

Example:

The following are examples of some typical wall constructions that achieve a surface density of 220 kg/m^2:

- Two leaves of clay or concrete masonry with each leaf 90 mm or greater in thickness
- Concrete wall panels with all vertical cores filled with concrete grout 140 mm (or greater) in thickness
- Dense-weight hollow concrete or clay blocks with all vertical cores filled with concrete grout 140 mm (or greater) in thickness
- Earth-wall construction with a minimum wall thickness of 200 mm

There are two exemptions to the requirements of 3.12.1.4(a) located in (iii) and (iv). The first exemption to the minimum *Total R-Value* requirements for *external walls* is for *opaque* non-glazed openings, such as doors, garage roller shutters and the like. The second exemption is for *glazing* unless it is covered by 3.12.1.4(c) which allows some trading between *glazing* and *external wall* performance.

If a door has *glazing*, the glazed area is exempt from requiring *insulation* but must comply with Part 3.12.2 External glazing, which is discussed in the next chapter of this Handbook.

8.8.2 **Total R-Value required**

3.12.1.4(b)

(b) Each part of an *external wall* must—

  (i) in *climate zones* 1, 2, 3, 4 and 5—

    (A) achieve a minimum *Total R-Value* of 2.8; or

    (B) —

      (aa) achieve a minimum *Total R-Value* of 2.4; and

      (bb) 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; or

  (ii) in *climate zones* 6 and 7, achieve a minimum *Total R-Value* of 2.8; or

  (iii) in *climate zones* 8, achieve a minimum *Total R-Value* of 3.8.

3.12.1.4(b) of NCC Volume Two sets the minimum *Total R-Value* for all *external walls* to achieve. A concessional option is given for *climate zones* 1 to 5 if shading to the *external wall* is also provided as specified. The *Total R-Value* includes all the individual elements that make up the wall, such as air films and air gaps and is the sum of these individual element's *R-Values*. However the *Total R-Value* does not include the *R-Value* from the frame as an allowance is already included for framing. Common construction solutions are described in Figure 3.12.1.3 of NCC Volume Two. These will be discussed in greater detail later in this section.

No shade concessions are provided for *climate zones* 6 to 8 as the conditioning requirement is heating dominated, so shade would not be as beneficial as it would reduce the amount of solar gain received.

8.8.3 High density walls

3.12.1.4(c)

(c) Each part of an *external wall* with a wall surface density of greater than or equal to 220 kg/m^2 must—

- (i) in *climate zones* 1, 2 and 3—
  - (A) for a storey, other than one with a storey above, shade the wall with a verandah, balcony, eaves, carport or the like that projects at a minimum angle of 15 degrees in accordance with Figure 3.12.1.2; and
  - (B) when the *external walls* are not shaded in accordance with (A) and there is another storey above, external *glazing* complies with 3.12.2.1 with the applicable value for C_{SHGC} in Tables 3.12.2.1a to 3.12.2.1c reduced by 20%; and
  - (C) incorporate insulation with an *R-Value* of greater than or equal to 0.5; and
  - (D) on the lowest storey containing *habitable rooms*, have either—
    - (aa) a concrete slab-on-ground floor; or
    - (bb) masonry *internal walls*; or
- (ii) in *climate zone* 5 (option a) —
  - (A) for a storey, other than one with a storey above, shade the wall with a verandah, balcony, eaves, carport or the like that projects

at a minimum angle of 15 degrees in accordance with Figure 3.12.1.2; and

(B) when the *external walls* are not shaded in accordance with (A) and there is another storey above, external *glazing* complies with 3.12.2.1 with the applicable value for C_{SHGC} in Table 3.12.2.1e reduced by 15%; and

(C) incorporate insulation with an *R-Value* of greater than or equal to 0.5; and

(D) on the lowest storey containing *habitable rooms*, have either—

(aa) a concrete slab-on-ground floor; or

(bb) masonry *internal walls*; or

(iii) in *climate zone* 5 (option b) —

(A) shade the wall with a verandah, balcony, eaves, carport or the like that projects at a minimum angle of 15 degrees in accordance with Figure 3.12.1.2; and

(B) have external *glazing* that complies with 3.12.2.1 with the applicable value for C_{SHGC} in Table 3.12.2.1e reduced by 15%; and

(C) on the lowest storey containing *habitable rooms*, have either—

(aa) a concrete slab-on-ground floor; or

(bb) masonry *internal walls*; or

(iv) in *climate zones* 4 and 6 (option a) —

(A) have external *glazing* that complies with 3.12.2.1 with the applicable value for C_U in Tables 3.12.2.1d and 3.12.2.1f reduced by 15%; and

(B) incorporate insulation with an *R-Value* of greater than or equal to 0.5; and

(C) on the lowest storey containing *habitable rooms*, have either—

(aa) a concrete slab-on-ground floor; or

(bb) masonry *internal walls*; or

(v) in *climate zones* 4 and 6 (option b), have external *glazing* that complies with 3.12.2.1 with the applicable value for C_U in Tables 3.12.2.1d and 3.12.2.1f reduced by 20%; or

(vi) in *climate zones* 4 and 6 (option c) —

(A) incorporate insulation with an *R-Value* of greater than or equal to 1.0; and

(B) on the lowest storey containing *habitable rooms*, have either—

(aa) a concrete slab-on-ground floor; or

(bb) masonry *internal walls*; or

(vii) in *climate zone 7* (option a) —

(A) have external *glazing* that complies with 3.12.2.1 with the applicable value for C_U in Table 3.12.2.1g reduced by 15%; and

(B) incorporate insulation with an *R-Value* of greater than or equal to 1.0; or

(viii) in *climate zone 7* (option b) —

(A) have external *glazing* that complies with 3.12.2.1 with the applicable value for C_U in Table 3.12.2.1g reduced by 20%; and

(B) incorporate insulation with an *R-Value* of greater than or equal to 0.5; or

(ix) in *climate zone* 7 (option c), incorporate insulation with an *R-Value* of greater than or equal to 1.5; or

(x) in *climate zone* 8, achieve a minimum *Total R-Value* of 3.8.

3.12.1.4(c) is for high density walls with a surface density of greater than 220 kg/m^2, and is more prescriptive in nature than 3.12.1.4(b). For *climate zones* 1 to 7, it provides a number of options for compliance, however for *climate zone* 8 the required performance is the same as that specified in 3.12.1.4(b).

The compliance options in 3.12.1.4(c) recognise that the impact of certain climates may be moderated by careful design and material selection. A good example of this is shading which, by keeping the sun off the building walls, reduces the heat build-up. The walls, in turn, help to keep internal temperatures more stable and reduce dependence on conditioning systems to maintain internal comfort levels.

Each of the options specified in the table may have more than one requirement that must be met to satisfy the requirements. In general if the requirements are linked by ‘and’ this indicates that more than one requirement is necessary to fulfil that option.

The options in 3.12.1.4(c) may include combinations of:

- insulation with a specified *R-Value* that must be incorporated into the *external wall;*
- *external wall* shading with a minimum 15 degree angle for the shading projection;
- a reduction of C_{SHGC} values for external *glazing* which means a reduction in the *glazing* allowance for solar gain;
- a reduction of C_{U} values for external *glazing* which means a reduction in the *glazing* allowance for conductance;
- slab-on-ground floor construction; and
- masonry *internal walls*.

Depending on the construction, *insulation* incorporated into the *external wall* may require a wall battening system to enable the *insulation* to be installed without compressing it, which would reduce its effectiveness. In *climate zones* with prolonged periods of cold weather this option recognises that the density of the wall does not sufficiently restrict the heat loss, so *insulation* must be installed.

8.8.4 **Thermal breaks**

3.12.1.4(d) requires a thermal break similar to that required for roofs. It only applies if there is a metal framing member that directly connects a lightweight *external wall* cladding and it’s lining, or where there is no wall lining. This is because metal framed walls are more prone to conductive thermal bridging than timber framed walls. The *Total R-Value* requirements for walls include an allowance for the effect of bridging from timber framing. The thermal break for metal framing must be installed between the external cladding and the metal frame.

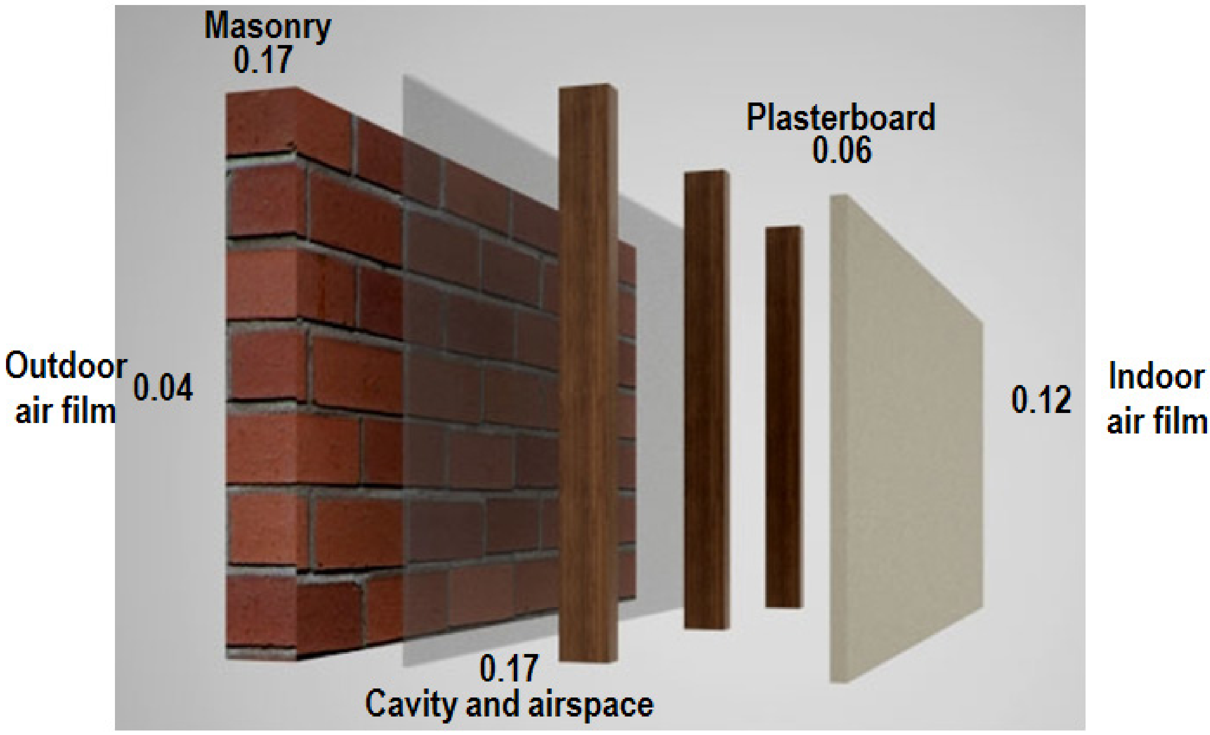
Thermal breaks can be provided by materials such as timber battens, plastic strips or polystyrene *insulation* sheeting; so long as it achieves the required *R-Value* of 0.2. The *R-Value* of the thermal break is not included when calculating the *Total R-Value* of the *external wall* if the thermal break is only applied to the metal frame, because this calculation is done for locations free of framing members.

Refer to Figure 8.4of this Handbook for an illustration of the thermal break requirements.

8.8.5 R-Values for typical wall constructions

3.12.1.4(e) refers to Figure 3.12.1.3 of NCC Volume Two which shows the inherent *Total R-Value* of typical wall constructions (e.g. clay masonry veneer and weatherboard). Users can work out the amount of additional *insulation* needed for each construction in order to meet the required minimum *Total R-Value* specified in 3.12.1.4(b) or 3.12.1.4(c). Figure 8.8 below illustrates the component *R-Values* for a typical wall construction.

Figure 8.8 Component R-Values for a typical wall



It is not necessary to use Figure 3.12.1.3 of NCC Volume Two in order to comply with the elemental *DTS Provisions* for *external walls*. However, it offers a convenient, even if conservative, source of *Total R-Value* information. An extract of the table for *external wall* construction is given in Figure 8.9 and Figure 8.10.

Figure 8.9 Weatherboard *external wall* construction

3.12.1.3(a) Weatherboard *external wall* construction — *Total R-Value* of 0.48

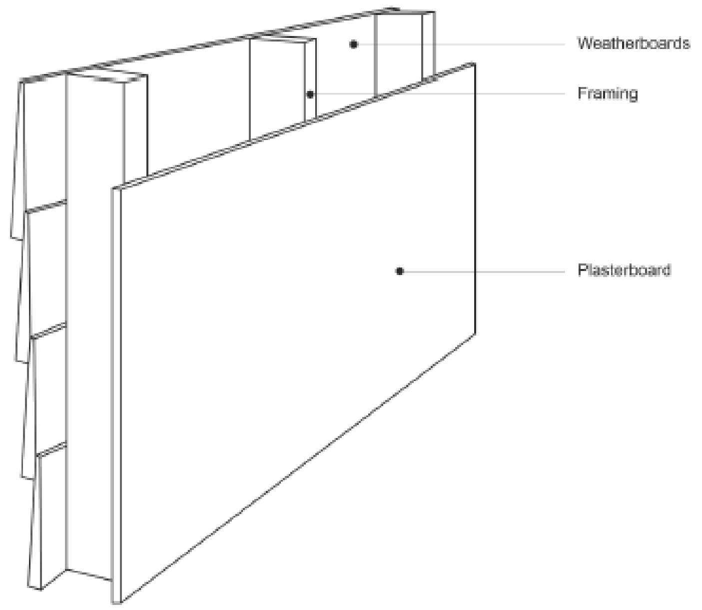
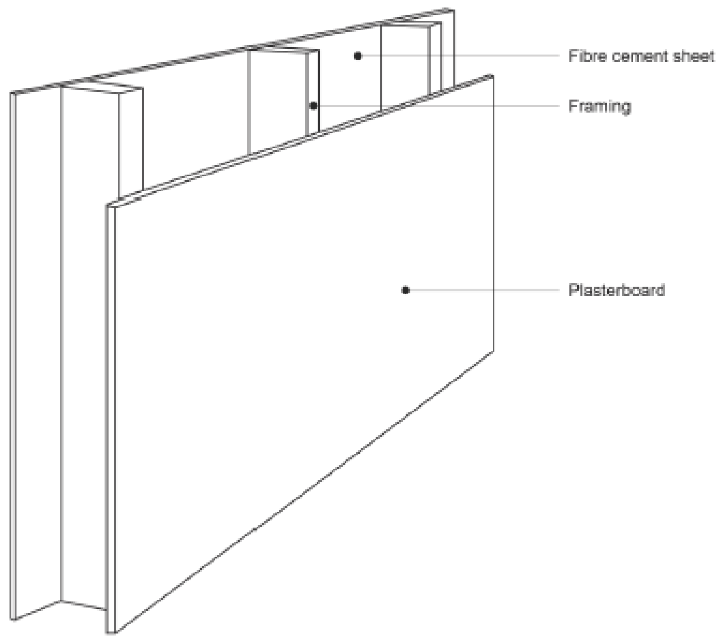


Figure 8.10 Fibre-cement sheet external wall construction

3.12.1.3(b) Fibre-cement sheet *external wall* construction — *Total R-Value* of 0.42



The explanatory information for Figure 3.12.1.3 of NCC Volume Two provides guidance on the performance of *reflective insulation* installed in wall airspaces. Refer to Figure 8.11 below for an excerpt. The values in the explanatory information table for *reflective insulation* are based on typical values.

Figure 8.11 Typical values for reflective insulation

Wall construction	Reflective airspace details	*R-Value* added by *reflective insulation*
Concrete or masonry with internal plasterboard on battens	One 20 mm reflective airspace located between *reflective insulation* (of not more than 0.05 emittance inwards) and plasterboard	0.48
External wall cladding (70 mm timber frame with internal lining)	One 70 mm reflective airspace located between *reflective insulation* (of not more than 0.05 emittance inwards) and plasterboard	0.43
Masonry veneer (70 mm timber frame with internal lining)	(a) One 70 mm reflective airspace located between *reflective insulation* and plasterboard; and (b) One 25 mm anti-glare airspace located between *reflective insulation* (of not more than 0.2 emittance outwards) and masonry	0.95
Cavity masonry	(a) No airspace between the *reflective insulation* and the inner leaf of masonry; and (b) One 35 mm anti-glare airspace located between *reflective insulation* (of not more than 0.2 emittance outwards) and the outer leaf of masonry	0.50

If the emittance of the *reflective insulation* or the arrangement of airspaces is different, then confirmation of the actual performance of each product should be obtained from the manufacturer's test data in accordance with AS/NZS 4859.1. Testing and subsequent compliance is required under clause 3.12.1.1 of NCC Volume Two.

8.9 Floors

Unlike the roof and *external wall* requirements, the requirements for floors address heat flow for two directions;

1. Vertical direction – a minimum *Total R-Value* for suspended ground floors is required and in some instances under-slab *insulation* with a specific *R-Value*; and

2. Horizontal direction – perimeter edge *insulation* required with a specific *R-Value*.

Subclauses 3.12.1.5(a) and (b) cover the requirements for suspended ground floors, and subclauses 3.12.1.5(c) and (d) cover the requirements for concrete slab-on-ground floors.

8.9.1 Suspended ground floors

3.12.1.5(a)(i) outlines the minimum *Total R-Value* requirements for suspended floors other than intermediate floors in a building with more than one storey. Put simply, this only applies to suspended ground floors. The *Total R-Values* are tabulated in Table 3.12.1.4 of NCC Volume Two and are shown below.

Total R-Value requirements for suspended ground floors

Climate zone	Direction of heat flow	Minimum *Total R-Value*
1	Up	1.5
2	Up	1.0
3	Up	1.5
4	Down	2.25
5	Down	1.0
6	Down	2.25
7	Down	2.75
8	Down	3.25

It should be noted that the inherent *R-Value* of an enclosed air space underneath a suspended floor and of the enclosure itself, can be included in the *Total R-Value* calculation for the floor.

In addition to the requirements in 3.12.1.5(a)(i), subclause (a)(ii) outlines requirements for the *insulation* of suspended concrete floor slabs with an in-slab or in-screed heating or cooling system, which apply in all *climate zones*.

The energy from a heated or cooled slab is distributed to all faces of the slab and not only to the surface located within the dwelling. This means energy is lost or gained from the external perimeter edges i.e. in the horizontal direction. To control this heat loss or gain from the vertical edge of the slab, subclause (a)(ii)(A) states the vertical edge must be insulated with an *R-Value* of greater than or equal to 1.0.

Subclause (a)(ii)(B) specifies that to control heat loss from the vertical direction, i.e. through direct conductance into the airspace below, a suspended concrete floor slab with an in-slab or in-screed heating or cooling system must have under-slab *insulation* with an *R-Value* of greater than or equal to 2.0.

Subclause (a)(ii) does not apply to an in-screed heating or cooling system solely used in a bathroom, amenity area or the like. Refer to subclause (e).

Subclause (a)(iii) requires suspended floors that have enclosed under-floor spaces to have a barrier installed at or below floor level to close off any gaps that may occur between the under-floor space and any wall cavities. It should be noted that imperforate *flashing* for damp proofing purposes is an acceptable barrier for the purposes of this subclause. Refer to Figure 8.12 and Figure 8.13 for two possible options.

Design alert: What is an unenclosed under-floor space?

An unenclosed under-floor space means that the floor is fully or partially open to the external weather conditions (such as cooling breezes), which impact on the thermal performance of the floor due to air movement. The exposure to external weather increases the heat flow through the floor, which in turn can increase the energy demand to keep the *conditioned space* at the desired temperature. Explanatory information states that an enclosed under-floor space means that the area beneath the floor is totally enclosed by ground-to-floor cladding such as masonry or fibre cement sheeting.

Figure 8.12 Example 1 of *cavity* barrier

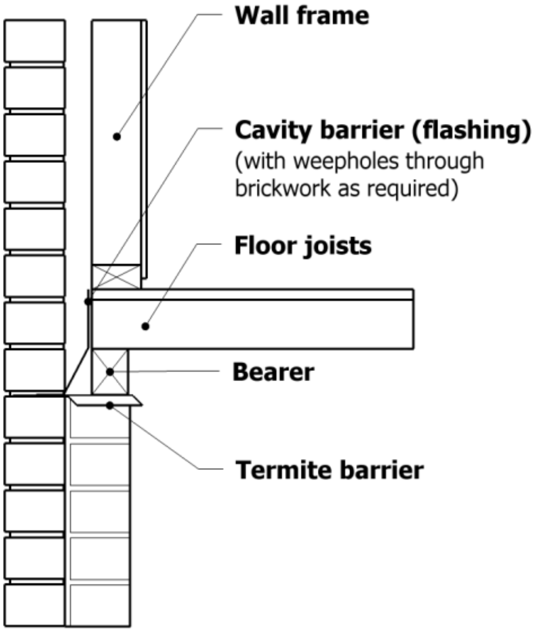
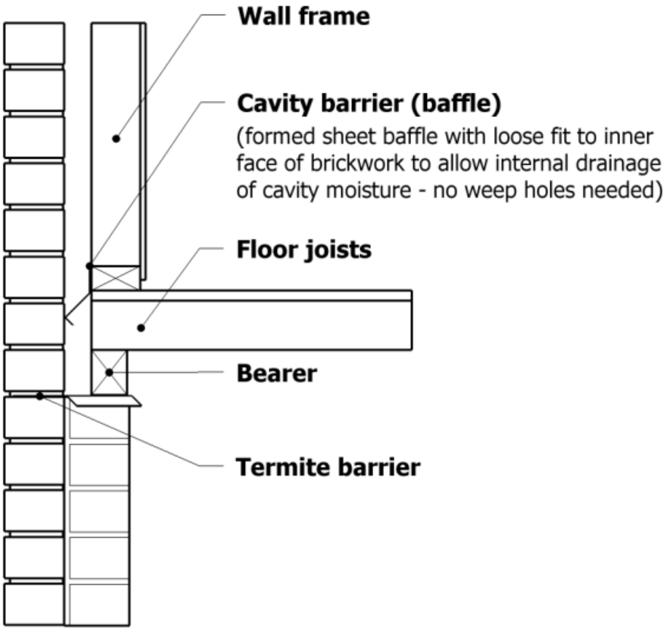


Figure 8.13 Example 2 of *cavity* barrier



Design Alert:

Air movement between the under-floor space and any wall cavities is to be prevented by the use of *flashing* in order to keep the temperature of the under-floor airspace as stable as possible.

3.12.1.5(b) provides a reference to Tables 3.12.1.5a and 3.12.1.5b of NCC Volume Two which shows the *Total R-Values* typical suspended floors can provide. This information allows the additional *R-Value* of *insulation* that is needed for each construction to meet the required *Total R-Value* from Table 3.12.1.4 to be worked out. It is not necessary to use the values in Tables 3.12.1.5a and 3.12.1.5b in order to comply with the *DTS Provisions.*

Note that the *R-Value* of any enclosure and the airspace it contains also contributes to the *Total R-Value* of the floor. The inherent *R-Value* of the floor varies with the height of the enclosed space.

If *reflective insulation* is used, a higher *Total R-Value* will be achieved than that specified in Tables 3.12.1.5a and 3.12.1.5b of NCC Volume Two, for a particular construction. The added *R-Value* due to the use of *reflective insulation* will need to be determined for each product in accordance with AS/NZS 4859.1.

The explanatory information for Tables 3.12.1.5a and 3.12.1.5b of NCC Volume Two notes that single sided *reflective insulation* installed shiny silver side up and with a 90mm airspace above could improve the *Total R-Value* by 0.43 for upwards heat flow and 1.32 for downwards heat flow. Double sided *reflective insulation* could further improve the *Total R-Value.* However as above, the added *R-Value* due to the use of *reflective insulation* will need to be determined for each product in accordance with AS/NZS 4859.1.

Design Alert:

Reflective or non-reflective building *insulation* should be installed with due consideration of potentially damaging *condensation* that may occur in some *climate zones,* as well as the associated interaction with adjoining building elements.

8.9.2 Concrete slab on ground floors

3.12.1.5(c) details the requirements for a concrete slab-on-ground.

3.12.1.5(c)(i) outlines that where the concrete slab has an in-slab or in-screed heating or cooling system, it must have *insulation* with an *R-Value* of greater than or equal to 1.0 installed around the vertical edge of its perimeter. This requirement applies to all *climate zones*.

3.12.1.5(c)(ii) outlines specific requirements for a concrete slab-on-ground located in *climate zone* 8. Perimeter *insulation* with an *R-Value* greater than or equal to 1.0 must be installed as well as under slab *insulation* with an *R-Value* of greater than or equal to 2.0. These requirements recognise that *climate zone* 8, which is a heating dominated climate, will require measures to reduce the loss of heat from the slab for the majority of the year.

Similar to the suspended ground floor requirements of subclause (a), subclause (c)(i) does not apply to an in-screed heating or cooling system solely used in a bathroom, amenity area or the like. Refer to subclause (e).

3.12.1.5(d) outlines the specific requirements of the vertical perimeter *insulation* that may be installed under (c). The insulation is required to be water resistant due to it being exposed to external conditions, and either be installed to the full depth of the vertical edge of the concrete slab or to a depth of greater than or equal to 300 mm. Care should be taken to ensure that the type of termite management system selected is compatible with the slab edge *insulation*.

8.9.3 Exemption for in-screed heating or cooling systems

This subclause identifies the exemption for in-screed heating or cooling systems used solely for a bathroom, amenity area or the like. This exemption is granted on the understanding that these areas are typically small areas.

8.10 Attached Class 10a buildings

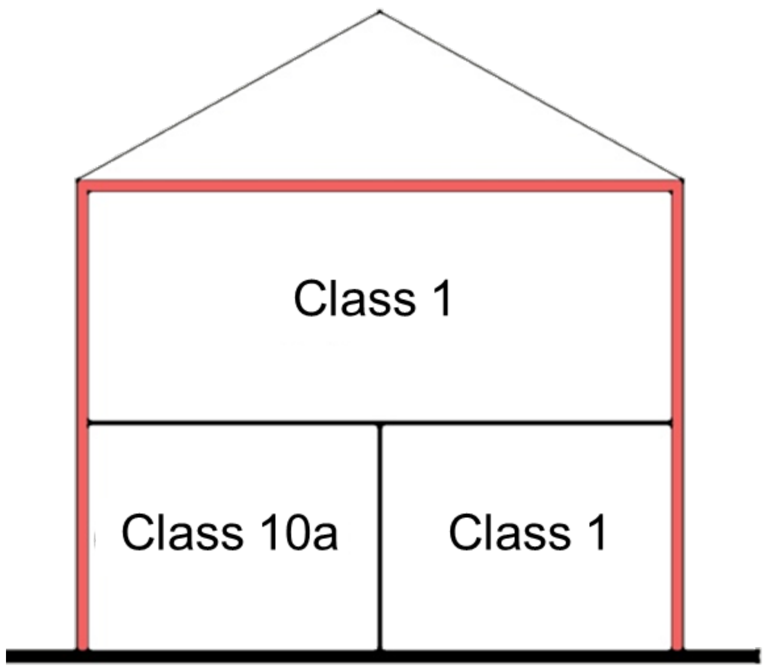
A Class 10a building attached to a Class 1 dwelling, such as a garage or pool enclosure should not compromise the thermal performance of the Class 1 dwelling. However it may assist the Class 1 dwelling in meeting the required level of thermal performance. Therefore the intent of the requirements in 3.12.1.6 is to ensure the thermal performance of the dwelling, which may include the attached Class 10a building, remains at a reasonable minimum level.

