ABCB

National Construction Code

Handbook

Energy efficiency

NCC Volume One

abcb.gov.au

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Enquiries about this publication can be sent to:

Australian Building Codes Board
GPO Box 2013
CANBERRA ACT 2601
Phone: 1300 134 631
Email: ncc@abcb.gov.au
Web: abcb.gov.au

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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 questions raised 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.

The NCC Volume One Energy Efficiency Handbook assists in understanding of the energy efficiency requirements and provides examples where relevant. It addresses issues in generic terms and is not a document that sets out the specific requirements contained in the NCC, but rather aims to explain the intent of the provisions. 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 was revised in 2010, 2014, 2015, 2016 and 2018. It was re-written in 2019 due to the significant changes made to the energy efficiency provisions in NCC 2019.

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- Department of the Environment and Energy (Australian Government);
- Office of Environment and Heritage (New South Wales Government);
- Illuminating Engineering Society;
- Fan Manufacturing Association of Australia and New Zealand (FMAANZ);
- Australian Institute of Refrigeration Air conditioning and Heating (AIRAH); and
- Building Products Innovation Council (BPIC).

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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 Background

The National Construction Code (NCC) is a performance-based code containing all *Performance Requirements* for the construction of buildings. A building, plumbing or drainage solution will comply with the NCC if it satisfies the *Performance Requirements*, which are the mandatory requirements of the NCC.

This document was developed to provide guidance to practitioners seeking to demonstrate compliance with the energy efficiency requirements of NCC Volume One, Section J.

1.1 Scope

This Handbook has been developed to assist NCC users in understanding and applying the energy efficiency requirements in NCC Volume One, Section J. It will be of interest to all parties who are involved in selecting or assessing elements of buildings that must comply with the NCC.

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

Further reading on this topic can be found with the references located in the body of this document.

1.2 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 used in this document. They may align with a defined term in the NCC or be defined for the purpose of this document alone. See Appendix C for further information.

References and further reading is also provided in Chapters 17 and 18.

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

Examples
NCC Extract
Alerts
Reminders

2 Energy efficiency

2.1 Background

Since 2006, the Building Code of Australia (BCA) Volumes One and Two have contained energy efficiency requirements for all building classifications. The inclusion of energy efficiency requirements in the NCC is part of a comprehensive strategy that was undertaken by the Commonwealth, State and Territory Governments to reduce greenhouse gas (GHG) emissions.

Climate change is considered an issue of major significance. Most of the world's leading scientists agree that climate change is occurring due in large part to human activity. This presents challenges for the way we live and work and will require action from industry, governments at all levels, the broader community and individuals.

On 20 November 1997, the then Prime Minister released a statement: “Safeguarding the Future: Australia’s Response to Climate Change”. In this statement, a range of requirements was announced to address global warming including the need to seek energy savings from the built environment through the introduction of mandatory *Minimum Energy Performance Standards (MEPS)* for all building classifications. After a period of consultation with the building industry and key stakeholders, the Australian Government announced in July 2000 that all State and Territory Governments had agreed to introduce mandatory energy efficiency standards into the BCA to reduce GHG emissions attributable to the operation of buildings.

The first stage of the initiative introduced energy efficiency requirements for housing into BCA Volume Two on 1 January 2003. The second stage introduced energy requirements for multi-residential buildings into BCA Volume One on 1 May 2005.

The third stage introduced energy efficiency requirements for all other building classifications in BCA Volume One for BCA 2006. Also, in 2006, the provisions for housing were increased in stringency to 5 stars under the Nationwide Home Energy Rating Scheme (NatHERS) or equivalent.

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 to a 6 star or equivalent level.

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 (SOUs)* 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.

For NCC 2019 Volume One there has been a significant increase in stringency which resulted in the redesigning of the existing provisions. The changes include:

- recognition of *NABERS Energy for Offices* and *Green Star* as alternative *Verification Methods* (JV1 and JV2);
- improving the existing *reference building Verification Method* JV3;
- introducing basic comfort levels for building occupants;
- shifting from the comparison of energy consumption to GHG emissions in *Verification Methods* JV1, JV2 and JV3 to reconcile the different emissions intensities of gas and electricity in Australia;

- introducing an alternate building sealing *Verification Method* (JV4);
- simplifying the *Deemed-to-Satisfy (DTS) Provisions*;
- introducing whole of façade analysis through combining Parts J1 and J2; and
- introducing provisions for vertical transport.

These changes are expected result in more energy efficient and comfortable buildings, while also simplifying compliance options. The changes will also play an important part in Australia meeting its GHG reduction and energy productivity targets.

2.2 Greenhouse gas emissions and energy efficiency

2.2.1 Greenhouse gas emissions

2.2.1.1 What are greenhouse gases?

GHG are a natural part of the Earth's atmosphere. They trap the sun's warmth and maintain the Earth's surface temperature at a level necessary to support life. The problem we now face is that human activities, particularly the burning of fossil fuels (such as coal, oil and natural gas) and land clearing, are increasing the concentrations of these gases in the atmosphere, causing global climate change.

2.2.1.2 What are the effects?

It is understood that the climate is changing and known temperatures, rainfall and climatic patterns are changing as a result. The impacts are both primarily negative, affecting the distribution of plants and animals, the frequency of storms and floods and the spread of weeds, pests and diseases which may influence agriculture and our health.

2.2.2 **Energy efficiency**

2.2.2.1 Why regulate buildings for energy use?

The building sector is one of the fastest growing GHG emissions sources. Energy used in buildings accounts for more than 20%[1] of all energy-related GHG emissions.

Improving the energy efficiency of buildings therefore represents one of the biggest opportunities to reduce GHG emissions in Australia. The use of renewable or low GHG intensity fuels can also reduce the GHG emission rate.

Consequently, the construction industry has an extremely important role in the abatement of Australia’s GHG emissions and in delivering economic, as well as social and environmental benefits to the community.

2.2.2.2 How is energy efficiency being progressed in our industry?

A multi-pronged approach has been adopted by the Australian Government to improve the energy efficiency of buildings. Support has been provided by Government and industry for the introduction of minimum energy efficiency *Performance Requirements* in NCC Volumes One and Two which are aimed at setting a community agreed baseline. Industry and consumers are being encouraged to embrace voluntary best practice initiatives, and *MEPS* have been developed for major items of equipment used in buildings.

The Commonwealth, State and Territory governments have a range of programs aimed at improving the energy efficiency of the building stock.

The ABCB commissioned and prepared many technical reports that have informed development of the energy efficiency provisions. These can be requested from the ABCB via the ‘Contact Us’ page on the ABCB website (abcb.gov.au).

[1] Emissions breakdown in Australia (ASBEC, 2017)

2.2.2.3 What is energy?

For the purposes of the NCC energy efficiency requirements, “energy” is the electricity (taken both from the electricity grid and generated onsite), gas, oil or other fuels used in buildings for heating, cooling or ventilation, for lighting or heated water supply or to operate other building 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 commercial buildings do not cover energy used for manufacturing processes or maintaining specialised environments inside buildings. They also do not apply to portable appliances (such as refrigerators, office equipment and the like) which are often subject to separate government schemes such as *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 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.

2.2.2.4 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 building services, whilst maintaining expected standards in these areas. This is the aim of the NCC requirements.

Energy efficiency means improving the performance of services and systems 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. This heat flow determines how hard the services work. Better fabric thermal performance can mean smaller *air-conditioning* plant, running for less time as well as reducing the need for heating or cooling in the first instance.

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 and their impact will be felt for a very long time.

2.3 Philosophy of the NCC requirements

Since 2003, the BCA 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. The energy efficiency requirements consider the:

- performance of the building fabric including external glazing and shading;
- sealing of the building;
- performance of *HVAC* systems;
- artificial lighting and power;
- heated water supply system and the heating and pumping of swimming pools and spas; and
- facilities to monitor energy use.

The philosophy underpinning the requirements is that several benefits are obtained by having a building designed with greater levels of energy efficiency. Build running costs are reduced. The building interior is likely to stay warmer in cold weather and cooler in hot weather. This can reduce the size of any equipment needed for heating and cooling and the occupants are less likely to feel the need to run the equipment.

2.4 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 they may change from time to time in response to changes in local government boundaries. Please refer to

Schedule 3 Definitions in NCC Volume One 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 and are shown in both a map and tabular format for the major cities.

The eight NCC *climate zones* were based on a list of six zones that were developed by the Bureau of Meteorology, 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	-	-
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

Note: *Climate zone* 8 is determined as per NCC Volume One definitions for NCC Alpine areas.

Where appropriate, the map was 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 that location.

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 building energy analysis software to meet the *Performance Requirements*, rather than the *DTS Provisions*.

2.4.1 **Energy efficient buildings in warmer climates**

For Australia's consistently hotter or warmer climates, *climate zones* 1, 3 and, to a degree, 2, the intent is to limit the yearly need for cooling services which generally use electricity. Although Australia's grid is steadily decarbonising, it is still the case that most of the nation's electricity supply has a higher GHG intensity than natural gas which is often used for heating. In these climates, heating is needed less frequently if at all.

The NCC Volume One *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 11 discusses in detail the impact of *glazing*.

2.4.2 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 buildings in these cold climates, the intent is primarily to reduce the need for heating services. There will still be some use of cooling services in *climate zone* 7 during the summer months and for much of the year in commercial buildings with high internal loads from computers and processing plants. Provisions addressing the thermal insulation of the *envelope*, the size and type of *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 orientated.

Heat loss may cause temperatures in the building 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) in a building located in a cold climate can reduce the need for heating services in a building located in a cold climate.

2.4.3 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, for this reason the NCC requirements 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, cooling or heating services are likely to be installed in buildings. The NCC Volume One requirements are attempting to reduce their energy use or how hard they work through efficient fabric design, not eradicate them.

3 Introduction to the performance-based NCC

3.1 The ABCB

The ABCB is a joint initiative of all three levels of government in Australia and includes representatives from the building and plumbing industries.

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

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).

3.1 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 pertains primarily to Class 2 to Class 9 buildings while NCC Volume Two pertains primarily to Class 1 and 10 buildings. NCC Volume Three pertains primarily to plumbing and drainage associated with all classes of buildings.

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 publishes 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 One.

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

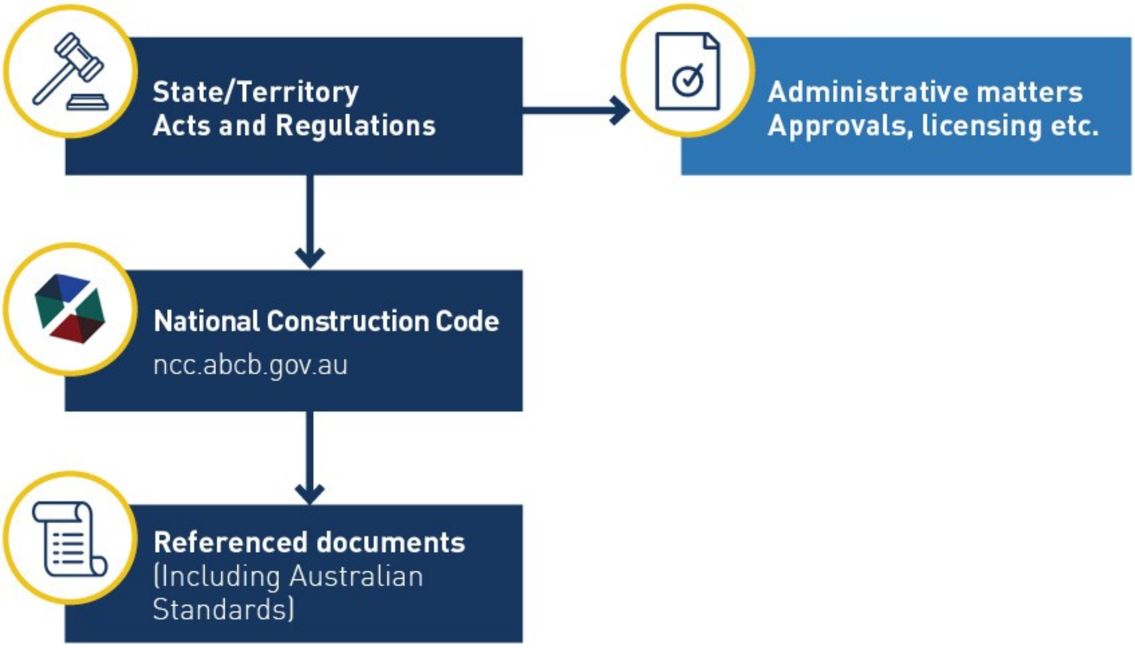
3.1.1 Legislation governing building, plumbing and drainage work

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 must 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 which 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



3.1.2 **Compliance pathways**

Compliance with the NCC is achieved by complying with the Governing Requirements of the NCC and relevant *Performance Requirements*. There are three options available to demonstrate compliance with the *Performance Requirements*:

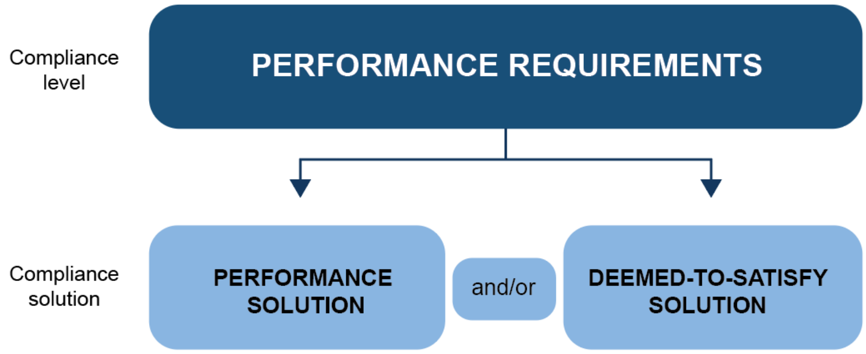
- A *Performance Solution*,
- A *DTS Solution*, or
- A combination of a *Performance Solution* and a *DTS Solution*.

Within the *Performance Solution* pathway, some options available are:

1. Direct application of the *Performance Requirements*, and
2. *Verification Methods*.

The structure of the performance-based NCC is shown in Figure 3.2 below.

Figure 3.2 NCC compliance structure



3.1.3 Energy efficiency compliance pathways

The following compliance pathways are available for energy efficiency in NCC Volume One:

1. *Performance Solution*
    (a) Direct application of JP1 and energy targets;
    (b) *Verification Methods* (JV1, JV2, JV3 and JV4);
    (c) Demonstrating equivalence to the *Verification Methods* or *DTS Provisions*[2]
2. *DTS Provisions* (Parts J0 to J8)
3. A combination of the above

Further information on compliance with the NCC is provided in Appendix A.

3.2 Performance-based design process

3.2.1 Performance-based design brief (PBDB)

A PBDB is a document that defines the process and scope of work for the energy analysis. Its purpose is to set down the basis on which analysis of the proposed

[2] Demonstrating compliance via the JP1 energy target, JV1, JV2 or JV3 generally requires a whole of building energy model. Where a building only has minor deviations from DTS these approaches may not be desirable or necessary. A *Performance Solution* may be completed by showing equivalence to the *Verification Methods* or *DTS Provisions*, for instance by showing that although one component of a design uses more energy than a DTS design, the energy usage is compensated for by other elements that use less energy than a DTS design.

building and its *Performance Solution* will be undertaken, as agreed by the relevant stakeholders.

A PBDB allows all relevant stakeholders to be involved in the development of a *Performance Solution*, and to share their specific knowledge and perspectives with the design team.

When developing a *Performance Solution*, a PBDB should be undertaken involving all relevant stakeholders to the building design.

Relevant stakeholders vary from design to design. Often relevant stakeholders include: the engineer, architect, developer, client and the building certifier. Note that some state legislation prevents the building certifier from being involved in the design process. If this is not the case, care is required to ensure the building certifier is not involved in design decisions that they will be certifying; as this would constitute a conflict of interest.

Relevant stakeholders can be determined by conducting a simple analysis as to who should be involved in the PDBD process. This analysis should identify stakeholders with a high interest in the design process.

While full agreement on all aspects of the PBDB is the preferred outcome, it is acknowledged that in some instances this may not be possible. If full agreement cannot be achieved through the PBDB process, dissenting views should be appropriately recorded so that it can be considered by the *Appropriate Authority* when determining compliance and as part of the approvals process.

3.2.2 **Design strategy**

The PBDB should cover the energy efficiency design strategy for the building, outlining the features that will be incorporated into the building to achieve the required energy efficiency outcome.

For example, the energy efficiency design strategy may be to minimise the impact of the *glazing* in an office building by focussing on the energy efficiency of the building's services and using on-site *renewable energy*.

3.2.3 **Project staging**

A project that is designed to meet the energy allowances specified in JP1 must be below the applicable energy allowance at each stage of the project, including an allowance for any future stages that are expected to occur.

For example, if the base building design is completed separately to the tenancy design the design team may need to determine in advance the allowable energy usage of each design stage. If this does not occur an overrun in the base building design may leave an insufficient energy allowance for the tenancy fit out.

3.2.4 **Performance-based design report**

Once the analysis has been completed, a final report should be prepared that includes the information from the agreed PBDB, all the modelling and analysis, and all other information required to clearly demonstrate that the building and system satisfies the target in JP1.

3.2.5 **Practitioner conduct**

When preparing a *Performance Solution*, practitioners should exercise their duties within a code of conduct. Key requirements include:

1. Acting in the public interest

In undertaking their duties, including meeting the needs of their client, a practitioner should exercise their discretionary powers in ways that safeguard the public interest.

2. Independence

In performing their professional duties, a certifier/building surveyor should be objective, impartial and free from any conflict of interest. Other practitioners should ensure any conflicts of interest are disclosed to all relevant parties.

3. Competence

A practitioner should not undertake professional work that they are not competent to perform. See Section 3.2.6 for further details of the peer review process.

3.2.6 **Peer review**

The appointment of a peer reviewer is recommended at the PBDB stage where a building and its *Performance Solution* are more complex. This includes those that have innovative designs, or challenging aspects of modelling or analysis which fall substantially outside the competence and expertise of the certifier.

The peer reviewer should have qualifications and experience which give them a level of competence equal to or better than the design team, and also be independent of the design team, to evaluate the *Performance Solution* proposed.

The peer review is potentially the most complex kind of review both technically and ethically. The peer review should consider the following:

- whether the completed work has met its objectives;
- whether the completed work matches the modelled building;
- other options that could have been included in the preliminary design;
- whether the evaluation of options is rigorous and fair;
- the validity of the assumptions;
- the validity of the conclusions;
- the process for completion of the construction work;
- the validity of the recommendations;
- the objectives set out for the work;
- adherence to other relevant regulations and codes of practice; and
- the fitness-for-purpose of the work.

The peer review may also consider elements of the design process, such as resources, value engineering, concept design, risk reviews and design methodology. Note that allowing a peer reviewer to have input into the scope of the work, the design process, project planning and the completed work review can lead to a better outcome for the project.

While the work is in progress, the peer reviewer can review inputs at specified points to aid the design process and avoid problems such as poor evaluation of options and incorrect assumptions. The peer reviewer may act as an adviser to the designer, depending on how the process and liability implications are managed.

4 Performance Requirement JP1

4.1 Introduction

The purpose of this Chapter is to explain the energy efficiency *Performance Requirement*, JP1 in Section J of NCC Volume One.

This Chapter reviews the intent of the energy efficiency requirements in Section J via the *Objective* and *Functional Statement* of the section and the mandatory *Performance Requirement* JP1.

Reminder:

Objectives and *Functional Statements* are used to provide guidance on the intent and interpretation of the *Performance Requirements*. They are found in The Guide to Volume One.

4.2 Objective

The *Objective*[3] relevant to Section J is JO1, which states:

"The *Objective* of this Section is to reduce greenhouse gas (GHG) emissions."

This reflects the Governments' policy of reducing GHG emissions. It was also stated in a COAG Energy Council communiqué following its meeting of 30 April 2009, prior to the BCA 2010 changes.

Improved energy efficiency plays a key part in achieving this goal. It should also be noted that whilst the primary goal is not obtaining optimal comfort, the requirements are partly based on achieving an internal environment in which conditions are sufficiently amenable for occupants to minimise their use of artificial heating, cooling or lighting.

[3] The *Objective* of Section J is found in The Guide to Volume One.

The energy use attributable to a building over its life 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 building and the GHG emissions attributable from the operational component is the focus of the NCC requirements. Broader environmental requirements such as embodied energy may be considered in the future subject to broader government support.

The *Objective* also does not have a limitation clause, which means that it is relevant to all buildings covered by NCC Volume One.

The relationship between reducing GHG emissions and improving energy efficiency is further explained throughout this Chapter.

4.3 Functional Statement

The *Functional Statement*[4] relevant to Section J is JF1, which states:

"To reduce greenhouse gas emissions, *to the degree necessary*-

- (a) a building, including its services, is to be *capable* of efficiently using energy; and
- (b) a building's services 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 such as reclaimed energy."

The *Functional Statement* recognises that there are two key contributors to GHG emissions pollution from buildings. The first is the amount of energy the building and its 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

[4] The *Functional Statement* of Section J is found in The Guide to Volume One.

replenished and available). Reclaimed energy may come from a co-generation plant, using heat recovered from the cooling water from a refrigeration chiller.

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 building owner might stop using it at any time during the building'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 clause and so is relevant to all buildings covered by NCC Volume One.

4.4 JP1 Performance Requirement

4.4.1 Energy efficiency

JP1 provides an absolute performance target for the energy use of air-conditioned buildings. This approach is intended to ensure that designers have a pure performance target and are thereby free to innovate across all aspects of design. As previously mentioned, JP1 is the only mandatory energy efficiency requirement in NCC 2019 Volume One.

JP1 is reproduced below:

JP1 energy use

A building, including its *services*, must have features that facilitate the efficient use of energy appropriate to—

(a) the function and use of the building; and
(b) the level of human comfort required for the building use; and
(c) solar radiation being—
    (i) utilised for heating; and
    (ii) controlled to minimise energy for cooling; and
(d) the energy source of the *services*; and
(e) the sealing of the building *envelope* against air leakage; and

JP1 energy use

(f) for a *conditioned space*, achieving an hourly *regulated energy* consumption, averaged over the annual *hours of operation*, of not more than—

(i) for a Class 6 building, 80 kJ/m².hr; and

(ii) for a Class 5, 7b, 8 or 9a building other than a *ward area*, or a Class 9b *school*, 43 kJ/m².hr; and

(iii) for all other building classifications, other than a *sole-occupancy unit* of a Class 2 building or a Class 4 part of a building, 15 kJ/m².hr.

Alert:

JP1 (f) is not applicable to Class 2 *SOUs* as quantified *regulated energy* consumptions targets are not developed for use at this time.

4.4.2 **Energy targets**

Incorporating energy targets into JP1 provides a quantified compliance pathway for buildings that are air-conditioned to meet the NCC *Performance Requirement* for energy efficiency, JP1. JP1 incorporates targets for the energy use of a building in units of kilojoules per square metre of *conditioned space* per hour (kJ/m^2.hr) of building operation, averaged over the course of a year. The quantified energy targets are only applicable to *conditioned spaces.*

Clause (f) of the *Performance Requirement* has three energy targets for three different groups of building classifications. These metrics have been set at a level of stringency to ensure they are generally at least as stringent as the *DTS Provisions*.

Unconditioned spaces, such as carparks and (unconditioned) warehouses, will not be able to fully use a direct *Performance Solution* for JP1, but are limited to *Performance Solutions* based on the unquantified elements of JP1. The quantified energy targets also do not apply to the *SOUs* in a Class 2 building or a Class 4 part of a building. *Performance Solutions* that use either the quantified or unquantified elements of JP1 are recommended to use the performance-based design process described in 3.2 of this Handbook.

It should be noted that JP1 specifies targets for energy use ($kJ/m^2.hr$) whereas in *Verification Methods* JV1, JV2 and JV3 there has been a shift from the comparison of energy consumption to (GHG) emissions ($kgCO_2$-e). JP1 requires efficient use of energy with consideration of the energy source, providing the link to GHG emissions used in the *Verification Methods*. GHG emissions due to electricity use varies widely around Australia. Therefore, the metric of energy use ensures consistent efficiency in consumption while the energy mix in the grid changes over time.

GHG emissions factors are in Table 3a of Specification JVb or the current full fuel cycle emissions factors published by the Australian Government.

4.5 JP1 Performance Solution using energy modelling

This section looks at what's needed when using energy modelling as a direct JP1 *Performance Solution* (i.e. a *Performance Solution* not using the *Verification Methods* JV1, JV2 or JV3).

4.5.1 Software requirements

Where used to demonstrate compliance with JP1, energy modelling software should:

- provide a detailed representation of the building design, including the building fabric, services and occupancy;
- calculate the operation of the building on a dynamic basis, allowing for effects of *thermal mass* in the building fabric, thermal properties of materials, the efficiency of plant items under varying operating conditions, and the control of services; and
- use a time-step of not more than one hour throughout an entire year from which to assess building performance, using representative local weather data as an input to calculations.

Modelling tools used for assessing JP1 compliance should meet the requirements of ANSI/ASHRAE Standard 140 (2007), i.e. the same Standard as the modelling tools used to comply with the *Verification Methods*. ANSI/ASHRAE Standard 140 uses a combination of analytical, comparative and empirical tests to confirm that the model:

- complies with the laws of physics;
- produces results that are comparable to other simulation packages; and
- can provide an acceptable representation of measured performance data for key tests.

Modelling of lift energy consumption, which is not covered in ANSI/ASHRAE Standard 140, should follow a well-defined procedure, such as that laid out in ISO 25745-2:2014.

4.5.1.1 Evaluation of results

The primary parameter for evaluating the performance of the proposed building is *regulated energy* consumption per square metre of conditioned floor area, divided by the total *hours of operation* of the building per year.

The *regulated energy* use is defined as the energy consumed by the building services, less any *renewable energy* generated and used on site. *Renewable energy* that is either not generated on site or is not used on site may not be subtracted from the *regulated energy* use total.

In practice, the *regulated energy* consumption includes all energy use other than for:

- emergency systems;
- cooking facilities;
- portable devices (computing equipment and other plug loads);
- process loads (equipment for the creation or processing of materials or data that is sited within the building, but is not associated with the provision of *air-conditioning*, *mechanical ventilation*, heated water supply, artificial lighting or any other services associated with the operation of the building in providing a habitable environment); and
- electric car charging stations.

Specifically, the *regulated energy* consumption includes all energy use associated with all components covered in Parts J1 to J7 of Section J.

Regulated energy includes energy from lifts. Where a lift serves multiple building classifications, the energy use from the lift may be apportioned based on the percentage of floor area of each classification that it serves. For a Class 2 building, this means the lift energy attributed to the common area is in the same proportion as the fraction of the total common area to the total area of the building. Note there is no energy target for *SOUs*, so while energy may be apportioned to *SOUs* in this calculation, the energy apportioned is not used as a comparison to an energy target in JP1.

4.5.2 **Inputs**

4.5.2.1 Climate

The climate at the building location should be represented using a weather file that provides data for an actual calendar year (e.g. test reference year) that is typical for the location. It should be selected based on a nearby climate station that experiences comparable climatic conditions to the building location. To be considered typical, the climate station should be within 50 km of the building location and within 100 m of the building altitude.

Where no such weather station exists, select two weather stations which can reasonably be expected to have similar climates. One weather station should be expected to have a slightly larger heating energy consumption, and the other a slightly larger cooling energy consumption. The building energy model should then be based on the *climate zone* which results in a higher energy consumption.

The model should incorporate ground temperatures that are realistic for the location.

4.5.2.2 Building form

The model should represent the building's shape, location, orientation, architecture and thermal properties with emphasis on representation of:

- the overall building *envelope* dimensions, including floor plate, height, building shape and self-shading components of the building;
- the orientation of the building relative to the path of the sun;
- the building *glazing*, including window locations both with respect to individual thermal zones of the building and with respect to the location of any elements that may cause shading of the window;
- the building location, including allowance for adjacent *permanent* buildings and landscape; and
- shading from vegetation, which may be represented only if it is within the footprint of the legal title within which the building is located. Growth of vegetation may be allowed for in the model for a maximum of 5 years into the future. Ground reflectance should be modelled in a manner representative of the local environment.

4.5.2.3 Thermal properties of the building

Opaque external building elements should be represented accurately with respect to:

- overall thermal resistance, allowing for *thermal bridging*;
- solar absorptivity; and
- materials, including their *thermal mass* and order in the building element construction.

Transparent external building elements should be represented correctly with respect to:

- transmittance, absorptance and reflectance properties at varying solar angles and in short wave and long wave spectrums;
- thermal conductance allowing for frames, edge-of-window and centre of window effects; and
- visual transmittance, if any form of daylight sensitive control is used based on internal light level in the building.

The values for transparent external building elements should be based on the technical protocols and procedures of the Australian Fenestration Rating Council (AFRC).

Building infiltration should be modelled at the appropriate rate for the building. The infiltration provisions of Specification JVb may be used for guidance.

Internal building element characteristics in the model should include:

- *thermal mass*;
- thermal resistance (where the building element separates different thermal zones); and
- reflectance, if daylight sensitive control based on internal light level is used.

Internal partitions do not need to be represented where they do not form part of the plans being submitted for approval.

4.5.2.4 Building services

The building services should be represented in detail, including:

- the capacity and efficiency of the individual plant items as their load varies across their operating range;
- thermal losses from circulating systems;
- standing loads from jacket heaters, sump heaters and similar parasitic power requirements for individual plant items;
- lift energy;
- on-site *renewable energy*; and
- domestic hot water energy.

The control of services should be modelled as they are intended to be used in the proposed building, including but not limited to:

- physical layout of control zones, allowing for some aggregation of thermally similar zones in the model relative to the building;
- zone temperature control, including set point, dead band and overall control band, local heating/cooling control and local airflow control;
- supply air temperature control;
- dehumidification/humidification control;
- economy cycle control;
- optimum start control;
- night purge/night ventilation control;
- fan control;
- chilled water pump control;
- hot water pump control;
- condenser water pump control;
- steam system control, where steam use falls within the definition of *regulated energy*;
- chiller staging control; and
- *boiler* staging control.

For further modelling detail, the provisions of Specification JVb Clause 4 may be used as a guide.

4.5.2.5 Occupancy

The representation of occupancy should follow a similar approach to Specification JVb3(c)(vii), i.e. based on either:

- Specification JVc; or

- *NABERS Energy for Offices* simulation requirements; or
- *Green Star* simulation requirements; or
- the proposed building operation if the operating hours are not less than 2500 hours per annum or the daily operating profiles are not listed in Specification JVc.

Occupant density and internal load density shall be modelled to represent expected normal operation, rather than design load operation.

For the purposes of thermal comfort calculations, the clothing and metabolic rates of the building occupants should be selected reflecting justifiable assumptions of the actual likely clothing and activity levels of the occupants, referenced to an external standard such as ANSI/ASHRAE Standard 55.

4.5.3 **Outputs**

For each separate iteration or scenario of the model presented in the reporting, the model outputs should include:

- the energy use by month and annually for subcategories including, but not limited to:
  - chillers;
  - cooling provided by systems other than chillers;
  - *boilers*;
  - heating provided by systems other than *boilers*;
  - humidifiers;
  - *air handling unit* (*AHU*) fans;
  - ventilation fans;
  - chilled water system pumps;
  - hot water system pumps;
  - other pumps;
  - lifts;
  - lighting;
  - internal/equipment/process loads;
  - on-site *renewable energy*;
  - for cogeneration and trigeneration systems;
    - electricity generated;
    - cooling generated;

- waste heat transferred to building services;
- waste heat rejected; and
- auxiliary energy.

- the hours of *air-conditioning* operation for each zone and the associated area of each zone;
- the total *regulated energy* usage of the *conditioned spaces*;
- the achievement of comfort conditions as appropriate to the building type and occupancy schedule based on a reputable methodology, such as ANSI/ASHRAE Standard 55. Note that unless specifically demonstrated as part of the design, the air speed should be modelled at 0.05 m/s. Results may be presented:
  - for each zone, the percentage of operating hours when the building is occupied, and the thermal comfort is acceptable;
  - for the building as a whole, an area-weighted average of the percentage of operating hours for each zone when the zone is occupied, and the thermal comfort is acceptable.

4.5.4 **Acceptance criteria**

The model satisfies the requirements of JP1 if the following has been demonstrated to the satisfaction of the *Appropriate Authority*:

- To meet JP1(a), the design outcome supports the intended function and use of the building and its services.
- To meet JP1(b), the design outcome delivers the required level of human comfort for the building use.
- To meet JP1(c), solar radiation is utilised for heating and controlled to minimise energy for cooling.
- To meet JP1(d), the building does not use an energy source which emits an excessively high amount of GHG.
- To meet JP1(e), the building *envelope* is sufficiently sealed against air leakage.
- To meet JP1(f), the total *regulated energy* usage of the *conditioned spaces* is less than or equal to the overall allowance, where the overall allowance is calculated by:
  - multiplying the allowance for each classification by the area-weighted hours of building operation for that space and the floor area of the *conditioned space* for that classification; and
  - summing the results for all *conditioned spaces* to obtain the overall allowance.

- For the purposes of JP1(f), the allowance for *regulated energy* consumption for each classification is:
  - for a Class 6 *conditioned space*, 80 kJ/m².hr; and
  - for a Class 5, 7b, 8 or 9a building other than a *ward area*, or a Class 9b *school*, 43 kJ/m².hr; and
  - for any other class of building other than the *SOU* of a Class 2 building or a Class 4 part of a building, 15 kJ/m².hr.

4.5.5 **Documentation**

The following documentation may be produced to demonstrate compliance with JP1.

4.5.5.1 Building form

- Three dimensional renderings of the building as represented in the model showing orientation, building form, *glazing* location, facade shading and shading from adjacent structures.
- A list of construction types (materials, their order and material properties) used in the model for *opaque* exterior walls, floors and roofs including modelled *R-Values*, solar absorptance and *thermal mass*.
- A list of window types used in the model including specifications of individual panes and gaps, frame type, and calculated AFRC U-Value and Solar Heat Gain Coefficient (SHGC), correct for window size, for each window.
- A list of construction types for internal walls between thermal zones, listing modelled *R-Value* and *thermal mass*.
- Plans showing the division of floorplates into thermal zones.
- Documentation justifying non-default infiltration figures.

4.5.5.2 Building services (as applicable)

- Coefficient of Performance (COP), Integrated Part Load Value (IPLV)/ Non-standard Part Load Value (NPLV) and nominal capacity of each chiller.
- COP or Energy Efficiency Ratio (EER) of each unitary air conditioning system.
- Absorbed power, motor power, design flow and design pressure of each fan and pump.
- Gross calorific efficiency and capacity of each *boiler*/water heater.
- COP and capacity of each hot water heat pump.
- Input power of each direct electric heating element.
- Modelled thermal losses for chilled water, hot water and steam systems.

- The relationship between field demand and percentage thermal energy requirement for fan and pump systems.
- Efficiency of on-site generation equipment.
- Control algorithms and settings for each control item under Section 4.5.2.4.
- Energy inputs used for lift energy calculation as per ISO 25745-2.
- Schedule of lighting power calculations for each zone.

4.5.5.3 Building occupancy

- Occupancy schedules and densities.
- Lighting schedules.
- Internal/process loads schedules and densities.

4.5.5.4 Model outputs

- Model outputs as per 4.5.3.

4.5.5.5 Sensitivity studies

The following sensitivity analyses are recommended:

- building performance in the absence of shade from vegetation;
- building performance at design occupancy and internal/process load densities;
- building performance with fewer *hours of operation*; and
- if a non-default infiltration rate has been used, building performance at default infiltration rates.

4.5.6 **Maintenance and management assumptions**

The report should list any assumptions made in relation to the operation of the building that are critical to any of the following:

- the achievement and maintenance of shading from vegetation;
- the operation of moveable facade elements;
- the achievement and maintenance of the efficiency of plant items;
- achievement of modelled internal load/process or lighting schedules; and
- achievement of thermal comfort.

5 NABERS Verification Method JV1

5.1 Introduction

Verification Method JV1 is a *Verification Method* that can be used to assess a *Performance Solution*, demonstrating compliance with the mandatory *Performance Requirement* JP1 in NCC Volume One. It can be used instead of the *DTS Provisions* of Parts J1 to J7.

It should be emphasised that it is not mandatory to use a prescribed NCC *Verification Method* as the *Assessment Method*.

5.2 Scope

JV1 is applicable to Class 5 buildings. It is not applicable to Class 2, 3, 4, 6, 7, 8 or 9 buildings.

5.3 Intent

The intent of any *Verification Method* is to demonstrate that a *Performance Solution* meets the *Performance Requirement*(s).

Due to the broad uptake and proven energy savings of the National Australian Built Environment Rating System for energy efficiency (NABERS Energy) *Verification Method* JV1 allows the use of the *NABERS Energy for Offices* base building Commitment Agreement modelling protocols and schedules to demonstrate compliance with JP1 for Class 5 buildings.

5.4 Methodology

JV1(a) outlines the criteria to be used for JV1.

Only one energy model is required for both the *NABERS Energy for Offices* base building Commitment Agreement and to demonstrate compliance with JP1. While the *NABERS Energy for Offices* base building Commitment Agreement and the *DTS Provisions* differ in scope slightly, both the *NABERS Energy for Offices* base building

Commitment Agreement and NCC Volume One Section J have the same *objective* of energy efficiency and reduced GHG consumption.

A Commitment Agreement is obtained when the property owner/ developer receives the counter singed Commitment Agreement from the NABERS National Administrator. By obtaining a Commitment Agreement, it ensures that the necessary rating will be verified through the NABERS Energy process; and the design will be followed through to construction completion and into the building's operation. Current commitment agreements are listed on the NABERS website (nabers.gov.au).

The *NABERS Energy for Offices* base building Commitment Agreement has a well-established energy modelling framework, which is used primarily to benchmark a building's energy use against a 6-star scale based on its actual energy consumption over a 12-month period. Compliance with JV1 is shown when the predicted GHG emissions of an energy model of the proposed building design is less than 67 percent of 5.5 stars on the *NABERS Energy for Offices* base-building scale, modelled using the Handbook for Estimating NABERS ratings available from the NABERS website (nabers.gov.au). 67 percent of 5.5 stars is roughly equivalent to a 6-star NABERS Energy rating. In most *climate zones*, offices compliant with the *DTS Provisions* were found to achieve between 5.5 and 6 star NABERS Energy ratings. Note that items such as tenant supplementary heating and cooling systems, external lighting and carpark services may be included in the model as they can have an impact on other equipment energy consumption. However, the items are not to be taken into consideration when calculating the GHG emission estimate for the base building rating. While these items are not included in the GHG emission estimate, they are still required to meet the additional *DTS* requirements in Specification JVa.

A *NABERS Energy for Offices* base-building Commitment Agreement for a minimum of 5.5 stars is also required to be obtained to demonstrate compliance under this *Verification Method*. The Commitment Agreement provides a level of reassurance that the project will be carried through to completion and adds a layer of oversight from the Office of Environment and Heritage (NSW), who manage NABERS on behalf of the Australian, State and Territory governments.

Alert:

For a definition of tenant supplementary heating and cooling systems refer to the NABERS rules.

For situations with onsite generation, the building may be modelled with all loads included (i.e. base building plus additional items outlined above) to calculate total emissions and export percentages. To calculate the figure for compliance, this full building emission result should be multiplied by the ratio of electricity use without exclusions JV1(a)(ii)(A)(aa), (bb) and (cc) to the electricity use with these items included.

GHG emissions calculated in accordance with JV1(a)(ii)(A) can incorporate savings from *renewable energy*. However, *renewable energy* must be consumed on site if it is to be counted.

Alert:

In some cases, project teams choose to apply risk management margins to the simulation results to safeguard against post construction performance risks. No such margin is required in relation to compliance with the NCC, however, it is not discouraged for the purpose of providing additional assurance.

An assessment of the *Predicted Mean Vote* (*PMV*) is also a requirement of *Verification Method* JV1. This ensures that occupant comfort is not compromised in the pursuit of energy efficiency. The *PMV* index predicts the mean response of a large group of people on a 7-point thermal sensation scale, from +3 (hot) to -3 (cold) where 0 is neutral.

As with JV2 and JV3, the JV1 *Verification Method* requires the *thermal comfort level* in the proposed building to be between a *PMV* of -1 to +1 across at least 95 percent of the floor area of all occupied zones for at least 98 percent of the *hours of operation*. A *PMV* of -1 to +1 means that 75% of people are satisfied and comfortable. Note, this is likely to be appropriate for buildings that meet the applicability criterion in Section 5.4.1 of ASHRAE 55-2013.

The *PMV* metric is designed for fully mechanically ventilated buildings. If a building is either mixed-mode or naturally ventilated, the Adaptive Thermal Comfort metric may be more appropriate. The Adaptive Thermal Comfort metric relates indoor design temperatures to outdoor temperatures (i.e. higher room temperatures during warmer weather) based on the understanding that occupants can adapt to, or even prefer a wider range of conditions. This can be used as a *Performance Solution* subject to the approval of the *Appropriate Authority*. Adaptive Thermal Comfort can also be used in combination with *PMV* in buildings that have both fully mechanical and partially naturally ventilated spaces.

Lastly, the building must also comply with the additional requirements in Specification JVa.

5.4.1 **Calculation method**

The calculation method used a Class 5 office building using this *Verification Method* under JV1(a) must comply with ANSI/ASHRAE Standard 140.

Alert:

ANSI/ASHRAE Standard 140 2007 is the Standard Method of test for the Evaluation of Building Energy Analysis Computer Programs. ANSI/ASHRAE Standard 140 specifies test procedures for evaluating the technical capabilities of software used to calculate the thermal performance of buildings and their *HVAC* systems.

6 Green Star Verification Method JV2

6.1 Introduction

Verification Method JV2 is a *Verification Method* that can be used to assess a *Performance Solution*, demonstrating compliance with the mandatory *Performance Requirement* JP1 in NCC Volume One. It can be used instead of the *DTS Provisions* of Parts J1 to J7.

It should be emphasised that it is not mandatory to use a prescribed NCC *Verification Method* as the *Assessment Method*.

6.2 Scope

JV2 is applicable to all Class 3, Class 5 to 9 buildings and common areas of Class 2 buildings. It cannot be applied to the *SOUs* of a Class 2 building or a Class 4 part of a building.

6.3 Intent

The intent of any *Verification Method* is to demonstrate that a *Performance Solution* meets the *Performance Requirement*(s).

Verification Method JV2 allows the use of the *Green Star* - Design & As-Built rating tool to demonstrate compliance with JP1 for Class 3, 5, 6, 7, 8 and 9 buildings. *Green Star* – Design & As-Built rates buildings across a range of sustainability categories, including energy efficiency, and uses similar methodology to the *DTS Provisions*.

Therefore, only one set of energy models is required to meet the requirements of both *Green Star* – Design & As-Built and to demonstrate compliance with JP1. While *Green Star* – Design & As-Built and the *DTS Provisions* differ in scope slightly, both *Green Star* and NCC Volume One Section J have the same *objective* of energy efficiency and reduced GHG consumption. The Green Building Council of Australia (GBCA) have rigorous governing frameworks that drive *Green Star* rated buildings to energy efficient outcomes.

Note, in fulfilling the conditional requirement of the *Green Star* – Design & As-Built credit for 'Greenhouse Gas Emissions Reduction – Reference Building Pathway', a building exceeds the energy efficiency requirements of JP1. However, the intent of the *Verification Method* is to allow buildings designed to achieve a *Green Star* – Design & As-Built rating to meet compliance without the need of separately showing compliance using the *Verification Method* JV3, saving both time and money.

JV2 compliance is shown when the annual GHG emissions of the proposed building are less than 90% of the annual GHG emissions of the *reference building*. Another way of saying this is the proposed building has 10% less the emissions of the *reference building*. This is consistent with the conditional requirement of *Green Star* - Design & As-Built's Greenhouse Gas Emissions Reduction – *Reference Building* Pathway, where project teams must demonstrate that the proposed building's GHG emissions are less than those of the equivalent Benchmark Building. A comparison of GHG emissions reconciles the different emission intensities of gas and electricity and allows credit for on-site *renewable energy*. This is detailed in Figure 6.1.

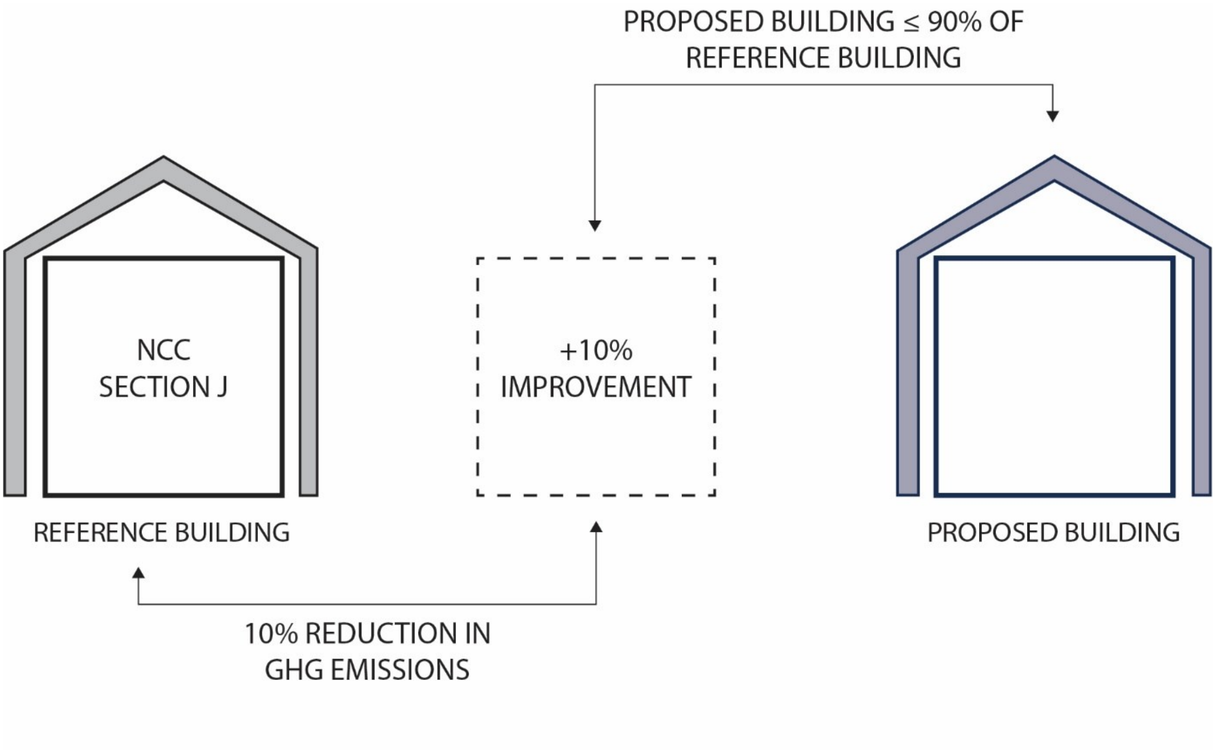
6.4 Methodology

JV2(a) outlines the criteria to be used for JV2.

The project is required to be registered for a *Green Star* - Design & As-Built rating to confirm its compliance with the *Green Star* – Design & As-Built modelling requirements. Registering the project ensures that the most recent *Green Star* – Design & As-Built rating tool is being used, reinforces the commitment to following through with the energy requirements, and adds a layer of oversight from the GBCA.

Additionally, an energy model is required to demonstrate that the base building's annual GHG emissions are less than 90% of the annual GHG emissions of the *reference building*.

Figure 6.1: JV2 compliance pathway



An assessment of the *PMV* is also a requirement of *Verification Method* JV2. This ensures that occupant comfort is not compromised in the pursuit of energy efficiency. The *PMV* index predicts the mean response of a large group of people on a 7-point thermal sensation scale, from +3 (hot) to -3 (cold) where 0 is neutral.

As with JV1 and JV3, the JV2 *Verification Method* requires the *thermal comfort level* in the proposed building to be between a *PMV* of -1 to +1 across at least 95 percent of the floor area of all occupied zones for at least 98 percent of the *hours of operation*. A *PMV* of -1 to +1 means that 75% of people are satisfied and comfortable. Note, this is likely to be appropriate for buildings that meet the applicability criterion in Section 5.4.1 of ASHRAE 55-2013. This is also a requirement of JV1 and JV2.

The *PMV* metric is designed for fully mechanically ventilated buildings. If a building is either mixed-mode or naturally ventilated, the Adaptive Thermal Comfort metric may be more appropriate. The Adaptive Thermal Comfort metric relates indoor design temperatures to outdoor temperatures (i.e. higher room temperatures during warmer weather) based on the understanding that occupants can adapt to, or even prefer a wider range of conditions. This can be used as a *Performance Solution* subject to the approval of the *Appropriate Authority*. Adaptive Thermal Comfort can also be used in combination with *PMV* in buildings that have both fully mechanical and partially naturally ventilated spaces as a *Performance Solution*.

Lastly, the building must also comply with the additional requirements in Specification JVa.

6.4.1 Calculation method

The calculation methods used for this *Verification Method* under JV2(b) must comply with ANSI/ASHRAE Standard 140 and Specification JVb.

Alert:

ANSI/ASHRAE Standard 140 2007 is the Standard Method of test for the Evaluation of Building Energy Analysis Computer Programs. ANSI/ASHRAE Standard 140 specifies test procedures for evaluating the technical capabilities of software used to calculate the thermal performance of buildings and their *HVAC* systems.

7 Reference building Verification Method JV3

7.1 Introduction

Verification Method JV3 is a *Verification Method* that can be used to assess a *Performance Solution*, demonstrating compliance with the mandatory *Performance Requirement* JP1 in NCC Volume One. It can be used instead of the *DTS Provisions* of Parts J1 to J7.

It should be emphasised that it is not mandatory to use a prescribed NCC *Verification Method* as the *Assessment Method*.

7.2 Scope

JV3 is applicable to all Class 3, Class 5 to 9 buildings and common areas of Class 2 buildings. It cannot be applied to the *SOUs* of a Class 2 building or a Class 4 part of a building.