There are three compliance options using a *DTS Solution* for Class 10a buildings which are attached to a Class 1 building, set out in the three subclauses of 3.12.1.6.

8.10.1 Thermal performance the same as the Class 1 building

This option states the Class 10a building must have an external *fabric* (including roof, *external walls* and floor) with the same level of thermal performance that is required for a Class 1 building. If the Class 10a is a *conditioned space* then this option would be the likely one chosen, as the *fabric* requirements already apply to a Class 10a building with a *conditioned space.* This is specified in Part 3.12.1 of NCC Volume Two. However this option may also be the preferred option for designers or prospective owners who would like to achieve a degree of thermal comfort in the Class 10a building. An example of this approach is shown in Figure 8.14.

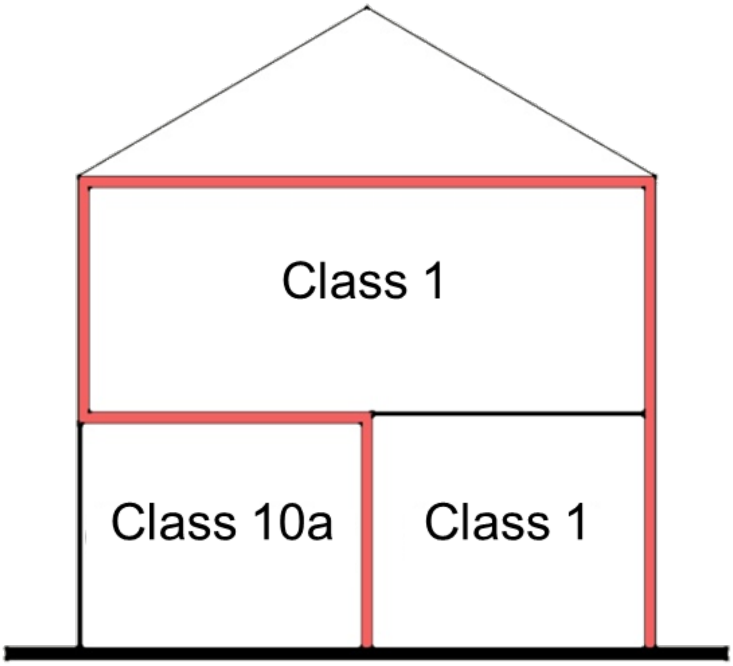
Figure 8.14 An example of the building envelope where the Class 10a component is considered with Class 1 dwelling. The building envelope is defined in red.



8.10.2 Thermal performance separated from the Class 1 building

3.12.1.6(b) outlines that an attached Class 10a building can be separated from the Class 1 building with construction having the same level of thermal performance that is required for the Class 1 building. This may include walls, and floors of the Class 10a building. An example of this approach is shown in Figure 8.15.

Figure 8.15 An example of the building envelope where the Class 10a component is separated from the Class 1 dwelling. The building envelope is defined in red.



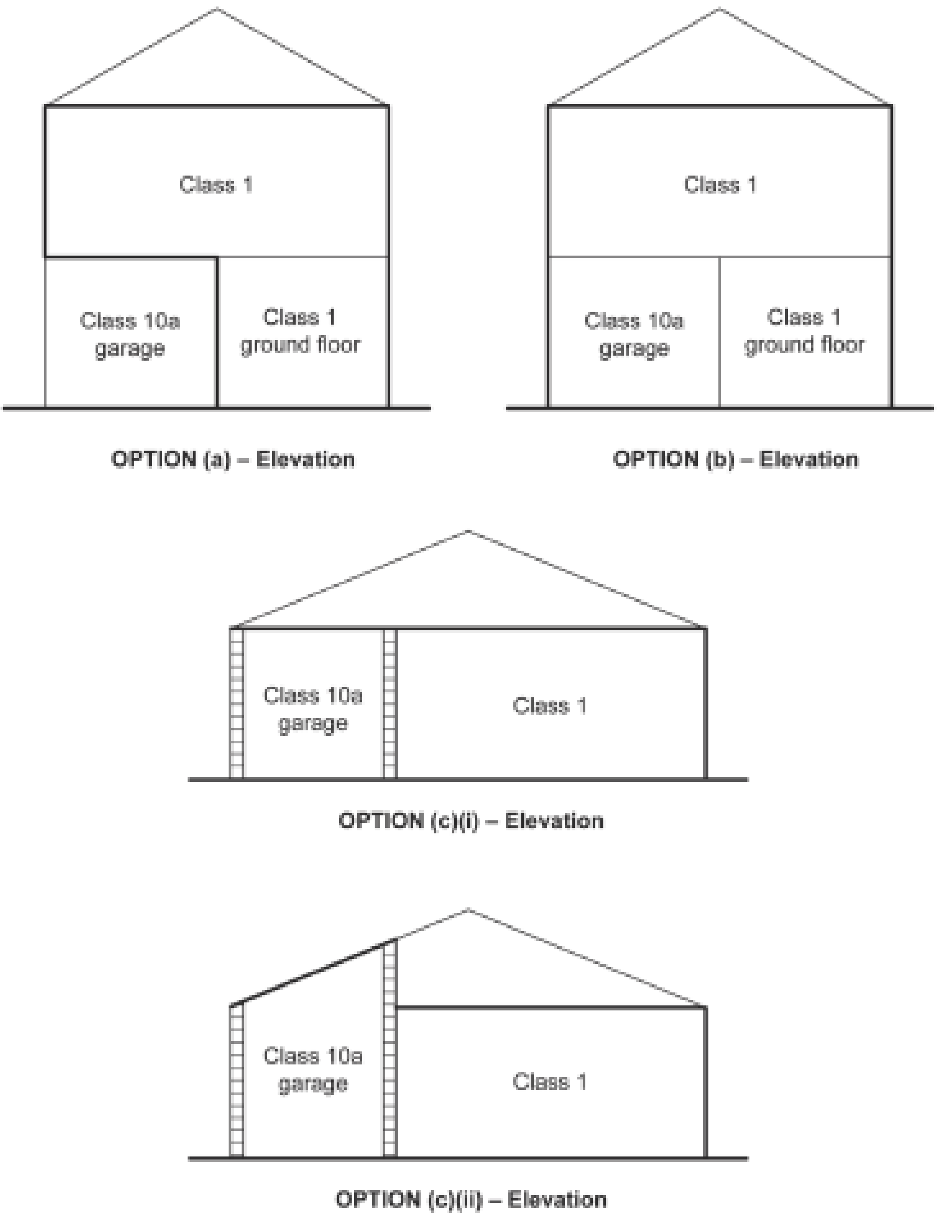
8.10.3 Climate zone 5 option

Another option is located in subclause 3.12.1.6(c), however it only applies in *climate zone 5*. This option outlines that the Class 10a building must have masonry walls, including between the Class 1 and Class 10 buildings (which must extend to the ceiling or roof). The ceiling over the Class 10a building must have the same level of performance as per the Class 1 building. Subclause (c) also requires the garage door of the attached 10a building to not face the east or west orientation, unless the *glazing* in the Class 1 building has its solar heat gain constant (C_{SHGC}) in Tables 3.12.2.1a to 3.12.2.1h of NCC Volume Two reduced by 15% (i.e. harsher *glazing* requirements).

This option can provide an annual total heating and cooling load for the Class 1 building equivalent to that with a complying "*external wall*" between the Class 1 building and the Class 10a building. Note that this option in subclause (c) cannot be used if the Class 10a building is a *conditioned space*.

The following diagram in Figure 8.16 shows the options available for meeting 3.12.1.6, as well as two versions of option (c).

Figure 8.16 Options for an attached Class 10a building to a Class 1 building



9 Part 3.12.2 - External glazing

9.1 Introduction

The treatment of *glazing* to limit unwanted heat gain or loss is one of the most important aspects of the energy efficiency requirements in NCC Volume Two.

Many factors contribute to solar heat gain and heat conduction through *glazing*, including-

- the location of the building (which includes *climate zone* and sun angles);
- the total area of *glazing*; the types of glass and frame used (which determine how readily they conduct heat and transmit solar radiation); and
- the degree of exposure to the sun (which depends on the direction the *glazing* faces and the extent of any shading).

The NCC Volume Two elemental *DTS Provisions* consider two major thermodynamic effects on *glazing*, namely:

(a) heat conduction through the glass and frame by virtue of a temperature difference between inside and outside; and
(b) solar radiation transmitted through the glass and frame into the building.

NCC Volume Two sets 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. The equations take into account *glazing* area, *glazing* thermal properties (*Total System U-Value* and *Total System SHGC)*, solar orientation and external shading projections or shading devices.

For the purposes of the NCC, *glazing* refers to *windows*, glazed doors and other transparent or translucent elements (such as glass bricks) located in the building *fabric*. It does not include *roof lights*. A *glazing* element includes the glass (or other *glazing* material), any air or gas fill, and the supporting frames. The performance of *glazing* is measured in terms of *Total System U-Value* and *Total System SHGC*.

It is essential that *glazing* elements are rated as a whole to account for the different thermal properties of the glass, any fills, the frame, and also the impact of the frame on the glass (edge-effect). These areas are indicated in Figure 9.1.

Figure 9.1 Glazing components

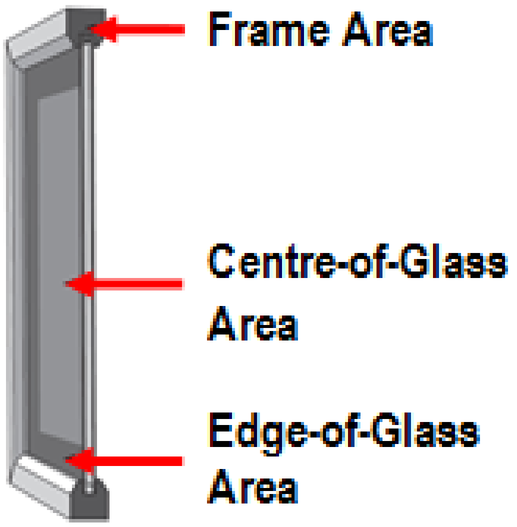


Figure courtesy of the Australian Window Association

The NCC requires *glazing* products to be rated in accordance with the Australian Fenestration Rating Council (AFRC) protocols and procedures. Standardised rating of *glazing* products ensures that a valid comparison can be made between the performance of different *glazing* products.

Glazing suppliers and manufacturers can provide the rated *Total System U-Value* and *Total System SHGC* for their *glazing* products.

The calculations in Part 3.12.2 can be done long hand or be automated by using a spreadsheet calculator. Refer to the ABCB Glazing Calculator in this chapter for more information. Other aids have also been developed by industry.

Alert:

Early resolution of the *glazing* design, including the type, size, orientation and shading of *glazing* elements, is critical as high-performance *glazing* alone may not be relied on to achieve compliance.

9.1.1 The importance of glazing

Some *glazing* systems commonly used in Australian houses can have thermal *insulation* qualities that are poor compared to other parts of the house *fabric*. Some elements of the building *envelope* of our houses (such as walls, floors and roofs) are heavily insulated against heat loss or gain. However, much of the heat can pass through the *glazing* unless orientation, shading devices and *glazing* performance (glass and frame) are managed appropriately.

In summer, sunlight radiates through the glass, bringing unwanted heat into the interior. However, in winter, solar heat gains through the glass can contribute usefully to the energy efficiency of a house where heating is desired. There are resources such as the Your Home website (yourhome.gov.au) which discuss these issues and broader passive solar design in detail.

The NCC *DTS Provisions* contain requirements for the thermal performance of *glazing* (including frames) depending on the *glazing* area, its orientation and the extent of any shading. This attempts to limit unwanted heat gain into the house in hot weather without unduly restricting the potential for solar heat gains in winter.

9.1.1.1 In houses

All elements of a house's *fabric* present opportunities for energy savings. The energy efficiency requirements emphasise the importance of maintaining the thermal performance of the building *fabric*. Heating and cooling equipment may be replaced many times over a house's life but fundamental *fabric* measures such as wall *insulation*, *window* sizes, shading, orientation and air tightness will likely remain for the life of the house.

For a unit or apartment with limited external *fabric* and limited *glazing* placement options, *glazing* can become the greatest source of heat transfer and of infiltration or air leakage, making it the critical element in achieving energy efficiency.

9.1.1.2 Improving energy efficiency

Poorly designed *glazing* can become the main thoroughfare for unwanted heat gain or heat loss. However, with the correct design, *window*s and glazed doors may provide opportunities to achieve greater energy efficiencies within the house by-

- maximising solar heat gains in cooler seasons lessening the need for heating;
- minimising unwanted heat gains in hotter seasons lessening the need for cooling;
- opening the house to air movement for cooling during the night in hot seasons; and
- providing natural light which can reduce the use of heat-producing artificial lighting in the house during daylight hours.

Design alert:

One of the main considerations in the design of air-conditioning for a house is the heating or cooling load resulting from the *glazing*. Correctly designed and installed *glazing* may reduce the size and capacity of the heating and cooling equipment needed in a house.

If used carelessly, *glazing* elements risk becoming a major weakness in the insulated building *envelope*. The requirements in NCC Volume Two Part 3.12.2 are intended to keep unwanted energy flows through the *glazing* within limits that are considered reasonable for each *climate zone*. In some house types in some locations, greater energy efficiency can be achieved by also making use of desirable solar gains in the colder periods.

9.1.1.3 Orientation

A comparison between Figure 9.2 and Figure 9.3 illustrates how the orientation of the *glazing* can receive beneficial winter sun but not unwanted summer sun. Figure 9.2 shows the relative size of the total solar gains from eight different orientation sectors through unshaded *glazing* in Brisbane during the three summer months from December to February. The centrelines of the main sectors (north, south, east and west) are marked by solid lines. The sectors in between align to north east, South east, south west and north west. The length of each sector shows the relative amount of solar heat gain received from that direction.

As can be seen, *glazing* facing the north or south sectors receives the least solar gain and much less than *glazing* facing the east and west sectors. In fact, north or south facing *glazing* receives just half of the summertime gains of east and west facing *glazing*.

Gains from any of the intermediate sectors are about equal to each other and closer in size to the east and west gains than they are to the north and south. Although the diagram illustrates the situation in Brisbane, the pattern is broadly similar in most other Australian locations. It suggests that the north and south orientation sectors are particularly favourable for summer conditions.

Figure 9.2 Relative solar gains from eight orientations during summer in Brisbane

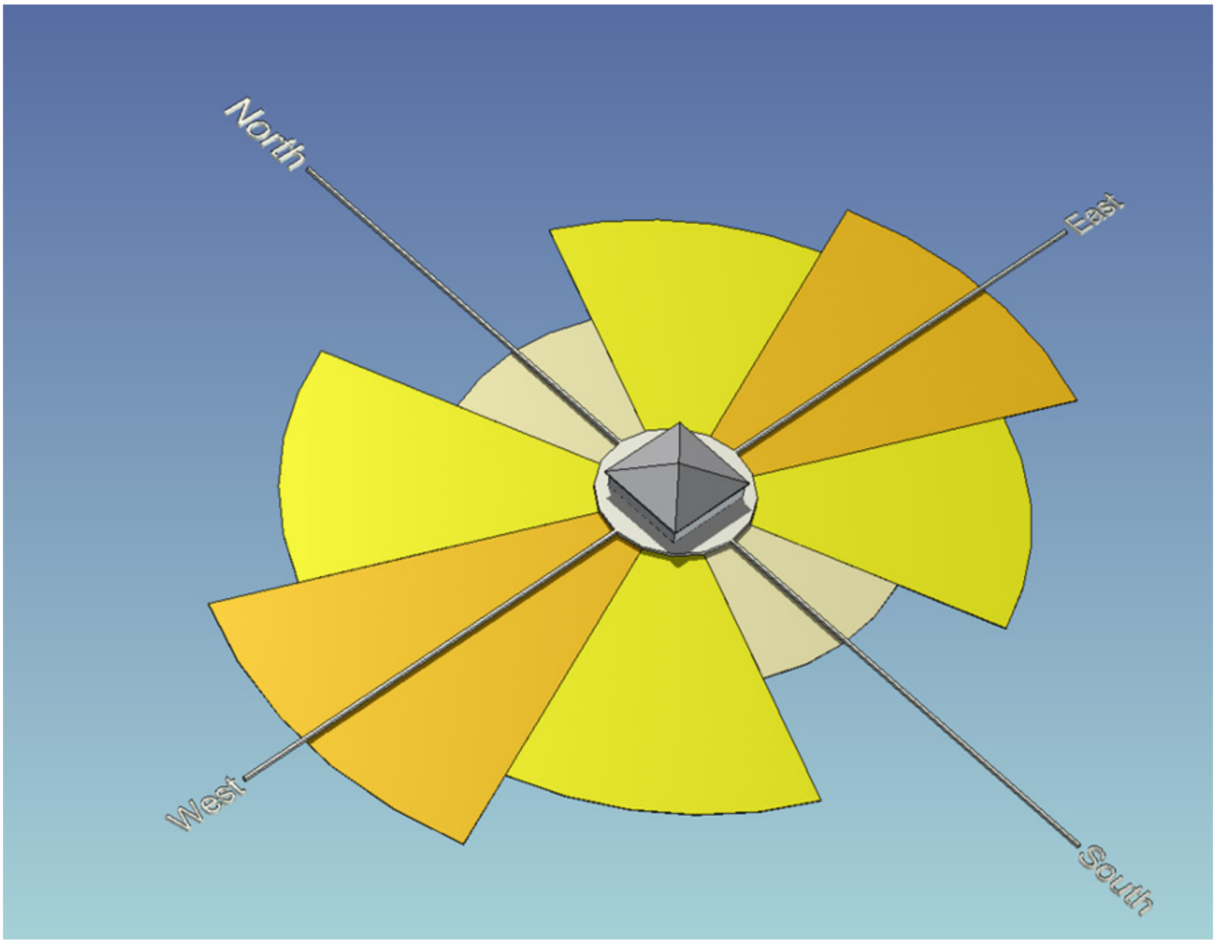


Figure 9.3 Relative solar gains from eight orientations during winter in Brisbane

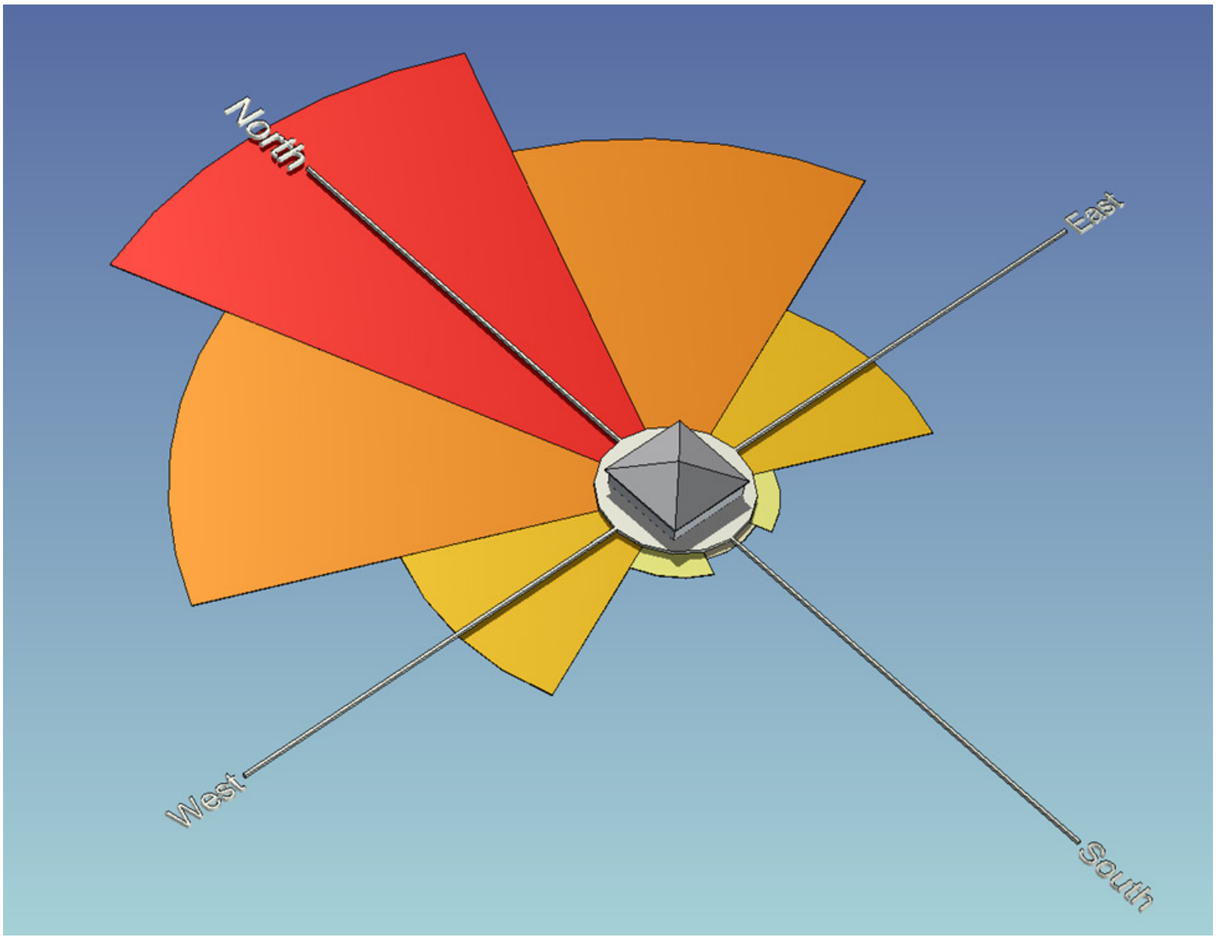


Figure 9.3 is the wintertime version of Figure 9.2 showing the relative size of total solar gains from the same eight orientation sectors in Brisbane during the three winter months from June to August. It is drawn at the same scale as the summertime diagram so that the size of the sectors on both diagrams can be compared directly.

What might be unexpected is that the north sector is the largest source of solar gain during winter and the east and west sectors provide gains that are less than half of those available from the north. This is a complete reversal of the summertime situation.

Solar gains from the intermediate north east and north west sectors again fall somewhere in-between the two. The remaining sectors (south east, south and south west) provide negligible heat gains during the months when they are most desirable.

Combining the summer and winter outcomes shows that the east and west sectors provide the highest level of unwanted summertime heat gains but less than half of this during winter when solar gains might be beneficial. The south sector provides the lowest summertime heat gains but virtually no useful heat gains in winter.

By contrast, the north sector has the same advantage during summer as the south sector but is the best source of heat gains during the winter months. This combination identifies the north orientation sector as uniquely favourable for avoiding heat gains when they are not wanted and being able to make use of them when they will be most beneficial.

The north east and north west sectors provide comparatively high levels of solar gains all year round, whether or not they are welcome. The south east and south west sectors have the disadvantage of high summertime heat gains with minimal compensating benefit in winter.

Orientation however is not directly important for conductance. Whether *glazing* faces north, south, east or west, the same amount of heat gain or loss is calculated to occur because the heat gain or loss depends on the air temperature inside the house compared to the air temperature outside, which is assumed to be similar in all directions. Good orientation however, can compensate for heat lost through conduction by providing offsetting solar gains.

9.1.1.4 Sun angles

The winter sun appears lower on the horizon at any time of day than the summer sun at the same time. Between the lowest winter position and the highest summer position there is a difference of about 47°. For unshaded *glazing*, the angle of the sun’s rays onto the glass will affect the amount of solar heat gain transmitted through the glass. The sharper the angle (closer to 90° from the horizontal), the greater the reflectance from the surface of the glass, which results in less solar heat gain. This is most effective in summer as the sun is higher in the sky and thus the angle is sharper, whilst the winter sun is lower in the sky and the angle is more direct. The effect of this and the differing hours of sunshine between the seasons is reflected in the previous diagrams Figure 9.2 and Figure 9.3, which illustrate results for unshaded *glazing*.

Another important benefit of the changing sun angles is that it is possible to provide shading devices that protect *glazing* from unwanted summer sun while allowing the lower winter sun to shine directly into the *window*s providing heat gains when they may be welcome.

9.2 Scope

The *glazing* provisions apply to a Class 1 building and to a Class 10a building with a *conditioned space* using the elemental *DTS Provisions*. It does not apply to houses assessed using 3.12.0(a) (the energy rating approach).

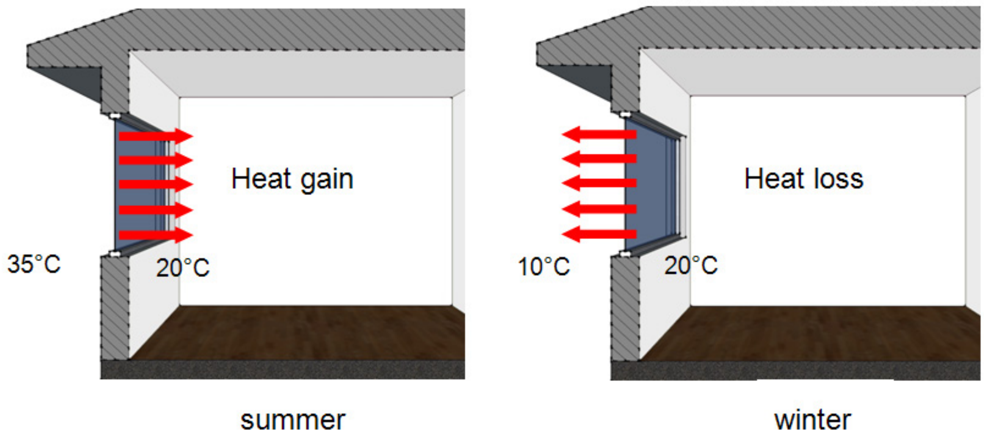
9.3 Intent

The intent of Part 3.12.2 is to control the amount of heat entering or leaving a building through *glazing.*

Heat energy enters or leaves a room through *glazing* principally by conduction, radiation and air infiltration. Infiltration is covered in the next chapter as part of the sealing requirements in Part 3.12.3, whilst conduction and solar radiation are addressed in this Part.