7.3 Intent

The intent of any *Verification Method* is to demonstrate that a *Performance Solution* meets the *Performance Requirement(s).*

Verification Method JV3 essentially provides flexibility where the prescriptive *DTS Provisions* may not work for certain building designs. The *Verification Method* can allow for innovation and better interaction of a building's fabric and services to increase building energy efficiency.

This flexibility is essential to an innovative building environment. Generally, no two buildings are the same in relation to energy efficiency. A fast food chain may aim to have a standard design for every outlet but needs to recognise that no two allotments are exactly the same. The same building, 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.

Buildings differ in their layout, orientation construction and services arrangements. In many cases, architects and developers use the external *glazing* and facade treatment to increase the building's marketing potential. However, the desired appearance may be to the detriment of energy efficiency.

JV3 assesses the annual GHG emissions (kgCO_2-e/annum) of the proposed building and compares it to the annual GHG emissions of a *reference building*. The *reference building's* characteristics are those of a building modelled using the minimum *DTS Provisions* of NCC Volume One Parts J1 – J7. A comparison of GHG emissions reconciles the different emission intensities of gas and electricity and allows credit for on-site *renewable energy*.

Verification Method JV3 allows certain "trade-offs", such as reducing the energy efficiency of the building's services (e.g. lighting and *HVAC*) below the minimum required using the *DTS Provisions* by increasing the energy efficiency of the building *envelope* or other services (e.g. more efficient *HVAC* could allow for less efficient lighting). This trade-off is only permitted in one direction, which means that if the energy efficiency of the building services is increased beyond that required by the *DTS Provisions*, the performance of the fabric may not be decreased below the minimum required by the *DTS Provisions*.

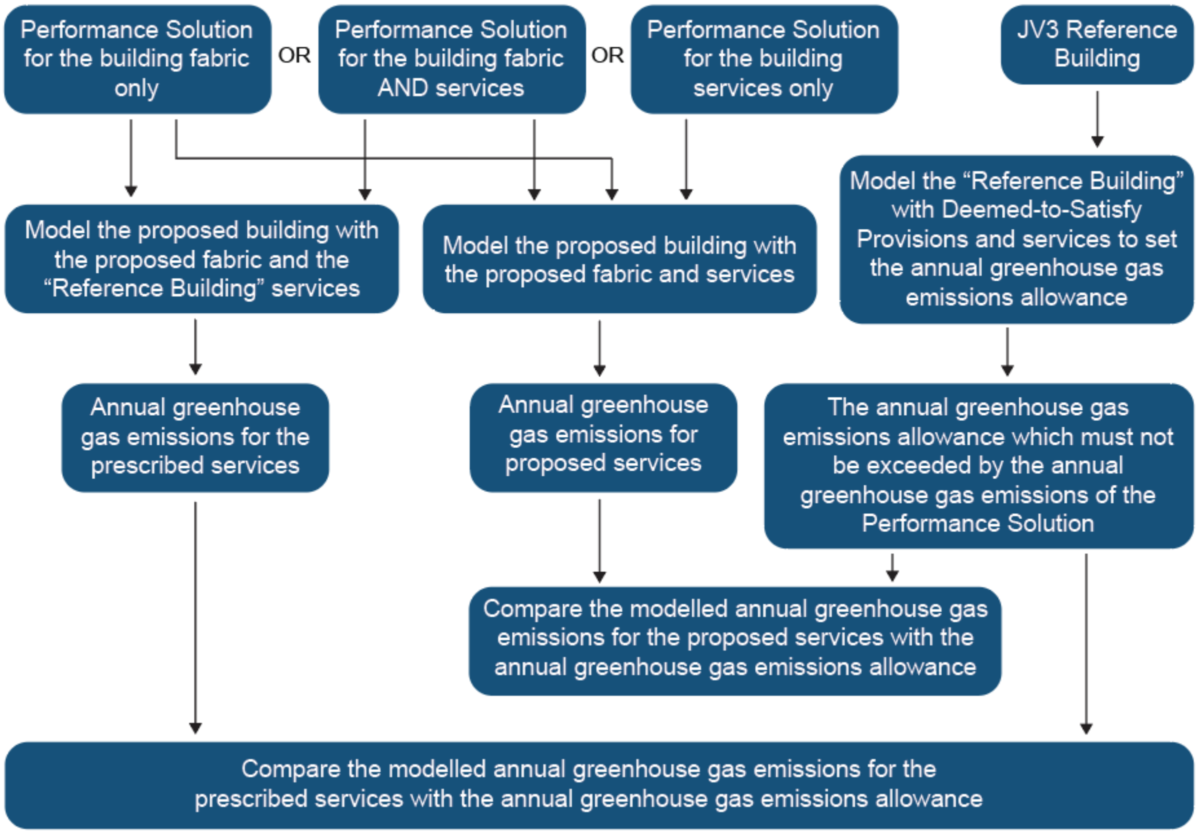
This method allows flexibility in the design of the wall-*glazing* construction (amount, quality, orientation and shading), insulation and sealing of the *envelope* (walls, floors and roof) and the configuration of *services* (*air-conditioning*, lighting, etc.).

Reminder:

Verification Methods other than those described in the NCC can be used provided they are acceptable to the *Appropriate Authority*.

Figure 7.1 illustrates how JV3 can be used to assess different *Performance Solutions.*

Figure 7.1 The use of Verification Method JV3



7.4 Methodology

The basic approach is that the annual GHG emissions of the proposed building are not to be more than the annual GHG emissions of a complying *reference building* which is based on the *DTS Provisions*.

In JV3(a), the following two scenarios must be met:

- JV3(a)(i)(A) with the proposed services in the proposed building and services complying with the *DTS Provisions* for the *reference building*; and
- JV3(a)(ii)(B) with the same services in both cases that comply with the *DTS Provisions*.

These two theoretical scenarios are necessary because, if only subclause JV3(a)(i)(A) was required, the thermal performance of the building’s *envelope* could be “traded-off” for more energy efficient building services. Whilst energy efficient building services are always desirable, the energy efficiency of a building’s *envelope* is of greater importance. Services may change over time or a lack of maintenance may cause the services to under-perform. However, once the passive energy efficiency requirements for the *envelope* are in place, they generally maintain their performance for the life of the building, which will exceed the life of the services. Services are also typically easier and more cost-effective to upgrade in comparison to the building fabric.

JV3 does, however, permit the trade-off to go the other way. Increasing the energy efficiency of the building's *envelope* can allow the performance of the building services to be beneath the standard required by the *DTS Provisions*.

This means that there are multiple steps to using this *Verification Method*.

1. Software run 1 - determine the annual GHG emissions allowance by modelling a *reference building*, which is a *DTS Provisions* compliant building based on the criteria in JV3(c).
2. Software run 2 - calculate the theoretical annual GHG emissions of the proposed *Performance Solution* using the parameters set in Specification JVb.
3. Software run 3 - calculate the theoretical annual GHG emissions of the proposed *Performance Solution*, with the services modelled as if they were the same as that of the *reference building*.
4. Compare the theoretical annual GHG emissions calculated in steps 2 and 3, to the annual GHG emissions allowance calculated in step 1, to ensure that in both cases, the annual GHG emissions are not more than the allowance, software run 1.

An assessment of the *PMV* is also a requirement of *Verification Method* JV2. This ensures that occupant comfort is not compromised in the pursuit of energy efficiency. The *PMV* index predicts the mean response of a large group of people on a 7-point thermal sensation scale, from +3 (hot) to -3 (cold) where 0 is neutral.

As with JV1 and JV2, the JV3 *Verification Method* requires the *thermal comfort level* in the proposed building to be between a *PMV* of -1 to +1 across at least 95 percent of the floor area of all occupied zones for at least 98 percent of the *hours of operation*. A *PMV* of -1 to +1 means that 75% of people are satisfied and comfortable. Note, this is likely to be appropriate for buildings that meet the applicability criterion in Section 5.4.1 of ASHRAE 55-2013.

The *PMV* metric is designed for fully mechanically ventilated buildings. If a building is either mixed-mode or naturally ventilated, the Adaptive Thermal Comfort metric may be more appropriate. The Adaptive Thermal Comfort metric relates indoor design temperatures to outdoor temperatures (i.e. higher room temperatures during warmer weather) based on the understanding that occupants can adapt to, or even prefer a wider range of conditions. This can be used as a *Performance Solution* subject to the approval of the *Appropriate Authority*. Adaptive thermal comfort can also be used in combination with *PMV* in buildings that have both fully mechanical and partially naturally ventilated spaces.

Lastly, the building must also comply with the additional requirements in Specification JVa for verification of compliance with JP1.

7.4.1 Renewable or “free” energy

JV3 allows on-site *renewable energy* sources and re-claimed energy from another process to be deducted from the annual GHG emissions of the proposed building. This means that the “annual greenhouse gas emissions” are the sum of the GHG emissions drawn annually from the electrical grid, the gas network or fuel brought in by road transport and not the total of the energy consumed by the services that use energy.

To obtain this concession, the *renewable energy* must be used and generated on-site. This means that electricity purchased as GreenPower for example does not comply with the concession as it is grid distributed. Energy that is exported to the grid cannot be used as part of this concession.

In determining the amount of *renewable energy*, a designer needs to consider the likely availability of energy from the source, including any down time the plant equipment may experience for maintenance.

Examples of reclaimed energy could be the waste heat captured to heat water from a refrigeration chiller (rather than being rejected to a cooling tower); or energy from a process unrelated to building services, such as steam condensate from a laundry process. Note that co-generation and tri-generation systems are excluded from providing any credit; as they are considered a service in their entirety, rather than a subsequent energy gain from a system already in place.

7.4.2 **Calculation method**

Subclause JV3(c) requires that the calculation methods used for JV3(a) and (b) must comply with ANSI/ASHRAE Standard 140 and Specification JVb.

Alert:

ANSI/ASHRAE Standard 140 2007 is the Standard Method of test for the Evaluation of Building Energy Analysis Computer Programs. ANSI/ASHRAE Standard 140 specifies test procedures for evaluating the technical capabilities of software used to calculate the thermal performance of buildings and their *HVAC* systems.

Example: Using of Verification Method JV3

A five storey Class 5 building located in Melbourne is proposed to be assessed under *Verification Method* JV3. In this case, the building has minimum DTS required insulation to the fabric and *envelope* of the building whilst the services will have energy efficiency parameters above the minimum standard of the *DTS Provisions*. The following calculations are made.

Step 1

A theoretical *reference building* is assessed having minimum *DTS Provisions* for the fabric as well as minimum *DTS Provisions* for services. The annual GHG emissions of the *reference building* are calculated at 32 $kgCO_2$-e/m^2.annum. This is the allowance.

Step 2

The annual GHG emissions of the proposed building with the proposed services is calculated to be 30 $kgCO_2$-e/m^2.annum.

Example: Using of Verification Method JV3

Step 3

The annual GHG emissions of the proposed building with the services modelled to the minimum *DTS Provisions* is calculated to be 35 $kgCO_2\text{-}e/m^2$.annum.

Step 4

By comparing the outcome of step 2 and step 3 with the allowance determined in step 1 we can determine whether the design complies with *Verification Method* JV3. The criteria in the JV3 *Verification Method* states that annual GHG emissions of both cases modelled (step 2 and step 3) are not to be more than the allowance calculated in step 1.

The proposed building with the proposed services is 30 $kgCO_2\text{-}e/m^2$.annum (step 2) is less than the allowance 32 $kgCO_2\text{-}e/m^2$.annum determined in step 1 and therefore meets the first criteria of JV3(a)(i)(A) for *Verification Method* JV3.

30 $kgCO_2\text{-}e/m^2$ (step 2) < 32 $kgCO_2\text{-}e/m^2$ (step 1) = ✓

The proposed building with the services modelled to minimum *DTS Provisions* (step 3) is greater than the allowance 32 kgCO2-e/m^2.annum determined in step 1. Therefore, the proposed building’s annual GHG emissions are greater than the annual GHG emissions of the *reference building* and thus does not comply with the second criteria in JV3(a)(i)(B).

35 $kgCO_2\text{-}e/m^2$ (step 3) > 32 $kgCO_2\text{-}e/m^2$ (step 1) = X

It is worth noting that although the performance of the proposed services was above that required by the minimum *DTS Provisions*, the performance of the building’s fabric cannot be reduced (traded away) below the minimum required by the *DTS Provisions*.

Example: Using of Verification Method JV3

Result

This means that the design does not comply with the *Performance Requirement* JP1 using *Verification Method* JV3 and will require either an alternative design to be developed or the use of a different *Assessment Method*.

8 Additional requirements for Verification Methods JV1, JV2 and JV3

Specification JVa specifies additional requirements that must be completed in addition to the modelling requirements of JV1, JV2 and JV3.

8.1 General (JV1, JV2 and JV3)

In addition to the necessary modelling, Clause 2 of Specification JVa lists requirements from the *DTS Provisions* and reference documents. This ensures all buildings designed under JV1 JV2 and JV3 cover the same range of energy efficiency aspects. The additional requirements are items that the energy model assumes are executed and relies on them to be accurate. Therefore, it must be properly demonstrated that the requirements have been met when constructing the building.

As an example, the standard of installing insulation is covered in subclause 2(a) of Specification JVa because it is not specifically addressed through modelling alone. Table 8.1 outlines the additional requirements below.

Table 8.1 Additional requirements - general

Building component	Compliance method
General thermal construction	J1.2
Floor edge insulation	J1.6(a)(ii), J1.6(b), J1.6(c) and J1.6(d)
Building sealing	JV4 or J3
Deactivation, control and insulation of *air-conditioning* and *mechanical ventilation* systems	J5.2(a)(i), J5.2(a)(ii)(A), J5.2(a)(iv), J5.2(a)(vi), J5.2(b), J5.2(d), J5.3(b), J5.3(d), J5.5, J5.6 and J5.8
Testing package *air-conditioning* equipment not less than 65*kWr*	AS/NZS 3823.1.2 at test condition T1
Testing a refrigeration chiller	AHRI 551/591
Interior artificial lighting and power control	J6.3
Interior decorative and display lighting	J6.4
Artificial lighting around the exterior of a building	J6.5

Building component	Compliance method
Boiling water and chilled water storage units	J6.6
Deactivation of swimming pool heating and pumping	J7.3(b)(ii) and J7.3(c)
Deactivation of spa pool heating and pumping	J7.4(b)(ii) and J7.4(c)
Facilities for energy modelling	Part J8
Deactivation of fixed outdoor space heating appliances	Clause J5.9(c)

8.2 NABERS Energy for Offices (JV1)

Clause 3 of Specification JVa prescribes *DTS Provisions* that must be complied with in addition to the modelling requirements of JV1.

The intent of *Verification Method* JV1 is to allow only one energy model for both the *NABERS Energy for Offices* base-building Commitment Agreement and to demonstrate compliance with JP1. The *NABERS Energy for Offices* base-building Commitment Agreement and the *DTS Provisions* differ in scope slightly, however both the *NABERS Energy for Offices* base-building Commitment Agreement and NCC Section J have the same goal of energy efficiency. Therefore, the provisions of Clause 3 provide additional compliance requirements not included in the *NABERS Energy for Offices* base-building Commitment Agreement energy simulation.

Table 8.2 below provides additional compliance requirements for areas not included in the building energy simulation to satisfy JV1(a).

Table 8.2 Additional requirements – NABERS Energy for Offices

Building component	Compliance method
Tenant supplementary heating and cooling system	J5.7
Carpark ventilation and lighting	J5.3, J5.4, J6.2 and J6.3
Heating, cooling and ventilation equipment not covered by the *NABERS Energy for Offices* base building rating	Part J5
Artificial lighting not covered by the *NABERS Energy for Offices* base building rating	Part J6

Examples of heating, cooling, ventilation equipment and lighting not covered by the *NABERS Energy for Offices* base building rating may include tenancy specific systems.

8.3 Green Star (JV2)

Clause 4 of Specification JVa prescribes *DTS Provisions* that must be complied with in addition to the modelling requirements of JV2.

The intent of *Verification Method* JV2 is to have only one energy model to meet the requirements of both *Green Star* – Design & As-Built and to demonstrate compliance with. *Green Star* – Design & As-Built and the *DTS Provisions* differ in scope slightly, however both *Green Star* and NCC Section J have the same goal of energy efficiency. Therefore, the provisions of Clause 4 provide additional compliance requirements not included in the *Green Star* – Design & As-Built energy simulation.

Table 8.3 below provides additional compliance requirements for areas not included in the building energy simulation to satisfy JV2(a).

Table 8.3 Additional requirements – Green Star

Building component	Compliance method
Heating, cooling and ventilation equipment outside the scope of the *Green Star* model	Part J5
Artificial lighting outside the scope of the *Green Star* model	Part J6

Examples of heating, cooling, ventilation equipment and lighting not covered by *Green Star* – Design & As-Built may include tenancy specific systems.

8.4 Modelling parameters (JV2 and JV3)

8.4.1 Reference building

A *reference building* is used to determine the maximum annual GHG emissions allowed. This is done by applying the *DTS Provisions*, along with certain fixed parameters, to a proposed design. The annual GHG emissions calculated then become the benchmark for a *Performance Solution*.

JV2 and JV3 require that the *reference building* be modelled with parameters which are considered typical for a range of buildings over their life. If these parameters were not fixed, the calculations could be manipulated by using less energy efficiency parameters when setting the allowance with the *reference building*.

Although the parameters may not be how the subject building is to operate, a building may change its use over its life; and may even change its building classification. Different owners and different tenants will have different internal loads, different operating times and other criteria. Even though the values stated may not be those of the proposed building, they are considered reasonable averages for how some buildings operate over their life.

The *reference building* is that which would have been built had the *Performance Solution* not been proposed. As an example, decorative lighting may be installed in a building for aesthetic purposes. DTS requirements specify maximum illumination power densities for different space types may be smaller than the illumination power density of the decorative lighting. The *reference building* would have DTS lighting requirements and the *Performance Solution* would have the installed decorative lighting (and the associated GHG emission penalty required to be made up elsewhere). Please note, while there are no DTS requirements for the maximum illumination power density for decorative lighting, there are specific control requirements.

8.4.1.1 DTS Provisions

The requirements for the *reference building* would be the minimum or the maximum as appropriate, required by the *DTS Provisions* of Parts J1 to J7. They would include only the minimum amount of *mechanical ventilation* required by Part F4 as it would be unreasonable to present an argument for a higher outdoor air rate for the *reference building* for improved health but not the proposed building. Chapters 11 to 15 of this Handbook detail the *DTS Provisions* of Part J1 to J7.

8.4.1.2 Solar absorptance

Subclause 2(b) of Specification JVb requires a solar absorptance of 0.6 for external walls. Typical solar absorptance ranges from around 0.30 for light cream, to 0.90 for a dark grey slate. Galvanised steel for example has a typical solar absorptance of around 0.55.

The roof solar absorptance is specified as per DTS requirements in J1.3(b). For *climate zones* 1 to 7, the solar absorptance must be no more than 0.45. In *climate zone* 8, the proposed and *reference building* must have the same solar absorptance.

8.4.1.3 Air-conditioning

Subclause 2(c) of Specification JVb specifies *air-conditioning* to condition the space to a range of 18°CDB to 26°CDB for 98% of the plant operation time for areas with occupancy that is transitory, and a range of 21°CDB to 24°CDB in all other *conditioned spaces*. If the proposed building requires temperature ranges outside that specified, for example an indoor aquatic centre, a *Performance Solution* may be required.

If the proposed building has no mechanically provided cooling or has mixed mode cooling, the *reference building* must have the same method of control and control set points as the non-mechanical cooling of the proposed building.

8.4.1.4 Infiltration

Infiltration values are to be 0.7 air changes per hour for all zones when there is no mechanically supplied outdoor air. At all other times the infiltration rate in each zone must be 0.35 air changes per hour.

8.4.1.5 Artificial lighting

Artificial lighting in the *reference building* must achieve the maximum illumination power density in Part J6 without applying any control device or light colour adjustment factors. Adjustment factors for light colours applied to the proposed building are not required in the *reference building*. This provides an advantage to the proposed building where better than average colour rendering is used in lighting. It would be unreasonable to claim that the *reference building* has motion detectors to increase the illumination power density allowance, when not the case. However, it would be reasonable to make allowances for Room Aspect Ratios based on the room arrangement of building layout.

8.4.1.6 MEPS

Subclause 2(f) of Specification JVb requires that for services not covered by Parts J5 to J7, *MEPS* must be applied.

8.4.2 **Building fabric - Proposed and reference building**

Clause 3 of Specification JVb outlines the parameters that must be the same in both the *reference building* and the proposed building. Again, this is to avoid using energy efficiency criteria or calculations that could result in a more generous allowance for the *reference building* that subsequently result in lower annual GHG emissions values for the proposed building. The parameters have been further updated as part of the 2019 revision of the NCC to increase the accuracy of the energy models.

Requirements outlined must be the same in all model runs; and are described in the subclauses below.

8.4.2.1 General

8.4.2.1.1 Calculation method

Subclause 3(a) of Specification JVb specifies that the same annual GHG emissions calculation method must be used for both the *reference building* and the proposed building. Advice from industry is that the use of a different software and/or a different operator when undertaking energy analysis may result in a difference in GHG emissions of up to 20%. Using the same software program and same operator in all runs considerably diminishes the software differences and the operator interpretations and is likely to result in a more accurate outcome.

8.4.2.1.2 Greenhouse gas emissions factors

The GHG emissions factors used in the calculations are to be either based on Table 3a in Specification JVb or the current full fuel cycle emissions factors published by the Australian Government. Cases where the published *greenhouse gas intensity* of electricity is less than half the *greenhouse gas intensity* of natural gas are to use Table 3a values.

8.4.2.1.3 Location

This is either the location where the building is to be constructed, if climatic data is available, or the nearest location with similar climatic conditions for which climatic data is available. 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 climate file that is used for the *reference building* also needs to be used for the proposed building.

8.4.2.1.4 Adjacent structures and features

It would be non-compliant to treat the *reference building* as an unobstructed site and the proposed building as part of a campus development with surrounding buildings providing shading.

8.4.2.1.5 Building orientation

It would be non-compliant to initially model a building with *glazing* facing East-West and then re-orientate it so that the *glazing* faces North-South for the proposed solution.

8.4.2.1.6 Building form

The building form includes the roof geometry, the floor plan, the number of storeys, the ground to lowest floor arrangements and the size and location of *glazing*. To change the form of any of these aspects could significantly change the energy consumption, particularly the *glazing*. The principle of the *reference building* is that it is the proposed building, were it designed using the *DTS Provisions*. For example, window sizes, number and orientation must remain the same for both runs but the performance of the *glazing* system (*Total System U-Value* and *Total System SHGC*), and the degree of shading, for the purposes of controlling solar gain (i.e. not shading from adjacent structures or building features such as balconies) can vary.

Calculating heat losses or gains through floors that are ground coupling and establishing ground temperatures under buildings is extremely difficult. Therefore, heat transfer through ground coupled floors (an uninsulated slab-on-ground) could be ignored, provided it is ignored in the modelling of both the *reference building* and the proposed building.

8.4.2.1.7 Testing standards

This includes testing standards for insulation, *glazing*, water heaters and package *air-conditioning* equipment. An example insulation rated using an international standard may produce ratings to a different scale, compared to ratings calculated to AS/NZS 4859.1. Likewise, a *boiler* unit's gross thermal efficiency determined using ANSI/AHRI 1500 and AS/NZS 5263.1.2 may also produce different results.

Again, the principle is to use the same approach with all software runs which, in the case of elements where there are specific requirements for the *reference building*, they must be the same in the proposed building. It should be noted that the conditions under which products are rated are only used for determining the performance rating and not the actual conditions in the proposed building or where the proposed building is to be located.

8.4.2.2 Fabric and glazing

Subclause 3(b) of Specification JVb specifies requirements of fabric and *glazing* that must be the same in the modelling of both the *reference building* and the proposed building.

Those requirements that must be the same in all runs are described in the subclauses below.

8.4.2.2.1 Quality of insulation installation

It is not appropriate to claim "typical" or "poor" installation for the *reference building* and "good" installation quality for the proposed building. If a designer wants to claim the benefit of a factory assembled panel system against a typical site assembled wall, it would again need to be via another *Assessment Method* or *Verification Method* and approval sought from the *Appropriate Authority*.

8.4.2.2.2 Thermal resistance of air films

This includes any adjustment factors, moisture content of materials and the like. Generally, there is no reason why these values should change from one run to the next, other than in an innovative solution where specific provisions are made such as reveals or other such protrusions or devices used to reduce the air velocity across the external surfaces.

8.4.2.2.3 Dimensions of external, internal and separating walls

If, for example, a *Performance Solution* to a NCC Volume One - Section C provision is proposed that would result in a reduction in wall dimensions, both the *reference building* and the proposed building must include the reduced dimension. Also, where tenancy fit-out layouts are not available, the same layout must be used in all runs.

8.4.2.2.4 Internal shading devices

Shading devices must be included with their colour and criteria for operation. It would not be compliant to assume dark venetian blinds or no blinds for the *reference building* but white closed blinds when the sun is on that window, for the proposed design. It would be compliant to assume the blinds would be closed if the shading devices were operated manually but this is likely to have already been taken into account when the *DTS Provision glazing* solution was determined.

8.4.2.3 Services

8.4.2.3.1 Number, sizes, floors and traffic served by lifts and escalators

These are not regulated (other than those for access for people with a disability) and so are determined on a commercial or waiting time basis. It would not be appropriate to vary any of these parameters between the runs.

8.4.2.3.2 Assumptions and means of calculating the temperature difference across air-conditioning zone boundaries

Different software programs use different approaches to thermal calculations. Therefore, it is essential that the same approach is used for all software runs.

8.4.2.3.3 Floor coverings, furniture and fittings density

Although not regulated, the amount of furniture can impact upon the energy consumption by providing a “thermal sink” which retains energy thereby reducing *air-*

conditioning peak loads. The extent depends upon the furniture density, type, location, floor coverings and *glazing* coverings.

8.4.2.3.4 Internal artificial lighting levels

The internal artificial lighting levels should be the same in both runs, and in all probability, based on the recommended levels in AS/NZS 1680. Were a designer to claim the benefit of lower lighting levels, say based on using some task lighting, it would need to be determined using another *Assessment Method* or *Verification Method*. The *Appropriate Authority* would need to be convinced of the likelihood of the philosophy used for the life of the building.

8.4.2.3.5 Internal heat gains

This includes people, lighting, appliances, hot meals and other electric power loads. As highlighted earlier, a building may change its use over its life and even its building classification. Different owners and different tenants will have different internal loads, different people density, different operating times and other criteria. Even though the values stated may not be those of the proposed building, they are considered reasonable averages for how most buildings operate over their life. Again, for a purposely built building, and subject to the *Appropriate Authority's* agreement, another *Verification Method* could be developed using different parameters.

8.4.2.3.6 Air-conditioning system configuration and zones

This is to avoid the calculations being manipulated by proposing a very basic single-zone system for the *reference building* and a more sophisticated variable-air-volume (VAV) multi-zone system that would be considerably more energy efficient for the proposed building. If this were not the case, this would effectively be an unintended allowance as most office buildings have VAV multi-zone systems. However, it is not intended to stifle innovative solutions such as chilled beam systems.

8.4.2.3.7 Profiles for occupancy, air-conditioning, lighting and internal heat gains

Subclause 3(c) of Specification JVb requires these parameters are set for the *reference building* and the same must also be used for the proposed building. These parameters are fundamental to how the building is used and are not technology based. If they were varied between software runs, it would have a major impact on the energy consumption. For example, a 24 hour/day operated building would use significantly more energy compared with a 12 hour/day operated building.

Internal heat gains include heat gains from people, hot meals, appliances, equipment and heated water supply.

The profiles are to be based on either Specification JVc, *NABERS Energy for Offices* base-building Commitment Agreement simulation requirements or *Green Star* – Design & As-Built simulation requirements. However, if the actual building's operating hours are greater than or equal to 2,500 hours per year, or if the daily operating profiles are not listed in Specification JVc, the proposed building's profiles may be used.

8.4.2.3.8 Supply heated water temperature and rate of use

The parameters for heated water temperature and rate of use are to be set for the *reference building* and the same must also be used for the proposed building unless again there is innovative technology used, in which case another *Verification Method* could be developed and used.

8.4.2.3.9 Infiltration values

The infiltration values must be the same unless there are specific additional sealing requirements, an intended building leakage of less than 10 $m^3/hr.m^2$ at 50 Pa, or pressure testing to be undertaken with the proposed building. In these instances, the intended building leakage at 50 Pa may be converted into a whole building infiltration value for the proposed building using Tables 4.16 to 4.24 of CIBSE Guide A.

8.4.2.3.10 Sequencing for water heaters, refrigeration chillers and heat rejection equipment such as cooling towers

Clauses for *air-conditioning* plant are intended to avoid the calculations being manipulated by proposing heat rejection plant such as air-cooled equipment for the *reference building* and then more efficient plant such as cooling towers for the proposed building. This is not to discourage any type of heat rejection equipment (which may be needed for other reasons such as legionella control), but simply to require the same equipment to be used in all runs.

8.4.2.3.11 Representation of clothing and metabolic rate for occupants

This subclause makes it clear that the same values are to be used in all runs. The metabolic rate is applied with the people density to determine the overall people load.

8.4.2.3.12 Control of air-conditioning

The control of *air-conditioning* systems must be constant in both the proposed and *reference building*. There are however, some exemptions to the clause. The *reference building* must have variable temperature control for chilled and heated water that modulates the chilled water and heated water temperatures as required to maximise the efficiency of the chiller or *boiler* operation during periods of low load. Additionally, if the controls for the proposed building are not specified or cannot be simulated, Appendix B of AIRAH-DA28 has sample control specifications that must be used.

8.4.2.3.13 Environmental conditions

These include ground reflectivity, sky and ground form factors, temperature of external bounding surfaces, air velocities across external surfaces and the like. All of these aspects would be the same for all runs if the software allows them to be considered.

8.4.3 **Services – proposed and reference building**

Clause 4 of Specification JVb prescribes the detailed modelling requirements for the services of both the proposed and *reference building*. These parameters were expanded in 2019 to increase the accuracy of energy models.

See the Development of *Performance Solutions* documents for additional guidance available on the ABCB website (abcb.gov.au). The documents provide details on preparing a PBDB, analysis, modelling and testing, evaluating results and preparing a final report.

8.4.3.1 System demand

For the purposes of calculating annual GHG emissions, system demand and response for all items of plant must be modelled to predict how the system will operate (as a minimum) hour to hour. Greater accuracy is allowable (i.e. predicting the performance on a 15-minute basis). At times less frequent than this, the modelling data becomes less accurate.

8.4.3.2 Plant items

The energy use of all plant items, for the purposes of calculating annual GHG emissions, must be calculated with allowances for part load performance and staging to meet system demand.

8.4.3.3 Cooling plant

The energy use of all cooling plant items, for the purposes of calculating annual GHG emissions, must be calculated with several allowances including:

- the impact of chilled water temperature on chiller efficiency;
- the impact of condenser water temperature on water-cooled plant efficiency;
- the impact of ambient temperature on air-cooled plant efficiency;
- the energy use of primary pumps serving individual chillers;
- the energy use of auxiliary equipment including controls and oil heating for chillers;
- thermal losses in the chilled water system; and
- the impact of chilled water temperature on thermal losses in the chilled water system.

These allowances consider the differences in efficiency and energy usage that may be observed in the chilled water system specified for the designed building as opposed to those specified using industry standard conditions by the manufacturer. Energy consumption of pumps and all auxiliary equipment is also to be considered as well as system thermal losses.

AHRI 551/591 specifies requirements on consistent testing and conformance conditions and may provide guidance on allowances for the above.

Alert:

AHRI 551/591 is the American Air-Conditioning & Refrigeration Institute (AHRI) Standard for the, “Performance rating of water-chilling and heat pump water-

Alert:

heating packages using the vapour compression cycle". The standard specifies the requirements for water-chilling and water-heating packages using the vapour compression cycle including test requirements, rating requirements, minimum data requirements, marking and nameplate data and conformance conditions.

8.4.3.4 Water heating systems for space heating

The energy use of all water heating systems for space heating, for the purposes of calculating annual GHG emissions, must be calculated with several allowances including:

- the impact of water temperature on water heater efficiency;
- the energy use of primary or feedwater pumps serving individual water heaters;
- thermal losses in water heating systems and the *thermal mass* of water heating systems; and
- accounting for thermal losses during periods when the system is not operating.

These allowances consider the differences in efficiency and energy usage that may be observed in the heating water system specified for the designed building as opposed to those specified by the manufacturer using industry standard conditions. Energy consumption of all auxiliary equipment is also to be considered as well as system thermal losses.

8.4.3.5 Fan and pump systems

The energy use of fan and pump systems, for the purposes of calculating annual GHG emissions, must be calculated with allowances for the method of capacity regulation and the use of either fixed or variable pressure control.

Capacity regulation and fixed or variable pressure control are considered, as changes in pressure and flow throughout the system correlate to changes in efficiency and energy usage. This allows for additional energy savings to be accounted that can be attributed to systems that incorporate static pressure control reset functionality.

8.4.3.6 Pump systems

The energy use of pump systems, for the purposes of calculating annual GHG emissions, must be calculated with allowances for the system fixed static pressure head.

8.4.3.7 Auxiliary equipment

The energy use of auxiliary equipment associated with co-generation and tri-generation systems including pumps, cooling towers and jacket heaters, for the purposes of calculating annual GHG emissions, must be calculated. The inclusion of all auxiliary equipment associated with co-generation and tri-generation systems must be accounted for when considering energy savings associated with these systems.

8.4.3.8 Heated water supply and vertical transport

Energy efficiency requirements for vertical transport (lifts or escalators) include standby performance levels, energy efficiency classes and controls for when not in use. Vertical transport and heated water supply for food preparation and sanitary purposes may be omitted from the annual GHG emissions calculations if they are the same in both the proposed building and *reference building*.

Alternatively, the performance of a basic but realistic system can be selected for the *reference building* and a higher performance system selected for the proposed building. In this way, a high performance heated water system or high-performance lift can provide “credit” and can contribute towards off-setting the under-performance of other services. The proposed solution is required to be approved by the *Appropriate Authority*.

8.4.3.9 Lifts with multiple classifications

Where a lift is included in the calculations and the lift serves more than one building classification, the energy consumption of the lift may be proportioned according to the number of storeys. This means that if four storeys of a building are retail (a Class 6 building) and 6 storeys are hotel accommodation (Class 3 building) then 40% of the annual GHG emissions produced by the lifts is attributed to the Class 6 building and 60% to the Class 3 building.

8.5 Modelling profiles (JV2 and JV3)

Specification JVc prescribes the operation profiles for *air-conditioning*, artificial lighting, equipment and appliances that may be used to model the proposed and *reference building*.

The specification sets standard operation profiles for calculating the annual GHG emissions of a proposed and *reference building*.

Daily occupancy and operating profiles are provided for:

- a Class 2 common area;
- a Class 3 hotel or motel building;
- a Class 5 office building;
- a Class 6 shop or shopping centre, restaurant or cafe;
- a Class 7 warehouse
- a Class 8 laboratory;
- a Class 9a clinic, day surgery or procedure unit;
- a Class 9a *ward area*;
- a Class 9b theatre, cinema, conference facility or *school*; and
- a Class 9c aged care facility.

It is not practical to have occupancy and equipment operation profiles for all possible uses of buildings. Tables 2a to 2k are for the most common applications. These occupancy and operating profiles include:

- occupancy starting and finishing times;
- artificial lighting percentage operating;
- appliances and equipment percentage operating; and
- *air-conditioning* operating (on/off).

This specification also contains internal heat gains from occupants, hot meals, appliances, equipment and artificial lighting, as well as heated water supply consumption rates.

The values are derived from industry accepted data sources. While the values may not be what is actually achieved in some buildings, the values are considered what is most typical. The profiles in the *NABERS Energy for Offices* base-building Commitment Agreement and *Green Star* – Design & As-Built simulation requirements can also be used (see subclause 3(c)(vii) of Specification JVb).

If the operating hours of the building used in the calculation are 2,500 hours/annum or greater, the proposed building's profiles may be used.

8.5.1 Air-conditioning

The *air-conditioning* within a building must be modelled on the basis of daily occupancy and operations profiles as well as internal heat gains within the building. The daily occupancy and operation profiles are provided in Tables 2a to 2k of the Specification. The internal heat gains from occupants and hot meals, appliances and equipment, and artificial lighting are specified in Table 2n, 2l and subclause 2(b) of the Specification. The number of people must be calculated in accordance with Clause D1.13.

8.5.2 Artificial lighting

Subclause 2(b) of Specification JVc specifies that the artificial lighting within a building must be modelled based on the proposed level of lighting in Tables 2a to 2k.

8.5.3 Heated water supply

Subclause 2(c) of Specification JVc specifies the heated water supply must be modelled based on the consumptions rates of Table 2m.

9 Building envelope sealing Verification Method JV4

9.1 Introduction

Verification Method JV4 is a *Verification Method* that can be used to assess a *Performance Solution*, demonstrating compliance with the mandatory *Performance Requirement* JP1(e) in NCC Volume One. It can be used instead of the *DTS Provisions* of Part J3.

It should be emphasised that it is not mandatory to use a prescribed NCC *Verification Method* as the *Assessment Method*.

9.2 Scope

JV4 is applicable to Class 2, 3, 5, 6, 7, 8 and 9 buildings and a Class 4 part of a building.

9.3 Intent

The intent of JV4 is to restrict unintended in/exfiltration in buildings (i.e. unwanted outdoor air into the building and the loss of conditioned air from the building). JV4 provides an alternative method to the building sealing requirements in Part J3 for demonstrating compliance with the building sealing requirements in JP1(e).

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.

Note that *envelope* sealing in some climates can have a reduced overall energy benefit. With reduced air infiltration, buildings in some climates are less likely to cool naturally overnight, particularly buildings in mild climates that do not operate overnight. However, if buildings in these *climate zones* operate their cooling system to expel warm air and draw cool air in overnight (typically known as night purging), then a lower air permeability rate could still be beneficial.

Note, a blower door test can only be completed at the end of the construction process, not prior to receiving a buildings design approval.

9.4 Methodology

JV4 specifies that the *envelope* be sealed at an air permeability rate, tested in accordance with Method 1 of AS/NZS ISO 9972. The clause outlines different permeability rates for different building classes. To demonstrate compliance, the results of the verified blower door test should be provided in accordance with Part A5 of NCC Volume One.

Alert:

AS/NZS ISO 9972 is the standard for thermal performance of buildings – determination of air permeability of buildings – fan pressurization method. Method 1 is a test of the building in use where the *natural ventilation* openings are closed, and the *mechanical ventilation* or *air-conditioning* openings are sealed.

Some *climate zones* are not included in the provisions below as in some cases air tightness has been found to increase energy consumption.

9.4.1 Air permeability rates

JV4 sets out the test method and criteria for the air permeability rates for different building classifications and *climate zones*. Table 9.1 summarises these requirements.

Table 9.1 Air permeability requirements for building envelope sealing tested in accordance with Method 1 of AS/NZS ISO 9972 (Source: NCC Volume One (2019))

Building classification	JV4 reference	Climate zone	Maximum air permeability rate ($m^3/hr.m^2$)
Class 2	JV4(a)	all	10
Class 3	JV4(c)	1, 3, 4, 6, 7, 8	5
Class 4 part of a building	JV4(a)	all	10
Class 5	JV4(b)	1, 7, 8	5
Class 6	JV4(b)	1, 7, 8	5
Class 7	n.a.	n.a.	n.a.
Class 8	JV4(b)	1, 7, 8	5
Class 9a (other than a *ward area*)	JV4(b)	1, 7, 8	5
Class 9a (*ward areas*)	JV4(c)	1, 3, 4, 6, 7, 8	5
Class 9b	JV4(b)	1, 7, 8	5
Class 9c	JV4(c)	1, 3, 4, 6, 7, 8	5

Notes:

Air permeability is at 50 Pa reference pressure

n.a. means JV4 not applicable

10 Part J0 – Energy efficiency

10.1 Introduction

Part J0 provides a directory to the different *DTS Provisions* for residential and commercial buildings.

The *DTS Provisions* for *SOUs* in a Class 2 building or a Class 4 part of a building are based on achieving an energy rating using NatHERS accredited software.

The *DTS Provisions* for other types of buildings and the common areas of a Class 2 building are elemental, where each building element and service element must achieve a specific performance.

10.2 Scope

The provisions of Part J0 address the following:

- application of Section J;
- heating and cooling loads of *SOUs* in a Class 2 building or a Class 4 part of a building;
- ceiling fans of a Class 2 building or a Class 4 part of a building;
- roof thermal breaks of a Class 2 building or a Class 4 part of a building; and
- wall thermal breaks of a Class 2 building or a Class 4 part of a building.

10.3 Intent

Part J0 defines the provisions required to meet compliance with *Performance Requirement* JP1 for all building types. *SOUs* in a Class 2 building or a Class 4 part of building have different thermal construction requirements to building types that to not contain dwellings.

This Chapter provides details of each of the above provisions in Part J0. It discusses important points that should be considered when determining a building's compliance with NCC Volume One *DTS Provisions*.

10.4 DTS Provisions

Where a solution is proposed to comply with the *DTS Provisions*, J0.0 clarifies that compliance with Parts J1 to J8 achieves compliance with JP1. Where a *Performance Solution* is proposed, the relevant *Performance Requirements* must be determined in accordance with A2.2(3) and A2.4(3). The *DTS Provisions* approach for the *SOUs* in a Class 2 building and a Class 4 part of a building differs to other commercial building classifications.

10.5 Application of Section J

J0.1 details the provisions of Section J and clarifies which apply to a *SOU* in a Class 2 building and a Class 4 part of building; or to all other classifications to satisfy *Performance Requirement* JP1.

J0.1(a) specifies that there are two compliance paths for the thermal performance of the building fabric. The two paths are dependent on whether the building contains *SOUs* in a Class 2 building or a Class 4 part of building or not (i.e. habitable dwellings or not).

For *SOUs* in a Class 2 building or a Class 4 part of building, the building fabric must comply with J0.2 to J0.5. For other building classifications, the building fabric must comply with Parts J1 and J3

All buildings must comply with J0.1(b) to (e) (the requirements for building services), including *SOUs* of a Class 2 building or Class 4 part. These include requirements for *air-conditioning* and ventilation, artificial lighting and power, heated water supply and swimming pool and spa pool plant, as well as facilities for energy modelling. This is because these matters are not assessed by house energy rating software.

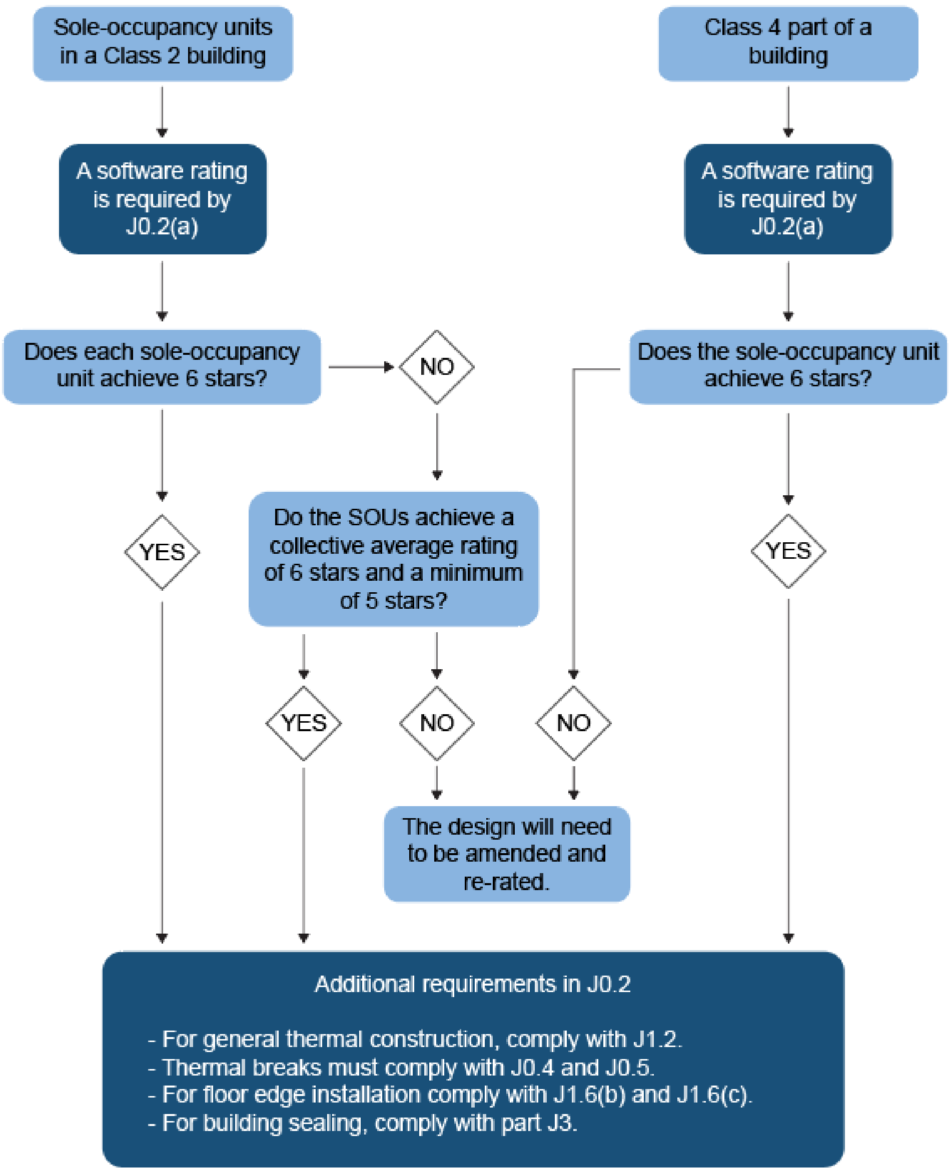
10.5.1 DTS compliance pathways for SOUs in a Class 2 building or a Class 4 part of a building

The approach for the *SOUs* in a Class 2 building or for a Class 4 part of a building is based on achieving an energy rating, using software accredited by NatHERS. The energy rating approach aids in the development of unique building solutions, however, it is limited to assessing the potential thermal efficiency of the dwelling *envelope* only. For this reason, there are additional requirements that must be met to demonstrate full compliance with the *DTS Provisions.*

The approach for other types of buildings is an elemental one where each building element and service element must achieve a specific performance. The latter is the more traditional *DTS Provision* approach.

The flow diagram in Figure 10.1 shows the compliance paths for residential dwellings in Section J.

Figure 10.1 Compliance pathways for residential *SOUs* in Class 2 buildings and a Class 4 part of a building



10.6 Heating and cooling loads for SOUs in a Class 2 building or a Class 4 part of a building

Clause J0.2 details provisions and requirements specific to *SOUs* in a Class 2 building or a Class 4 part of building.

The requirements for a *SOU* in a Class 2 building or a Class 4 part of a building are similar to those for Class 1 buildings in NCC Volume Two - Housing Provisions. This is for consistency in approaches and there are similarities in their use with higher occupancy at night. J0.2(a) contains the energy ratings that must be achieved by the *SOUs* in a Class 2 building, collectively and individually. The current criterion for the average energy rating of all *SOUs* is 6 stars. Individual *SOUs* can have energy ratings as low as 5 stars, but other units must then have energy ratings higher than 6 stars to maintain the collective average required, 6 stars.

For a Class 4 part of a building the minimum house energy rating required is 6 stars. Note that these requirements may differ per jurisdiction.

The star rating is determined using house energy rating software (software accredited by NatHERS) using load limits specified in the ABCB Standard for NatHERS Heating and Cooling Load Limits. Information about building modelling using house energy rating software is available at from the NatHERS website (nathers.gov.au) and The ABCB Standard for Heating and Cooling Load Limits can be accessed at from the ABCB website (abcb.gov.au).

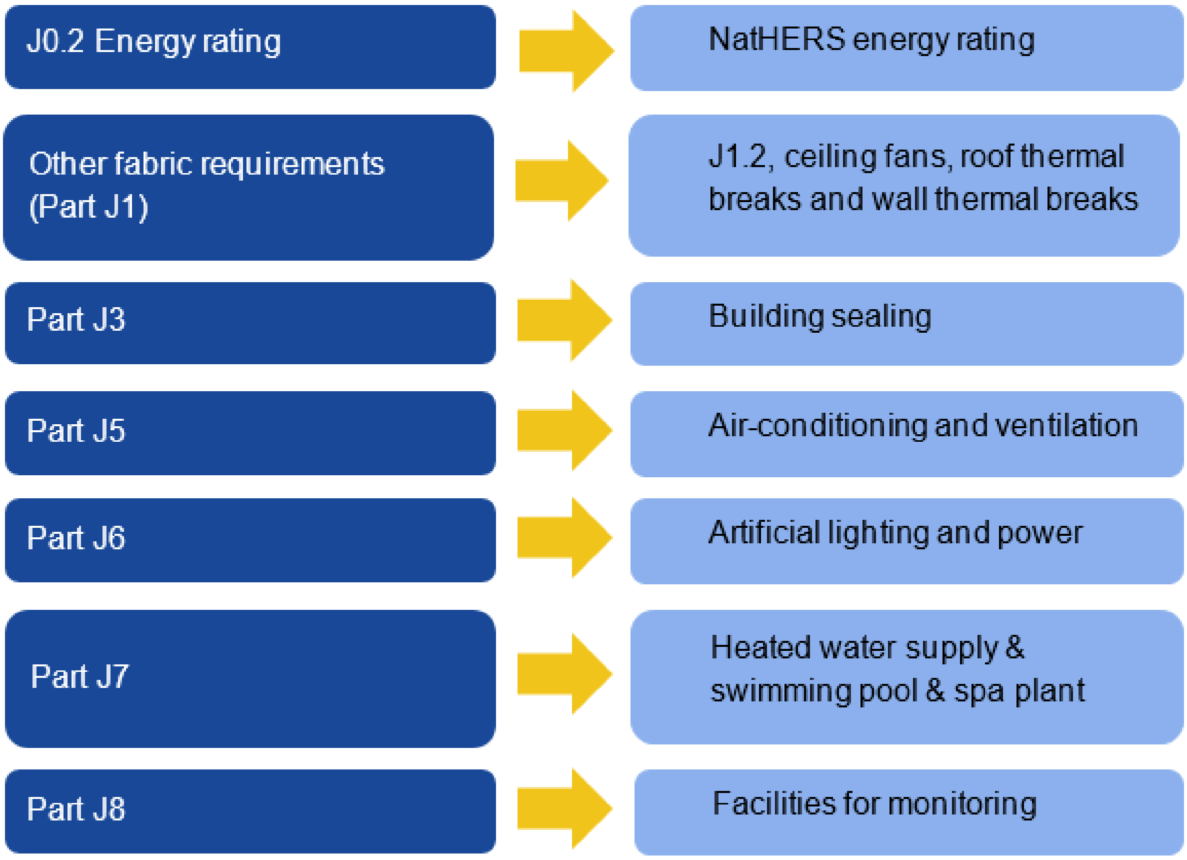
Clause J0.2 also requires the building solution to comply with other specific energy efficiency requirements in the NCC, for aspects that the house energy rating software does not cover. These include:

- J1.2 for thermal construction details;
- J0.4 and J0.5 for thermal breaks;
- J1.6(b), J1.6(c) and J1.6(d) for floor edge insulation; and
- Part J3 for building sealing.