Conduction through *glazing* occurs when there is a temperature difference between the inside and the outside of the *glazing*. Refer to Figure 9.4. If it is cold outside and warm inside a building, the warmth inside will tend to travel through the *glazing* to the outside. Alternatively, if it is cool inside and warm outside, the warmth from the outside will tend to travel through the *glazing* to the inside. Conduction through both glass and frame must be considered.

Figure 9.4 Conduction and solar heat gain through glazing

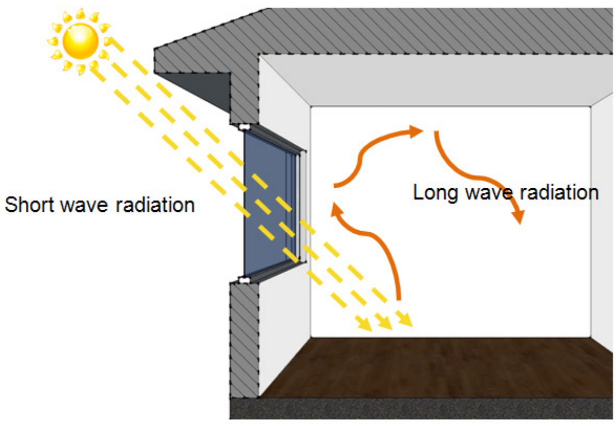


Solar radiation passes through *glazing* principally as direct beams of sunlight. Refer to Figure 9.5. This figure describes how short wave radiation passes through glass. The frame also absorbs and re-radiates heat inwards and outwards. Heat is absorbed by interior surfaces and re-radiated and this re-radiated long wave radiation is trapped inside the *glazing*.

However solar radiation also includes significant components of diffuse (or scattered) radiation and reflected radiation. Shading projections can reduce direct solar radiation but are less effective against diffuse and reflected radiation.

The intensity of solar radiation from different directions varies throughout the year depending on the location of the building. The effect of shading projections also varies.

Figure 9.5 Radiant heat gain through glazing



Reminder:

For the purposes of the requirements, *glazing* refers to *windows*, glazed doors and other transparent or translucent elements (such as glass bricks) located in the building *fabric*. It does not include *roof lights*. A *glazing* element includes the glass (or other *glazing* material), any air or gas fill, and the supporting frames.

9.3.1 Performance Requirement

Although not directly aligned to occupant comfort, the measures are based on achieving internal environments which are sufficiently comfortable for occupants to minimise their use of artificial heating and cooling.

The relevant part of the *Performance Requirement* P2.6.1 states:

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 -…

(e) solar radiation being:

(i) utilised for heating; and

(ii) controlled to minimise energy for cooling; and …

The design of the building *envelope* is a major factor in controlling unwanted heat loss in winter and heat gain in summer. The main contributors to heat loss or gain through the *envelope* are usually *window* or door openings containing *glazing*. The rate of energy transfer through basic single *glazing* can be 10 to 20 times higher than through insulated walls.

Reducing unwanted heat movement through the building *envelope* will provide a major contribution to occupant satisfaction and subsequent use of energy for heating or cooling. The *DTS Provisions* for external *glazing* are based on this general intent.

9.4 Application

Clause 3.12.2 is the application of this Part, and it states that the *glazing* provisions apply to a Class 1 building and to a Class 10a building with a *conditioned space*. This clause does not apply to the house energy rating *DTS Provision* option.

9.5 External glazing

The *glazing* requirements are based on conductance and solar heat gain, with the requirements separated into two main clauses, namely sub-clauses (a) and (b).

Subclause (a) contains the calculation of the aggregate **conductance** of the *glazing* in each *storey*.

Subclause (b) contains the calculation of the aggregate **solar heat gain** of the *glazing* in each *storey*.

Both subclauses require the aggregate conductance and solar heat gain not to exceed the allowances calculated with figures obtained from Tables 3.12.2.1a to 3.12.2.1h and includes separate calculations for determining the aggregate allowance and that for the proposed building. Each *storey* of the house must be assessed separately.

In addition, for the conductance calculation, *climate zone* 1 has a different calculation method to that of the other *climate zones*. The conductance allowance aims to limit conduction into a possibly air-conditioned interior. In *climate zones* other than *climate zone* 1, there is a noticeable winter, even if it is short or mild in some locations. And hence solar heat gain from the *glazing* is accounted for to balance potential passive heat gains and the heat lost by conduction.

The calculations lend themselves to being expressed in a spreadsheet (as used for the ABCB Glazing Calculator) or some other automated approach. It uses the formulas and the related constants in 3.12.2.1 to calculate the total (aggregate) conductance and solar heat gain allowances and that of the proposed design.

Design alert:

"Each *storey* of a building" is in relation to a building that has more than one level. The *glazing* must be assessed separately for each separate *storey*.

9.5.1 Step 1 – Calculate the allowances

The conductance allowance and the solar heat gain allowance are determined separately. *Climate zone* 1 also has a different calculation method to that of the other *climate zones*.

9.5.1.1 Conductance allowance calculation

9.5.1.1.1 Climate zone 1

The conductance allowance *for climate zon*e 1 is determined by multiplying the floor area of the *storey* by the conductance constant C_U. C_U is obtained from Table 3.12.2.1a. This calculation for the conductance allowance in *climate zone 1* can be simply expressed by the following formula:

$$Glazing\ conductance\ allowance = Floor\ Area\ \times C_u$$

9.5.1.1.2 Climate zones 2 to 8

The conductance allowance for *climate zones* 2 to 8 does not depend on floor area. The allowance is simply the conductance constant C_U itself. Again, C_U is obtained from Table 3.12.2.1b to Table 3.12.2.1h. The conductance allowance for *climate zones* 2 to 8 can be simply expressed as:

$$Glazing\ conductance\ allowance = C_u$$

Table 3.12.2.1 b to Table 3.12.2.1h gives different constants, depending on the type of floor construction and the level of air movement provided by *ventilation openings* on each *storey*. Refer to the extract of Table 3.12.2.1b to Table 3.12.2.1h. The selection of floor construction and air movement level must be made separately for each *storey* if there is more than one. Note the air movement doesn't change the conductance allowance, only the solar heat gain allowance.

9.5.1.2 Solar heat gain allowance calculation

9.5.1.2.1 All climate zones

The solar heat gain allowance for all *climate zones* is determined by multiplying the floor area of the *storey* by the solar heat gain constant C_{SHGC}. C_{SHGC} is obtained from Table 3.12.2.1a to Table 3.12.2.1h.

This calculation for the solar heat gain allowance can be simply expressed by the following formula:

$$Glazing\ solar\ heat\ gain\ allowance = Floor\ Area\ \times C_{SHGC}$$

As previously mentioned, this table gives different constants, depending on the type of floor construction and the level of air movement provided by *ventilation openings* on each *storey*. Refer to Table 3.12.2.1a to Table 3.12.2.1h in NCC Volume Two. The selection of floor construction and air movement level must be made separately for each *storey* if there is more than one. By increasing the air movement, the solar heat gain allowance is increased. This is due to the benefit of increased air movement reducing the heat gain within the house and the related cooling load. High air movement is determined in conjunction with Part 3.12.4 which is discussed in Chapter 11.

Design alert: What if my house is part suspended floor and part slab on ground on the same storey?

In this situation, the different floor types can be combined in a single calculation by averaging the allowances in proportion to area of each type. (The Glazing Calculator automatically averages allowances for different floor types on the same *storey*). Otherwise, the different floor types can be treated as separate calculations or the worst case allowance can be applied to the whole floor area of the *storey* (i.e. the whole floor being suspended).

Reminder:

The floor area of the *storey* is measured "within the enclosing walls". The floor area of any *storey* will include all spaces such as wet areas (bathrooms, laundries and the like), cupboards, the area of the actual stairs (excluding voids) in two *storey* houses, mezzanines, etc.

9.5.2 Step 2 – Conductance and solar heat gain calculation

9.5.2.1 Conductance calculation

To calculate the aggregate conductance of the proposed design's *glazing* in—

1. *climate zone* 1, use the formula in subclause 3.12.2.1(a)(ii)(A); and
2. *climate zones* 2 to 8, use the formula in subclause 3.12.2.1(a)(ii)(B).

Conductance is calculated separately for each *storey* if there is more than one.

9.5.2.1.1 Climate zone 1

Aggregate conductance for *climate zone* 1 is calculated by a formula which multiplies the area of each *glazing* element by the *Total System U-Value* of that *glazing* element and sums the results.

The formula is as follows:

$$(A_1 \times U_1) + (A_2 \times U_2) + (A_3 \times U_3) + \ldots$$

Where-

$A_{1,2,\text{etc.}}$ = the area of each *glazing* element

$U_{1,2,\text{etc.}}$ = the *Total System U-Value* of each *glazing* element

9.5.2.1.2 Climate zones 2 to 8

Aggregate conductance for *climate zones* 2 to 8 uses a formula that is slightly different to that for *climate zone* 1. The winter exposure factor and the *Total System SHGC* for each *glazing* element are also accounted for in addition to the *glazing* area and *Total System U-Value*.

The formula is as follows:

$$[(A_1 \times U_1) + (A_2 \times U_2) + \cdots] \div [(A_1 \times SHGC_1 \times E_{W1}) + (A_2 \times SHGC_2 \times E_{W2}) + \cdots]$$

Where-

$A_{1, 2, \text{etc.}}$	=	the area of each *glazing* element
$U_{1, 2, \text{etc.}}$	=	the *Total System U-Value* of each *glazing* element
$SHGC_{1, 2, \text{etc.}}$	=	the *Total System SHGC* of each *glazing* element
$E_{W1, 2, \text{etc.}}$	=	the winter exposure factor of each *glazing* element obtained from Tables 3.12.2.2a to 3.12.2.2g

9.5.2.2 Solar heat gain calculation

To calculate the aggregate solar heat gain of the proposed design's *glazing* in *climate zones* 1 to 8, use the formula in NCC Volume Two subclause 3.12.2.1(b)(ii).

Solar heat gain is calculated separately for each *storey* if there is more than one.

9.5.2.2.1 Climate zones 1 to 8

Aggregate solar heat gain is calculated by a formula which multiplies the area of each *glazing* element by its *Total System SHGC* and by the summer exposure factor from Tables 3.12.2.2h to 3.12.2.2o for each *glazing* element.

The formula is as follows:

$$(A_1 \times SHGC_1 \times E_{S1}) + (A_2 \times SHGC_2 \times E_{S2}) + \ldots.$$

Where-

$A_{1, 2, \text{etc.}}$	=	the area of each *glazing* element

$SHGC_{1, 2, etc.}$ = the *Total System SHGC* of each *glazing* element

$E_{S1, 2, etc.}$ = the summer exposure factor of each *glazing* element obtained from Table 3.12.2.1b

Reminder:

The formula must be applied separately for the *glazing* in each *storey*. The values for the formula described above are described in greater detail at the end of this section. The calculations can also be simplified by using the ABCB Glazing Calculator.

Design alert:

This calculation favours orientations with higher potential solar gains in winter and the use of shading rather than glass toning. Shading that is effective in summer can still allow welcome solar gains in winter but toning reduces solar gains all year round.

9.5.3 Step 3 – Compliance criterion

Compare the conductance and solar heat gain of the proposed design's *glazing* with the allowances. Both the conductance and solar heat gain must not exceed the allowance.

The criterion can be expressed simply as:

$$Design\ (Step\ 2\ )\ \leq\ Allowance\ (Step\ 1)$$

9.5.4 Explanation of the formula terms

Area of each glazing element ($A_{1, 2\ etc.}$)

The area of each *glazing* element includes the area of the glass and the frame. This information can usually be obtained from the *window* schedule. Refer to the definition of *glazing* in Appendix C for more information. In addition, if a *window* has 6 panes of glass, then the area of *glazing* for the *window* includes all 6 panes and all the framing that holds the glass.

Total System U-Value ($U_{1, 2 etc.}$) and Total System SGHC ($SHGC_{1, 2 etc.}$)

The *Total System U-Value* ($U_{1, 2 etc.}$) means the thermal transmittance of the composite element allowing for the effect of any air spaces and associated surface resistances. Put simply, it is a measure of the conductance of the *glazing*.

The *Total System SHGC* ($SHGC_{1, 2 etc.}$) is the fraction of incident irradiance on *glazing* that adds heat to a building's space. Put simply, it is a measure of the solar heat gain of the *glazing.*

These values for each *glazing* element can be obtained from the *glazing* manufacturer. The measurement of the *Total System U-Value* and *Total System SHGC* is specified in the Technical Protocols and Procedures Manual for the Energy Rating of Fenestration Products of the Australian Fenestration Rating Council (AFRC). This provides a standard testing and reporting format that is being adopted internationally.

Various assessors using AFRC procedures might refer to their published performance values by slightly different terms (including "U-factor", "U-Value" or "U_w" for *Total System U-Value* and "SHGC" for *Total System SHGC*). Such values may be used in 3.12.2 provided they measure combined glass and frame performance according to AFRC requirements.

Total System U-Values and *Total System SHGCs* are shown for some simple types of residential *glazing* elements in the explanatory information below 3.12.2.1. The values give worst case assessments of *glazing* elements, which can be improved by obtaining custom product assessments from suppliers, manufacturers, industry associations (including their online resources) and from competent assessors. Custom assessments consider *glazing* element components in more detail and return the highest levels of assessed performance for a given type of *glazing* element.

There is a range of frames and glass types with different thermal characteristics that can have a significant effect on the performance of the *glazing* system. The basic types of frame materials include standard aluminium, thermally broken aluminium, timber and UPVC. Typical glass types include clear, tinted, coated and double glazed (two panes of glass separated by an air-gap). The type of frame, the details of its geometry and the fraction it makes up of the *glazing* element area as well as the type of glass used, all affects the overall performance of the *glazing* element.

Design alert: What happens if non-standard windows and one-off architectural windows and glazed doors are used?

The *Total System U-Value* and *Total System SHGC* for the *glazing* system can still be obtained from the manufacturer or supplier who will have completed a generic or custom rating for that particular system.

Winter and summer exposure factors ($E_{W1,\,2\,etc.}$ & $E_{S1,\,2\,etc.}$)

The winter exposure factors (E_W) and summer exposure factors (E_S) depend upon the *climate zone*, orientation sector and any shading of the *glazing.* The shading is represented by P/H. E_W and E_S for each *glazing* element are obtained from Tables 3.12.2.2a to 3.12.2.2o. How to use these tables and the associated terms are described below.

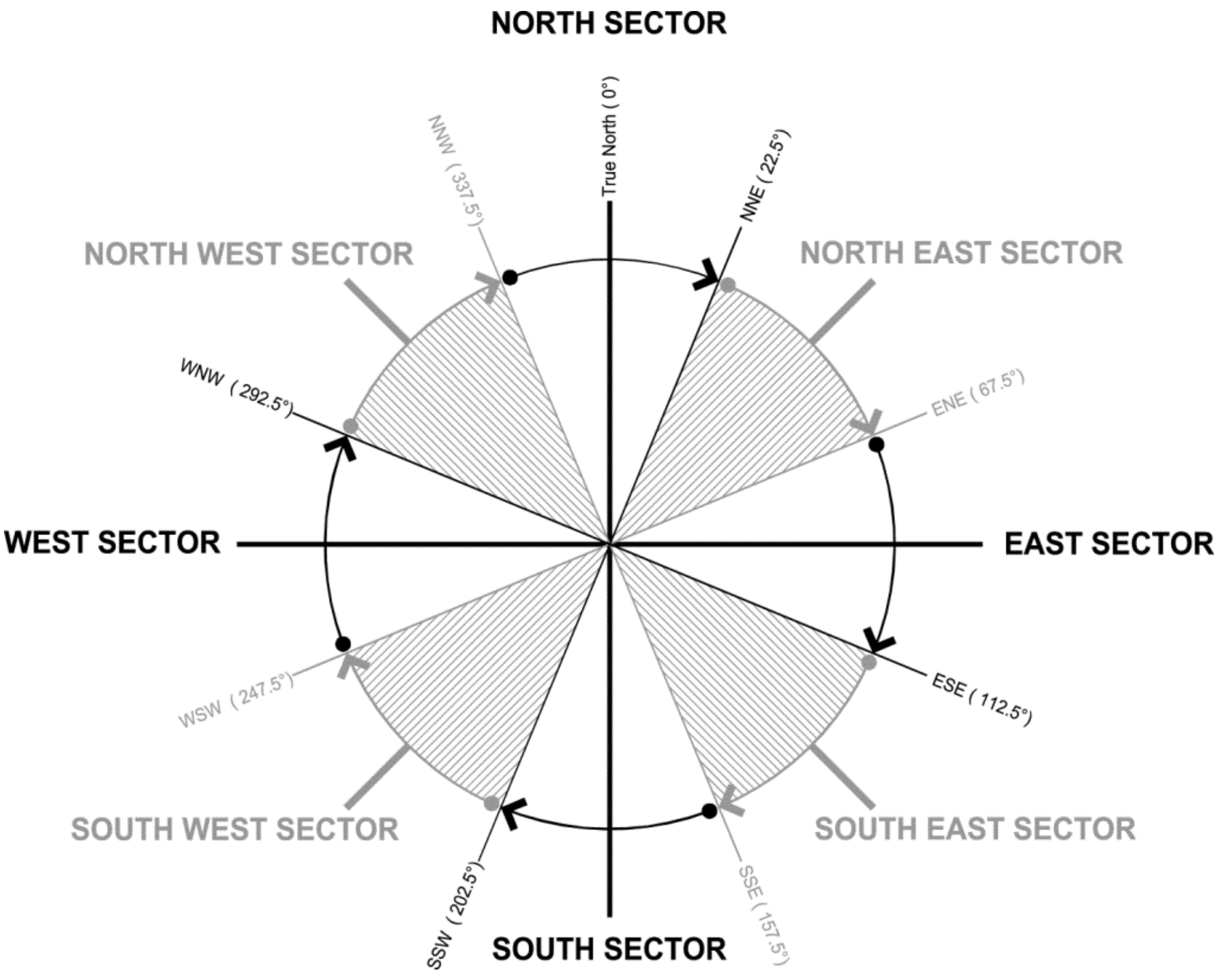
1. Determine the relevant *climate zone* for the building.
2. Determine the orientation sector for each *glazing* element (see further explanation below).
3. Determine the P/H ratio for shading projections and devices (refer to NCC Volume Two Figure 3.12.2.2 and clause 3.12.2.2 or the explanation below).
4. Determine the winter and summer exposure factors from Table 3.12.2.1a to Table 3.12.2.2o.

Orientation Sector

The orientation sector can be determined for each *glazing* element using Figure 3.12.2.1 in NCC Volume Two, which recognises 8 orientations; north, north east, east, south east, south, south west, west and north west. Figure 3.12.2.1 is reproduced below in Figure 9.6.

This figure shows the extent of the sectors within their boundaries labelled as angles measured clockwise from north. Curved arrows define where each sector begins and ends. The dot at the tail of each arrow shows that the sector starts just beyond the nearest marked angle. The head of each arrow falls on the angle that marks the clockwise limit of the sector. For example, east north east (ENE) falls into the north east sector and east south east (ESE) falls into the east sector.

Figure 9.6 Orientation sectors



P - Projection

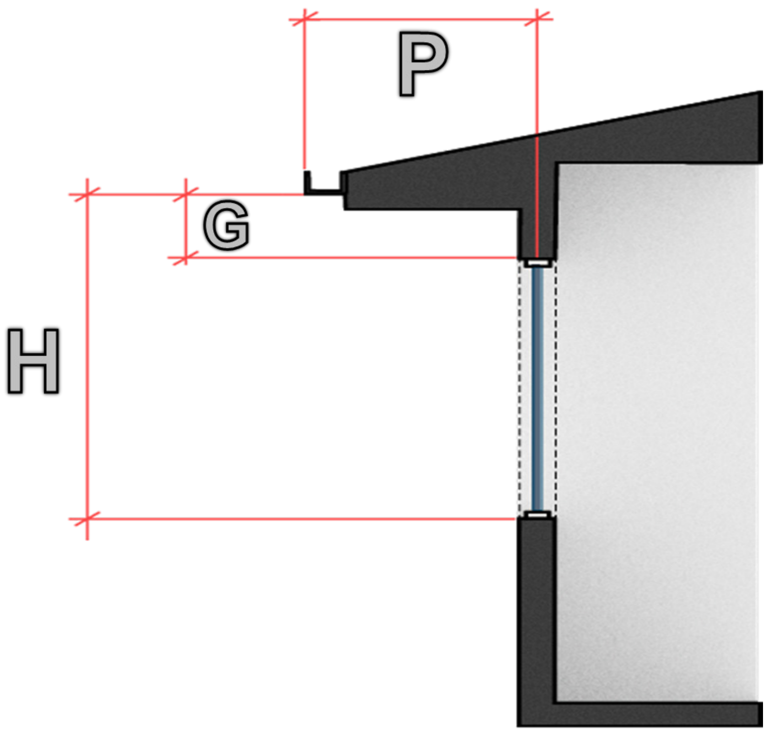
P is the horizontal projection of the shading projection from the face of the *glazing*. The projection is measured from the external face of the *window* glass to the shadow-casting edge of the projection. This may include the guttering on any eaves if it is mounted no higher on the facia than its own width.

H - Height

H is height of the shadow-casting edge of the projection above the base of the *glazing* element and the difference between the two is referred to as G. See Figure 9.7 below. If the height of the shading projection or device varies, the highest point shall be used.

Note that a shading device that complies with Clause 3.12.2.2(b) is considered to achieve a P/H value of 2.00 and when G exceeds 500 mm or more the value of P must be halved. This information is located in the Notes of Figure 3.12.2.2 in NCC Volume Two.

Figure 9.7 Method of measuring P and H



9.6 Shading

There are a range of options for shading but they commonly fall into two groups, namely:

(a) an external *permanent* projection; or
(b) an external shading device.

Either can be used for determining P/H.

Subclause 3.12.2.2(a) specifies that a *permanent* projection includes those such as a verandah, balcony, fixed canopy, eaves, shading hood, carport or the like.

A key requirement for a *permanent* projection is that it must extend horizontally on both sides of the *glazing* for at least the same distance as the projection distance P (as commonly occurs with eaves) or the equivalent shading must be provided by a reveal or the like.

Design alert: What is a reveal?

This is a surface formed when a *window* is recessed into the building face. The depth of a reveal can be increased (for shading purposes) by a vertical fin projecting from the building face. A reveal that extends for the full height of the opening and projects as far as the shading projection above would be considered to provide equivalent shading.

The second option for shading under clause 3.12.2.2 is in subclause (b) which specifies requirements for shading devices such as shutters or blinds or vertical / horizontal building screens with *fabric*, blades, battens or slats. Among other possible options, shutters can be side swing shutters that open or close across a *window* or roller shutters that can completely cover the glass.

To meet the requirements of 3.12.2.2(b) a shading device:

(a) must be capable of restricting at least 80% of summer solar radiation (this may be measured cumulatively over the three month period December to February for a fixed device, where the shading effect varies at different times, or be a constant 80% opacity for devices that shade by fully covering the *glazing*); and
(b) if adjustable, must be readily operated, including types which can be manually, mechanically or automatically adjusted by the occupants.

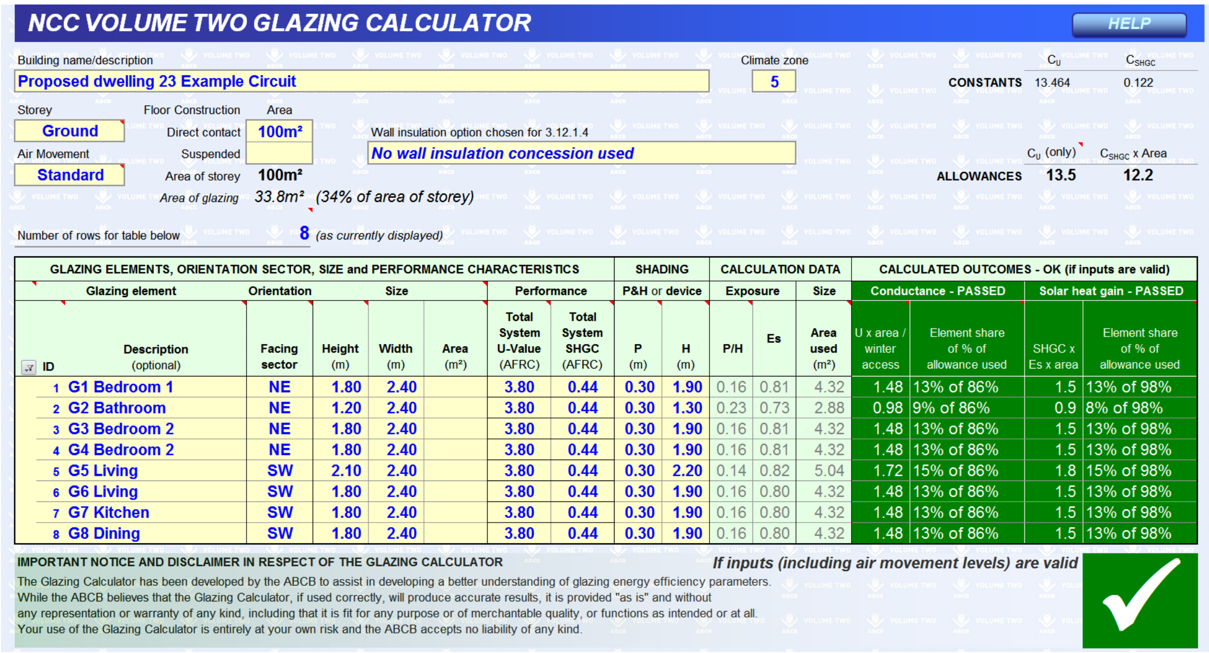
There is software available outside of the NCC than can calculate the summer solar radiation.

9.7 Glazing Calculator

The ABCB has developed a Glazing Calculator for NCC users to assist with demonstrating compliance with the NCC energy efficiency requirements for *glazing.* Practitioners may undertake to develop their own but need to demonstrate compliance with the NCC clauses, formulae and tables. Figure 9.8 shows a screenshot of the ABCB Glazing Calculator.

There is also a short YouTube clip describing the ABCB Glazing Calculator for NCC Volume Two available from the ABCB website (abcb.gov.au).

Figure 9.8 Screenshot of NCC Volume Two Glazing Calculator


NCC VOLUME TWO GLAZING CALCULATOR

HELP

Building name/description: Proposed dwelling 23 Example Circuit

Climate zone: 5

CONSTANTS: C_U 13.464; C_{SHGC} 0.122

Storey: Ground

Floor Construction / Area: Direct contact 100m²; Suspended

Air Movement: Standard

Area of storey: 100m²

Area of glazing: 33.8m² (34% of area of storey)

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

ALLOWANCES: C_U (only) 13.5; C_{SHGC} x Area 12.2

Number of rows for table below: 8 (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 / winter access	Element share of % of allowance used	SHGC x Es x area	Element share of % of allowance used
1	G1 Bedroom 1	NE	1.80	2.40		3.80	0.44	0.30	1.90	0.16	0.81	4.32	1.48	13% of 86%	1.5	13% of 98%
2	G2 Bathroom	NE	1.20	2.40		3.80	0.44	0.30	1.30	0.23	0.73	2.88	0.98	9% of 86%	0.9	8% of 98%
3	G3 Bedroom 2	NE	1.80	2.40		3.80	0.44	0.30	1.90	0.16	0.81	4.32	1.48	13% of 86%	1.5	13% of 98%
4	G4 Bedroom 2	NE	1.80	2.40		3.80	0.44	0.30	1.90	0.16	0.81	4.32	1.48	13% of 86%	1.5	13% of 98%
5	G5 Living	SW	2.10	2.40		3.80	0.44	0.30	2.20	0.14	0.82	5.04	1.72	15% of 86%	1.8	15% of 98%
6	G6 Living	SW	1.80	2.40		3.80	0.44	0.30	1.90	0.16	0.80	4.32	1.48	13% of 86%	1.5	13% of 98%
7	G7 Kitchen	SW	1.80	2.40		3.80	0.44	0.30	1.90	0.16	0.80	4.32	1.48	13% of 86%	1.5	13% of 98%
8	G8 Dining	SW	1.80	2.40		3.80	0.44	0.30	1.90	0.16	0.80	4.32	1.48	13% of 86%	1.5	13% of 98%

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If inputs (including air movement levels) are valid

The following is a description of key cells in the Glazing Calculator to explain its use. Additional advice can be found in the Help Screen of the Calculator.

9.7.1 Building parameters

(a) Building name/description – is used to identify the house that is being assessed by this spreadsheet (for example the street address).

(b) *Climate zone* – This cell requires the input of the proposed house's *climate zone;* which will be dependent upon the location of the house.

(c) *Storey* – Each *storey* of the house must be assessed using a different calculator sheet. Since *glazing* is assessed separately for each *storey*, input a number or word that clearly identifies which *storey* is being assessed by the calculator form.
(d) Air movement – This cell identifies the air movement as either “Standard”, “High” or an interpolated value between the two. How to determine the level of air movement is described in 3.12.2.1(c). This input must be separately verified as the Glazing Calculator does not determine what value should be used.
(e) Floor area - enter the floor area of the *storey* (as previously described in this chapter) subdividing the floor, if necessary, into the two floor types recognised, direct contact or suspended. For the purposes of Tables 3.12.2.1a to 3.12.2.1h, "Direct contact” is a floor in direct contact with the ground and "Suspended” is a suspended floor including a second *storey* floor. Note you do not need to input the “m^2” as this will automatically occur after you have entered the floor area value.
(f) Wall *insulation* option chosen for 3.12.1.4 – This outlines optional trading between *external wall* and *glazing* requirements in certain *climate zones* and relates to high mass walls. If a wall concession is used, the *glazing* allowance is decreased making the *glazing* requirements harder to achieve.

9.7.2 Constants and allowances

There is no user access to these cells to input data. However, once the building parameter cells have data in them (i.e. the *climate zone*, air movement and floor area), the constants and allowances will automatically change. The aggregate value for all the *glazing* elements combined must not be more than the allowances to achieve a pass.

9.7.2.1 Glazing elements details

(a) ID – The Calculator can display up to 80 rows. Not all the rows will be visible unless you change the number of rows displayed using the input immediately above the glazing elements table. Each row is numbered by default. You can use these numbers or any preferred code to identify each *glazing* element. Most architectural drawings and *window* schedules have nominated *window* numbers which can be used in this column or the adjoining “Description” column.
(b) Description - Input any desired description of the *glazing* element (e.g. room, size code, etc.). This is an optional input for the convenience of the user and the assessor.
(c) Facing sector - This is the orientation sector on Figure 3.12.2.1 that the *glazing* element faces. Eight orientation sectors are provided in the drop down box.

Select the applicable sector for each *glazing* element. It is important to select the right sector as this impacts which summer and winter exposure factors are used.

(d) Height, width, area - Rectangular *glazing* elements can be described by height and width. These are the outside frame dimensions. If height and width are entered, it is not necessary to input the area. If the *glazing* element is a non-rectangular shape, or identifies several identical elements being grouped as one, the area can be manually calculated and input into the area cell. For *glazing* elements with shading projections, it will still be necessary to input the height for the calculator to determine the shading effect. Note that height is not needed when a shading device is used.

9.7.2.2 Glazing performance

(a) *Total System U-Value* (AFRC) - This is the performance of the *glazing* (frame + glass) in terms of conduction.

(b) *Total System SHGC* (AFRC) - This is the performance of the *glazing* (frame + glass) in terms of its ability to transmit solar heat gain.

9.7.2.3 Shading (P/H or device)

(a) P – This is the horizontal distance (in metres) from the glass face to the shadow casting edge of any shading projection in accordance with clause 3.12.2.2. If a shading device that complies with subclause 3.12.2.2(b) is used, input the word “device” in the cell (and leave the corresponding H cell blank).

(b) H – This is the vertical distance from the base of the *glazing* element to the same shadow casting edge used to measure P.

If there is no shading, leave the P and H cells blank.

9.7.2.4 Calculation data

There is no user access to these cells which show the values being used to calculate the conductance and solar heat gain of each *glazing* element.

(a) P/H - This is automatically calculated from the values of P and H previously given. There are two important points to note: P/H values greater than 2 will receive the same shading credit as a value of 2 since this is the limit of the exposure factor tables (any such values will be highlighted in red bold font). Where the shading edge is more than 0.5 m above the head of the *glazing*, the value of P is halved when calculating P/H, in accordance with Figure 3.12.2.2 (any such values will be also highlighted by red italics font).

(b) Summer exposure factors (Es) - These are taken from Tables 3.12.2.2h to 3.12.2.2o for the appropriate *climate zone*, orientation sector and P/H. Where the P/H value falls between those shown in the table, the exposure factor is automatically interpolated.

(c) Area used -This is either the *glazing* element height multiplied by its width or any area given in the area column, whichever is the larger value.

9.7.2.5 Calculated outcomes

Calculated outcomes are not displayed until any input issues have been resolved. These issues will be highlighted by formatting or advisory messages. There are separate columns for the conductance and solar heat gain outcomes.

(a) U x area / winter access (conductance) - This automatically calculates the conductance of the individual *glazing* element in accordance with sub-clause 3.12.2.1(a). “Winter access” refers to the availability of wintertime solar gains to offset conducted heat losses.

(b) Element share of % of allowance used - The text message shows two percentage figures separated by “of”. The first percentage is the percentage that the individual *glazing* element contributes to the aggregate conductance for all listed *glazing* elements. It allows users to quickly identify which *glazing* elements are using the most from the allowance.

    The second percentage shows how the aggregate performance compares to the conductance allowance. This value will be 100% or less for complying designs. When it is less than 100%, users can readily see how much “headroom” exists in the *glazing* design for conductance. When the second percentage is more than 100%, it shows the extent of “overrun”. By looking at both percentages, users can identify how far the conductance needs to be improved and which elements are most influencing the result.

(c) SHGC x E_s x area (Solar heat gain) - This automatically calculates the solar heat gain of the individual *glazing* element in accordance with Clause 3.12.2.1(b).

(d) Element share of % of allowance used - This information is comparable to the details provided for conductance but is based on the outcomes for solar heat gain. The first percentage figure (for the element’s share of the aggregate outcome) is particularly important because the effect of exposure and shading make it harder for users to otherwise identify which elements are having the greatest effect on the solar heat gain result.

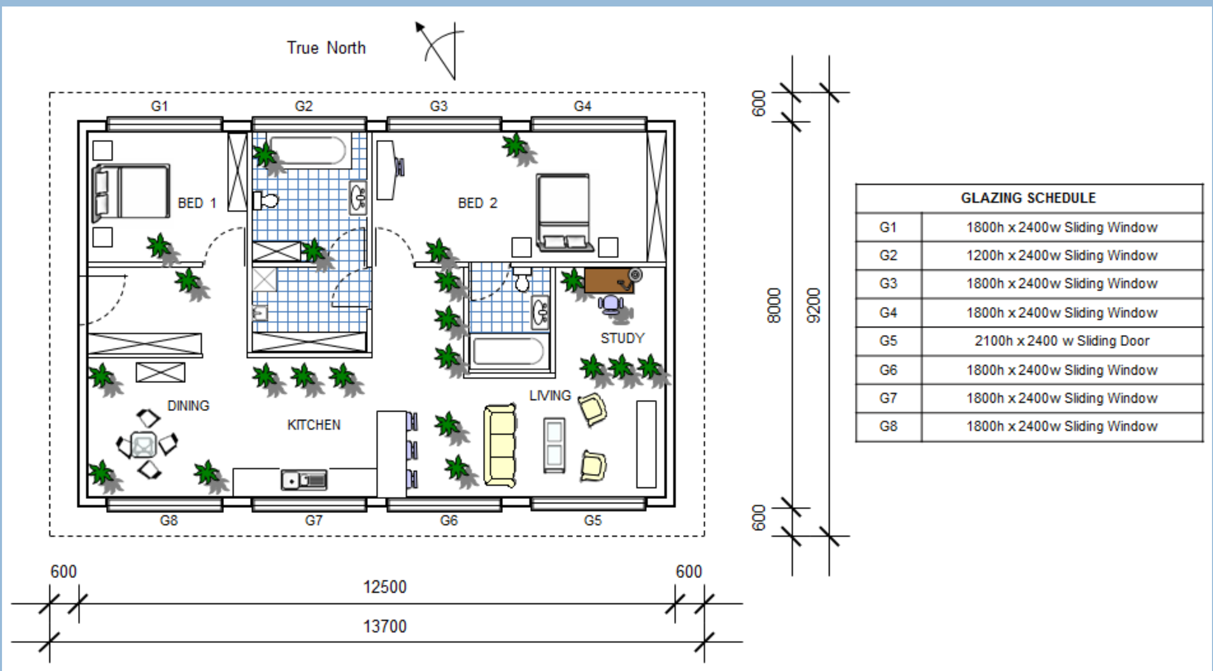
(e) Compliance indicator – The box below the calculated outcomes in the *glazing* elements table indicates whether the proposed *glazing* design meets the requirements of Part 3.12.2, provided inputs to the calculator are in accordance with those requirements. The calculator attempts to highlight improbable inputs but cannot validate every input. Subject to those qualifications, a tick means compliance has been achieved and a cross means compliance with the *glazing* requirements has not been achieved.

If the overall design does not comply, some of the design parameters (orientation, size, performance or shading) will need to be changed with the aid of the information provided in the two “element share of % of allowance used” columns.

Example:

The following is an example of how the Part 3.12.2 *DTS Provisions* are applied to a single *storey* house with a total floor area of 100 m^2 in *climate zone* 5 (illustrated below).

Figure 9.9 Floorplan and glazing schedule for the example



There are 8 external glazing elements and the glazing schedule is provided above. All of the *glazing* is proposed to be single pane glass in standard aluminium frames, which has a *Total System U-Value* of 7.9 W/m^2.K and a *Total System SHGC* of 0.81.

The house has a slab-on-ground floor and brick veneer *external walls*. The main entry door faces North West. The ceiling height is 2.4 m and there are 300 mm wide eaves located 100 mm above the *window* head height on all 4 sides.

No ceiling fans are installed in the house. However, the *glazing* and doors provide *ventilation openings* equal to about 14% of the floor area, which falls short of the 15% needed in *climate zone* 5 to be considered as having 'high' air movement. As this falls between the 'high' and 'standard' air movement the interpolated value of 1.85 will be used. (The design is 85% of the difference between standard (7.5%) and high (15%)).

Step 1 - Determine the allowances for the conductance and solar heat gain

Conductance

In *climate zones* 2 to 8, the conductance allowance is equal to the conductance constant (C_U).

$$Conductance\ allowance = C_u$$

For *climate zone* 5, the conductance constant (C_U) from Table 3.12.2.1e for a house with a floor in direct contact with the ground is **13.464.**

Solar heat gain

The solar heat gain allowance in all *climate zones* is calculated by multiplying C_{SHGC} by the floor area of the *storey*.

$$Solar\ heat\ gain\ allowance = Floor\ Area\ \times C_{SHGC}$$

The floor area of the house is 100 m^2. The solar heat gain constant (C_{SHGC}) from Table 3.12.2.1e for a house with a floor in direct contact with the ground and an interpolated air movement of 1.85 in *climate zone* 5 is 0.132. This is calculated as lying at the 85% point between the standard and high C_{SHGC} values, 0.122 and 0.134.

$$Solar\ heat\ gain\ allowance = 100\ \times 0.132 = 13.2$$

For this house, the solar heat gain allowance is **13.2.**

Step 2 - Determine the conductance and solar heat gain of the proposed design

Conductance

In *climate zone* 5, the conductance of the proposed design is calculated using the formula in 3.12.2.1(a)(ii)(B).

$$[(A_1 \times U_1) + (A_2 \times U_2) + \cdots] \div [(A_1 \times SHGC_1 \times E_{W1}) + (A_2 \times SHGC_2 \times E_{W2}) + \cdots]$$

The *glazing* schedule provides the area details and the *Total System U-Value* and *Total System SHGC* were identified earlier as 7.9 and 0.81 respectively. The remaining values to be determined are the appropriate winter exposure factors (E_w), which requires the P and H shading values to be calculated.

P is measured horizontally from the face of the glass to the shadow casting edge of the shading projection. Allowing for no setback of the *window* (i.e. no external reveal) and a 300 mm eaves, including the standard fascia gutter, P is 300 mm or 0.3 m for all *glazing* elements. H is measured vertically from the base of each *glazing* element to the outer shadow casting edge of the projection. In this case, that is the lower edge of the fascia gutter, which is mounted 100mm or 0.1m above the bottom of the fascia. Assume that the bottom of the fascia is at head height for all *windows* and doors. The value of H will vary for *glazing* elements of different heights but will be equal to the *glazing* height plus 0.1 m. The P/H and E_w for the different *glazing* elements are detailed below.

Table 9.1 P/H and Ew for different glazing elements

Glazing element ID	Orientation	P/H	E_w
1	NE	0.3/1.9=0.16	1.27
2	NE	0.3/1.3=0.23	1.24
3	NE	0.3/1.9=0.16	1.27
4	NE	0.3/1.9=0.16	1.27
5	SW	0.3/2.2=0.14	0.29
6	SW	0.3/1.9=0.16	0.29
7	SW	0.3/1.9=0.16	0.29
8	SW	0.3/1.9=0.16	0.29

Tables 3.12.2.2a to 3.12.2.2g for winter exposure factors, E_w, includes P/H values of 0.10, 0.20 and 0.40. P/H values between those shown in Tables 3.12.2.2a to 3.12.2.2g must be rounded down to the nearest smaller P/H value or interpolated if

greater precision is wanted. The E_w in the table above have been interpolated. The Glazing Calculator automatically interpolates intermediate values.

Using all the information for this example in *climate zone* 5, the conductance of the design is calculated below. Note *glazing* elements with common characteristics have been grouped together.

$$\frac{[(A_1 \times U_1) + (A_2 \times U_2) + \cdots]}{[(A_1 \times SHGC_1 \times E_{W1}) + (A_2 \times SHGC_2 \times E_{W2}) + \cdots]}$$

$$\frac{[6 \times (4.32 \times 7.9) + (2.88 \times 7.9) + (5.04 \times 7.9)]}{[3 \times (4.32 \times 0.81 \times 1.27) + (2.88 \times 0.81 \times 1.24) + (5.04 \times 0.81 \times 0.29) + 3 \times (4.32 \times 0.81 \times 0.29)]}$$

The aggregate conductance of the proposed design is **13.07**. This not more than the allowance of **13.464** and therefore the conductance complies.

Solar heat gain

In *climate zone* 5, the solar heat gain of the proposed design is calculated using the formula in 3.12.2.1(b)(ii).

$$(A_1 \times SHGC_1 \times E_{S1}) + (A_2 \times SHGC_2 \times E_{S2}) + \ldots.$$

As described earlier, the *glazing* schedule provides the area details and the *Total System U-Value* and *Total System SHGC* being 7.9 and 0.81 respectively. The remaining values to be determined are the appropriate summer exposure factors (E_s), which requires the P and H shading values calculated earlier. The E_s for the different *glazing* elements are added to the previous table and shown below.

Table 9.2 P/H value, Ew and Es for each glazing element in this example

Glazing element ID	Orientation	P/H	E_w	E_s
1	NE	0.3/1.9=0.16	1.27	0.81
2	NE	0.3/1.3=0.23	1.24	0.73
3	NE	0.3/1.9=0.16	1.27	0.81
4	NE	0.3/1.9=0.16	1.27	0.81
5	SW	0.3/2.2=0.14	0.29	0.82
6	SW	0.3/1.9=0.16	0.29	0.80

Glazing element ID	Orientation	P/H	E_w	E_s
7	SW	0.3/1.9=0.16	0.29	0.80
8	SW	0.3/1.9=0.16	0.29	0.80

Like the winter exposure factors, Tables 3.12.2.2h to 3.12.2.2o for summer exposure factors, E_s, includes P/H values of 0.10, 0.20 and 0.40. P/H values between those shown in Tables 3.12.2.2h to 3.12.2.2o must be rounded down to the nearest smaller P/H value or interpolated if greater precision is wanted. The E_s in the table above have been interpolated. The Glazing Calculator automatically interpolates intermediate values.

Using all the information for this example in *climate zone* 5, the solar heat gain of the design is calculated below. Note *glazing* elements with common characteristics have been grouped together.

$$(A_1 \times SHGC_1 \times E_{S1}) + (A_2 \times SHGC_2 \times E_{S2}) + \ldots.$$

$$3 \times (4.32 \times 0.81 \times 0.81) + (2.88 \times 0.81 \times 0.73) + (5.04 \times 0.81 \times 0.82) + 3 \times (4.32 \times 0.81 \times 0.80)$$

The aggregate of solar heat gain of the proposed design is **21.952.** This is more than the allowance of **13.2** and therefore the solar heat gain does not comply.

Step 3 Compliance criterion

In summary, the aggregate conductance and solar heat gain for the proposed design must be less than the allowances in both cases.

$$Design\ (Step\ 2\ )\ \leq\ Allowance\ (Step\ 1)$$

All the inputs must accurately represent the *climate zone*, the floor type, the floor area, the air movement level, the location and size of every *glazing* element, the thermal performance values for the *glazing* type(s) and any shading provisions. Shading must also meet the requirements of Clause 3.12.2.2 for the results to be valid.

Conductance

In this example, the aggregate conductance of the proposed design is **13.07**. This not more than the allowance of **13.464** and therefore the conductance complies.

Solar heat gain

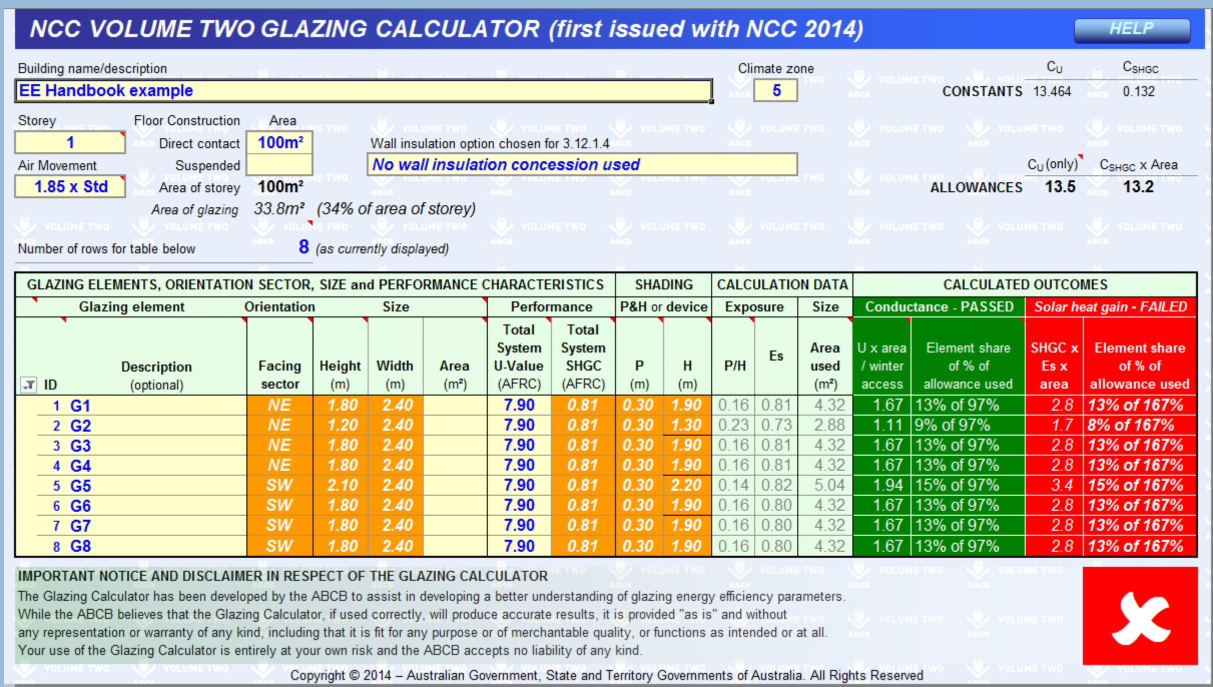
In this example, the solar heat gain of the proposed design is **21.952.** This is more than the allowance of **13.2** and therefore the solar heat gain does not comply.

Since both the conductance and solar heat gain are not less than their respective allowances, this design does not comply. To achieve compliance, changes to the *glazing* are necessary.

The Glazing Calculator

The figure below shows the Glazing Calculator for this example.

Figure 9.10 Glazing calculator for this example



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

HELP

Building name/description: EE Handbook example

Climate zone: 5

CONSTANTS: C_U 13.464; C_{SHGC} 0.132

Storey: 1

Floor Construction / Area: Direct contact 100m²; Suspended; Area of storey 100m²

Area of glazing 33.8m² *(34% of area of storey)*

Air Movement: 1.85 x Std

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

ALLOWANCES: C_U (only) 13.5; C_{SHGC} x Area 13.2

Number of rows for table below: 8 *(as currently displayed)*

GLAZING ELEMENTS, ORIENTATION SECTOR, SIZE and PERFORMANCE CHARACTERISTICS								SHADING		CALCULATION DATA			CALCULATED OUTCOMES			
Glazing element		Orientation	Size			Performance		P&H or device		Exposure		Size	Conductance - PASSED		*Solar heat gain - FAILED*	
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 / winter access	Element share of % of allowance used	SHGC x Es x area	Element share of % of allowance used
1	G1	NE	1.80	2.40		7.90	0.81	0.30	1.90	0.16	0.81	4.32	1.67	13% of 97%	2.8	13% of 167%
2	G2	NE	1.20	2.40		7.90	0.81	0.30	1.30	0.23	0.73	2.88	1.11	9% of 97%	1.7	8% of 167%
3	G3	NE	1.80	2.40		7.90	0.81	0.30	1.90	0.16	0.81	4.32	1.67	13% of 97%	2.8	13% of 167%
4	G4	NE	1.80	2.40		7.90	0.81	0.30	1.90	0.16	0.81	4.32	1.67	13% of 97%	2.8	13% of 167%
5	G5	SW	2.10	2.40		7.90	0.81	0.30	2.20	0.14	0.82	5.04	1.94	15% of 97%	3.4	15% of 167%
6	G6	SW	1.80	2.40		7.90	0.81	0.30	1.90	0.16	0.80	4.32	1.67	13% of 97%	2.8	13% of 167%
7	G7	SW	1.80	2.40		7.90	0.81	0.30	1.90	0.16	0.80	4.32	1.67	13% of 97%	2.8	13% of 167%
8	G8	SW	1.80	2.40		7.90	0.81	0.30	1.90	0.16	0.80	4.32	1.67	13% of 97%	2.8	13% of 167%

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Achieving compliance

An option to achieve compliance for this example is to improve the performance of the *glazing* elements (i.e. the *Total System U-Value* and *Total System SHGC*). By improving the *glazing* performance from a single, clear glass in an aluminium frame to a tinted, low emissivity glass in a standard aluminium frame, the *Total System U-*

Value and *Total System SHGC* change to 4.5 and 0.45, respectively. Note these are not representative of a specific *window* manufacturer's data. Data relevant to the specific *windows* being installed should be used.

Changing the *glazing* performance using the Glazing Calculator, shown below, demonstrates that this achieves compliance (a pass) for the proposed design.

Figure 9.11 Updated glazing calculator after improving glazing performance

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

Building name/description: EE Handbook example

Climate zone: 5

CONSTANTS: C_U 13.464; C_{SHGC} 0.132

Storey: 1

Floor Construction / Area: Direct contact 100m²; Suspended

Area of storey: 100m²

Air Movement: 1.85 x Std

Area of glazing: 33.8m² (34% of area of storey)

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

ALLOWANCES: C_U (only) 13.5; C_{SHGC} x Area 13.2

Number of rows for table below: 8 (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 / winter access	Element share of % of allowance used	SHGC x Es x area	Element share of % of allowance used
1	G1	NE	1.80	2.40		4.50	0.45	0.30	1.90	0.16	0.81	4.32	1.71	13% of 99%	1.6	13% of 93%
2	G2	NE	1.20	2.40		4.50	0.45	0.30	1.30	0.23	0.73	2.88	1.14	9% of 99%	0.9	8% of 93%
3	G3	NE	1.80	2.40		4.50	0.45	0.30	1.90	0.16	0.81	4.32	1.71	13% of 99%	1.6	13% of 93%
4	G4	NE	1.80	2.40		4.50	0.45	0.30	1.90	0.16	0.81	4.32	1.71	13% of 99%	1.6	13% of 93%
5	G5	SW	2.10	2.40		4.50	0.45	0.30	2.20	0.14	0.82	5.04	1.99	15% of 99%	1.9	15% of 93%
6	G6	SW	1.80	2.40		4.50	0.45	0.30	1.90	0.16	0.80	4.32	1.71	13% of 99%	1.6	13% of 93%
7	G7	SW	1.80	2.40		4.50	0.45	0.30	1.90	0.16	0.80	4.32	1.71	13% of 99%	1.6	13% of 93%
8	G8	SW	1.80	2.40		4.50	0.45	0.30	1.90	0.16	0.80	4.32	1.71	13% of 99%	1.6	13% of 93%

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Your use of the Glazing Calculator is entirely at your own risk and the ABCB accepts no liability of any kind.