Please note that the requirements of J0.2 apply to *SOUs* in a Class 2 building, not common areas of a Class 2 building. Common areas of a Class 2 building must meet the requirements of J1, J3, J5, J6, J7 and J8. These include the requirements for building fabric (where a *conditioned space* exists), *air-conditioning* and ventilation, lighting, power, vertical transport, heated water supply, swimming pool and spa pool plant, and facilities for energy modelling.

For example, if part of the building *envelope* is around a common ground floor lobby of a Class 2 building, the DTS fabric requirements of J1 would need to be applied to the *envelope* around the ground floor lobby.

Figure 10.2 DTS Provisions for SOUs of a Class 2 building or a Class 4 part of a building



Design alert:

Can heavy drapes be included in the energy rating assessment?

That is for the building official to decide but there is no guarantee that future occupants will retain the heavy drapes initially installed. The software used to undertake the energy rating should only accept “Holland blinds” on windows in the

Design alert:

Can heavy drapes be included in the energy rating assessment?

automatic regulatory mode. This is considered reasonable because most people will have some form of blind or curtain for privacy.

10.7 Ceiling fans

If a ceiling fan is required as part of a house energy rating software solution, clause J0.3 specifies the minimum requirements for these fans.

The required ceiling fans must be permanently installed and have a method of controlling the speed.

The ceiling fan must serve the whole room under the following floor area conditions to allow for appropriate movement of air:

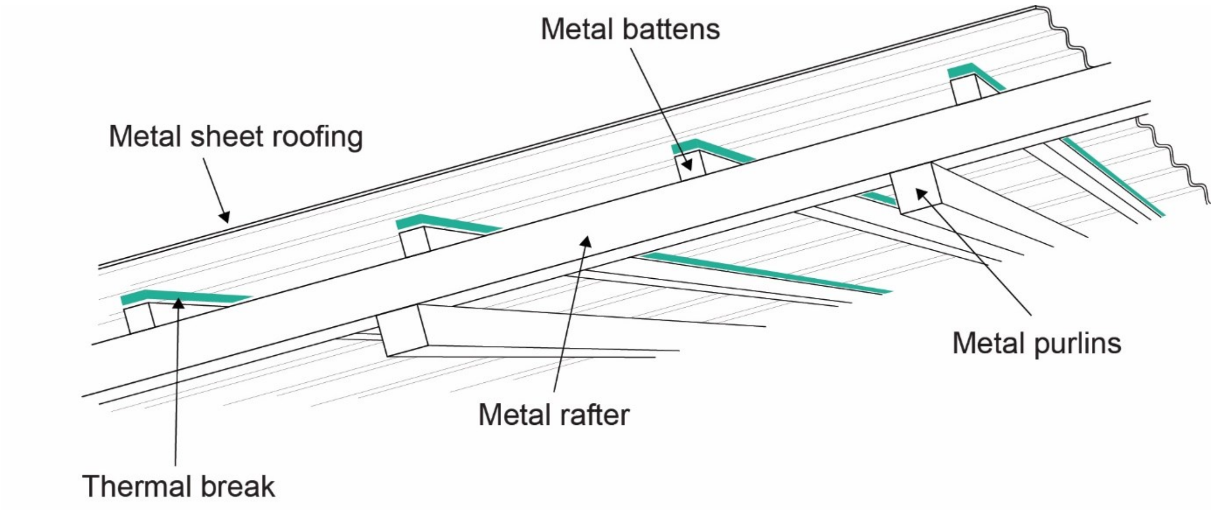
- A single fan serving a floor area less than or equal to 15 m^2 must have blade rotation diameter of at least 900 mm; and
- A single fan serving a floor area of less than or equal to 25 m^2 must have a blade rotation diameter of at least 1,200 mm.

10.8 Roof thermal breaks

To comply with J0.2(c), a metal sheet roof that is fixed to metal purlins, rafters or battens that does not have a ceiling lining or that has a ceiling lining fixed directly to those metal purlins, rafters or battens must have a thermal break.

The thermal break must consist of a material with an *R-Value* of greater than or equal to R0.2. The thermal break must be installed at all points where the metal sheet roofing and its supporting metal purlins, rafters or battens are in contact.

Figure 10.3 Example roof thermal break construction

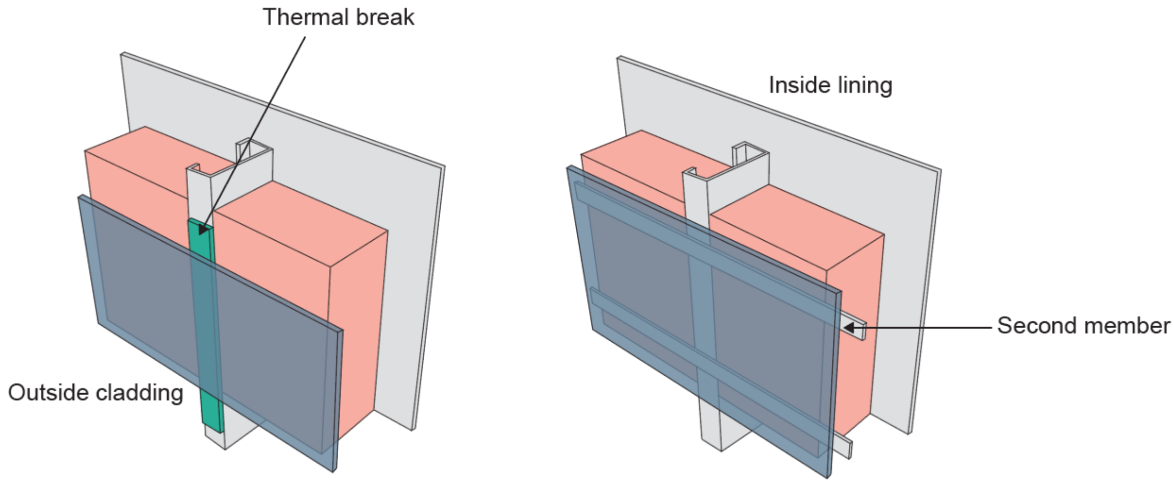


10.9 Wall thermal breaks

To comply with J0.2(c), a wall that does not have a wall lining or has a wall lining that is fixed directly to the same metal frame, and has lightweight external cladding fixed to a metal frame must have a thermal break.

The thermal break must consist of a material with an *R-Value* greater than or equal to R0.2, installed at points where the external cladding and the metal frame are in contact.

Figure 10.4 Wall thermal break construction



Thermal break needed

Thermal break **not** needed

11 Part J1 – Building fabric

11.1 Introduction

The NCC Volume One *DTS Provisions* for building fabric require minimum acceptable level of thermal efficiency of the *opaque* building components, *glazing* and *roof lights* of the building *envelope*.

As with all other aspects of the *DTS Provisions*, each element within Section J of NCC Volume One is designed to work as part of a system to ensure the building achieves the minimum level of energy efficiency.

Class 3 and Class 5 to 9 buildings are diverse, with some *air-conditioned* and some not. Those that are air-conditioned are likely to have a higher energy use than in a private residence, for reasons such as occupant comfort and employee health.

To address this increased complexity, the fabric provisions not only focus on the external fabric; but include internal walls, floors and ceilings where they separate a *conditioned space* from a non-conditioned space.

Reminder:

Only certain clauses in Part J1 apply to the *SOUs* in a Class 2 building or Class 4 part of a building. Refer to J1.1 Application of Part for more information.

11.2 Scope

The building fabric provisions address the following:

- general requirements for the thermal construction of a building such as the testing, installation and calculation of the amount of bulk insulation required;
- roof and ceiling construction - including internal elements between *conditioned spaces* and non-conditioned spaces (internal and external ceilings are not limited to the area immediately below the roof and include the ceiling between a *conditioned space* and a non-conditioned space such as a plant room);

- *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 a wall-*glazing* construction and are addressed under Part J1.5;
- external walls and *glazing* and internal walls and *glazing* that separate a *conditioned space* from a non-conditioned space; and
- floor construction - this includes some internal floors between *conditioned spaces* and non-conditioned spaces.

As previously discussed, the *DTS Provisions* are based on eight NCC *climate zones*. They divide Australia into broad regional areas with similar climatic conditions, allowing the requirements to be applied on a national basis. Each *climate zone* will have similar thermal requirements irrespective of the State or Territory where the building is located. NCC *climate zones* are explained in more detail in the Guide to Volume One.

The other relevant aspects of Part J1 are the Specifications J1.2, J1.5a, J1.5b and J1.6. These specifications contain detailed information that contribute to complying with certain *DTS Provisions*. They are referenced through the related clause in the *DTS Provision*. The Specifications provide more detailed requirements than can be accommodated in an NCC clause. Accordingly, the specifications are integral to Part J1.

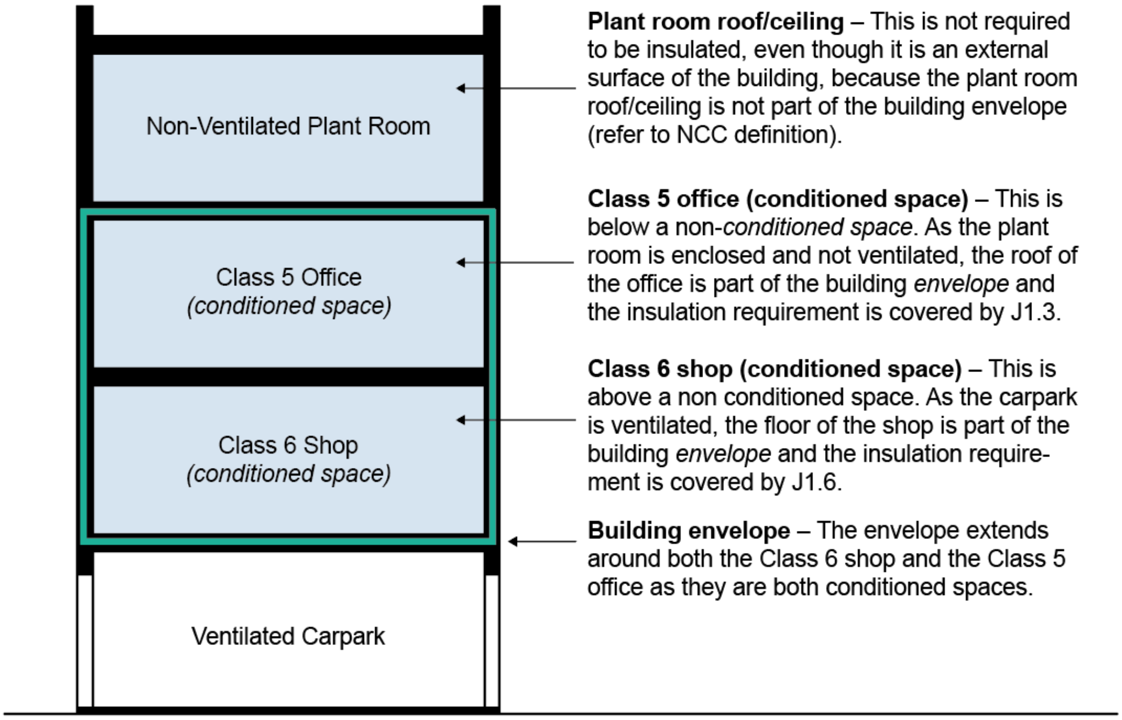
11.3 Intent

11.3.1 Building fabric provisions

An essential aspect of energy efficiency for a building is to ensure that the building is constructed in a manner that provides an adequate level of comfort for occupants so that they feel 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 thermal barrier between the internal and external (non-conditioned) environment. This is even more important in a commercial building that is likely to be air-conditioned for much of the time.

The term *envelope* is defined in NCC Volume One and introduces an important difference from the energy efficiency requirements in the Housing Provisions contained in NCC Volume Two. The key to this difference is that the insulation requirements apply not only to the external components of the building; but to internal walls, floors and ceilings that separate a *conditioned space* from a non-conditioned space. This means designers will need to consider the provision of conditioned air to each room or space within the building to determine where the *envelope* is located, and subsequently, the appropriate level of insulation required. See Figure 11.1 describing the building *envelope* below.

Figure 11.1 Building envelope



In practice, occupied spaces are likely to be conditioned at some time over the life of the building and their external elements will form the building *envelope*. The *envelope* can extend through multiple floors of a building encompassing any number of *conditioned spaces* that are located side by side or one above the other. However, the floor or wall between two *conditioned spaces* is not part of the *envelope* by definition because very little energy transfer is expected to occur.

The intent of the building fabric *DTS Provisions* in Part J1 is to ensure that the construction around the *conditioned spaces* has a sufficient level of thermal performance to ensure energy is not used unnecessarily due to the influence of the external environment. The requirements in Part J1 achieve an outcome by requiring certain elements to have minimum thermal properties. For roof, ceiling, wall and floor construction this includes levels of insulation, either through adding insulation, such as bulk or reflective foil, or through the inherent thermal qualities of the building fabric, for instance the thermal resistance and *thermal mass* of a masonry wall. For wall-*glazing* constructions and *roof lights* this includes the inherent thermal qualities of the *glazing* such as *Total System U-Value* and Total System SHGC.

The fabric requirements are based on recognition of occupant response to the predominant annual external climatic conditions. For instance, in Hobart, where the climate is considered 'cool temperate', the energy used for heating exceeds the energy used for summer cooling. Accordingly, the NCC Volume One *DTS Provisions* are designed so the building uses less energy to heat the occupied areas. This is achieved by installing insulation or by otherwise increasing the capacity of the building structure to resist heat loss. For Darwin, the opposite is the case and the predominant mode is cooling. It is recognised that for most commercial buildings in most *climate zones*, cooling is the predominate mode due to the high internal heat loads. Therefore, a greater emphasis is on Total System SHGC over Total System U-Value.

The underlying philosophy to this approach is that, by applying requirements to the enclosing *envelope*, the internal environment will be more comfortable for the occupants without excessive use of *air-conditioning* in both residential and commercial buildings.

11.3.2 **Specifications**

The specifications have been developed to provide more detailed information and requirements than can be included in the *DTS Provisions.* The specifications contain accepted design solutions that can be adopted by the building designer if desired.

The design of energy efficient buildings can be a complex matter with numerous approaches available to achieve the desired level of thermal performance. A key aspect of effective design is identifying the applicable thermal characteristics of the construction materials being used. To assist, many typical materials and construction types have been identified and their thermal performance listed in Specification J1.2 of the NCC.

The reason for this approach is to provide some direction and standardisation of values. It must be noted that appropriate alternative values specific for the material could be available from the product supplier or manufacturer. However, these alternatives should be substantiated with appropriate test reports or other evidence as described in Part A5 of NCC Volume One.

This Chapter provides a detailed analysis of key clauses in Part J1 Building Fabric. It discusses important points that should be considered when designing or assessing a building for compliance with Part J1.

11.4 DTS Provisions

J1.0 clarifies that the *DTS Provisions* in Part J1 are part of a suite of *DTS Provisions* within Section J that must be applied as a package to be used as a *DTS Solution* to meet the *Performance Requirement* JP1.

In simple terms, the building must comply with all the designated *DTS Provisions* in Section J for the building to comply with the energy efficiency requirements of NCC Volume One.

Accordingly, if there is any variation from the *DTS Provisions* in one part, then the entire set of energy efficiency requirements for the building will need to be checked to ensure that there is no unintended effect on the other parts because of a *Performance Solution* being adopted for one part. See subclause A2.4 of NCC Volume One or Chapter 3 of this Handbook for further information.

11.5 Application

The requirements of Part J1 apply to building elements that form part of the *envelope*. The *envelope* refers to parts of a building's fabric (i.e. roofs, walls, *glazing* and floors) that separates a *conditioned space* from a non-conditioned space.

The *DTS Provisions* of J1.2(e), J1.3, J1.4, J1.5 and J1.6(a) do not apply to a Class 2 *SOU* or a Class 4 part of a building.

Similarly, the provisions of Part J1 do not apply to Class 8 electricity network substations as the *air-conditioning* systems in these buildings are designed to maintain the efficient operation of sensitive electrical equipment.

Please note that the phrase "likely by the intended use of the space to be air-conditioned" is in the definition of a *conditioned space.* Class 6 and 9b buildings cover wide ranges of uses and could reasonably be expected to be air-conditioned at some time in the future. In these cases, the building fabric requirements would need to be met. Some Class 6, 7, 8 and 9b buildings that are not a *conditioned space* by definition, may be excluded from controls for building fabric. Similarly, the external elements of an atrium or solarium that is not a *conditioned space* may also be excluded. Atriums may be attached to certain buildings and would therefore, inherit some of the requirements appropriate for that building type. In this case, there is often no energy saving to be made by thermally treating the elements, or the saving is below the minimum threshold and so not cost-effective.

11.6 Thermal construction - general

This provision contains a broad range of general requirements that apply to insulating the building fabric so that the required thermal performance is achieved. An important aspect of J1.2 is the testing needed to ensure the validity of the insulation products.

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 Volume One and this documentation forms an integral part of the *building approval*.

Alert:

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 to test their products using a specified method and then provide a data sheet which explains the thermal performance properties and the installation requirements of the product. The standard notes that the thermal resistance of a material is fully

Alert:

representative of the element of construction, i.e. environmental factors can lower the long-term thermal resistance.

11.6.1 Integrity of the insulation barrier

Subclause J1.2(a) requires any mandatory insulation, when installed in a building, to form a consistent and continuous barrier other than at supporting members. This means that insulation is to be fitted tightly to each side of framing members but need not be continuous over the framing member. 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.

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 overall level of performance for the wall. The wall framing elements, in conjunction with the insulation, are deemed to achieve the required level of performance.

It is recognised however, that certain gaps are essential so that insulation does not affect the safety or performance of services and fittings. Examples of services and fittings may include heating flues, recessed light fittings, transformers for low voltage lighting, gas appliances and general plumbing and electrical components.

Appropriate clearance should therefore be provided, as detailed in relevant legislation and referenced standards such as for electrical, gas and fuel oil installations. Expert advice may be needed to determine these appropriate clearances, such as how much bulk insulation can be placed over electrical wiring.

Note that the addition of insulation to other building elements may alter the fire properties of those elements. Re-testing or re-appraisal of these elements may be required.

Manufacturer's data sheets should be utilised by both building designers and building surveyors as documentary evidence of the performance of the insulation and may be required to form part of the *building approval* documentation.

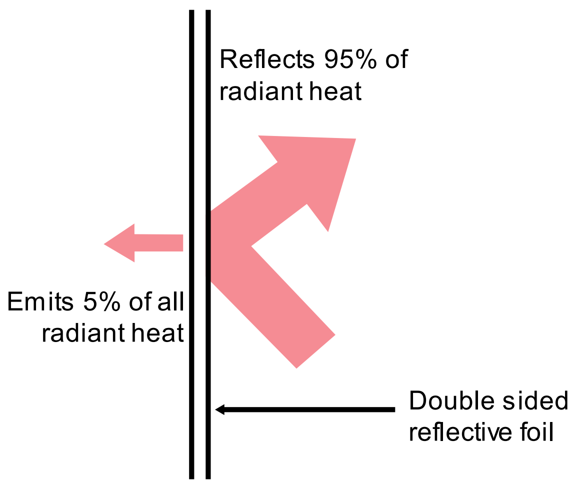
11.6.2 Reflective insulation installation

Subclause J1.2(b) provides a list of requirements for reflective insulation. 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, board or other 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, as without this airspace, the reflection will not occur. Refer to Figure 11.2 for an illustration of reflective insulation.

Figure 11.2 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.

From an Occupational Health and Safety (OH&S) point of view, the dull coloured side is installed facing outwards to prevent eye injury, which could occur if the high reflectivity from the silver side was on the outside.

Subclause J5.2(b)(i) specifies the reflective insulation must be installed with enough airspace to achieve the required *R-Value*. Where the width of airspace is to be achieved in a wall cavity or the like, care should be taken to ensure compliance with all other applicable NCC provisions. For example, the provisions relating to weatherproofing masonry may require a greater width of cavity.

Subclause J5.2(ii) and (iii) require that the reflective insulation must closely fit against any penetration or door or window opening and must be supported by a wall frame.

Subclause J5.2(iv) specifies that overlapping of reflective insulation should be at least 50 mm, otherwise it must be taped together. This aligns with the requirements of Standard AS/NZS 4200, the standard covering the installation of pliable building membranes.

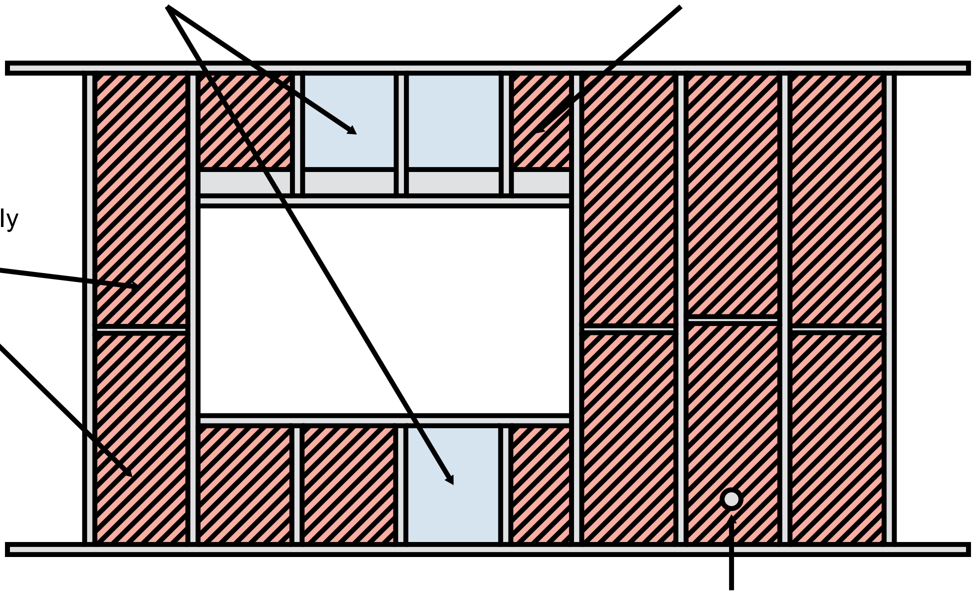
11.6.3 **Bulk insulation installation**

Subclause J1.2(c) provides a list of requirements 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 within the insulation that are fundamental to their ability to limit heat flow.

J1.2(c)(i) requires that bulk insulation must remain in position and not be compressed. The thermal performance of bulk insulation depends 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 pockets as the fibre contact increases, which in turn will reduce its capacity to achieve the tested *R-Value*.

Walls and cathedral ceiling framing are examples where there may be limitations in the space required for bulk insulation. In some cases, either larger framing members or thinner insulation material, such as polystyrene boards, may be required to ensure that the insulation achieves its required *R-Value* once installed. Refer to Figure 11.3 for installation of bulk insulation in walls.

Figure 11.3 Installing bulk insulation in framed walls



The requirement recognises that the practical limitations of maintaining the position and thickness of bulk insulation where it is likely to be compressed between cladding, supporting members, water pipes and electrical cabling. In these instances, compression of the bulk insulation may occur but should be limited where possible.

J1.2(c)(ii) specifies that where there is no bulk insulation or reflective insulation in a wall, the bulk insulation in the ceiling must overlap the wall by 50 mm or more.

Design alert:

Insulation materials used in a Class 2 to 9 building must also comply with the appropriate non-combustibility requirements and fire hazard properties. This may require the insulation used in these buildings to be of negligible fire hazard by complying with the non-combustibility, flammability, spread of flame and smoke development requirements of this clause. The performance of the insulation used should be validated by test reports and these reports should form part of the *building approval* documentation.