If inputs (including air movement levels) are valid ✓

9.8 Glazing strategies

9.8.1 Balancing summer and winter performance using E_W/E_S

The E_W/E_S value indicates the relative impact of the winter and summer exposures for a given *glazing* orientation and shading arrangement. A number greater than 1 indicates a *glazing* element where there is significant benefit in winter without too much penalty in summer. A number lower than 1 indicates that increasing the area will cause a summer penalty greater than the winter benefit.

9.8.2 Device shading

One way of balancing winter and summer performance is to use a "device" which can be adjusted to suit the season (see subclause 3.12.2.2(b) in NCC Volume Two). Adjustable shading, such as a rollup awning, can be assessed in the Calculator by completing two separate reports. A first report, for "summer performance", would include the "device" and demonstrate compliance with solar heat gain requirements by not exceeding 100% of the solar heat gain allowance. The second report, for "winter performance" would replace the "device" by shading P/H values which reflect its retracted state and demonstrate compliance for conductance by not exceeding 100% of the conductance allowance. The two reports, taken together, would provide evidence of overall compliance, provided they vary only in the extent of shading provided by the "device".

9.9 Additional Information

9.9.1 Changes in the calculation methodology

The methodology used to determine *glazing* compliance using the *DTS Provisions* changed in BCA 2010 to better align with the energy rating approach. These changes are described below.

9.9.1.1 Conductance calculation

The conductance calculation for *climate zones* 2 to 8 no longer sets an allowance based on the floor area. The calculation is best thought of as "winter performance" and, despite being labelled "conductance", is also affected by the *Total System SHGC* and shading. The "winter performance" aims to ensure that the total heat lost by conduction through the *glazing* will not exceed the direct solar gains available across all *glazing* in that *storey* of the dwelling. The new calculation has a number of implications:

- Lower *Total System U-Values* are generally better, as they limit the heat lost through the *glazing* in winter and the amount of unwanted heat gained by conduction during summer.

- In cooler *climate zones*, higher *Total System SHGCs* are better, as they allow more direct solar gains.
- Using shading, rather than tinting, can allow compliance with the summer-based solar heat gain calculation while still achieving useful winter solar gains. Tinting (which lowers the *Total System SHGC*) has the same effect in both summer and winter.
- Over-shading (that is, having too much shading) is heavily penalised in cooler *climate zones* as it limits the amount of direct solar gains in winter. This can be recognised when the Calculator shows that the “% of allowance used” for solar heat gain is very low. Optimal shading for winter conditions still needs to be balanced with the solar heat gain, or “summer performance”.
- The winter solar gains are generally only high enough to be beneficial on the north, north east and north west orientations. The more *glazing* on the E-SE-S-SW-W orientations, the greater the amount needed to compensate on the NW-N-NE orientations. For alterations and additions, this can have a significant impact. Further guidance is provided below.
- Because the requirement does not depend on floor area, there is no arbitrary limit to the amount of *glazing.* Sometimes the answer is to put in more *glazing* (of a suitable type) on beneficial orientations. Changing the shape of *glazing* can also help. For an opening of a given area, lowering the sill can expose the *glazing* to winter sun while keeping it fully shaded in summer. Where it is not possible to add *glazing* on the beneficial orientations, it may be necessary to decrease the amount of *glazing* on the other orientations or to select *glazing* with lower *Total System U-Values*.

Note that the conductance calculation methodology for *climate zone* 1 did not changed.

9.9.1.2 Exposure factors

The calculation now uses exposure factors for both winter and summer performance. They depend on the orientation and the shading.

- E_W refers to the winter exposure factor. Higher numbers are better. Generally, a number greater than 1 indicates a “beneficial” exposure, that is, a good combination of orientation and shading for *glazing* in winter. Conduction compliance may be assisted by **increasing** *glazing* areas with “beneficial” exposures. Exposure factors below 1 can still be viable but may require *glazing* with better (that is, lower) *Total System U-Values*.

- E_s refers to the summer exposure factor. Lower numbers are better. A larger number indicates that, for the same *glazing* type and area, the *glazing* will use up more of the solar heat gain allowance.

Guidance on how to balance summer and winter *glazing* performance using the ratio of E_w to E_s (E_w/E_s) is given in other parts of this section.

9.9.2 Changes to the Glazing Calculator layout

The more significant additions and changes to the layout of the Glazing Calculator (first issued with BCA 2010 and compared to previous versions BCA 2009 and earlier) are identified below.

9.9.2.1 Climate zone

The *climate zone* is now entered in the cell to the right of the building description.

9.9.2.2 Floor construction

The floor construction is now more clearly identified. Rather than the floor type being identified as Type A or B it is now described as “Direct Contact” or “Suspended”. Either or both types can be used. Where two floor types are nominated, they must be on the same *storey*. The Calculator will determine a composite *glazing* stringency for the *storey*, taking account of the relative areas of each floor type. Previous Calculators reported the outcomes separately for each floor type.

9.9.2.3 Orientation/facing sector

The orientation is now a single column due to the change in how the floor construction is entered.

9.9.2.4 Air movement

The air movement is now entered in the cell below the *storey* rather than the cell beneath the *floor area*, and is denoted by the words “Standard” or “High” rather than S or H. A number between 1 and 2 can be entered if the *ventilation opening* area is between Standard and High, and the solar heat gain allowance will be adjusted accordingly.

9.9.2.5 Wall insulation concession (first added in BCA 2010 Glazing Calculator)

This cell refers to the optional trade-offs between wall *insulation* and *glazing* performance permitted by 3.12.1.4(c) for high-mass walls. Where such an *insulation* concession is used, the *glazing* stringency is increased as indicated in the top-right-hand corner of the Glazing Calculator.

9.9.2.6 Exposure factor (variable display first added in BCA 2010 Glazing Calculator)

Clicking in the title row under “Exposure” makes a drop-down menu available to change the exposure factor information currently displayed. Choose from either “E_S”, “E_W” or “E_W/E_S”. These are described previously in the changes to the calculation methodology and *glazing* strategies.

Note that dwellings with multiple *storeys* still require a separate Glazing Calculator report for each storey.

9.9.3 Glazing in alterations and additions

The information below is of a general nature as the application of the NCC requirements to alterations and additions is governed by State and Territory building and plumbing legislation. The specific arrangements in the relevant State or Territory jurisdiction may be different to that described below. The final decision will be determined by the *Appropriate Authority* and is dependent upon the particular characteristics of the existing building, and the type and extent of work being carried out.

9.9.3.1 Where an upgrade is required by the State or Territory legislation

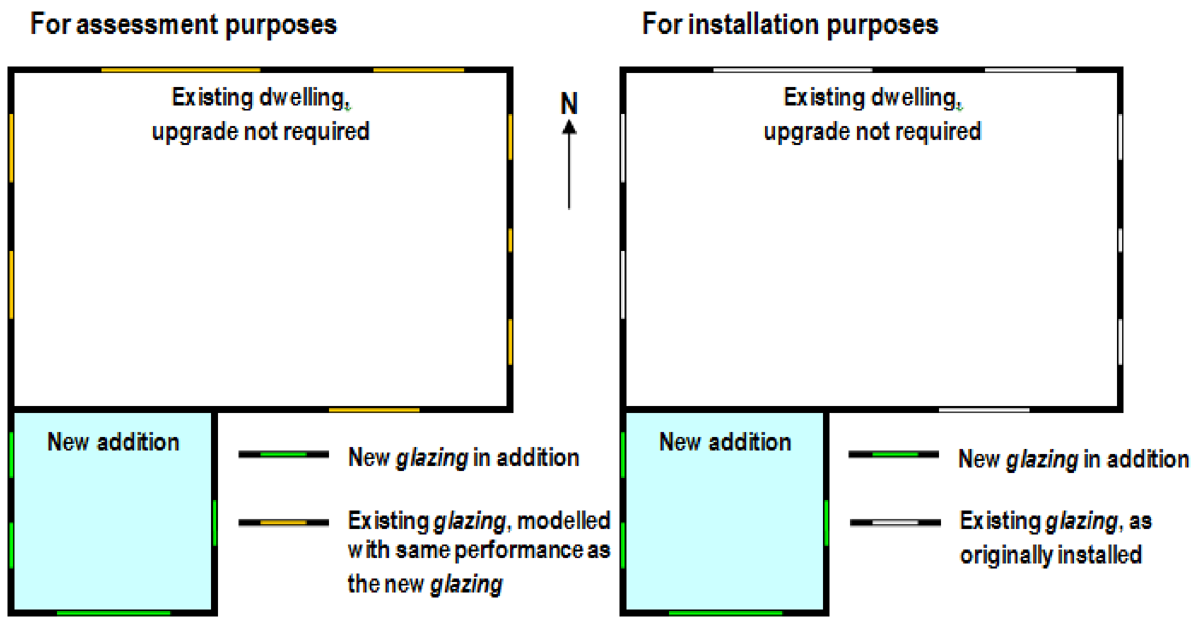
Where an upgrade to the existing dwelling is required, the existing *glazing* may also need to be replaced in accordance with requirements of the *Appropriate Authority*.

9.9.3.2 Where an upgrade is not required by the State or Territory legislation

Where an upgrade to the existing dwelling is not required, it would be reasonable to assess the compliance as if the new *glazing* were uniformly applied to the whole *storey*, but to require the complying *glazing* to be installed only in the alteration or addition.

It may be very costly or even impossible for new *glazing* in an alteration or addition to compensate for the poor performance of existing *glazing*, especially for an alteration or addition that does not have any north-facing *glazing* in a cooler climate.

Figure 9.12 Potential option for assessing glazing in an alteration or addition



Alert:

Remember to check with the *Appropriate Authority* as to whether or not this approach is applicable or acceptable in that jurisdiction.

10 Part 3.12.3 - Building sealing

10.1 Introduction

The NCC Volume Two building sealing *DTS Provisions* have been developed to limit unwanted air leakage into or out of the building. Any unintended air leakage may mean the loss of conditioned air, or short circuit the controlled air movement requirements of Part 3.12.4, which will be discussed in the next chapter of this Handbook.

Overall, the *DTS Provisions* encourage ventilation that can be controlled by occupants to make use of warmer or cooler outside air when desirable, and to also maintain a healthy indoor environment. Building sealing supports that goal by reducing the pathways for unseen and unintended leakage of air that has been heated or cooled for the comfort of occupants. This, in turn, has the capacity to reduce the energy required for artificial heating, cooling and dehumidifying. Health and amenity requirements can be found in Part 3.8 of NCC Volume Two. This includes minimum requirements for ventilation and managing *condensation*.

As with all aspects of the *DTS Provisions*, each element within Part 3.12.3 is designed to work as part of a system approach to ensure the building achieves the desired level of energy efficiency.

Reminder

The requirements in Part 3.12.3 of NCC Volume Two apply to Class 1 dwellings, even if a house energy rating approach has been used. Refer to Chapter 7 for more information.

10.2 Scope

The building sealing requirements address the following elements of a building:

(a) chimneys and flues;
(b) *roof lights*;

(c) external *windows* and doors;
(d) exhaust fans;
(e) construction of ceilings, walls and floors; and
(f) *evaporative coolers.*

The requirements have been developed to address conditions most likely to be experienced in the eight *climate zones* adopted by the NCC, appropriate to the use of particular spaces within a dwelling, and whether artificial heating or cooling is used.

A number of concessions and exemptions are provided and these are described later in this chapter.

10.3 Intent

The intent of Part 3.12.3 is to restrict the unintended leakage of outdoor air into the dwelling and the loss of conditioned air from the dwelling.

In addition to unnoticed air leakage, drafts caused by poorly sealed external openings and construction gaps can affect the building occupants' sense of comfort, causing them to increase the use of artificial heating and cooling. Leakage of humid air into an air-conditioned building can increase energy needed for dehumidification.

Air leakage most commonly occurs at the:

- roof to wall junction;
- floor to wall junction;
- wall to door frame junction;
- wall to *window* frame junction; and
- all services penetrations.

The requirements in 3.12.3 are designed to control this leakage and the loss of conditioned air. In hotter climates, an air-conditioning system will initiate the requirements through the defined term *conditioned space*. In cooler climates, where heating will be used during winter months, the building is required to be sealed to prevent the undue loss of heated air.

However, the application of these requirements does not prevent occupants from using *windows* and doors to control ventilation as needed to maintain indoor air quality, or to open the house to favourable outdoor conditions. These ventilation requirements are recognised in Part 3.12.4, which is discussed in the next chapter of this Handbook. The intention of the sealing requirements of Part 3.12.3 of NCC Volume Two is to minimise unwanted air leakage only.

10.4 Application

The sealing requirements apply to all Class 1 buildings (dwellings) and Class 10a buildings (garages and carports etc.) with a *conditioned space*. However there are a number of exemptions intended to exempt buildings or parts of buildings that should not be sealed for one reason or another. These exemptions are:

1. buildings in *climate zones* 1, 2, 3 and 5 where *evaporative coolers* are the only means of air-conditioning; and

2. *ventilation openings* needed for the safe use of a gas appliance. However, the concession is limited only to the opening necessary for the use of that appliance.

The first exemption recognises that an *evaporative cooler* requires external air to be introduced to allow the cooler to work effectively and *climate zones* 1, 2, 3 and 5 generally require more cooling rather than heating. This concession does not extend to *climate zones* 4, 6, 7 & 8 due to the likelihood of heating being needed during colder periods, which will require sealing measures to prevent heat loss.

As outlined in the second exemption, *ventilation openings* installed in the building for the safe operation of gas appliances do not need to comply with the requirements. This may include wall vents and the like, needed for the appliance. However, the concession is limited to the areas required for the safe operation of that equipment. Appropriate ventilation and associated area for gas appliances can be obtained from relevant legislation, standards and product installation manuals.

10.5 Chimneys and flues

A chimney or flue serving an open solid fuel burning appliance is required to have a damper or flap fitted that can be closed to seal the chimney or flue. The damper or flap may be operated by the occupants to close off the flue to prevent conditioned air being drawn up the chimney or flue when the appliance is not in use, especially during the summer months.

It is important to note that only appliances with an open face, which burn a solid fuel such as wood, coal or the like, are required to have a damper or flap. This clause is not applicable to gas and liquid fuel burning devices. Part 3.10.7 of NCC Volume Two should also be referred to for relevant fire safety requirements.

10.6 Roof lights

10.6.1 What roof lights need sealing?

Clause 3.12.3.2(a) provides general requirements for sealing *roof lights,* and covers two distinct situations where *roof lights* must be sealed, or *capable* of being sealed. The first situation is when they serve a *conditioned space*. The second situation is when they serve a *habitable room* in *climate zones* 4, 5, 6, 7 and 8.

Subclause (a)(i) indicates that all *conditioned spaces* must have sealed *roof lights*, irrespective of whether the room is habitable or not. Accordingly, a *roof light* in *climate zone* 1 will need to be sealed if it serves a laundry that is artificially heated or cooled. Conversely, it would not require sealing if the laundry was not artificially heated or cooled, because the room is not considered to be a *habitable room* for the purposes of the NCC.

10.6.2 How are roof lights sealed?

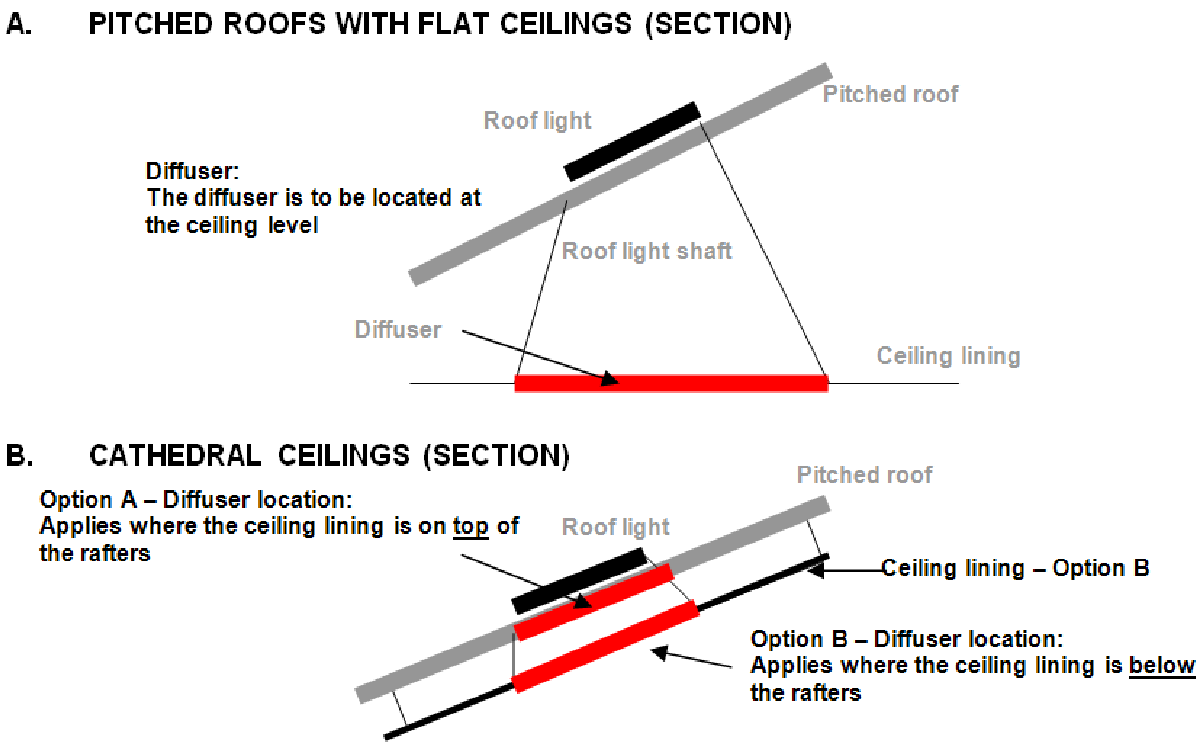
There are three options for achieving a complying seal;

1. An imperforate (secondary) diffuser installed at the ceiling level or the internal lining level. In cathedral ceilings, the diffuser can be installed at the lower edge of the *roof light* shaft opening. The diffuser is typically an *opaque* sheet of plastic used to reduce glare from the *roof light*. Refer to 1 for suitable ceiling diffuser locations.

2. A weatherproof seal can be installed and although it is not mentioned in the clause, the seal could be a foam or rubber compressible strip or the like similar to those for sealing external doors and *windows*.

3. A shutter system can be installed that is operated either manually, electronically or mechanically. It is also a requirement to make sure the operating mechanisms are easily accessible to the occupant so they can be readily used.

Figure 10.1 Suitable location of ceiling diffusers



Reminder:

A *window* is considered to be a *roof light* only when in a plane that is between 0 and 70 degrees measured from the horizontal. Glazed openings that are installed in roofs with a greater angle are considered to be *windows* and are addressed in Chapter 9. Further detail on *roof lights* is located in Chapter 8 of this document.

10.7 External windows and doors

3.12.3.3(a) outlines that external doors, internal doors between a Class 1 building and an unconditioned Class 10a, openable *windows* and similar openings must be sealed when they serve a *conditioned space* in any *climate zone,* or a *habitable room* in *climate zones* 4, 5, 6, 7 and 8.

Internal doors between a Class 1 building and an unconditioned Class 10a (e.g. a private garage) should also be sealed to stop air leakage, which can undermine the thermal performance of the Class 1 building.

3.12.3.3(b)(i) states a door must have a seal on the bottom edge that is a draft protection device and (ii) outlines that any openable device (door, *window* or shutter) must have a seal on all edges, which can be a foam, rubber compressible strip, fibrous seal or the like.

The intention of these requirements is to limit unintended leakage of outdoor air into the dwelling and the loss of conditioned air from the dwelling when *windows*, doors and other openings are closed.

3.12.3.3(c) exempts *windows* from the requirements of (b)(ii) if they comply with maximum air infiltration rates in the standard AS 2047 Windows in buildings – selection and installation. The *window* sealing requirements within this standard are deemed to be acceptable.

10.8 Exhaust fans

Unsealed exhaust fans are essentially openings in the insulated *envelope*, through which conditioned air will escape when they are not operating. Accordingly, the intention of this requirement is to restrict the extent of air leakage through intermittently operating fans; requiring them to be sealed when not in operation. The requirement applies to exhaust fans when they are located in a *conditioned space* in any *climate zone,* or serving a *habitable room* in *climate zones* 4, 5, 6, 7 and 8.

This requirement can be achieved by simple flap damper systems that are readily available for most fan types. Alternatively, a mesh filter system, similar to that used in kitchen range hoods, is acceptable as it significantly restricts the flow of air when the fan is not operating.

10.9 Construction of ceilings, walls and floors

This requirement applies to the external *fabric* elements of the building such as ceilings, walls and floors and any opening in those elements, again, when they are located in a *conditioned space* in any *climate zone* or serving a *habitable room* in *climate zones* 4, 5, 6, 7 and 8.

The requirement is intended to limit air leakage through gaps at the junctions of each element and around openings, such as between a *window* or door frame and a wall lining.

In most instances, conventional internal fixing and finishing procedures will be sufficient to comply with the required seal, provided linings are close fitting at ceiling, wall and floor junctions; or sealed at junctions and penetrations by skirtings, architraves, cornices, or expanding foam, rubber compressive strip, caulking or the like.

Design alert: What does close fitting mean?

If we consider that doors and *windows* require a compressible seal, it would not be acceptable to have visible gaps surrounding the *window* or door unit. Accordingly, a reasonable interpretation of “close fitting” could be having a gap less than that between a closed *window* or door and the associated frame.

It is noted that some lining systems such as plasterboard require gaps to allow for movement of sheeting, and this is acceptable. Square set ceilings without cornices could also be sufficient to minimise air leakage.

As already mentioned, in most instances, this clause will be addressed by conventional construction practices i.e. no additional measures will be required to seal the internal space from the external space. Where gaps occur and architraves, skirtings or cornices are not being used, it is necessary to seal any opening with caulking or other flexible sealant, such as expanded foam or other gap filling material.

10.10 Evaporative coolers

Similar to fans, *evaporative coolers* must have self-closing dampers to prevent loss of heated air in those climates where heating may be needed in the winter. Typically, as per the requirement, this would occur in *habitable rooms* in *climate zones* 4, 5, 6, 7 and 8. However, dampers are also required in any *climate zone* if the space served by the *evaporative cooler* has a heating system, even if the space is non-habitable. This is because heated air will leak through the unsealed cooler or its ductwork.

11 Part 3.12.4 - Air movement

11.1 Introduction

The NCC Volume Two air movement *DTS Provisions* for energy efficiency have been developed to take advantage of two cooling effects that are provided by air movement. The first effect occurs by increasing the speed of air passing over the skin. Moving air can make building occupants feel cooler, even when the air temperature inside the building has not changed. This effect can be provided by fans or by natural cross flow ventilation.

The second effect occurs when cooler outside air flows into the building and displaces warmer air. This effect is most likely to be available when overnight temperatures drop significantly from daytime levels.

11.2 Scope

The air movement requirements specify minimum total *ventilation openings* to *habitable rooms* and include some concessions for the use of ceiling fans and *evaporative coolers*.

11.3 Intent

The applicable part of the *Performance Requirement* P2.6.1 states:

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 -…

(f) the utilisation of air movement to assist cooling …

The intention of this *Performance Requirement* is for the building to have features that enable artificial heating and cooling to be used in an efficient manner, thereby reducing energy consumption and associated greenhouse gas emissions. By providing the cooling effects of natural cross flow ventilation and of ceiling fans or *evaporative coolers*, the likelihood of artificial cooling systems being used and the extent of their use may be reduced.

Ventilation, even by ceiling fans or *evaporative coolers*, is a cost effective solution that results in lower GHG emissions than artificial cooling systems such as refrigerated air-conditioning.

11.4 Application

Clause 3.12.4 outlines that the requirements in Part 3.12.4 are only applicable to *habitable rooms* in Class 1 buildings. This means the requirements are not applicable to non-*habitable rooms* such as bathrooms, laundries, corridors etc.

11.5 Air movement

Air movement requirements must be provided in accordance with Table 3.12.4.1 of NCC Volume Two which specifies the minimum total *ventilation opening* area required for each *habitable room*, expressed as a percentage of the *floor area*.

The requirements recognise the contribution of ceiling fans and *evaporative coolers*, as well as *ventilation openings* such as *windows* and doors. *Ventilation openings* are required to be sized and located to *facilitate* cross flow ventilation through all *habitable rooms*. The blue dashed arrows in Figure 11.1 below illustrate cross flow ventilation.

Figure 11.1 Cross flow ventilation

Table 3.12.4.1 includes variables such as *climate zones*; and whether the room has a ceiling fan or *evaporative cooler* with options being:

- without a ceiling fan or *evaporative cooler*;
- with a ceiling fan; and
- with an *evaporative cooler*.

Design alert:

As air movement mainly provides a cooling effect, ventilation requirements beyond those required by Part 3.8.5 of NCC Volume Two are specified only for the *climate zones* with extended periods of hot weather, i.e. NCC *climate zones* 1, 2, 3, 4 and 5.

This is because the openings required by Part 3.8.5 of NCC Volume Two are considered sufficient for *climate zones* 6, 7 and 8.

Part 3.8.5 of NCC Volume Two covers the minimum ventilation requirements to address adequate health and amenity.

Design alert:

Since *evaporative coolers* are less effective than ceiling fans in more humid locations, the requirement for *ventilation openings* in *climate zones* 1, 2 and 5 in Table 3.12.4.1 with an *evaporative cooler* is the same as without one.

11.5.1 Ventilation from adjoining rooms

In the case where the minimum total *ventilation opening* area required to a *habitable room* by subclause 3.12.4.1(a) and Table 3.12.4.1 cannot be provided by *ventilation openings* in the *external wall* of the actual room, the minimum total *ventilation opening* area may use "borrowed" ventilation from adjoining rooms. This concept is similar to the requirements of NCC Volume Two Subclause 3.8.5.2(b), which utilises "borrowed" natural ventilation and recognises that whilst the opening may not specifically be located in that room the effects of that opening may be felt.

Subclause 3.12.4.1(b) specifies conditions for using "borrowed" ventilation, namely-

- the adjoining room cannot be a sanitary compartment (i.e. a closet pan or urinal);
- the opening/s between the adjoining room and the *habitable room* complies as the minimum total *ventilation opening* area required for the *habitable room* (note that this may be in proportion to any partial "borrowing" required for compliance); and
- the *ventilation opening* in the adjoining room complies with Table 3.12.4.1 for the *floor area* required for both the adjoining room and the *habitable room* concerned.

11.5.2 Concession

Subclause (c) provides an alternative for buildings in Region D severe tropical cyclone areas, where large opening windows are more difficult to protect. This option includes shading of *external walls*, such as with a verandah, balcony, eaves, carport or the like. The shading must project at a minimum angle of 15 degrees in accordance with the shading requirements which form part of the *glazing* requirements of Part 3.12.2 of NCC Volume Two. Refer to Chapter 9 of this document for more information.

Design alert:

Further information on cyclone regions is provided in Figure 3.10.1.4 of NCC Volume Two.

11.6 Ventilation openings

3.12.4.2 specifies further requirements for the minimum total *ventilation opening* area required by Table 3.12.4.1, which is referenced in 3.12.4.1, for *climate zones* 1 to 5, to enhance air movement within the building. The requirements cover *breeze paths* connecting *ventilation openings* and the placement of openings in individual rooms.

Subclause 3.12.4.2(a) states that the *ventilation opening* area required by Table 3.12.4.1 to a *habitable room* must be either:

- connected by a *breeze path* to another *ventilation opening* in another room, or
- provided by a minimum of two *ventilation openings* located within the same room.

A *breeze path* assists cross flow ventilation and is an unimpeded route for air to move from one *ventilation opening* in a *habitable room* to a *ventilation opening* in another room via internal openings such as doors. The other room does not need to be a *habitable room*. Typically, this could be achieved by a *ventilation opening* of a bedroom through the internal door of the bedroom into the adjoining lounge room and out through the *ventilation opening* of the lounge room. Subclause (b) contains specific requirements for *breeze paths*. The alternative option in subclause (a) to providing a complying *breeze path* is to provide two *ventilation openings* in the same room. In this case, any one *ventilation opening* must be at least 25% of the minimum total *ventilation opening* area required by Table 3.12.4.1.

Design alert:

Note that the two *ventilation openings*, such as *windows*, may be located in the same *external wall* and alongside one another. Although not ideal, in some instances it is reasonable for the two openings to be in the same wall even though the breeze needs to take a "U" turn. This can happen, particularly if the wall has reveals or other features that cause turbulence to the air flow.

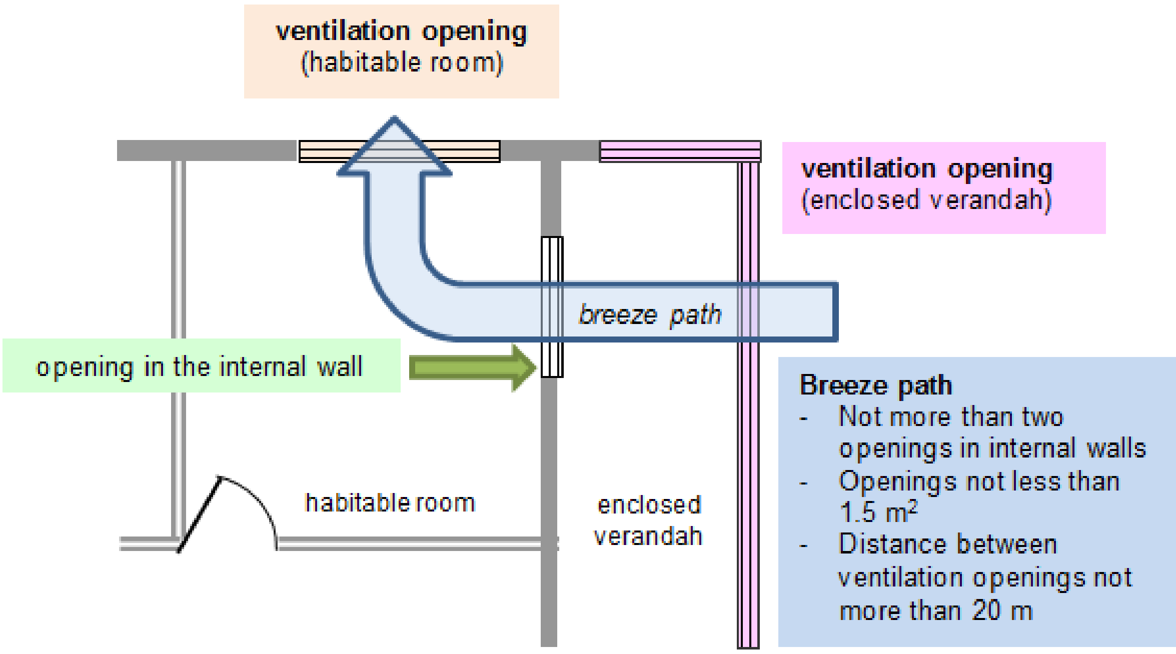
There is also no minimum distance specified between the openings.

11.6.1 Breeze paths

Subclause (b) specifies the requirements for a *breeze path* used in subclause (a)(i). A *breeze path* may pass through no more than two internal wall openings (such as doors) of an area of not less than 1.5 m^2 per opening. In addition, the distance along the *breeze path* between the *ventilation openings* cannot be more than 20 metres.

Figure 11.2 shows how a *breeze path* can operate with borrowed ventilation.

Figure 11.2 Breeze path for a habitable room using borrowed ventilation from an enclosed verandah



Example: Breeze path

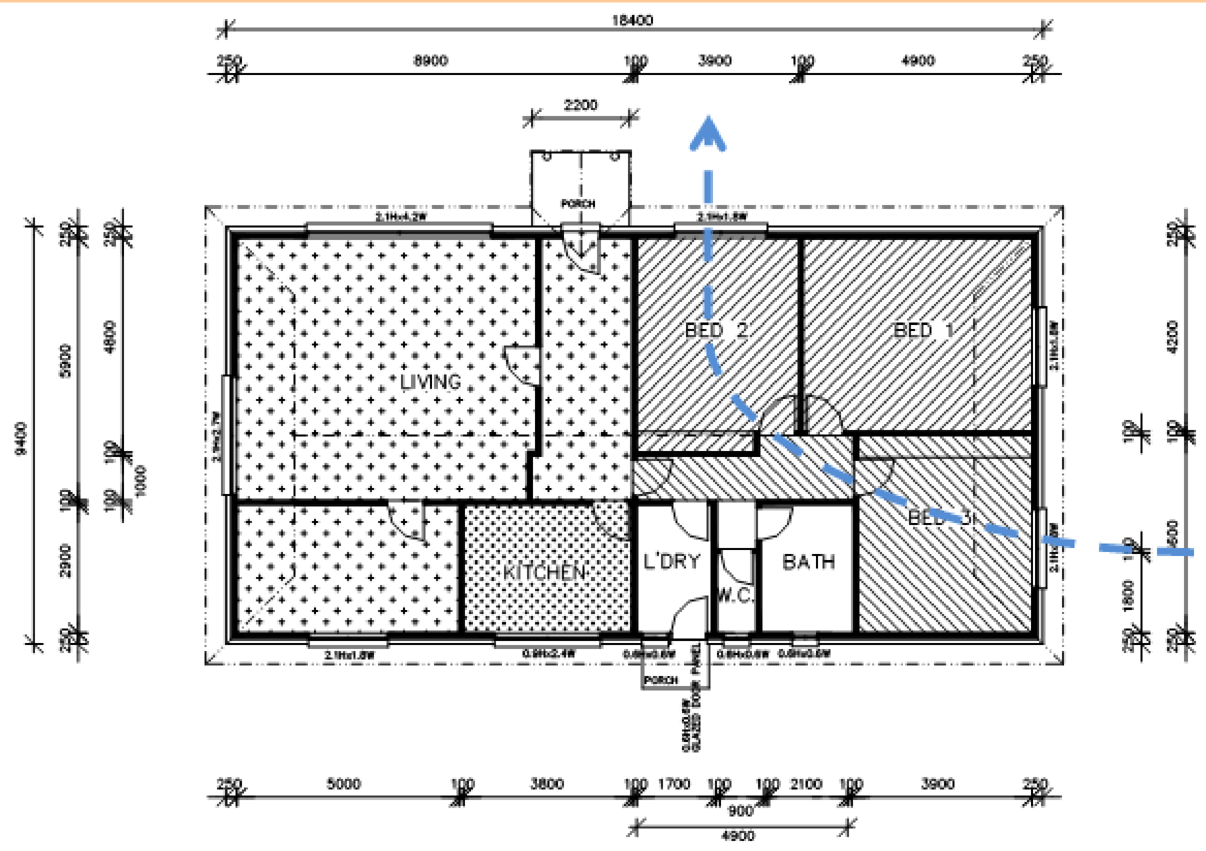
Using the floorplan below, the following *breeze path* for Bedroom 2 provides compliance.

Start at the *window* of Bedroom 3 (a *ventilation opening* compliant with Table 3.12.4.1) follow it through the bedroom door (having an area not less than 1.5 m^2) into the corridor, then through the Bedroom 2 doorway (having an area not less than 1.5 m^2) and through the *ventilation opening* in Bedroom 2 (a *ventilation opening* compliant to Table 3.12.4.1).

The total distance from the *ventilation opening* in Bedroom 2 to the *ventilation opening* in Bedroom 3 is not more than 20 m. Therefore, the *breeze path* complies for Bedroom 2.

Note: this *breeze path* also complies for Bedroom 3 as the breeze may flow in either direction.

Figure 11.3 Breeze path showed in the floor plan for this example



11.7 Ceiling fans and *evaporative coolers*

This clause outlines specific requirements for ceiling fans and *evaporative coolers* where they are used to meet the requirements of other energy efficiency provisions, specifically clause 3.12.0.1 and Table 3.12.4.1 of NCC Volume Two.

Ceiling fans or *evaporative coolers* must:

- be permanently installed; and
- have a speed controller; and
- for a ceiling fan, have a blade rotation diameter of greater than or equal to—
  - 900 mm for a space of not more than 15 m^2; and
  - 1200 mm for a space of not more than 25 m^2.

The performance of the fan will depend on a number of factors including blade design, ceiling clearance, the proximity of walls and the power of the fan.

12 Part 3.12.5 - Services

12.1 Introduction

The NCC Volume Two services *DTS Provisions* for energy efficiency have been developed to minimise the amount of energy lost and used through the various *domestic services* of a building that use energy.

As part of the consolidation of NCC *heated water* energy efficiency provisions for NCC 2014, some provisions which previously appeared in Part 3.12.5 of NCC Volume Two have been relocated to Part B2 of NCC Volume Three – Plumbing Code of Australia. Whilst these provisions now appear in NCC Volume Three, they are still discussed in detail in this chapter.

12.2 Scope

The services requirements address the following *domestic services*:

- insulating central heating water *piping*;
- sealing and insulating of air-conditioning ductwork;
- controls and limits on electric resistance space heating;
- controls and limits on artificial lighting;
- *heated water* supply systems (located in Part B2 of NCC Volume Three);
- *swimming pool* heating and pumping; and
- spa pool heating and pumping.

12.3 Intent

This Part has been developed to reduce the use of energy and generation of greenhouse gas emissions attributed to specific *domestic services*.

Requirements for appliances and some plant items have not been included because they are outside the scope of the NCC and likely to be regulated under the MEPS administered by the Australian Government.

12.4 Application

The provisions apply to all Class 1 and 10a buildings, as well as Class 10b *swimming pools* associated with these buildings.

12.5 Insulation of services

To be effective over a reasonable period of time, the thermal *insulation* material used to insulate central heating water *piping* and heating and cooling ductwork must be protected against the adverse effects of the weather and sunlight, must be able to withstand the temperatures within the *piping* or ductwork itself and use thermal *insulation* material in accordance with AS/NZS 4859.1. This clause contains basic requirements that address this issue. The central heating water *piping* requirements apply to systems designed to heat the building via water, such as a hydronic heating system.

Protection against the effects of weather and sunlight may be achieved by enclosing the *insulation* in a protective sheathing such as formed metal sheeting, external grade plastics or other similar material.

Alert:

AS/NZS 4859.1 is the Australian and New Zealand standard, “Materials for the thermal buildings” and contains the general criteria and technical provisions for determining the *R-Value* of *insulation* materials.

12.6 Central heating water piping

The *insulation* requirements for *piping* used in a central heating water system are dependent on the location of the *piping* in the building and the *climate zone* where it is being installed. Generally, the more exposed the *piping* is to the external environment, the higher the *insulation* requirements. Likewise, the colder the *climate zone*, the higher the *insulation* requirements. This clause provides the detail of the specific *R-Value required* based on the *climate zone* and location of the *piping*.

The *insulation* material must be tested in accordance with AS/NZS 4859.1, as stated in 3.12.5.1. An appropriate test certificate should be provided with the material to ensure that complying *insulation* is being used and it achieves the thermal performance determined by the testing. This information should form part of the *building approval* documentation. Alternatively, NCC Volume Two also provides typical *R-Values* for some pipe *insulation* in the explanatory information related to this clause. These values are representative of smaller diameter *piping*.

Note that the pipework inside the *conditioned space* (but not within an *internal wall*) need not be insulated. This is because the heat is intended to be released into that space and so *insulation* serves no purpose.

12.7 Heating and cooling ductwork

Subclause 3.12.5.3(a) requires heating and cooling ductwork; and fittings to be protected, sealed and insulated. Like central heating water *piping*, the amount of *insulation* differs depending upon the location in the building and with *climate zone*. *Insulation* for ductwork and associated fittings are specified in Part 3.12.5.3(d) of NCC Volume Two.

A concession for the *required R-Value* of the *insulation* is also available in certain *climate zones* for ductwork associated with combined heating and refrigerated cooling systems if the ductwork is located under a suspended floor with an enclosed perimeter or in a roof space with *insulation* of not less than R0.5 directly beneath the roofing.

The *insulation* material must be tested in accordance with AS/NZS 4859.1, as stated in 3.12.5.1. An appropriate test certificate should be provided with the material to ensure that complying *insulation* is being used and it achieves the thermal performance determined by the testing. This information should form part of the *building approval* documentation. Alternatively, NCC Volume Two also provides typical *R-Values* for some ductwork and fittings *insulation* in the explanatory information located after subclause 3.12.5.3(d).

The ductwork and associated fittings must also be sealed against air loss with adhesives, mastics, sealants, gaskets or the like as prescribed in AS 4254.1 and

AS 4254.2 or with a draw band in conjunction with a sealant or adhesive tape for flexible ductwork.

Alert:

AS 4254 is the Australian standard, “Ductwork for air-handling systems in buildings” for flexible and rigid ducts. It contains requirements for materials, construction and installation, including some aspects of performance, for flexible duct for air-handling systems in buildings and systems designed in accordance with the requirements of AS/NZS 1668.1 and AS 1668.2.

12.7.1 Duct insulation

This subclause contains some installation requirements for duct *insulation*, including its protection when located outside the building and its continuity. The *insulation* must also maintain its position and thickness other than at flanges and supports.

12.7.2 Ductwork within an insulated space

Again like central heating water *piping*, the requirements do not apply where the ductwork is inside the *envelope* (essentially the *conditioned space)*. This is because the heat is intended to be released into that space and so *insulation* serves little purpose.

12.7.3 R-Values for services

Clause 3.12.5.3(d) outlines a minimum material R-value for heating and cooling ductwork. R-value is determined by taking into account the climate zone and features of the system (e.g. heating or cooling only with an *evaporative cooling system* or combined heating and refrigerated cooling system).

This subclause also indicates that a concession of 0.5 may apply for a combined heating and refrigerated cooling system in climate zones 1, 3, 4, 6 and 7 if conditions in 3.12.5.3(d)(iii) are met.

12.8 Electric resistance space heating

These requirements only apply to an electric resistance space heating system that serves more than one room. The system must have separating isolating switches for each room, separate temperature controllers and time switches for each group of rooms with common heating needs and the power loads must not exceed 110 W/m² and 150 W/m² for living areas and bathrooms respectively.

These requirements apply to in-slab electric heating systems.

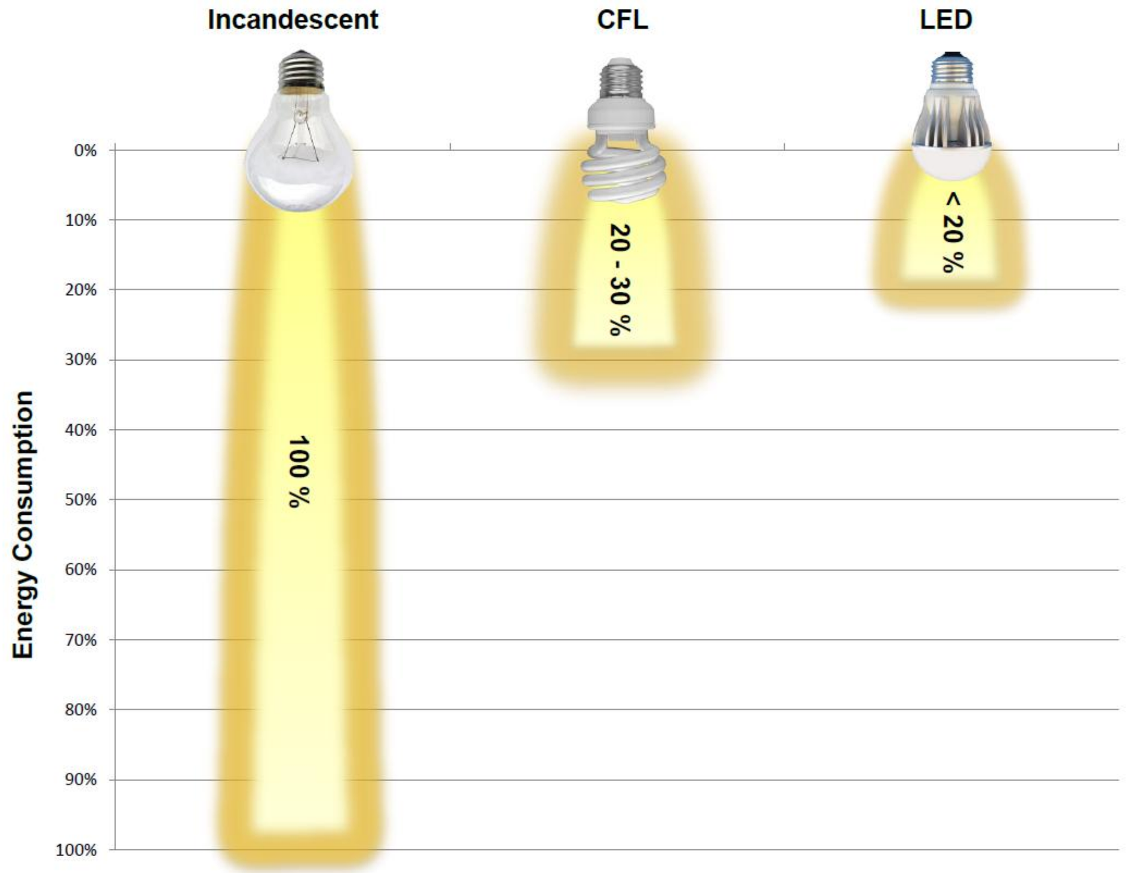
Design alert:

MEPS administered by the Australian Government, may also have additional requirements for these systems. The NCC requirements are in addition to any of these requirements.

12.9 Artificial lighting

The artificial lighting requirements have been developed to curb unreasonable energy use from lighting systems. Given that different types of lamps use different levels of energy, the NCC requirements promote using more efficient lighting systems through different lighting technology and/or control devices. To provide an indication of the energy consumption of different lamps, Figure 12.1 shows a comparison of incandescent lamps, compact fluorescent lamps (CFL) and light emitting diodes (LED).

Figure 12.1 Comparison of the energy use of different lamps (using an incandescent lamp as the reference)



The energy efficiency requirements for artificial lighting provides limits for the efficiency or power consumption rate of artificial lighting installations, both inside the dwelling and those associated with the verandah, balcony or the like of a Class 1 building, associated Class 10a buildings (such as garages) and perimeter lighting. The artificial lighting requirements in 3.12.5.5 are also to be read in conjunction with the artificial lighting requirements in 3.8.4.3.

The *DTS Provisions* allow two approaches for achieving compliance, based on using the *lamp power density* or the *illumination power density*. Regardless of the approach taken, both require that the power of the lighting design must not exceed the allowance.

Subclause (a) of 3.12.5.5 provides the maximum allowance in watts per square metre for the different space types. The allowed values are:

- 5 W/m^2 for a Class 1 building (the dwelling);

- 4 W/m^2 for a verandah, balcony or the like attached to the Class 1 building; and
- 3 W/m^2 for a Class 10a building associated with a Class 1 building (such as a garage).

The first step in achieving compliance is to determine the relevant *lamp power density* or *illumination power density* allowance. Generally, the *lamp power density* is the relevant allowance above. However, the *illumination power density* allowance increases this allowance when lighting control devices are used. Clause 3.12.5.5(f) provides the adjustment factors for lighting control devices.

The second step in achieving compliance is to assess the overall *lamp power density* or overall *illumination power density*.

Example: Step 1 Calculating the allowance

This example uses a 110.5 m^2 house with an associated garage of 12.1 m^2.

Lamp power density

The house does not have any control devices or regulators applied to the lighting. The *lamp power density* is calculated using 3.12.5.5(a) and the area.

The house wattage allowance is 110.5 m^2 x 5 W/m^2 = 553 *Watts*.

The garage wattage allowance is 12.1 m^2 x 3W/m^2 = 36 *Watts*.

Illumination power density

Using the same house as above and providing a dimmer switch to control the lighting for 80% of the lounge, living & dining areas, the allowance can be adjusted using the *illumination power density* approach. The total area of the lounge, living & dining area that is controlled by the lighting dimmer switch is 50.4 m^2. The remaining part of the house without lighting control devices is 60.1 m^2.

For the areas of the house and verandah that do not have any control devices or regulators applied to the lighting, the allowance is calculated using 3.12.5.5(a) and the area. For the lounge, living & dining areas controlled by the dimmer switch, the allowance is calculated using 3.12.5.5(a), 3.12.5.5(b) and the area. From 3.12.5.5(f), the *illumination power density* adjustment factor for a dimmer switch is 0.85.

The house wattage allowance (excluding the lounge, living & dining areas) is:
60.1 m^2 x 5 W/m^2 = 301 *Watts*.

The garage wattage allowance is 12.1 m^2 x 3 W/m^2 = 36 *Watts*.

Lastly, the allowance for the lounge, living and dining area with the adjustment factor is calculated using 3.12.5.5(f). From 3.12.5.5(f), there is a requisite to have 75% of the area of the space controlled by the manually operated dimmers to qualify for use of it. This is the case for this design. Next to note is that the adjustment factor given for use with manual dimming is 0.85.

The house allowance for the lounge, living & dining areas is:
5 W/m^2 ÷ 0.85 = 5.9 W/m^2.
This is the increased allowance based on applying 3.12.5.5(b).

The house wattage allowance for the lounge, living & dining areas is:
5.9 W/m^2 x 50.4 m^2 = 297 *Watts*.

Therefore, using the *illumination power density* approach, the overall allowance for the house is higher than using the *lamp power density* approach due to the installation of the dimmer switch as a lighting control device.

The overall house wattage allowance is 598 W (301 W + 297 W).

The garage wattage allowance is 36 W.

Example: Step 2 Calculating the design wattage

The overall *lamp power density* and *illumination power density* is calculated by adding the maximum power ratings of all the permanently installed lamps in a space and dividing them by the area of the space.

A. Add up all the wattages for the proposed design.

This is where all the proposed hardwired light’s maximum wattages are added up to achieve a total. Desk lamps, floor lamps and the like that are plugged into general power outlets are not included; it is only the *permanent* lighting in a space that is regulated.

B. Compare the wattage of the proposed design to the allowance.

If the proposed design is equal to or less than the allowance then compliance is achieved. If it is over the allowance – reworking of the proposed design is needed to achieve compliance.

In the example above, using the—

- *lamp power density,* if the proposed design total wattage does not exceed 553 *Watts*, compliance is achieved.
- *illumination power density* and dimmer switches, if the proposed design total wattage does not exceed 598 *Watts*, compliance is achieved.

As demonstrated in the examples above, the allowable design load has to be calculated separately for each different part of the building (i.e. separately for the dwelling, verandah and associated Class 10a) and trading of allowances between these different parts is not allowed. However, trading within each allowance is permitted (e.g. between rooms within the dwelling).

Due to the defined terms *lamp power density* and *illumination power density*, the requirements only apply to permanently installed artificial lights. Therefore, portable lamps and lights connected by plugs to general electricity power outlets are exempt.

For simple systems that do not involve current regulators or control devices, the *lamp power density* is the easiest way to meet the specified requirements of subclause (a).

For systems that are more complicated, i.e. where current regulators and control devices are used, the *illumination power density* approach can be used. In using this approach, the *illumination power density* adjustment factor as specified in 3.12.5.5(f) allows for an increase in the power density allowed (i.e. and increase in the W/m² allowance). This is because additional lighting controls are likely to further reduce the energy used.

Subclause (d) of 3.12.5.5 requires halogen and fluorescent lamps to be separately switched. This is so that the more efficient fluorescent lamps can be used routinely, while the less efficient halogen lamps can be turned on only when required. Subclause (e) deals with external artificial lighting around the perimeter of the building. Here the lighting does not need to comply with a maximum power density as the lighting needed or the area of the space generally cannot be easily defined. Instead, external lights are required to be controlled by daylight sensors and must be efficient, having an average lighting efficacy of not less than 40 Lumens/W.

Figure 12.2 and Table 12.1 shows a typical complying lighting design for a house, including its garage and porch.