11.6.4 Thermal properties of materials

Subclause J1.2(d) refers to Specification J1.2 and provides the link between the *DTS Provisions* and the specification. The information contained within the specification can be used for assessing the contribution of construction components towards meeting the *Total R-Value* requirements contained in the *DTS Provisions* or for developing a *Performance Solution*.

Further details on Specification J1.2 is found in 11.6.6 of this Handbook.

Design alert:

Specification J1.2 relates only to compliance with Section J requirements, the condensation requirements of Part F6 must also be complied with concurrently, if applicable.

11.6.5 Calculating thermal performance

J1.2(e) specifies the general requirements for determining *Total R-Values* and *Total System U-Values*. J1.2(e) is a design clause, where compliance is shown in the design phase of the project and within design documentation. It is however, important that what is designed is also constructed.

The means of achieving the required *Total R-Value* for a roof or floor must be determined in accordance with AS/NZS 4859.2. This Standard contains a calculation method (NZ 4214) that takes into account the impact of *thermal bridges* on the thermal performances of a facade. Extra insulation or thermal breaks may need to be installed for a facade to be compliant, if there are significant *thermal bridges* within a facade.

Subclause J1.2(e) also specifies that the required *R-Value* and *Total System U-Value* for wall-glazing constructions must be determined in accordance with Specification J1.5a and soil or sub-floor spaces in accordance with Specification J1.6.

Reminder:

J1.2(e) does not apply to a Class 2 *SOU* or a Class 4 part of a building.

11.6.6 **Determining material properties**

Specification J1.2 provides a list of common construction materials and their associated thermal performance. The values have been developed by industry experts and are based on the latest scientific test information. Other values for materials may be acceptable, however, these should be validated by supporting information as prescribed in Part A5 of NCC Volume One.

The thermal values in Specification J1.2 have been provided in NCC Volume One predominantly to assist designers calculate the *Total R-Value* of common construction systems for demonstrating compliance by either the DTS or for developing *Performance Solutions*. However, they also assist people wishing to understand the thermal performance of common construction types and are useful when changing the thickness of a particular material.

11.6.6.1 Thermal conductivity of typical wall, roof/ceiling and floor materials

NCC Volume One Specification J1.2 -Table 2a contains the thermal conductivity values of typical wall, roof, ceiling and floor materials. This table and the two qualities, material density and thermal conductivity are nominated as explained in Table 11.1 below.

Table 11.1 Extract from Specification J1.2 - Table 2a Thermal Conductivity of typical wall, roof/ceiling and floor materials

Material description		Material density (kg/m^3)	Thermal conductivity (W/m.K)
1.	**Framing**		
(a)	Steel	7850	47.5
(b)	Timber – kiln dried hardwood (across the grain)	677	0.16
(c)	Timber – Radiata pine (across the grain)	506	0.10
2.	**Roof Cladding**		
(a)	Aluminium sheeting	2680	210
(b)	Concrete or terra cotta tiles	1922	0.81
(c)	Steel sheeting	7850	47.5

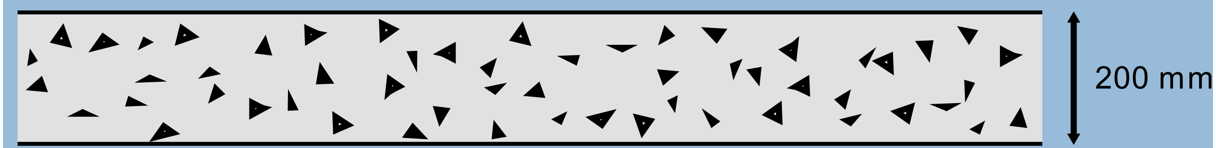
Material density is the mass of a cubic metre of the material

Thermal conductivity is a measure of a material's ability to transmit heat (i.e. the rate at which heat is to be conducted through a 1 m² sample of the material which is 1 metre in thickness)

Note 1 to Table 2a explains the process for determining the tabulated material densities and thermal conductivities for materials such as cored brickwork, hollow blockwork and cored floor or wall panels that include cores or hollows. For these materials, the densities and thermal conductivities are based on the gross density, which is the mass divided by the external dimensions.

Note 2 explains the process for calculating a materials *R-Value*. The *R-Value* is equal to the thickness of the materials in metres divided by the thermal conductivity in W/m.K.

Figure 11.4 Example: R-Value

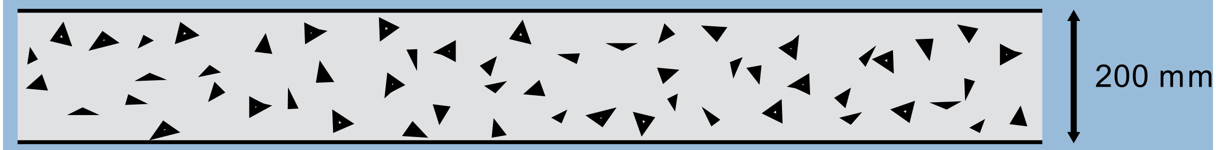


A solid concrete slab is 200 mm thick.

Table 2a in Specification J1.2 specifies that the thermal conductivity for solid concrete is equal to 1.44.

The *R-Value* is equal to the thickness of the concrete divided by the thermal conductivity.

Figure 11.4 Example: R-Value



R-Value = 0.20 m / 1.44 W/m.K

R-Value = 0.14

11.6.6.2 Typical R-Values for airspaces and air films

Table 2b in Specification J1.2 provides typical *R-Values* of air films and airspaces. There is a general understanding that the thermal efficiency of the wall, floor or ceiling is achieved by simply installing insulation. However, the performance of the thin layers of air that adjoin building materials and the larger airspaces in areas such as roofs adjacent to the insulation have a noticeable impact on the thermal performance of the composite element. Table 2b provides information on the levels of performance from airspaces and air-films for heat flowing up, down or horizontally.

The Table also delineates between still and moving air for air films. This is important as air movement will have an impact on the thermal performance of the film. Typically, air movement will occur in exposed external environments around a building, while still air can be found inside the building, including within enclosed spaces such as the cavities of brick veneer walls.

Table 11.2 Extract from Specification J1.2 Table 2b Typical R-values for airspaces and air films

Position of airspace	Direction of heat flow	*R-Value*
1. Airspaces non-reflective unventilated		
In a roof with a pitch of not more than 5°	Up	0.15
	Down	0.22
In a roof with a ceiling that is parallel with a roof with a pitch more than 5° and not more than 15°	Up	0.15
	Down	0.21
In a roof with a ceiling that is parallel with a roof with a pitch more than 22° and not more than 45°	Up	0.15
	Down	0.18
In any roof space with a horizontal ceiling, with a pitch more than 5°	Up	0.18
	Down	0.28
In a wall	Horizontal	0.17
2. Airspaces non-reflective ventilated		
In any roof with a pitch not more than 5° and 100 mm deep airspace	Up	Nil
	Down	0.19

Direction of heat flow refers to either heat flow into the building or heat loss out of the building. 'Down' indicates a summer heat (downwards heat flow into the building) is the major concern. 'Up' indicates that heat loss from the building during winter is the major concern. 'Up' indicates that heat loss from the building during winter is the major concern.

Note that the *R-Values* in Table 2b are for a temperature of 10°C and a temperature difference of 15 K. If the temperature is to differ from this, *R-Value* calculations are to be shown and approved by the building certifier.

11.6.6.3 Performance of reflective insulation

Subclause (c) of Specification J1.2 provides guidance on the performance of reflective surfaces installed in walls and roof spaces. These values are typical and can be used on the proviso that the emittance values, as listed in the clause, or the first column of Table 2c of Specification J1.2, are achieved by the reflective insulation. If the emittance is different, then confirmation of the actual performance of the product should be obtained from the manufacturer's test data in accordance with AS/NZS 4859.1. Testing and subsequent compliance is required under subclause J1.2(a).

Subclause(c)(i) refers to the material emittance values. The definitions of reflectance and emittance are complex. However, the relationship between the two can be simply expressed as follows:

Emittance = 1 - Reflectance

Therefore, the more reflective the material, the lower its emittance value and the greater its insulative performance.

In simple terms, an unreflective material will tend to absorb heat and re-radiate it effectively. A shiny material will absorb less heat, as most of the heat is reflected, and re-radiates very little of it.

In Specification J1.2, subclause (c)(ii) outlines the performance of reflective insulation in roof spaces. Subclause (c)(ii) refers to Table 2c (Table 11.3 of this document) which provides information on the performance of reflective insulation in roof spaces and refers to “inner” and “outer”. In this instance, “inner” means facing inwards towards the building, while “outer” means facing outwards from the building.

As discussed previously, airspaces are essential to the performance of reflective insulation. The size and configuration of roof spaces vary considerably, and this has an impact on the thermal properties of the roof when reflective insulation is installed. Table 2c covers many scenarios, including whether the direction of heat flow is upwards or downwards, which also has a significant impact on the performance of the insulation. Refer to Table 11.3 of this document for further information.

Table 11.3 Extract from Specification J1.2a - Table 2c Typical thermal properties for reflective surfaces with airspaces in roofs

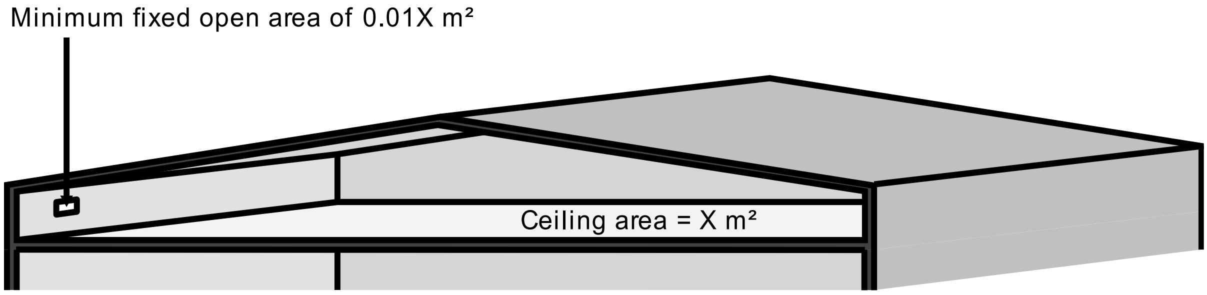
Emittance of added *reflective insulation*	Direction of heat flow	*R-Value* added by a reflective surface					
		Pitched roof (>10°) with horizontal ceiling		Flat, skillion or pitched roof (≤10°) with horizontal ceiling	Pitched roof with cathedral ceiling		
		Ventilated roof space	Non-ventilated roof space		15° to not more than 25° pitch	more than 25° to not more than 35° pitch	more than 35° to 45° pitch
0.2 outer 0.05 inner	Downwards	1.21	1.12	1.28	0.96	0.86	0.66
0.2 outer 0.05 inner	Upwards	0.59	0.75	0.68	0.72	0.74	0.77

The angle of reflective insulation is the angel at which the reflective insulation is installed.

11.6.6.4 Ventilated roof space

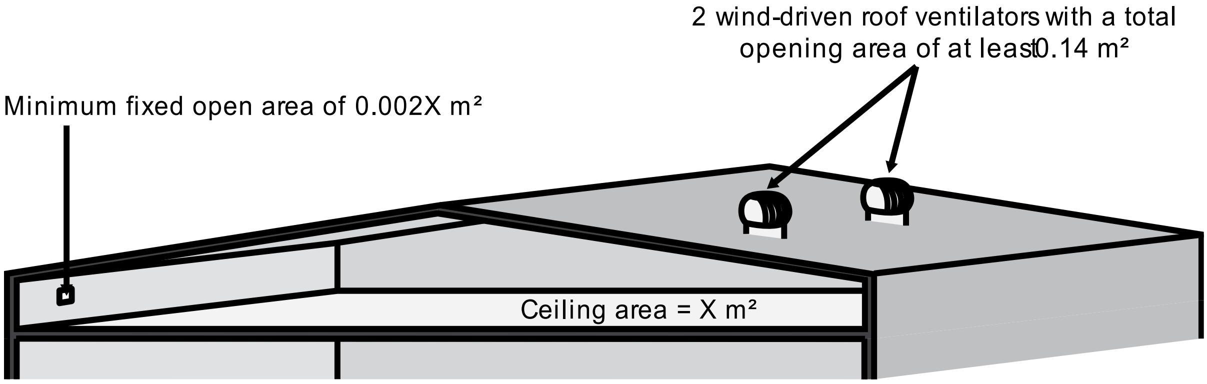
Subclause (d) of Specification J1.2 provides the definition of a ventilated roof space. Subclause (d)(i) specifies that a ventilated roof space can be a roof space with vents that allow air to flow freely without obstructions, ensure there are no spaces with no air movement and have a fixed open area of at least 1.0% of the ceiling area.

Figure 11.5 Ventilated roof space requirements Specification J1.2 subclause d(i)



Subclause (d)(ii) specifies that a ventilated roof space could also be a roof space with at least 2 wind-driven roof ventilators with a total opening area of at least 0.14 m^2. This requirement must be accompanied by vents with a total fixed open area of at least 0.2% of the ceiling area.

Figure 11.6 Ventilated roof space requirements Specification J1.2 subclause d(ii)



Subclause (d)(iii) specifies that a ventilated roof space can also be a roof space that is tiled and has no sarking-type material at roof level.

11.7 Roof and ceiling construction

J1.3 covers roofs, including their ceilings, and any ceiling that is part of an intermediate floor forming part of the building's *envelope*, or where there is no ceiling.

Reminder:

J1.3 does not apply to a Class 2 *SOU* or a Class 4 part of a building.

11.7.1 Total R-Value requirement

Reminder:

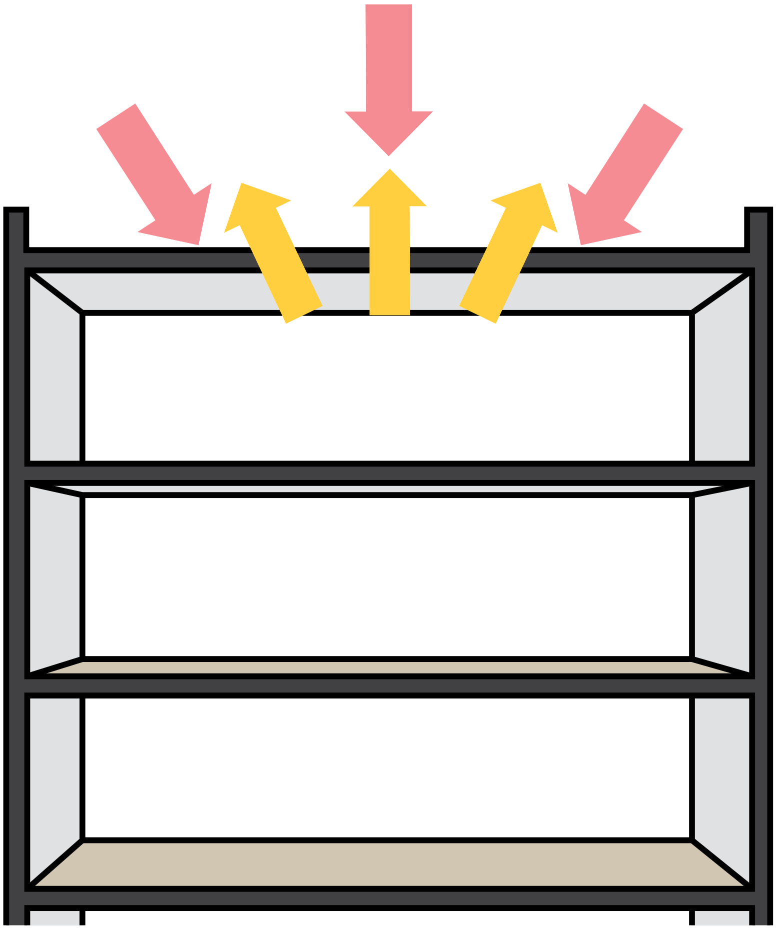
The calculation method used to determine the *Total R-Value* must comply with AS/NZS 4859.2.

J1.3(a) details the insulation properties and minimum *Total R-Value* required of a roof or ceiling. The *Total R-Value* may be provided by the roof construction itself and include any insulating properties of the roof and airspaces. If the *Total R-Value* provided by the roof is significant, the amount of insulation needed is reduced.

The definition of a *conditioned space* refers to a space, if the ceiling space below the roof is used as the return air plenum, it is considered part of the *conditioned space*. In this instance, air from the *conditioned spaces* collects in the ceiling space and is drawn back into the *HVAC* equipment for more heating or cooling. Therefore, the *envelope* boundary for the roof and ceiling construction is located at the roof as conditioned air is within the ceiling space.

The direction of heat flow listed in J1.3(a) refers to either heat flow into the building or heat loss out of the building and is based on conditions in each *climate zone*. Where “downwards” is specified, this indicates that summer heat (a downwards heat flow into the building) is the major concern. An “upwards” flow indicates that heat loss from the building during winter is the major concern. This concept is explained further in Figure 11.7.

Figure 11.7 Upwards and downwards heat flow



The direction of heat flow stated in J1.3(a) should not be taken as the only direction in which any insulating properties operate. The direction is a statement of the prominent direction for that *climate zone*, i.e. the sun's radiant energy creates heat flow in a downwards direction into buildings in warmer climates, and warmth from conditioned air leaves a building in an upwards direction overnight in the cooler months in cooler *climate zones*. It is assumed that construction and insulating materials will also have insulating properties in the other direction.

For residential buildings, the night time direction is important as the buildings are most likely to be occupied at that time. During the night, the outside temperature likely to be the lowest of the day, therefore, warm conditioned air may leave the building in an upwards direction overnight. A non-residential commercial building is likely to be air-conditioned and likely to have more day time use. The main heat flow direction for these buildings is therefore downwards for all *climate zones* except 7 and 8.

Design alert:

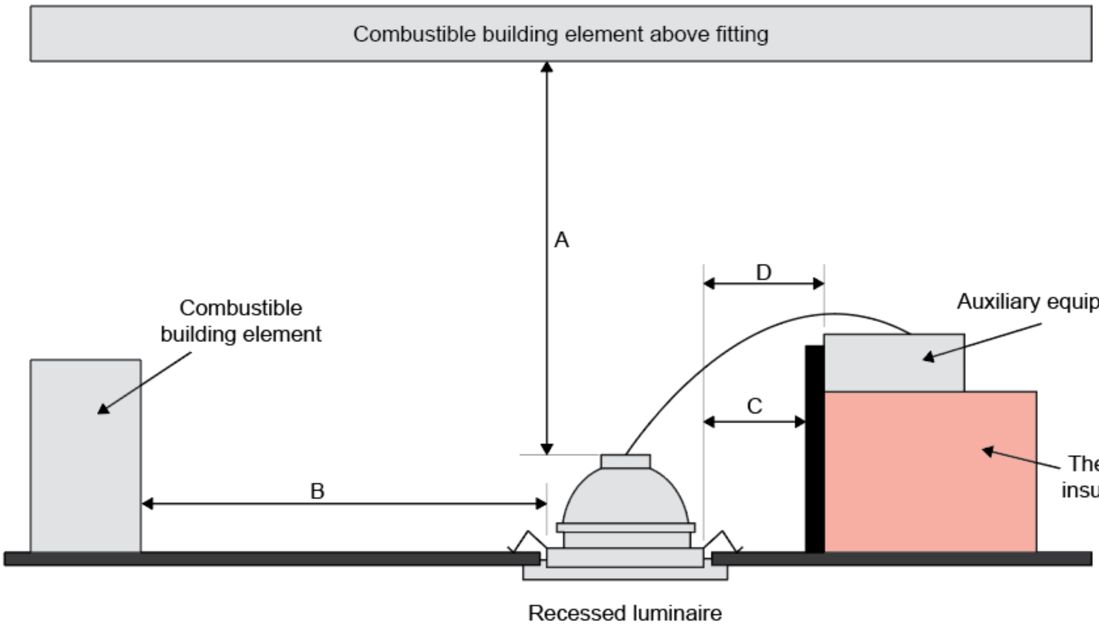
An important issue for roof design, especially where higher *Total R-Values* are required, will be to ensure that the roof structure has sufficient space to accommodate the insulation without compressing it. Any compression of the insulation will reduce its *Total R-Value* and consequently the effectiveness of the insulation.

The effect of *thermal bridging* must be taken into account by using the calculation method specified in AS/ NZ 4859.2 (2018) when determining if the minimum *R-Value* of a roof has been achieved. In some cases, thermal breaks will be necessary to achieve compliance.

A thermal break may be provided by materials such as timber or expanded polystyrene strips, plywood or bulk insulation. Reflective insulation alone is not suitable for use as a thermal break because it requires an adjoining airspace to achieve the specified *R-Value*.

There may be instances where downlights, fans or other ceiling penetrations limit the location of ceiling insulation. In these circumstances it is the responsibility of designers to determine how they will achieve the required *Total R-Value* given the construction of the roof and the penetrations. Although not referenced by NCC Volume One, Australian Standard AS/NZS 3000: 2018 – Electrical Installations (known as the Australian/New Zealand wiring rules) requires insulation to be kept away from downlights. A diagram to explain the requirements of the Standard is at Figure 11.8. Alternatively, there are covers for downlights or special downlight fittings that allow insulation to come closer to the downlight.

Figure 11.8 Downlight and fan insulation compensation



Notes to Figure 11.8:

A = 200 mm clearance above the recessed luminaire.

B = 200 mm clearance to the side of the recessed luminaire to combustible building element.

C = 50 mm clearance to the side of the recessed luminaire to bulk insulation.

D = 50 mm clearance to any auxiliary equipment (This would include the transformer for the luminaire).

11.7.2 Roof solar absorptance

Subclause J1.3(b) specifies the solar absorptance of the upper surface of a roof to be less than or equal to 0.45 in *climate zones* 1-7. Solar absorptance refers to the proportion of solar radiation that is absorbed by the material. A lower solar absorptance will reflect more heat than a roof with a higher solar absorptance and is therefore usually a lighter colour. Colours with a greater solar absorptance will require *Performance Solutions*.

11.8 Roof lights

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

Remember that *roof lights* have a specific meaning within NCC Volume One as follows:

NCC Volume One Schedule 3 Definitions

Roof light, for the purposes of **Section J** and **Part F4** in Volume One, and **Parts 2.6, 3.8.4** and **3.12** in Volume Two, 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* may 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.

The thermal performance of *roof lights* is expressed in terms of Total System U-Value and Total System SHGC. Refer to Schedule 3 of NCC Volume One for further information on these terms.

Reminder:

J1.4 does not apply to a Class 2 *SOU* or a Class 4 part of a building.

11.8.1 **Area**

The provisions of J1.4(a) specify the maximum area of *roof lights*. The size of *roof lights* is limited to no more than 5% of the floor area of the space served to ensure that the thermal performance of a roof is not compromised to too great an extent.

Larger *roof lights* will need to achieve compliance through a *Verification Method* or as *Performance Solution*.

The calculation floor area is based on the floor area of the space the *roof lights* serve. If the *roof light* is serving a single room, the floor area is simply the area of the room. In multi storey buildings, this would relate only to the top storey immediately below the *roof lights*. Accordingly, the area of other floors is not taken into consideration. In situations where there is an atrium, the floor area at the bottom of the atrium would be used to determine the total floor area served by the *roof light*.

11.8.2 **Thermal performance**

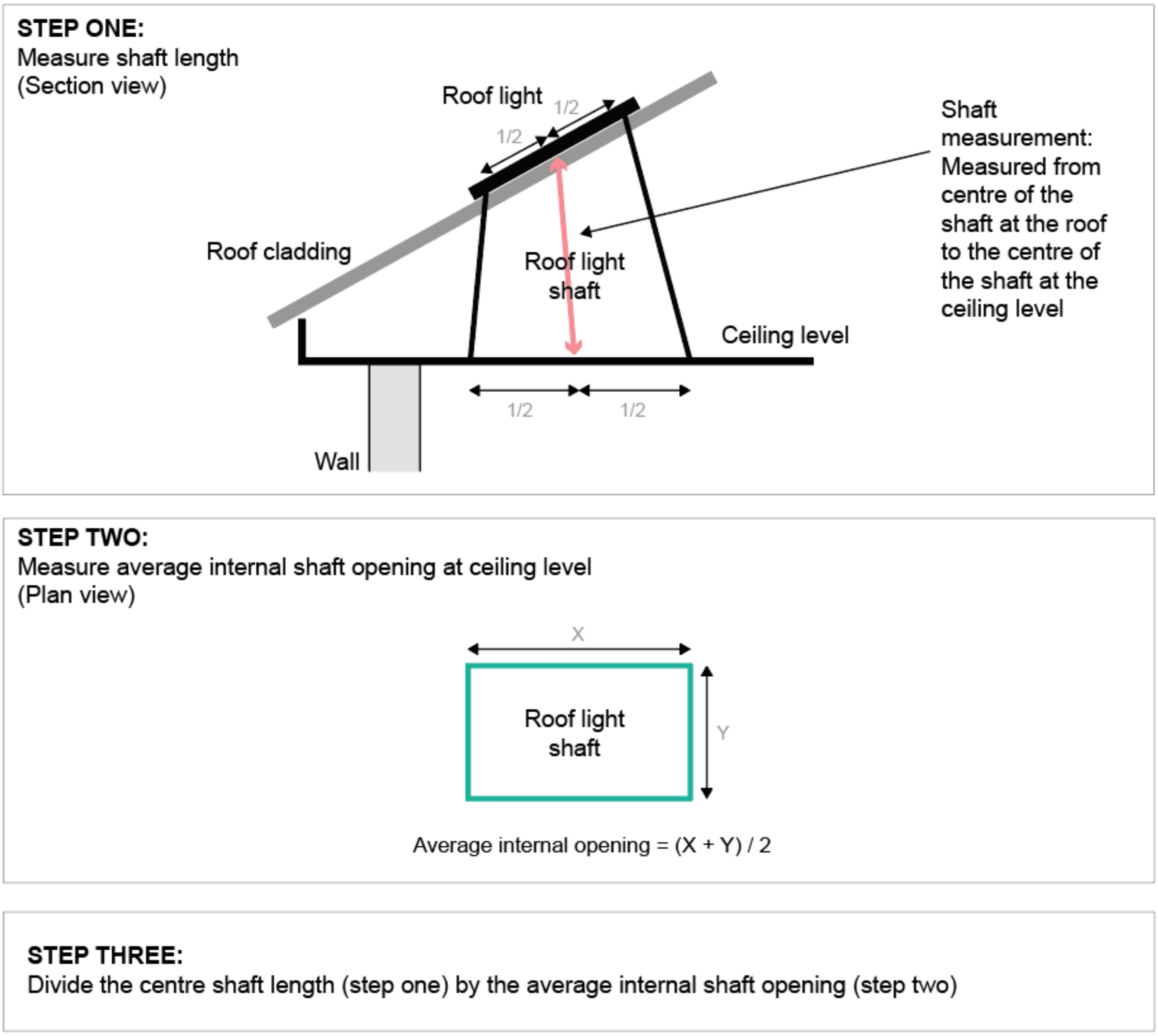
J1.4(b) has values for *Total System SHGC* and *Total System U-Values*, which are expressed in accordance with the AFRC Protocol.