Figure 12.2 Typical complying layout for a house including its garage

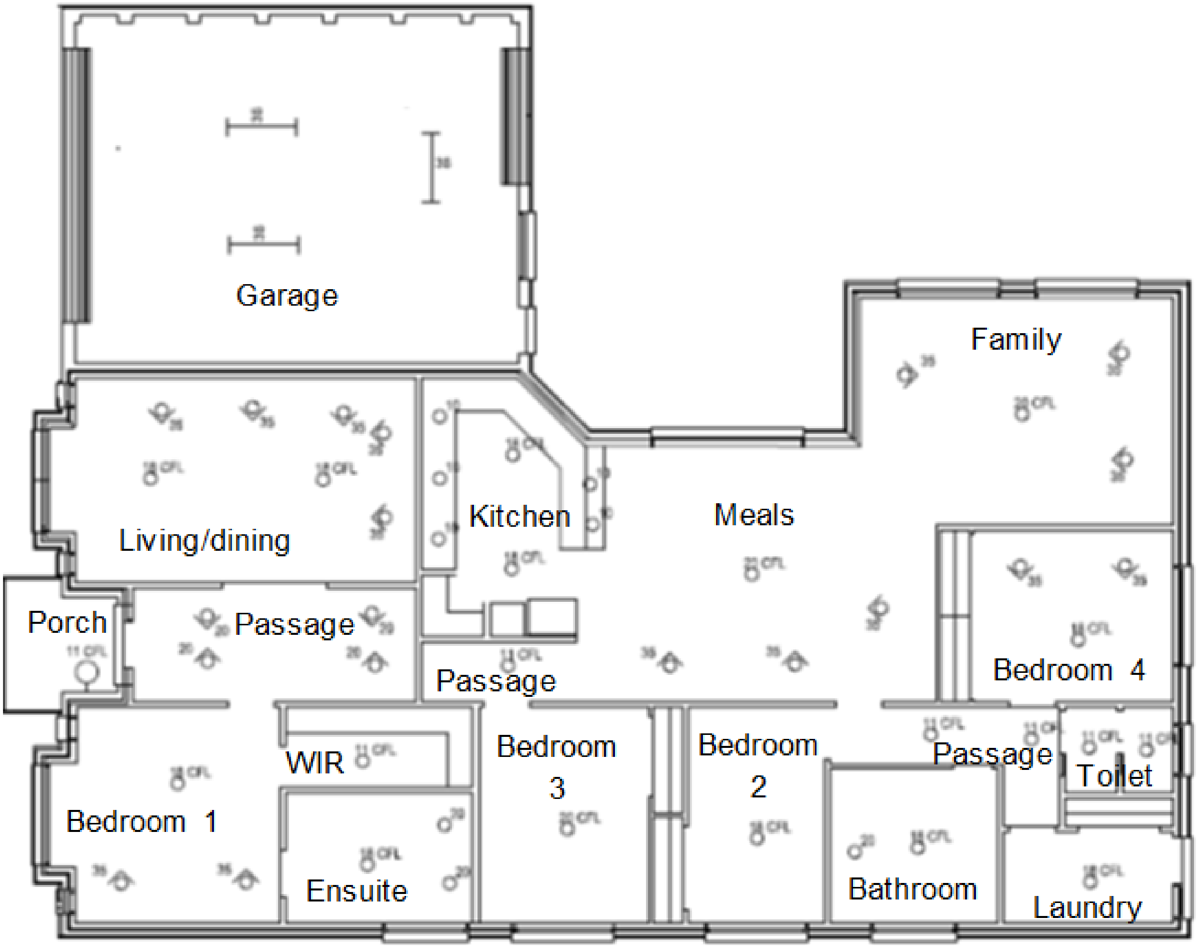


Table 12.1 Lighting design for Figure 12.2

Space	CFL 11W	CFL 18W	CFL 20W	THL 10W	THL 20W	THL 35 W	Fluorescent lamps 36W
Living/dining	-	2	-		1	4	-
Kitchen	-	2	-	5	-	-	-
Meals	-	-	1	-	-	3	-
Family	-	-	1	-	-	3	-
Laundry	-	1	-	-	-	-	-
Toilet	2	-	-	-	-	-	-
Passage	3	-	-	-	4	-	-
Porch	1	-	-	-	-	-	-
Bedroom 1	-	1	-	-	-	2	-
Walk-in Robe	1	-	-	-	-	-	-
Ensuite	-	1	-	-	2	-	-
Bedroom 2	-	1	-	-	-	-	-
Bedroom 3	-	-	1	-	-	-	-
Bedroom 4/Study	-	1	-	-	-	2	-
Bathroom	-	1	-	-	1	-	-
Garage	-	-	-	-	-	-	3

CFL refers to compact fluorescent lamps and THL refers to tungsten halogen lamps.

12.9.1 Lighting Calculator

The ABCB has produced a calculator to assist users in assessing compliance with 3.12.5.5. There is also a short YouTube clip describing the ABCB Lighting Calculator for NCC Volume Two available from the ABCB website (abcb.gov.au).

The following is a description of key cells in the Lighting Calculator to explain its use. Additional advice can be found in the Help Screen of the Calculator.

12.9.1.1 Building parameters

(a) Building Name/Description – is used to identify the building or parts of the building that is being assessed by this spreadsheet- for example the street address.

(b) Classification cell – requires the nomination of the Class of building that is being assessed by the spreadsheet.

12.9.1.2 Lighting details

(a) ID - The calculator can display up to 40 rows. Not all of the rows will be visible unless you change the number of rows displayed using the input immediately above the lighting detail table. Each row is numbered by default (from 1 to 40). You can use these numbers or any preferred code to identify each space.

(b) Description - Input any desired description of the room or space. This is an optional input for the convenience of the user and the assessor.

(c) Type of space - This cell is used to select the type of space under assessment. Each space may have a different power allowance depending upon the function and use of the space. Select the appropriate option from the dropdown box.

(d) Floor area of the space – This is the floor area of the space that the lights serve.

(e) Design lamp or illumination power load – this is where the total sum of the power (in W) for a space is entered into the spreadsheet.

(f) Location – Select the building classification or location associated with the space from the dropdown box. The three options available are Class 1 building, Class 10a building and verandah or balcony.

(g) Adjustment Factor One – The use of the adjustment factor dropdown box can be used where sophisticated lighting control devices are used, such as dimmers. This means that the W/m^2 will increase for that space. Click on the red adjustment factor button to view the adjustment factors as well as any prerequisites for their use. The other columns in the Adjustment Factor One column are used for specific adjustment factors. Prompts will occur if the input of additional data is required.

(h) Adjustment Factor Two – This column is similar to the Adjustment Factor One column and is used where more than one control device is used for a space. Selection of the control device used is the same as for Adjustment Factor One described above.

12.9.1.3 Calculated outcomes

There is no need for the user to input additional parameters into the spreadsheet as the values used to calculate the outcome are automated in the background of the

Lighting Calculator. The calculated outcomes are not displayed until any input issues have been resolved. These issues will be highlighted by formatting or advisory messages.

(a) *Lamp or Illumination Power Density* - System Allowance – This shows the current maximum allowance for that space. Green cells indicate a pass and it is important to note that any excess wattage for a space that has not been used can be used in another space.

(b) *Lamp or Illumination Power Density* - System Design - This shows the calculated design power density for that space. Green cells indicate a pass and it is important to note that any excess wattage for a space that has not been used can be used in another space. White cells with red text identify spaces within the design that are above the allowance. Note the excess wattage from other spaces can be used to enable an overall design pass, even if some spaces are above the allowance.

(c) System Share of % of Aggregate Allowance Used – the first percentage shows how much the lighting in the individual space is contributing to the total allowance used. The second percentage is the same for every space in that column, and shows the total amount of the allowance that has been used by the overall lighting design i.e. from all the spaces combined. By looking at both percentages, users can identify which results need to be improved and which spaces are most influencing the result.

(d) Total floor area and total wattage – These untitled cells are below the floor area of the space and the design lamp or illumination power load columns. They show the totals of these columns.

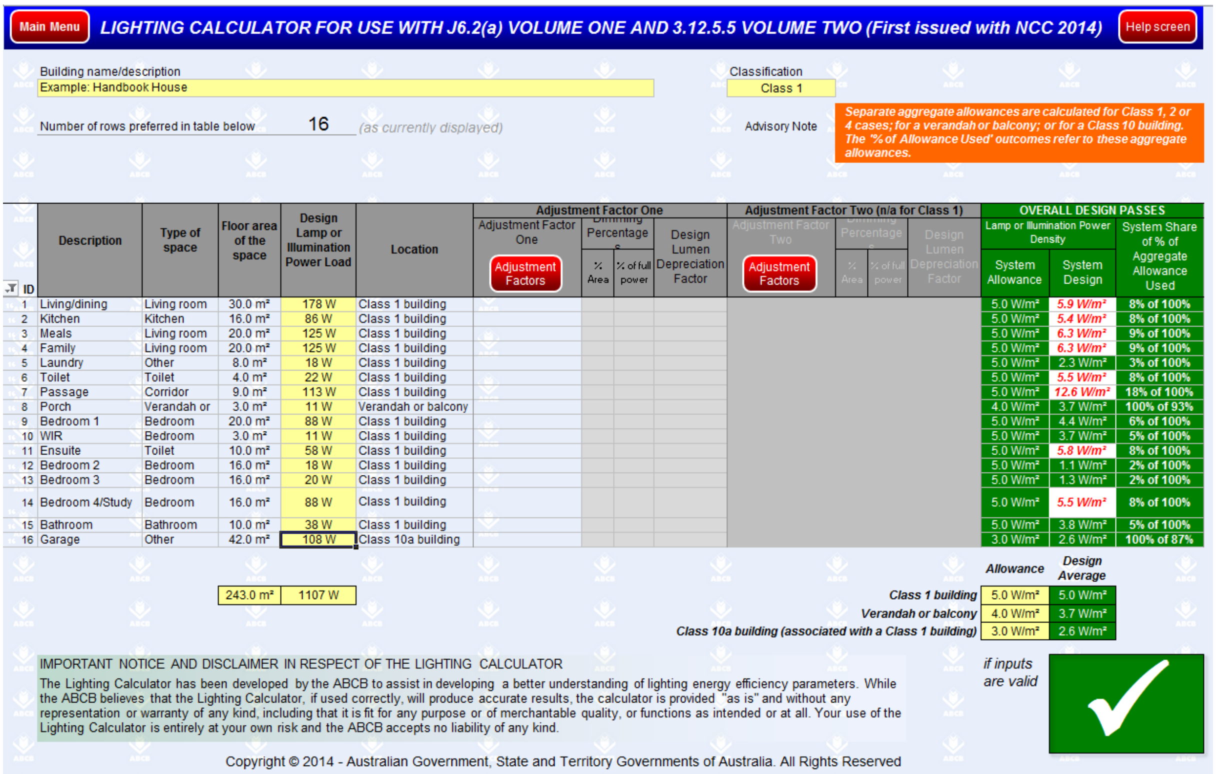
(e) Allowance and Design Average – the allowance column shows the allowance for the different locations. The design average shows the average design value.

(f) Compliance indicator – The box below the calculated outcomes indicates whether the proposed lighting design meets the requirements of 3.12.5.5. The Calculator attempts to highlight improbable inputs but cannot validate every input. Subject to those qualifications, a green tick means compliance has been achieved and a red cross means compliance with the lighting requirements has not been achieved.

If the overall design does not comply, some of the design parameters will need to be changed with the aid of the information provided in the “Lighting System Share of % of Aggregate Allowance Used” column.

The following figure, Figure 12.3 Screenshot of the lighting calculator shows a screenshot of the Lighting Calculator. The data entered in this screen shot matches the typical complying layout from the previous Figure 12.3.

Figure 12.3 Screenshot of the lighting calculator


Main Menu

LIGHTING CALCULATOR FOR USE WITH J6.2(a) VOLUME ONE AND 3.12.5.5 VOLUME TWO (First issued with NCC 2014)

Help screen

Building name/description: Example: Handbook House

Classification: Class 1

Number of rows preferred in table below: 16 (as currently displayed)

Advisory Note: *Separate aggregate allowances are calculated for Class 1, 2 or 4 cases; for a verandah or balcony; or for a Class 10 building. The '% of Allowance Used' outcomes refer to these aggregate allowances.*

ID	Description	Type of space	Floor area of the space	Design Lamp or Illumination Power Load	Location	Adjustment Factor One: Adjustment Factor One	Adjustment Factor One: Dimming Percentages % Area	Adjustment Factor One: Dimming Percentages % of full power	Adjustment Factor One: Design Lumen Depreciation Factor	Adjustment Factor Two (n/a for Class 1): Adjustment Factor Two	Adjustment Factor Two: Dimming Percentages % Area	Adjustment Factor Two: Dimming Percentages % of full power	Adjustment Factor Two: Design Lumen Depreciation Factor	OVERALL DESIGN PASSES: Lamp or Illumination Power Density System Allowance	OVERALL DESIGN PASSES: Lamp or Illumination Power Density System Design	OVERALL DESIGN PASSES: System Share of % of Aggregate Allowance Used
1	Living/dining	Living room	30.0 m²	178 W	Class 1 building									5.0 W/m²	5.9 W/m²	8% of 100%
2	Kitchen	Kitchen	16.0 m²	86 W	Class 1 building									5.0 W/m²	5.4 W/m²	8% of 100%
3	Meals	Living room	20.0 m²	125 W	Class 1 building									5.0 W/m²	6.3 W/m²	9% of 100%
4	Family	Living room	20.0 m²	125 W	Class 1 building									5.0 W/m²	6.3 W/m²	9% of 100%
5	Laundry	Other	8.0 m²	18 W	Class 1 building									5.0 W/m²	2.3 W/m²	3% of 100%
6	Toilet	Toilet	4.0 m²	22 W	Class 1 building									5.0 W/m²	5.5 W/m²	8% of 100%
7	Passage	Corridor	9.0 m²	113 W	Class 1 building									5.0 W/m²	12.6 W/m²	18% of 100%
8	Porch	Verandah or	3.0 m²	11 W	Verandah or balcony									4.0 W/m²	3.7 W/m²	100% of 93%
9	Bedroom 1	Bedroom	20.0 m²	88 W	Class 1 building									5.0 W/m²	4.4 W/m²	6% of 100%
10	WIR	Bedroom	3.0 m²	11 W	Class 1 building									5.0 W/m²	3.7 W/m²	5% of 100%
11	Ensuite	Toilet	10.0 m²	58 W	Class 1 building									5.0 W/m²	5.8 W/m²	8% of 100%
12	Bedroom 2	Bedroom	16.0 m²	18 W	Class 1 building									5.0 W/m²	1.1 W/m²	2% of 100%
13	Bedroom 3	Bedroom	16.0 m²	20 W	Class 1 building									5.0 W/m²	1.3 W/m²	2% of 100%
14	Bedroom 4/Study	Bedroom	16.0 m²	88 W	Class 1 building									5.0 W/m²	5.5 W/m²	8% of 100%
15	Bathroom	Bathroom	10.0 m²	38 W	Class 1 building									5.0 W/m²	3.8 W/m²	5% of 100%
16	Garage	Other	42.0 m²	108 W	Class 10a building									3.0 W/m²	2.6 W/m²	100% of 87%
			243.0 m²	1107 W												

	Allowance	Design Average
Class 1 building	5.0 W/m²	5.0 W/m²
Verandah or balcony	4.0 W/m²	3.7 W/m²
Class 10a building (associated with a Class 1 building)	3.0 W/m²	2.6 W/m²

if inputs are valid

IMPORTANT NOTICE AND DISCLAIMER IN RESPECT OF THE LIGHTING CALCULATOR

The Lighting Calculator has been developed by the ABCB to assist in developing a better understanding of lighting energy efficiency parameters. While the ABCB believes that the Lighting Calculator, if used correctly, will produce accurate results, the calculator is provided "as is" and without any representation or warranty of any kind, including that it is fit for any purpose or of merchantable quality, or functions as intended or at all. Your use of the Lighting Calculator is entirely at your own risk and the ABCB accepts no liability of any kind.

Alert:

On 20 April 2018, COAG Energy Council agreed to improve lighting energy efficiency by phasing out inefficient halogen lamps in Australia and introducing minimum standard for LED lamps in Australia. Further information is available on the energy rating website (energyrating.gov.au).

12.10 Water heater in a heated water supply system

As previously mentioned, the requirements of clause 3.12.5.6 and the related acceptable construction manual 3.12.5.0 are now contained in Part B2 of NCC Volume Three – Plumbing Code of Australia (PCA). Compliance with the relevant provisions of the PCA satisfies these requirements in the BCA.

The requirements were relocated to the PCA as much of this type of work will be carried out by plumbers, and in line with other requirements contained in the plumbing and *drainage* standards. It has also been transferred to the PCA to avoid duplication and maintain consistency across the NCC, by consolidating all plumbing requirements into Volume Three.

Alert:

It is important to be aware when using these provisions that State and Territory plumbing legislation may already require compliance with the plumbing and *drainage* standards irrespective of the NCC requirements.

Research suggests that a *heated water* supply system accounts for up to 27 percent of the total greenhouse gas emissions attributed to a house. Accordingly, there are valid reasons for pursuing control of the way *heated water* systems are selected and installed.

Storage water heaters operate by maintaining stored water at a specified temperature, irrespective of when the water is to be used. Maintaining water at a temperature above ambient will incur energy loss. Accordingly, measures have been introduced to reduce the amount of heat loss from these units, which in turn will provide tangible reductions in greenhouse gas emissions.

12.10.1 NCC Volume Three – Part B2 Heated water services

12.10.1.1 B2.2 Water heater in a heated water supply system

Part B2.2 in NCC 2019 Volume Three contains the *heated water* requirements related to energy efficiency previously located in NCC Volume Two. The *DTS Provisions* state:

B2.2 Water heater in a heated water supply system

(1) In a new Class 1 or Class 10 building—

(a) a water heater in a *heated water* supply system must be—
  (i) a solar water heater complying with B2.2(1)(b); or
  (ii) a heat pump water heater complying with B2.2(1)(b); or
  (iii) a gas water heater complying with B2.2(1)(c); or
  (iv) an electric resistance water heater only in the circumstances described in B2.2(1)(d); or
  (v) a wood fired thermosiphon water heater or direct fired water heater each complying with AS/NZS 3500.4; and

(b) a solar water heater and a heat pump water heater must have—
  (i) for a building with 1 or 2 bedrooms—
    (A) at least 14 *Small-scale Technology Certificates* for the zone where it is being installed; or
    (B) an energy saving of not less than 40% in accordance with AS/NZS 4234 for a “small” load system; and
  (ii) for a building with 3 or 4 bedrooms—
    (A) at least 22 *Small-scale Technology Certificates* for the zone where it is being installed; or
    (B) an energy saving of not less than 60% in accordance with AS/NZS 4234 for a “medium” load system; and
  (iii) for a building with more than 4 bedrooms
    (A) at least 28 *Small-scale Technology Certificates* for the zone where it is being installed; or
    (B) an energy saving of not less than 60% in accordance with AS/NZS 4234 for a “large” load system; and

(c) a gas water heater must be rated not less than 5 stars in accordance with AS 4552; and

(d) an electric resistance water heater with no storage or a *heated water* delivery of not more than 50 litres in accordance with AS 1056.1 may be installed when—
  (i) the building has—
    (A) not more than 1 bedroom; and
    (B) not more than 1 electric resistance water heater installed; or
  (ii) the building has—
    (A) a water heater that complies with B2.2(1)(b) or B2.2(1)(c); and

(B) not more than 1 electric resistance water heater installed; or

(iii) the greenhouse gas emission intensity of the public electricity supply is low.

These requirements have been developed to favour solar, heat pump and gas *heated water* supply systems over electric resistance water heaters.

The requirements for solar and heat pump water heaters are based on the number of bedrooms in the house and once determined, two pathways for compliance are given. Either the water heater obtains the number of required *Small-scale Technology Certificates* (STCs) or it can comply with the specified energy saving in accordance with AS/NZS 4234.

Design Alert:

AS/NZS 4234 is the Australian and New Zealand standard, "*Heated water* systems – Calculation of energy consumption" and contains a method for evaluating the annual energy performance of water heaters. This approach is also used to determine *STCs*.

For gas water heaters the only requirement is for it to be rated no less than 5 stars in accordance with AS 4552.

Design Alert:

AS 4552 is the Australian standard, "Gas fired water heaters for hot water supply and/or central heating" and contains requirements for gas water heaters and central heating boilers.

Where electric resistance heating is used, subclause (d) limits their use to one bedroom buildings.

Electrical water heaters also need to be of the "no storage" type, (instantaneous) or if it is of the storage type not more than 50L of water delivery in accordance with AS 1056.1. An exemption to limit electric resistance water heaters in one bedroom buildings is made if the electrical resistance water heater is also used in conjunction with a solar, heat pump or gas system.

Design Alert:

AS 1056.1 is the Australian standard, "Storage water heaters – General requirements" and contains requirements for storage water heaters using solely electricity for heating.

12.10.1.2 B2.9 General requirements

The general requirements of B2.9 in NCC Volume Three contain the *heated water* requirements previously located in NCC Volume Two. The *DTS Provisions* state:

B2.9 General requirements

(1) The design, construction, installation, replacement, repair, alteration and maintenance of a *heated water* service must be in accordance with AS/NZS 3500.4.

(2) A solar *heated water* supply system for food preparation and sanitary purposes, where installed in a new building in *climate zones* 1, 2 or 3, is not *required* to comply with Section 8 of AS/NZS 3500.4.

It is important to note that solar *heated water* supply systems in *climate zones* 1, 2 and 3 are exempt from complying with Section 8 of AS/NZS 3500.4 because the temperature of the water is not sufficiently above ambient temperature (the temperature of the air surrounding the system) to justify *insulation*, particularly as the solar energy is free and the electric booster is unlikely to be used. It would not be cost effective to impose the requirements in these instances. However, in cooler *climate zones*, where there is likely to be significant mains boosting, the measures are cost effective.

The other aspect of these requirements is to insulate *heated water* supply pipes irrespective of whether the pipes are fitted to a storage or instantaneous water heater.

Design Alert:

AS/NZS 3500 Part 4 is the Australian and New Zealand standard for “Plumbing and *drainage* – Heated water services” & “Plumbing and *drainage* – Housing installations”. They contain requirements for the design, installation and commissioning of *heated water* services.

12.11 Swimming pool heating and pumping

The intent of the *DTS Provisions* relevant to *swimming pools* is to **limit** the-

(a) energy supply to a less greenhouse gas intensive energy source, e.g. not resistive heating by electricity;
(b) amount of energy used; and
(c) loss of heat by conduction and convection.

Subclause (a) requires the heating for a *swimming pool* to be from any one of four energy sources or from a combination of them. These requirements effectively exclude oil heating and electric resistance heating, either as the only heating method or to boost a solar heater system. This requirement is in line with the *Performance Requirement* P2.6.2, which limits energy sources used for heating to those with a low GHG intensity or from a *renewable energy* source. *Swimming pools* must be heated by:

- a solar heater not boosted by electric resistance heating; or
- a heater using reclaimed energy; or
- a gas heater; or
- a heat pump; or
- a combination of the above options.

Where a gas heater or a heat pump provides the heating, subclause (b) requires a pool cover, if the pool is not in a *conditioned space*, and a time switch to control the operation of the heater. A cover will reduce evaporation and subsequent heat loss. It should be noted that some jurisdictions may have a requirement for a pool cover under the Smart Approved Water Mark Scheme. The Smart Approved Water Mark

Scheme is an Australia's water conservation labelling scheme, which certifies water efficient products and services in Australia and Europe.

Subclause (c) requires the time switch to operate the circulation pump to reduce the amount of time and associated energy consumed when the pump is operating when not needed.

The fourth subclause, (d) clarifies that this clause is about *swimming pools* and not about spa pools. Spa pools are covered by 3.12.5.8.

12.12 Spa pool heating and pumping

Subclause (a) restricts the heating sources for a spa pool to the same ones permitted for a *swimming pool* where it shares a water recirculation system with a *swimming pool.* These requirements do not apply to portable spas. The form of heating for the spa pool must be by:

- a solar heater; or
- a heater using reclaimed energy; or
- a gas heater; or
- a heat pump; or
- a combination of the above.

The second subclause, (b) requires a cover, regardless of the spa location plus a push button switch and a time switch to control the heater where either a gas heater or a heat pump, is used.

Subclause (c) requires a time switch to be provided to control the operation of a circulation pump for a spa pool having a capacity of 680 litres or more. 680 litres is generally accepted as the capacity of when a spa bath becomes a spa pool.

13 Further reading

The following reference documents are recommended if further information is required regarding the energy efficiency provisions of NCC Volume Two. These documents can be downloaded from the ABCB website (abcb.gov.au).

- ABCB Standard for NatHERS Heating and Cooling Load Limits (2019)
- Energy efficiency provisions (Part 2.6 and 3.12) in NCC Volume Two (2019)
- Final Decision Regulation Impact Statement (RIS), heating and cooling load limits (2018)
- Residential energy efficiency: heating and cooling load limits report (2018).

APPENDICES

Appendix A Compliance with the NCC

A.1 Responsibilities for regulation of building and plumbing in Australia

Under the Australian Constitution, State and Territory governments are responsible for regulation of building, plumbing and development / planning in their respective State or Territory.

The NCC is an initiative of COAG and is produced and maintained by the ABCB on behalf of the Australian Government and each State and Territory government. The NCC provides a uniform set of technical provisions for the design and construction of buildings and other structures, and plumbing and *drainage* systems throughout Australia. It allows for variations in climate and geological or geographic conditions.

The NCC is given legal effect by building and plumbing regulatory legislation in each State and Territory. This legislation consists of an Act of Parliament and subordinate legislation (e.g. Building Regulations) which empowers the regulation of certain aspects of buildings and structures, and contains the administrative provisions necessary to give effect to the legislation.

Each State's and Territory's legislation adopts the NCC subject to the variation or deletion of some of its provisions, or the addition of extra provisions. These variations, deletions and additions are generally signposted within the relevant section of the NCC, and located within appendices to the NCC. Notwithstanding this, any provision of the NCC may be overridden by, or subject to, State or Territory legislation. The NCC must therefore be read in conjunction with that legislation.

A.2 Demonstrating compliance with the NCC

Compliance with the NCC is achieved by complying with the Governing Requirements of the NCC and relevant Performance Requirements.

The Governing Requirements are a set of governing rules outlining how the NCC must be used and the process that must be followed.

The *Performance Requirements* prescribe the minimum necessary requirements for buildings, building elements, and plumbing and *drainage* systems. They must be met to demonstrate compliance with the NCC.

Three options are available to demonstrate compliance with the *Performance Requirements*:

- a Performance Solution,
- a DTS Solution, or
- a combination of a Performance Solution and a DTS Solution.

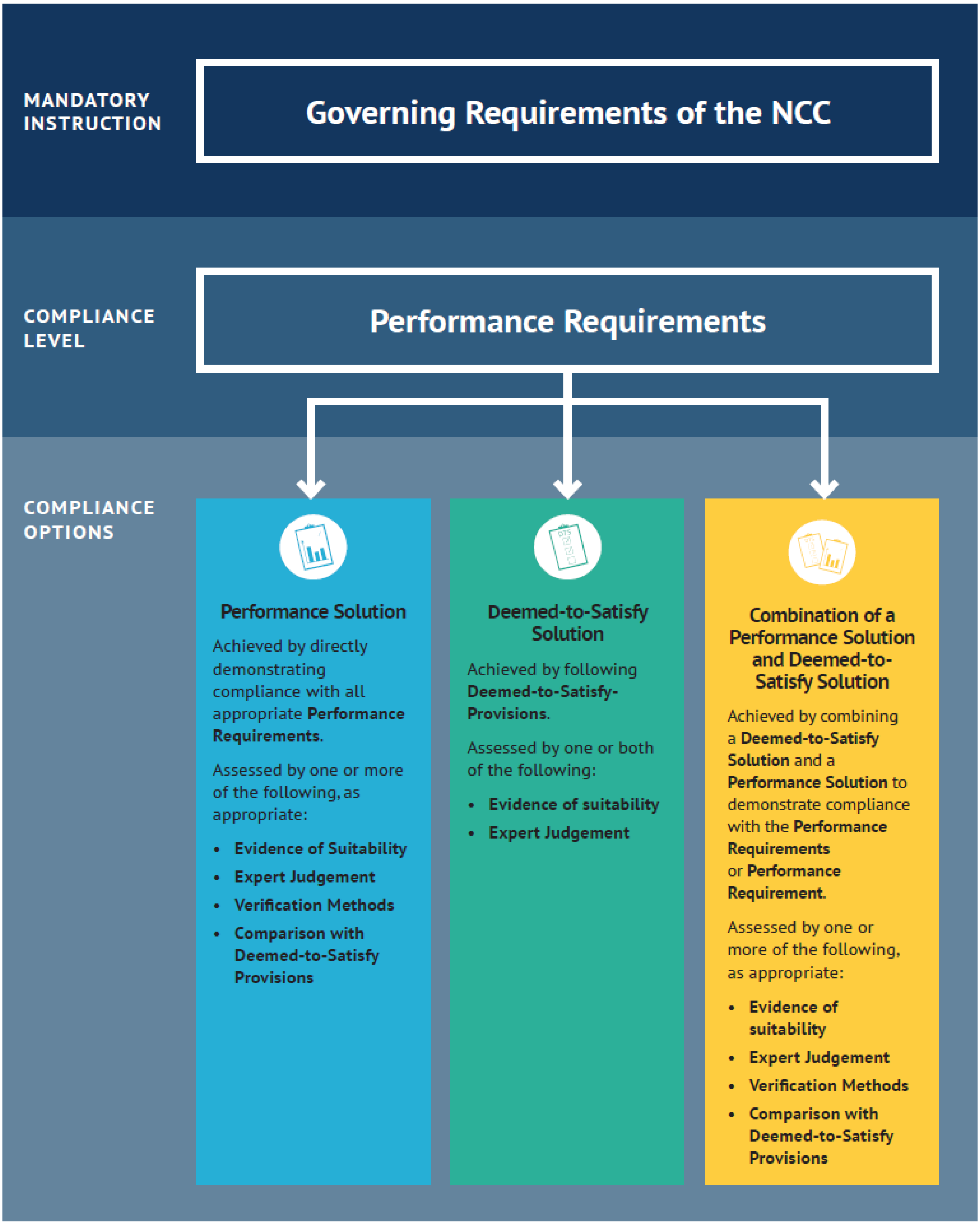
All compliance options must be assessed using one or a combination of the following Assessment Methods, as appropriate:

- Evidence of Suitability
- Expert Judgement
- Verification Methods
- Comparison with DTS Provisions.

A figure showing hierarchy of the NCC and its compliance options is provided in Figure A.1. It should be read in conjunction with the NCC.

To access the NCC or for further general information regarding demonstrating compliance with the NCC visit the ABCB website (abcb.gov.au).

Figure A.1 Demonstrating compliance with the NCC



Appendix B Acronyms and symbols

The following table, Table B.1 contains acronyms and symbols used in this document.

Table B.1 Acronyms and symbols

Acronym/Symbol	Meaning
ABCB	Australian Building Codes Board
ACH	Air Changes per Hour
AccuRate	One of the accredited NatHERS software tools managed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO)
AFRC	Australian Fenestration Rating Council
BASIX	Building Sustainability Index
BCA	Building Code of Australia
BERS Pro	One of the accredited NatHERS software tools managed by Energy Inspection
BOM	Bureau of Meteorology
C_{SHGC}	Solar heat gain constant
C_u	Glazing conductance allowance (constant for conductance)
COAG	Council of Australian Governments
CFL	Compact fluorescent lamps
CSOG	Concrete slab-on-ground
DTS	Deemed-to-Satisfy
E_s	Summer exposure factor
E_w	Winter exposure factor
FirstRate 5	One of the accredited NatHERS software tools managed by Sustainability Victoria
G	The difference between height and the base of the glazing element
GHG	Greenhouse gas

Acronym/Symbol	Meaning
H	Height of the shadow-casting edge of the projection above the base of the glazing element
HVAC	Heating, ventilation and air-conditioning
IGA	Inter-government agreement
LED	Light-emitting diode
MEPS	Minimum Energy Performance Standards
NatHERS	Nationwide House Energy Rating Scheme
NCC	National Construction Code
NEEP	National Energy Productivity Plan
NT	Northern Territory
OP	Occupancy profiles
P	Horizontal projection of the shading projection from the face of the glazing
PCA	Plumbing Code of Australia
PFC	Propose for Change
QA	Quality Assurance
Qld	Queensland
SA	Solar absorptance
SF	Suspended Floor
SHGC	Total System Solar Heat Gain Co-efficient
STC	Small scale Technology Certificate
Tas	Tasmania
U-Value ($W/m^2.K$)	Total System U-Value
W	Watt
WA	Western Australia

Appendix C Defined terms

C.1 NCC defined terms

NCC definitions for the terms used in this handbook can be found in:

- Schedule 3 of NCC 2019 Volumes One, Two and Three.

Building classifications can be found in:

- Part A6 Building Classifications of NCC 2019 Volumes One, Two and Three

C.2 Other terms

Administration means the State or Territory Government organisation responsible for the administration of building and/or plumbing legislation in that jurisdiction.

Breeze path is the path from one *ventilation opening* in a dwelling to another *ventilation opening* in the same dwelling, along which air can move freely. The breeze path must be unimpeded for natural breezes to pass through the dwelling and, in so doing, provide natural cooling by skin cooling or admission of outside air when conditions are suitable.

Building approval means granting of an approval, building licence, building permit, building rules, or other forms of consent or certification by an *Appropriate Authority*.

Capable the word "capable" is used in the *Functional Statement* and is important, as energy consumption in a dwelling is highly dependent on how the dwelling is used. Energy efficiency cannot be assured simply by including appropriate requirements into the dwelling as it also needs to be operated, managed and maintained in an appropriate way.

"Capable" is also used to cover buildings that may not initially have *domestic services* installed. Many buildings are constructed with minimum *domestic services* provided; allowing the occupants or tenants to install their own preferred *domestic services* at a later stage. As such, the NCC Volume Two energy efficiency requirements must be capable of catering for these *domestic services* after the base dwelling is constructed.

CO_2-e/MJ means equivalent carbon dioxide per mega joule(s).

Efficient use of energy

P2.6.1 refines the intention of the *Objective* and covers those aspects of the building *fabric* that must be considered for the dwelling to achieve the required thermal performance.

Evaporative cooling systems (evaporative cooler) are typical for residential dwellings and are usually placed on the roofs. Evaporative coolers work best in climates where the air is hot and the humidity is low. They operate by drawing warm outside air into the unit through filter pads made wet by a cold water supply. The air passing through the pads drops in temperature due to the dry air becoming more humid. The cool, humidified air is discharged indoors, but must also be vented through judiciously opened *windows* and doors in order to avoid a build-up of humidity and to maintain the efficiency of the evaporation process.

Facilitate the term "facilitate" is used in the *Performance Requirement* P2.6.1 to highlight the need to consider energy efficiency measures in a dwelling where it is likely that an artificial heating or cooling system will be installed. This also includes situations where artificial cooling is not installed during construction but is considered likely to be installed at some point during the lifetime of the dwelling.

Factors influencing the likelihood of artificial cooling being installed later include:

- dwelling alterations or additions resulting in a need to contain artificially cooled air;
- post occupancy need to cool the dwelling beyond what can be naturally achieved;
- the likelihood of changing occupant needs; and
- increased capacity to afford artificial cooling.

The term also indicates that energy efficiency is not an assured outcome but may be achieved if the dwelling is used and maintained correctly. Energy consumption is still deemed to be largely dependent on occupant behaviour and their interaction with a building; the NCC does not regulate occupant behaviour.

Functional Statement means a statement providing guidance on how buildings and building elements achieve the *Objectives*. It is found in explanatory information within NCC Volume Two.

Greenhouse gas intensity means the average rate of a given pollutant from a given source relative to the intensity of a specific activity, commonly measured in CO_2-e/MJ.

Joule (J) is the SI (international system of measuring units) unit for energy or work.

Objective means a statement providing guidance on the community expectations of requirements in the NCC. For energy efficiency provisions in Volume Two, the *Objective* is to reduce greenhouse gas emission. It is found in explanatory information in Part 2.6.

Opaque means a non-transparent building material, i.e. one that does not allow light to pass through. This includes masonry, timber, stone, fibre cement lining board, etc. A typical transparent or translucent material would be glass or polycarbonate sheeting. The term is important to the application of the building *fabric* and *glazing* provisions.

Generally, *opaque* materials such as walls are considered in Part 3.12.1 – Building *Fabric*, whereas transparent or translucent elements are typically considered as *glazing* in Part 3.12.2 – External Glazing.

Permanent in P2.6.1(d) of the *Performance Requirement*, the term “permanent” is used to describe features which will have a long term impact on the house. This could include natural features of the landscape, such as mountains and escarpments, while *permanent* man-made features would include houses likely to be in place for a long period of time.

Solar absorptance is a measure of the solar radiation, commonly heat, which an object can absorb. The higher the solar absorptance, the more heat it can absorb. Prior to the development of newer technologies, the solar absorptance was commonly related to the colour of a material, where the darker the colour, the higher the absorptance. Lighter coloured materials are commonly more reflective and absorb less heat.

To the degree necessary the term “to the degree necessary” has been included in the *Performance Requirement* because:

(a) there may be a minimum energy consumption below which it may be unnecessary or impractical to require energy efficiency features;
(b) there may be dwellings in some situations; where it may be unnecessary or impractical to require energy efficiency features; and
(c) some of the features may not be appropriate for some dwellings.

It may also be inappropriate to require energy efficiency in some instances, for example where there may be a conflict with health or safety requirements. Another example of when it may be impractical to regulate for energy efficiency may be a remote hut that is occupied on an infrequent basis.

The term also accounts for specific situations where there may not be a need to provide heating and cooling. For example, free-running dwellings where the design intent and construction techniques used in the design means the inclusion of artificial cooling at the time of construction, or post-occupancy, is highly unlikely. Significant alterations would be needed to enable the containment of conditioned air in free-running dwellings, which would be likely to require new *building approval*.

Watt (W) is the determined metric or SI (international system of measuring units) value for power and is used to rate electrical motors, appliances, lights etc. and in expressing both energy loads and energy consumption.

Appendix D Acts, Regulations and design responsibilities

D.1 Other Applicable Acts, Regulations and design responsibilities

There is other legislation (both Commonwealth, and State and Territory) which may impact on *building approval* and design.

For instance, the NCC does not regulate matters such as the roles and responsibilities of building and plumbing practitioners. These fall under the jurisdiction of the States and Territories.

State and Territory building and plumbing legislation is not nationally consistent in relation to these matters with significant variations with respect to:

- registration of practitioners
- mandatory requirements for inspections during construction.

The design and approval of building and plumbing and *drainage* solutions will need to consider these variations.

In addition to the relevant legislation, Workplace Health and Safety (WHS) legislation is also applicable which requires safe design principles to be applied.

A Code of Practice on the safe design of structures has been published by Safe Work Australia (2012) which provides guidance to persons conducting a business or undertaking work in regard to structures that will be used, or could reasonably be expected to be used, as a workplace. It is prudent to apply these requirements generally to most building classes since they represent a workplace for people undertaking building work, maintenance, inspections at various times during the building life.

The Code of Practice defines safe design as:

> "the integration of control measures early in the design process to eliminate or, if this is not reasonably practicable, minimise risks to health and safety throughout the life of the structure being designed".

It indicates that safe design begins at the start of the design process when making decisions about:

- the design and its intended purpose
- materials to be used
- possible methods of construction, maintenance, operation, demolition or dismantling and disposal
- what legislation, codes of practice and standards need to be considered and complied with.

The Code of Practice also provides clear guidance on who has health and safety duties in relation to the design of structures and lists the following practitioners:

- architects, building designers, engineers, building surveyors, interior designers, landscape architects, town planners and all other design practitioners contributing to, or having overall responsibility for, any part of the design
- building service designers, engineering firms or others designing services that are part of the structure such as ventilation, electrical systems and *permanent* fire extinguisher installations
- contractors carrying out design work as part of their contribution to a project (for example, an engineering contractor providing design, procurement and construction management services)
- temporary works engineers, including those designing formwork, falsework, scaffolding and sheet piling
- persons who specify how structural alteration, demolition or dismantling work is to be carried out.

In addition, WHS legislation places the primary responsibility for safety during the construction phase on the builder.

From the above it is clear that the design team in conjunction with owners / operators and the builder have a responsibility to document designs, specify and implement procedures that will minimise risks to health and safety throughout the life of the structure being designed.

A key element of safe design is consultation to identify risks, develop practical mitigation measures and to assign responsibilities to individuals / organisations for ensuring the mitigation measures are satisfactorily implemented.

This approach should be undertaken whichever NCC compliance pathway is adopted.

Some matters specific to health and safety are summarised below, but this list is not comprehensive.

- The NCC and associated referenced documents represent nationally recognised minimum standards for health and safety for new building works.
- The NCC's treatment of safety precautions during construction is very limited. Additional precautions are required to address WHS requirements during construction.
- Detailed design of features to optimise reliability and *facilitate* safe installation, maintenance and inspection where practicable.
- Document procedures and allocate responsibilities for determining evidence of suitability for all health and safety measures.
- Document procedures and allocate responsibilities for the verification and commissioning of all health and safety measures.
- Provide details of health and safety measures within the building, evidence of suitability, commissioning results and requirements for maintenance and inspection to the owner as part of the building manual. (Note: Some State and Territory legislation contains minimum requirements for inspection of fire safety measures)
- The building manual should also provide information on how to avoid compromising fire safety through the life of a building (e.g. preventing disconnection of smoke detectors or damage to fire resistant construction).

Some health and safety measures will be impacted by other legislation that may be synergistic with the NCC requirements or potentially in conflict particularly in relation to natural hazards these include:

- planning / development
- conservation

Appendix E Floor plans for examples

The following floor plans are referenced in both the verification using a *reference building* examples in Chapter 5 and the heating and cooling load limits examples in Chapter 7.

Table E.1 Floorplan and example cross reference

Floorplan	Example reference
Figure E.1 Lightweight construction	Example 5.6.1 (Brisbane)
Figure E.1 Lightweight construction with SF	Example 7.7.1 (Brisbane)
Figure E.2 Double brick construction	Example 5.6.2 (Perth)
Figure E.2 Double brick construction with CSOG	Example 7.7.2 (Perth)
Figure E.3 and E.4 Brick Veneer construction	Example 5.6.3 (Albany)
Figure E.3 and E.4 Brick Veneer construction with mixed floor type	Example 7.7.3 (Albany)

Please Note:

These floor plans are for reference purposes only and are indicative of the situations described in the examples to provide location and situational context. They are not to be used for any other purpose they are not intended for.

Figure E.1 Floor plan showing lightweight construction (not to scale) (Examples 5.6.1 and 7.7.1 in Brisbane)

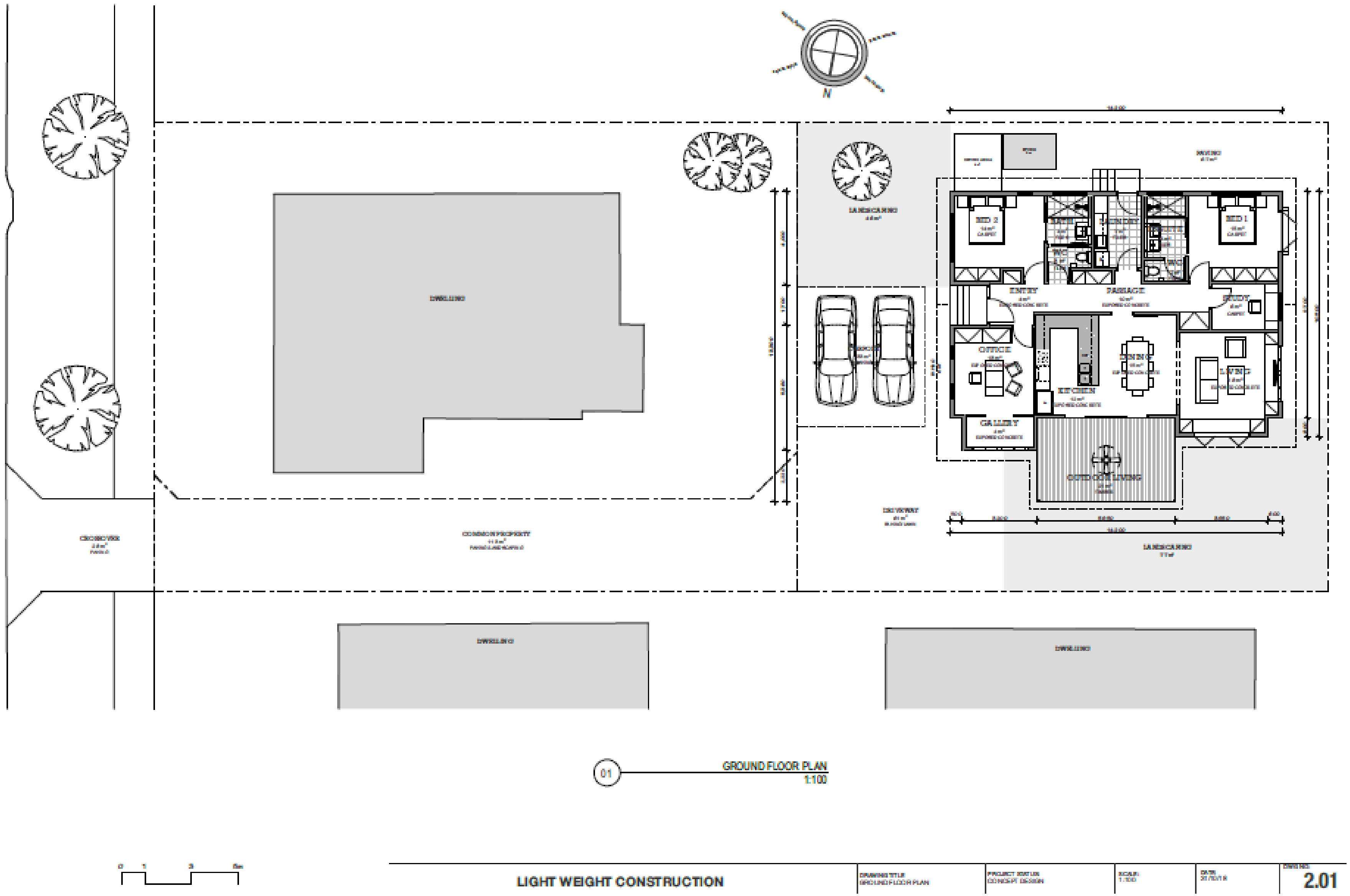


Figure E.2 Floor plan showing double brick construction (not to scale) (Examples 5.6.2 and 7.7.2 in Perth)

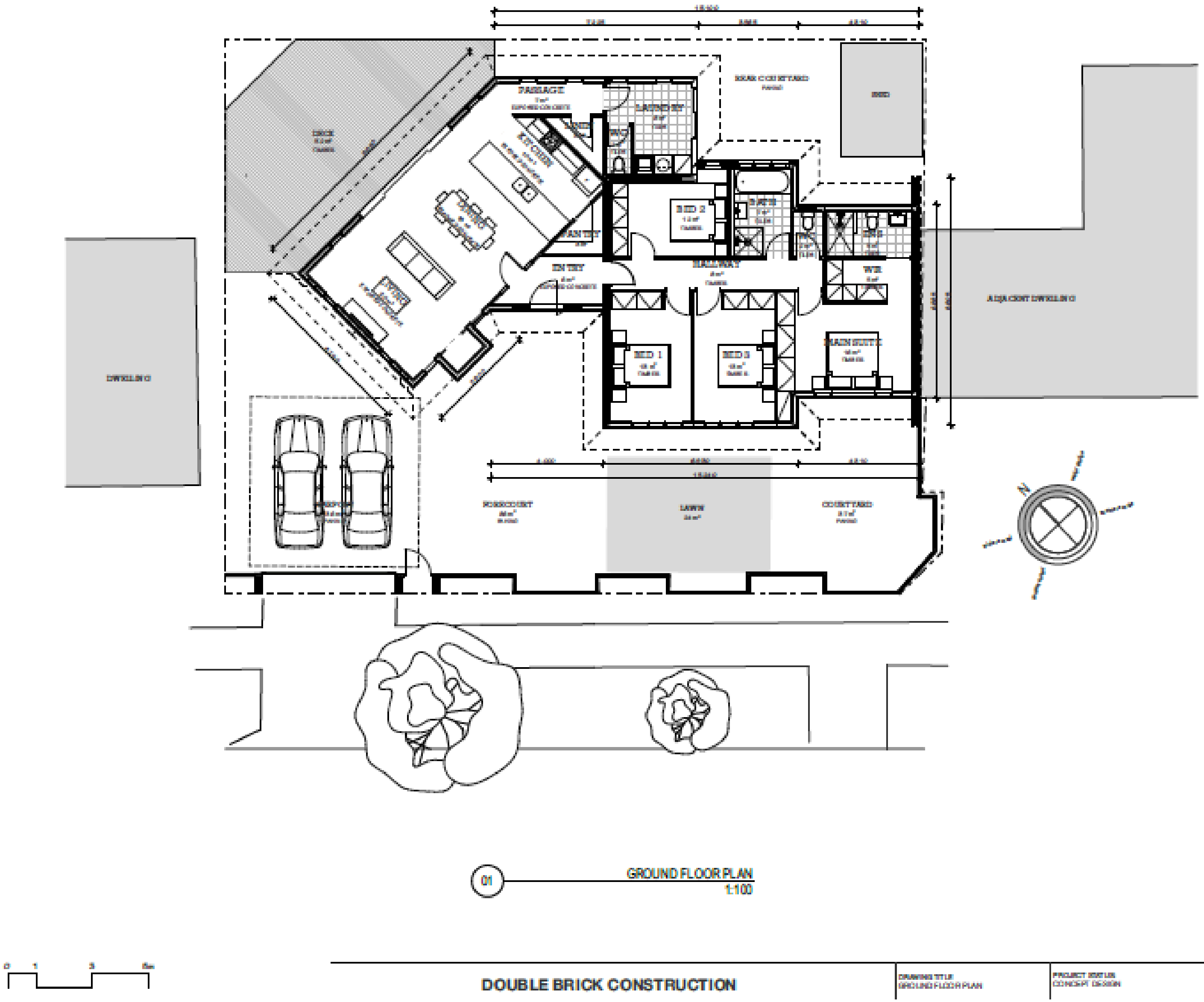


Figure E.3 Floor plan showing brick veneer construction - ground floor (not to scale) (Example 5.6.3 and 7.7.3 in Albany)

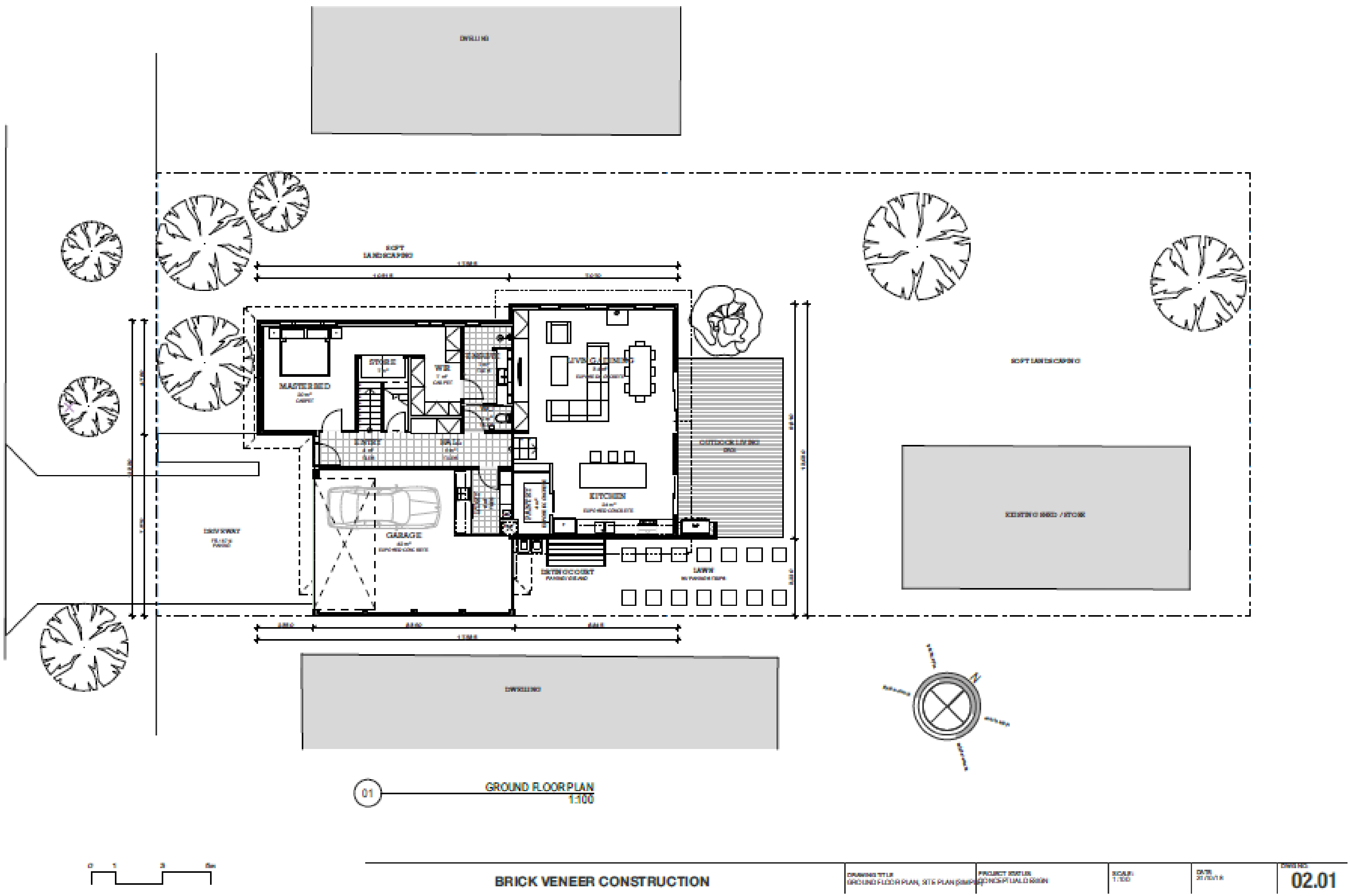


Figure E.4 Floor plan showing brick veneer construction - upper floor (not to scale) (Example 5.6.3 and 7.7.3 in Albany)