The provisions of J1.4(b) require *roof lights* to have transparent and translucent elements with a maximum *Total System U-Value* of 3.9 and *Total System SHCG* in accordance with Table J1.4, including any ceiling diffusers.

Table J1.4 provides the *Total System SHGC* requirements that satisfy J1.4.

Note 1 to Table J1.4 provides an explanation on how to determine the *roof light* shaft index, a ratio of the vertical distance of the *roof light* to the ceiling level and the *roof light* opening at the ceiling level. Determining the *roof light* shaft index specified in Table J1.4 can be calculated using Figure 11.9 below.

Figure 11.9 Determining roof light shaft index



Note 2 to Table J1.4 specifies that the area of a *roof light* is equal to the area of the opening in the roof that allows light into the building. Combining the values of individual *roof lights* gives the total area of *roof lights* serving a room or space.

11.9 Walls and glazing

The construction of walls and *glazing* are a major contributing factor in the overall thermal performance of the building. J1.5 states the requirements for walls and windows as a wall-glazing construction, both internal and external that form part of the *envelope*.

Reminder:

Wall-glazing construction means the combination of wall and *glazing* components comprising the *envelope* of a building, excluding:

(a) display glazing; and
(b) *opaque* non-glazed openings such as doors, vents, penetrations and shutters.

This means that the elements in (a) and (b) are subtracted from the area of the façade during calculations.

Provisions for *Total System U-Value* and solar admittance for a wall-glazing construction are specified in J1.5. These provisions require the thermal performance (glass and frame) of the *glazing* elements in the wall-glazing construction. These values 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 Energy Rating of Fenestration Products of the AFRC.

Similarly, provisions for the *Total R-Value* of the wall component of a wall-glazing construction are provided.

When considering the requirements in J1.5, it is important to appreciate that this provision applies to the walls and windows of the building *envelope*, which can include internal walls as well as external walls.

Design alert:

When is a wall an internal wall?

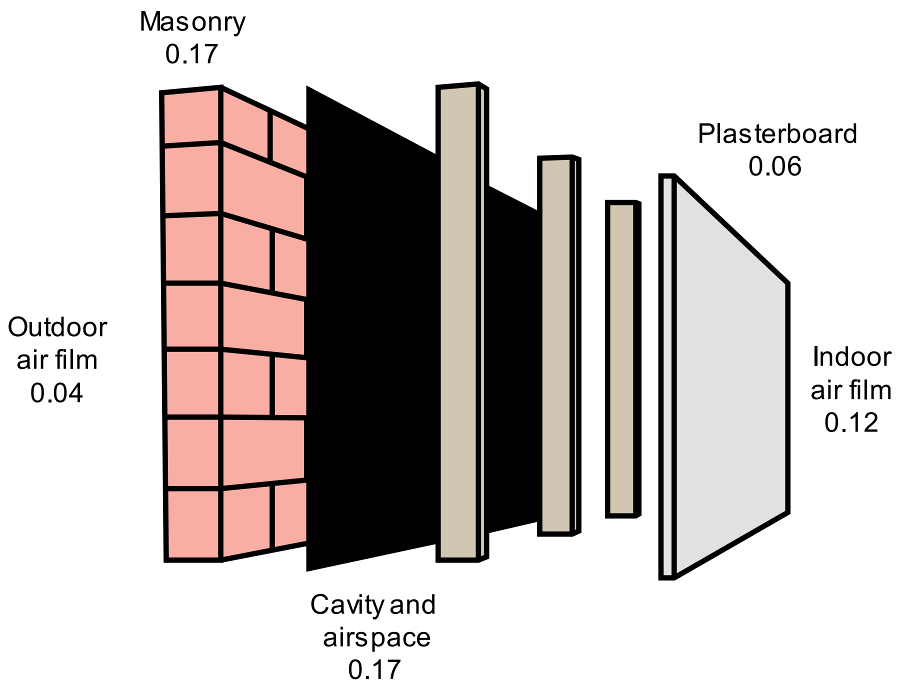
For the purposes of this subclause, an internal wall is a wall that is protected from the external elements by another wall, window or door. An external wall would be a wall open to the external environment, even though it may be within the roof line of the building. This is based on the idea that the wall is exposed to the external temperatures, sun and wind.

Walls adjoining an open courtyard area within the roof line would be considered external while a wall of a supervisor's office overlooking a factory floor would be internal. Refer to the defined term external wall in the NCC for further guidance.

11.9.1 Typical constructions

The following figure describes the component *R-Values* for a typical wall construction.

Figure 11.10 Typical wall construction R-Values



The figures below provide more detailed examples of typical insulation locations in various types of wall construction. The *Total R-Value* required is achieved by adding the material *R-Value* of the basic wall and the material *R-Value* of any additional insulation incorporated. The *Total R-Value* of the typical wall construction has been produced by adding together the material *R-Values* for outdoor air film, wall cladding, wall airspace, internal lining and internal air film.

Note it should not be assumed that these figures are representative of all construction scenarios. For example, the spacing of framing members, the number of windows or the specific type of frame could all affect the actual *Total R-Value* by creating *thermal bridging* between elements or by compressing insulation. If developing a *DTS Solution*, *Total R-Value* must be calculated using the methods prescribed in AS/NZS 4859.2 to properly account for these effects.

The most common forms of construction for low-rise buildings are represented in the examples below. It has not been possible to cover other forms of construction, particularly those used for high-rise construction, because of the wide range and the greater influence of winds, cyclones and earthquakes on the elements of the building. The *Total R-Value* of other forms of construction can be determined by adding the individual *R-Values* together.

Reflective insulation that has just one reflective surface is considered to achieve the *R-Values* when used in conjunction with the *Total R-Value* of the common wall construction stated in the figure below. The actual *R-Value* added by reflective insulation should be determined for each product in accordance with the standards prescribed in the NCC, which take into consideration factors such as the number of adjacent airspaces, dimensions of the adjacent airspace, whether the space is ventilated and the presence of an anti-glare coating.

The width for any reflective airspace adjacent to reflective insulation will not override other requirements such as minimum cavity requirements for masonry waterproofing.

Where a diagram shows reflective insulation or other insulation, these are indicative only. In some climates and using certain materials, neither may be necessary. In other cases, reflective insulation or insulation may be provided separately or in combination to give the required *R-Value*.

A minimum thickness of 70 mm is stated for framing. In some cases, the frame thickness may need to be increased to avoid compressing the bulk insulation and thus reducing its *R-Value*.

Walls with a large surface density can achieve higher levels of thermal performance in certain *climate zones* due to their ability to store heat and therefore slow the heat transfer through the building fabric. This can be demonstrated through a *Performance Solution*.

> ***Alert:***
>
> Examples of typical constructions for low rise construction can be found in the Guide to Volume One.

> ***Reminder:***
>
> J1.5 does not apply to a Class 2 *SOU* or a Class 4 part of a building.

11.9.2 **Total System U-Value for wall-glazing construction**

> ***Reminder:***
>
> The calculation method used to determine the *Total System U-Value* must comply with Specification J1.5a.

J1.5(a) contains the basic *Total System U-Values* that need to be achieved by wall-glazing construction forming the *envelope* of a building. Importantly, this applies to both external and internal wall-glazing construction that form part of the building *envelope*.

Subclause J1.5(a)(i) applies to Class 2 common areas, Class 5, 6, 7, 8 or 9b buildings or Class 9a buildings other than a *ward area*. For these building types the *Total System U-Value* must be less than or equal to U2.0.

Subclause J1.5(a)(ii) applies to Class 3 or 9c buildings or Class 9a *ward areas*. In *climate zones* 1, 3, 4, 6 or 7, the *Total System U-Value* must be less than or equal to U1.1, in *climate zones* 2 or 5, the *Total System U-Value* must be less than or equal to U2.0, and in *climate zone* 8, the *Total System U-Value* must be less than or equal to U0.9.

J1.5(c) requires that for wall-glazing constructions the *Total System U-Value* must be calculated in accordance with Specification J1.5(a).

11.9.3 **Total R-Value for wall components**

> ***Reminder:***
>
> The calculation method used to determine the *Total R-Value* must comply with Specification J1.5a.

J1.5(d) outlines requirements for wall components of wall-glazing constructions based on the percentage of area the wall component makes up of the total construction. If the wall component is less than 80% of the total area of the wall-glazing construction, the required *Total R-Value* is at least R1.0. If the wall component is greater than 80% of the total area the *Total R-Value* is specified in Table J1.5a.

The *Total R-Values* for wall-glazing constructions where the wall component makes up less than 80% of the construction are less than the *Total R-Values* for constructions where the wall component makes up more than 80% of the wall-glazing construction. It is considered that once the *glazing* component is greater than 20% of the construction the *glazing* becomes the primary driver of energy use. Therefore, *Total R-Values* for the wall components can be less when the *glazing* component is relatively large.

> ***Reminder:***
>
> The definition of a wall-glazing construction comprises of wall and *glazing* components that make up the *envelope* of the building. If a basement qualifies as a *conditioned space*, basement walls would be required to comply with this clause.

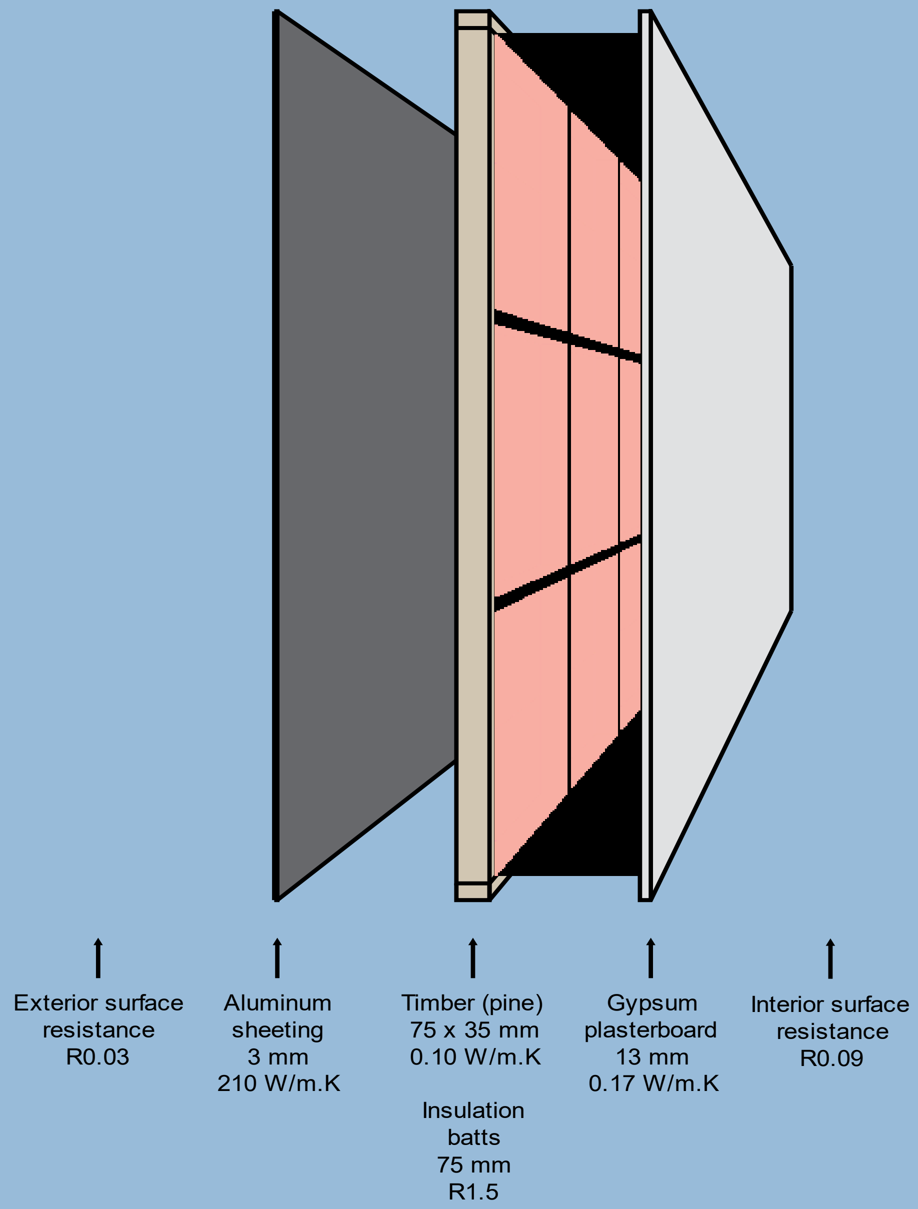
Table J1.5a specifies *Total R-Values* based on *climate zones* and building class types.

Example: Total R-Value Calculation

(showing bridging calculation as per NZ 4214)

A stud wall consists of 3 mm thick aluminium sheeting, 75 mm thick bulk insulation with an *R-Value* of 1.5, and 13 mm thick gypsum plasterboard. The insulation layer is bridged by 75 mm x 35 mm framing studs at 600 mm centres, noggings at 800 mm centres, and 35 mm height top and bottom plates. The wall is 2.4 m tall.

Figure 11.11: Stud wall section



The *Total R-Value* is calculated by determining the thermal resistance of each layer, surface layer, and any bridged layers in the wall.

Example: Total R-Value Calculation

(showing bridging calculation as per NZ 4214)

Exterior surface resistance:

See NZS 4214 Section 5.2.

R = 0.03 m^2.K/W

Layer 1: 3 mm aluminium sheeting

$$R = \frac{0.003\ \text{m}}{210\ \text{W/m.k}}$$

R = 0.00001 m^2.K/W

Layer 2: Insulation with timber *thermal bridge*

See NZS 4214 Section 5.7.

First the *R-values* of each material in the layer is determined.

R_1 (75 mm thick R1.5 insulation batts) = 1.5 m^2.K/W

$$R_2\ (\text{75 mm deep timber framing}) = \frac{0.075\ \text{m}}{0.10\ \text{W/m.k}}$$

R_2 (70 mm deep timber framing) = 0.75 m^2.K/W

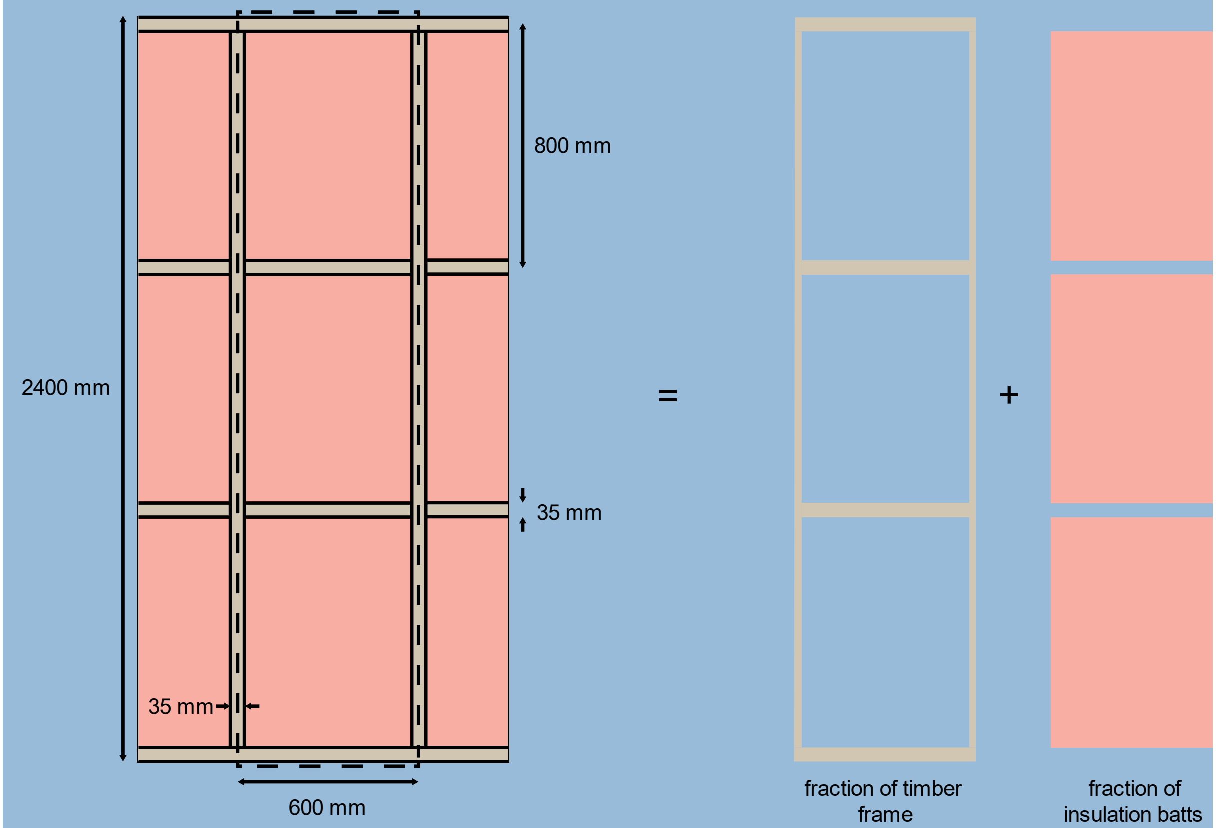
Next, the fraction of the cross-section at right angles to the direction of heat flow occupied by each region in the layer is determined.

One repeated section of the wall can be examined to determine the fraction of each region in the layer as per Figure 11.12.

Example: Total R-Value Calculation

(showing bridging calculation as per NZ 4214)

Figure 11.12 Insulation with framing acting as a *thermal bridge*



$$f_1(\text{fraction of insulation batts}) = \frac{\text{area of insulation}}{\text{total area}}$$

$$f_1(\text{fraction of insulation batts}) = \frac{(600\times2400)-((2400\times35)+((600-35)\times35\times4))}{600\times2400}$$

f_1 (fraction of insulation batts) = 0.8867

$$f_2(\text{fraction of timber framing}) = \frac{\text{area of timber framing}}{\text{total area}}$$

$$f_2(\text{fraction of timber framing}) = \frac{((2400\times35)+((600-35)\times35\times4))}{600\times2400}$$

f_2 (fraction of timber framing) = 0.1133

Next the total resistance of the layer is calculated.

Example: Total R-Value Calculation

(showing bridging calculation as per NZ 4214)

See equation 5 and 6 of NZS 4214.

$$\frac{1}{R} = \frac{f_1}{R_1} + \frac{f_2}{R_2} = \frac{0.8867}{1.5} + \frac{0.1133}{0.75} = 0.742$$

$$R = \frac{1}{0.742}$$

R = 1.347 m^2.K/W

Layer 3: 13 mm gypsum plaster board

$$\mathrm{R} = \frac{0.013\ \mathrm{m}}{0.17\ \mathrm{W/m.k}}$$

R = 0.076 m^2.K/W

Interior surface resistance:

See NZS 4214 Section 5.2.

R = 0.09 m^2.K/W

Total thermal resistance (*Total R-Value*):

The total thermal resistance is the sum of all the layers, the surface layers and any bridge layers (i.e. layer 2).

Total R-Value = 0.03 + 0.00001 + 1.347 + 0.076 + 0.09

Total R-Value = 1.544

Please note this calculated *Total R-Value* is representative of the wall where the timber frame and insulation batts are consistent with the area used in this example. The areas on the edge of the wall, for example, would therefore have a different *Total R-Value* as the fraction of timber would be larger due to the edge stud components.

11.9.4 Solar admittance

J1.5(e) contains the basic solar admittance values that must not be exceeded by externally-facing wall-glazing construction. Importantly, this subclause only applies to external wall-glazing construction forming part of the building *envelope*. Tables J1.5b and J1.5c specify maximum solar admittance values based on building class and direction.

The lower solar admittance values in Table J1.5c reflect the stricter *Total System U-Value* requirements of the identified building types. This is because of the likely 24/7 operation of these buildings. 24/7 operation means that the buildings do not cool down overnight and therefore have greater cooling requirements.

J1.5(c) requires that for wall-glazing constructions, the solar admittance must be calculated in accordance with Specification J1.5(a).

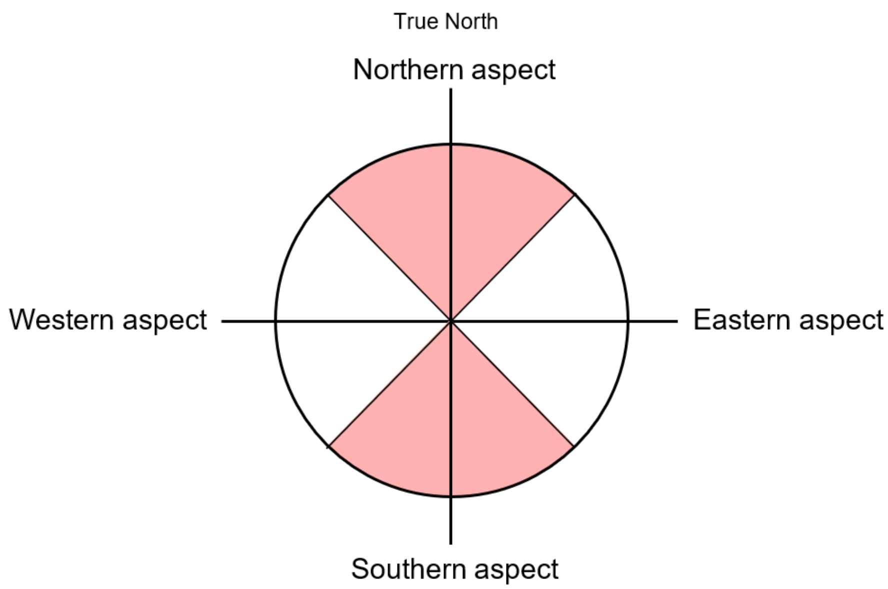
11.9.5 **U-Value and solar admittance calculation**

Specification J1.5a describes the two calculation methods for determining if wall-glazing construction complies with the U-Value and solar admittance requirements in J1.5. The methods are dependent on whether the wall-glazing construction includes walls and *glazing* facing a single aspect or multiple aspects.

Determining the aspect of the wall-glazing construction is as follows:

- True north or within 45° of true north = northern aspect
- True south or within 45° of true south = southern aspect
- True east or within 45° of true east = eastern aspect
- True west or within 45° of true west = western aspect

Figure 11.13 Northern, eastern, southern and western aspects



When applying the methods described below, the *Total System U-Value* and *Total System SHGC* of *glazing* must account for the combined effect of the glass and frame. The measurement of the *Total System U-Value* and *Total System SHGC* is specified in the Technical Protocols and Procedures Manual for Energy Rating of Fenestration Products of the AFRC.

Various assessors using AFRC procedures might refer to their published performance values by slightly different terms (including "U-factor" or "Uw" for *Total System U-Value* or "SHGC" for *Total System SHGC*). These values can be used under Specification J1.5 providing they measure combined glass and frame performance according to AFRC requirements.

For the compliance pathways within Specification J1.5(a), Method 1 includes calculations for wall-glazing constructions facing a single aspect. Method 2 includes calculations for wall-glazing constructions facing multiple aspects.

11.9.5.1 U-Value - Method 1 (single aspect)

For Method 1, each aspect of wall-glazing construction is required to meet the applicable *Total System U-Value* for the building classification and *climate zone*.

Clause 3(b) specifies that the *Total System U-Value* of the wall component is calculated as the inverse of the *Total R-Value*, with allowances made for *thermal bridging*. The thermal conductivity of typical materials provided in Specification J1.2 can aid in calculating material *R-Values*. All calculations are to be made in accordance with AS/NSZ 4859.2 or Specification J1.5b.

Alert:

As/NZS 4859.2 is the design standard for thermal insulation materials for buildings. The standard provides prescriptive system *R-Value* calculations.

Subclause 3(c) specifies the *Total System U-Value* of the wall-glazing construction is calculated as an area-weighted average of the *Total System U-Value* of each component of the construction. This value must be less than or equal to the applicable value in J1.5(a) as per subclause 3(d).

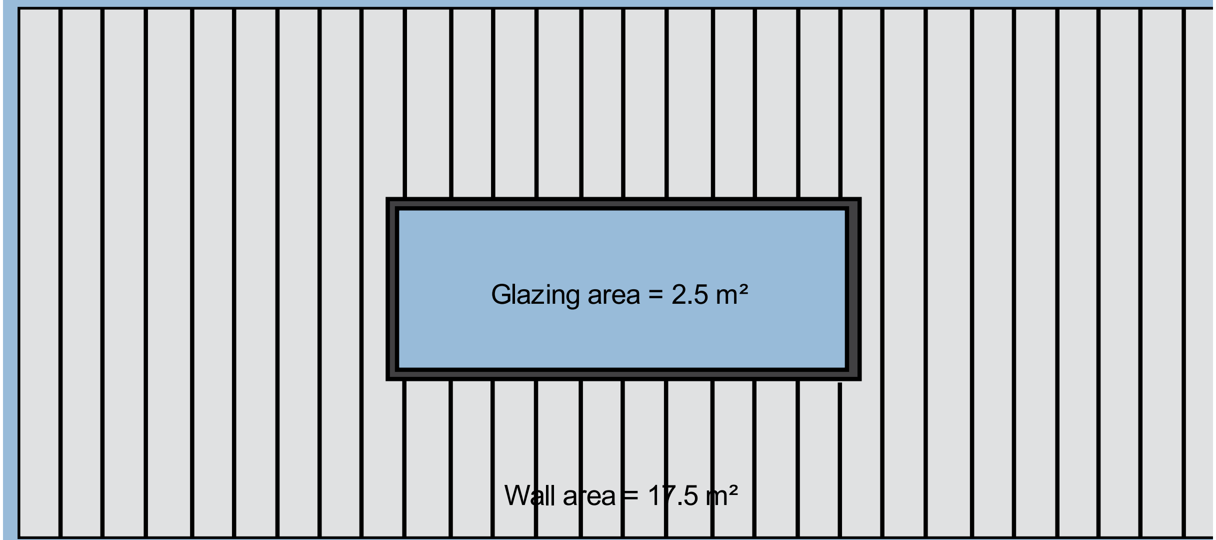
Example: Wall-glazing construction Total System U-Value calculation

Wall-glazing constructions refer to the combination of wall and *glazing* components that make up the *envelope* of a building. They exclude display glazing and *opaque* non-glazed openings such as doors, vents, penetrations and shutters.

The following *wall-glazing construction* is facing north. As the wall glazing-construction is facing only the northern aspect, the single aspect calculation method (Method 1) can be used.

The *wall-glazing construction* is part of a Class 6 building and is in *climate zone* 7.

Figure 11.14 Window to Wall ratio



The U-Value of the *glazing* is equal to U3.5.

The wall component is a stud wall that is made up of 3 mm thick aluminium sheeting, bulk insulation with an *R-Value* of 1.5, and 13 mm thick plasterboard and the *Total R-Value* is equal to 1.54.

Wall construction R-Value:

The *Total R-Value* of 1.54 is calculated in accordance with AS/NZS 4859.2, with allowances for *thermal bridging*.

Example: Wall-glazing construction Total System U-Value calculation

Please note the ABCB Façade Calculator provides a *Total System R-Value* Calculator that enables the input of material layers and determines the *Total R-Value* with allowances for *thermal bridging* in accordance with AS/NZS 4859.2.

The percentage area of the wall component can be calculated as the area of the wall component divided by the total area.

17.5 / 20 = 0.875 or 87.5%

As the percentage of wall area is greater than 80% of the *wall-glazing construction*, the minimum *R-Value* is specified in Table J1.5a.

Per Table J1.5a, the minimum requirement for a Class 6 building in *climate zone* 7 is R1.4.

As 1.54 is greater than R1.4 the wall component meets the requirements of J1.5(d).

Wall construction U-Value:

The *Total System U-Value* of the wall component can be calculated as the inverse of the *Total R-Value*.

Total System U-Value = 1 / 1.54 = 0.65

Total System U-Value:

The *Total System U-Value* of the wall-glazing construction is calculated as the area weighted average of the *Total System U-Value* of each component.

The percentage area of the wall component is equal to 87.5% as calculated above.

The percentage area of the *glazing* component can be calculated as the area of the *glazing* component divided by the total area.

2.5 / 20 = 0.125 or 12.5%

Example: Wall-glazing construction Total System U-Value calculation

The area weighted average is then calculated by multiplying the percentage area by the U-Value of each component and adding them together.

Percentage wall x wall U-Value + Percentage *glazing* x *glazing* U-Value =

0.875 x 0.65 + 0.125 x 3.5 = 1.00

Result

As the *Total System U-Value* (1.00) does not exceed the requirements of J1.5(a)(i) *Total System U-Value* no greater than U2.0 for a Class 6 building), the *wall-glazing construction* meets J1.5 and Specification J1.5(a) requirements.

For complicated wall-glazing constructions, the ABCB Façade Calculator can provide a quicker way to undertake the required calculations.

11.9.5.2 U-Value - Method 2 (multiple aspects)

Wall-glazing constructions facing multiple aspects can be assessed together to determine if they collectively achieve the applicable *Total System U-Value* and solar admittance. Method 2 effectively allows for trading of thermal performance values between different aspects and is intended to make it easier for a building to have the same *glazing* system in all directions.

Please note, orientations may also be considered separately using Method 1.

11.9.5.3 Solar admittance - Method 1 (single aspect)

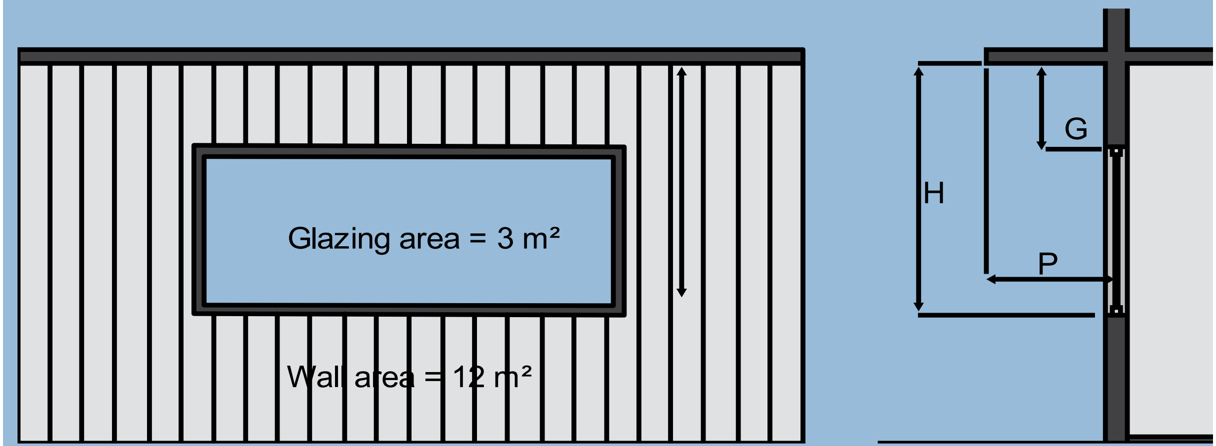
Subclause 5(a) in Specification J1.5a provides a formula to determine the solar admittance of a wall-glazing construction facing a single aspect. The calculated solar admittance of the construction must be less than or equal to the applicable value in J1.5(b).

Example: Solar admittance

The following example is a north facing wall of a Class 3 building in *climate zone* 2. The SHGC of the proposed *glazing* is 0.45.

In the example G = 0.6 m, P = 0.8 m, and H = 2 m.

Figure 11.15 window to wall ratio and shading



Area of each *glazing* element (A_W)

As there is only one *glazing* element, A_{W1} = 3.0 m^2

Shading multiplier of each *glazing* element (S_W)

To determine the shading multiplier, G/H and P/H must first be calculated.

G/H = 0.6 / 2 = 0.3

P/H = 0.8 / 2 = 0.4

The shading multiplier can be found in Table 7a of Specification J1.5a and is therefore, 0.89.

S_{W1} = 0.89

SHGC of each *glazing* element ($SHGC_W$)

$SHGC_{W1}$ = 0.45

Area of the wall-glazing construction (A_{Wall})

A_{Wall} = 15 m^2

Example: Solar admittance

Calculation of solar admittance

The values determined can now be used in the solar admittance equation provided in Specification J1.5a Cause 5.

$$SA = \frac{A_{W1} \times S_{W1} \times SHGC_{W1}}{A_{Wall}}$$

$$SA = \frac{3.0 \times 0.89 \times 0.45}{15}$$

SA= 0.080

The calculated solar admittance must be less than or equal to the values specified in J1.5(e).

For a Class 3 building, the maximum solar admittance factor is found in Table J1.5c and is determined to be 0.10.

Result

As the calculated solar admittance of 0.080 does not exceed the applicable value in J1.5(e)(0.10), the proposed design meets the requirements.

11.9.5.4 - Solar admittance - Method 2 (multiple aspects)

Method 2 specifies the solar admittance for a *wall-glazing construction* facing multiple aspects. Please note aspects may also be considered separately using Method 1.

Method 2 requires a representative *air-conditioning* energy value less than that achieved by a reference case.

The calculation requires the area of each *wall-glazing construction*, the solar admittance weighting coefficient of each aspect and the *wall-glazing construction* solar admittance of each aspect.

For *glazing* on an aspect with an area of less than 20% of the wall-glazing construction the solar admittance is 0. This is to not gain unreasonable allowances for *glazing* on other aspects. Where *glazing* is less than 20%, it is recommended that Method 1 is used.

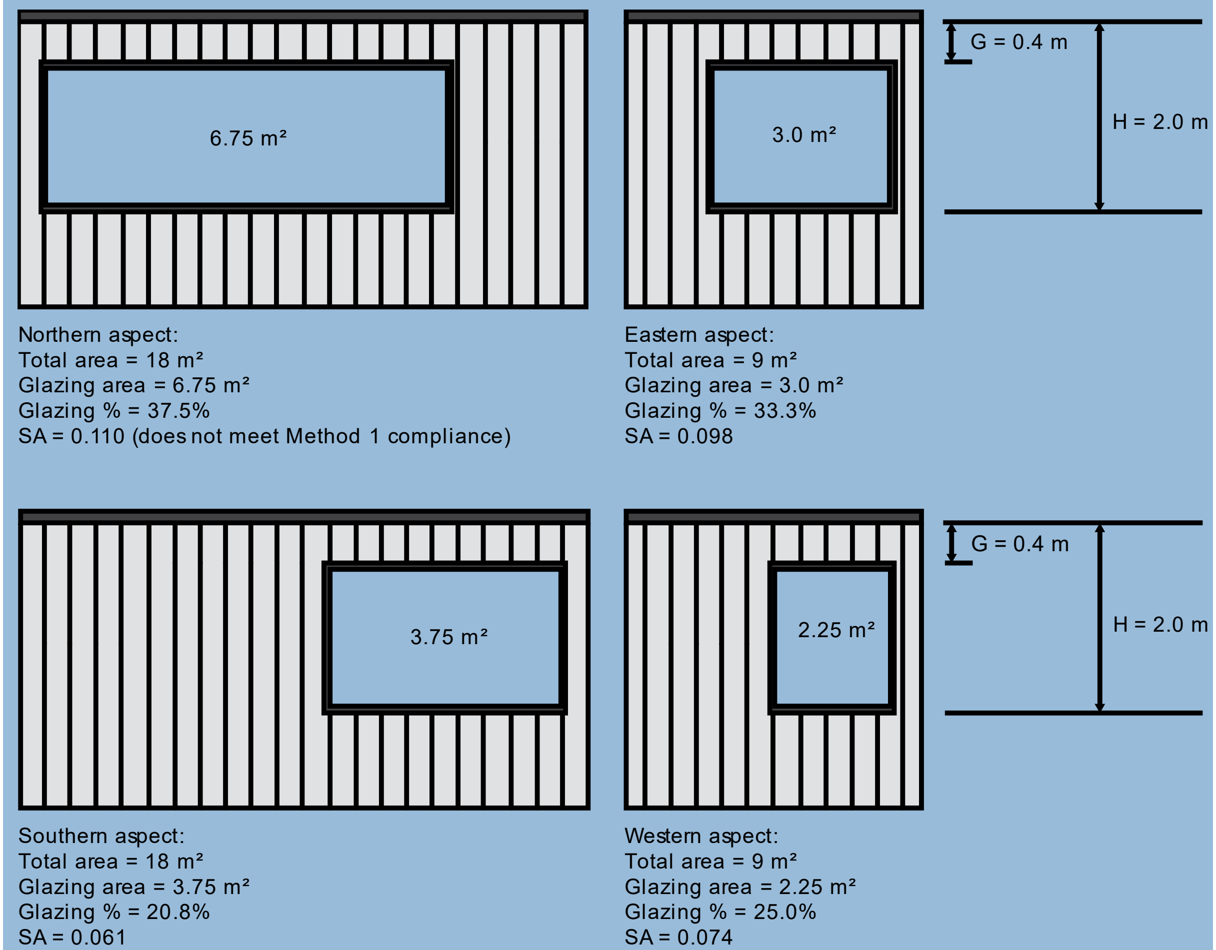
Example: Solar admittance

The following example is for a Class 3 building located in *climate zone* 5.

The solar admittance for each aspect has been pre-determined for the proposed building in accordance with Clause 5 of Specification J1.5a (Method 1). The solar admittance is based on a SHGC of 0.30 for all *glazing*. There is an external shading projection of 0.2 m.

The solar admittance does not meet the requirements for Method 1 on the northern aspect. Therefore, Method 2 is to be used to see if overall compliance can be met for the whole building.

Figure 11.16 window to wall ratio



Solar admittance weighting coefficient ($\alpha_{N, E, S, W}$)

The solar admittance weighting coefficient of each aspect is based on the percentage of *glazing* area per each aspect. If the *glazing* area is greater than or

Example: Solar admittance

equal to 20%, the weighting coefficients are listed in Table 6a and 6b in Specification J1.5a.

As the percentage of *glazing* is greater than 20% on each aspect, the solar admittance weighting coefficients can be found in Tables 6a and 6b. For this example, the solar admittance weighting coefficients are found in Table 6b for a Class 3 building.

For a Class 3 building in *climate zone* 5:

The northern aspect solar admittance weighting coefficient = 1.88

The eastern aspect solar admittance weighting coefficient = 1.48

The southern aspect solar admittance weighting coefficient = 1.00

The western aspect solar admittance weighting coefficient = 1.52

To summarise:

$\alpha_N = 1.88$

$\alpha_E = 1.48$

$\alpha_S = 1.00$

$\alpha_W = 1.52$

Wall-*glazing* construction solar admittance ($SA_{N, E, S, W}$)

Reference case:

Values for the *wall-glazing construction* solar admittance for the reference case are found in J1.5(e).

$SA_N = 0.10$

$SA_E = 0.10$

$SA_S = 0.10$

$SA_W = 0.10$

Proposed case:

The values for *wall-glazing construction* solar admittance for the proposed case are calculated in accordance with Clause 5(a) and in this example, are pre-determined. See examples of this method in the example above.

Example: Solar admittance

SA_N = 0.011

SA_E = 0.098

SA_S = 0.061

SA_W = 0.0.074

Representative *air-conditioning* energy value (E_R)

Reference case:

$E_R = A_N\alpha_N SA_N + A_E\alpha_E SA_E + A_S\alpha_S SA_S + A_W\alpha_W SA_W$

E_R = (18 x 1.88 x 0.10) + (9 x 1.48 x 0.10) + (18 x 1.00 x 0.10) + (9 x 1.52 x 0.10)

E_R = 7.884

Proposed case:

E_R = (18 x 1.88 x 0.110) + (9 x 1.48x 0.098) + (18 x 1.00 x 0.061) + (9 x 1.52 x 0.074)

E_R = 7.144

Result

As the proposed case representative *air-conditioning* energy value (7.144) is less than that of the reference case (7.884), the *wall-glazing construction* meets the requirements for Method 2.

Where there are large numbers of different wall-glazing construction elements, the ABCB Façade Calculator can provide a quicker way to undertake the calculations.

11.9.5.5 Shading

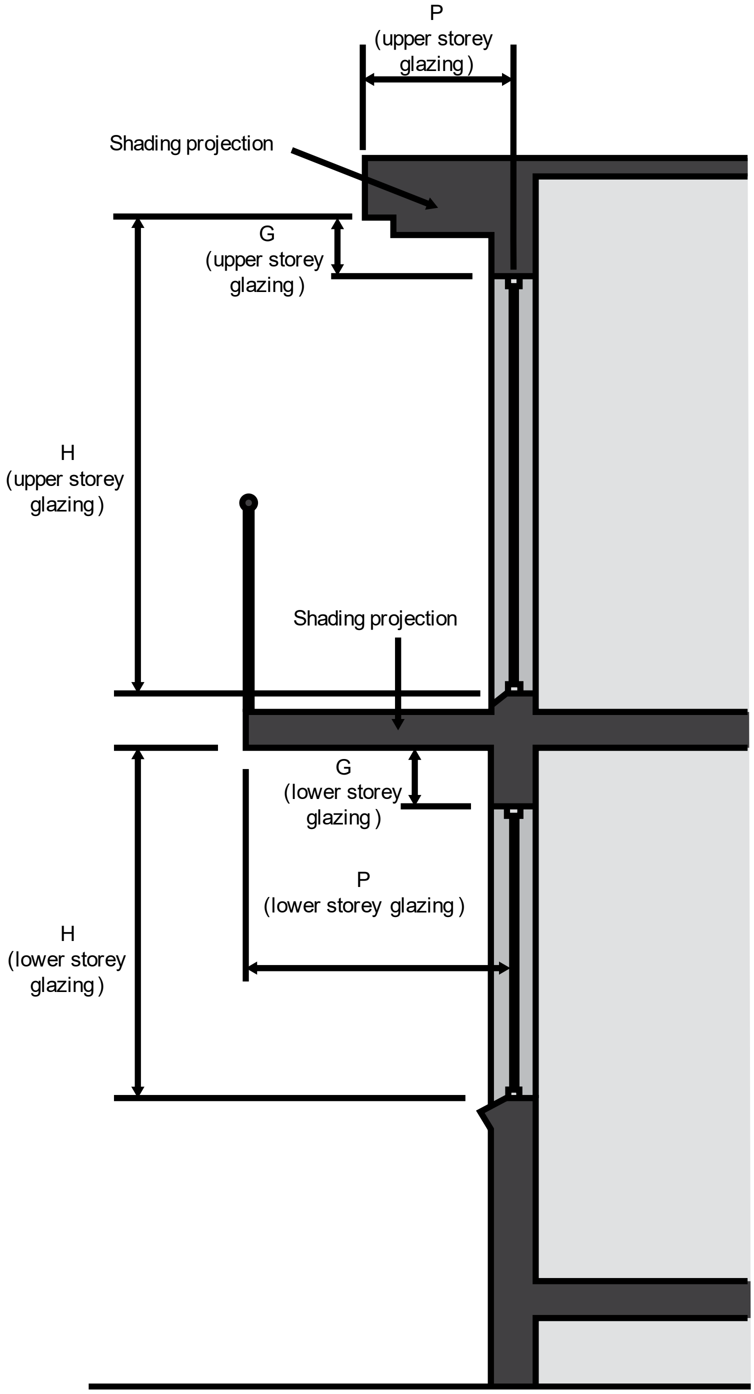
Clause 7 in Specification J1.5a specifies the shading multiplier for calculating solar admittance.

The presence of shading projections and devices reduces the level of thermal performance required for *glazing*. However, to be effective, shading projections and devices must restrict a significant proportion of solar radiation.

Subclause 7(a) specifies the shading multiplier for northern, eastern or western aspects in Table 7a and for southern aspects in Table 7b, for shading provided by permanent external projections. The projection must extend horizontally on both sides of the *glazing* for the same distance, as shown in Figure 11.17 as distance P. Examples of this may include balconies.

Where the ratio of P/H or G/H are between the values stated, interpolation may be used to determine the shading multiplier.

Figure 11.17 Shading projection coefficients



Subclause 7(b) specifies a shading multiplier equal to 0.35 for external shading devices such as shutters, blinds, vertical or horizontal building screens with blades, battens or slats. The external shading devices are required to restrict the amount of summer solar radiation that reaches the *glazing* by 80% or more. Additionally, the device must operate automatically in response to the level of solar radiation if adjustable, as devices operated manually are considered less likely to be used efficiently. Vertical shading is commonly used, however often does not meet the DTS requirements and therefore does not receive the available shading multipliers. Vertical shading provides great benefits, particularly on East and West facing facades as the sun angles are low. Therefore, vertical shading could form the basis of a *Performance Solution* if they are unable to restrict the amount of summer solar radiation that reaches the *glazing* by 80% or more.

The restriction of summer solar radiation is the sum of the amount of hour-by-hour summer (December, January, February) solar radiation that does not reach the *glazing* as a percentage of what would have reached the *glazing* if the shading device was not fitted. If the device adjusts automatically in response to the sun, the worst-case scenario during the period of December to February can be used.

The 80% figure acknowledges that while a device may be *capable* of providing 100% shade during summer, some leakage of solar radiation may occur at the sides of the device.

A degree of judgement is required to determine whether the amount of summer solar radiation that reaches the *glazing* at the sides of a device exceeds that permitted. Generally, close fitting blinds or horizontal screens that extend either side of the *glazing* by the same projection distance (P) should sufficiently restrict the amount of summer solar radiation that reaches the *glazing* at the sides of the device.

Note that the shading projection for walls is measured from the wall face whereas for *glazing* the projection is measured from the glass face.

11.9.6 **Display glazing**

The definition of display *glazing* is as follows:

NCC Volume One Schedule 3 Definitions

Display *glazing* means *glazing* used to display retail goods in a shop or showroom directly adjacent to a walkway or footpath, but not including that used in a café or restaurant.

11.9.6.1 Total System U-Value

J.15(b) specifies that the *Total System U-Value* of display *glazing* must be less than or equal to U5.8.

11.9.6.2 Total System SHGC

J1.5(g) specifies that for display *glazing*, the *Total System SHGC* must be less than or equal to 0.81 divided by the applicable shading factor specified in Clause 7 of Specification J1.5a. Clause 7 requires external shading measurements of P, G and H. Please see Figure 11.17 for a description of these measurements.

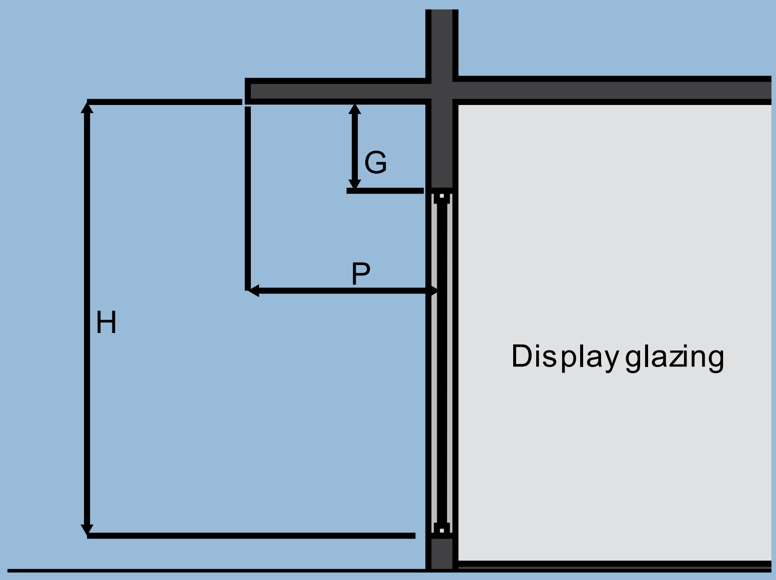
Example: Display glazing Total System SHGC

The following wall-glazing construction is east facing with a permanent projection shading the window. The suggestion *Total System SHGC* for the *glazing* is 0.4.

H = 2.5 m
P = 1 m
G = 0.5 m

Example: Display glazing Total System SHGC

Figure 11.18 Shading



To determine the shading multiplier, G/H and P/H must first be calculated.

G/H = 0.5 / 2.5 = 0.2

P/H = 1 / 2.5 = 0.40

The shading multiplier can be found in Table 7a of Specification J1.5a and is therefore, 0.82.

Total System SHGC

The *Total System SHGC* must a maximum of 0.81 divided by the calculated shading multiplier.

0.81 / 0.82 = 0.99

Therefore, as 0.4 is less than 0.99 the system meets the requirements of J1.5(g).

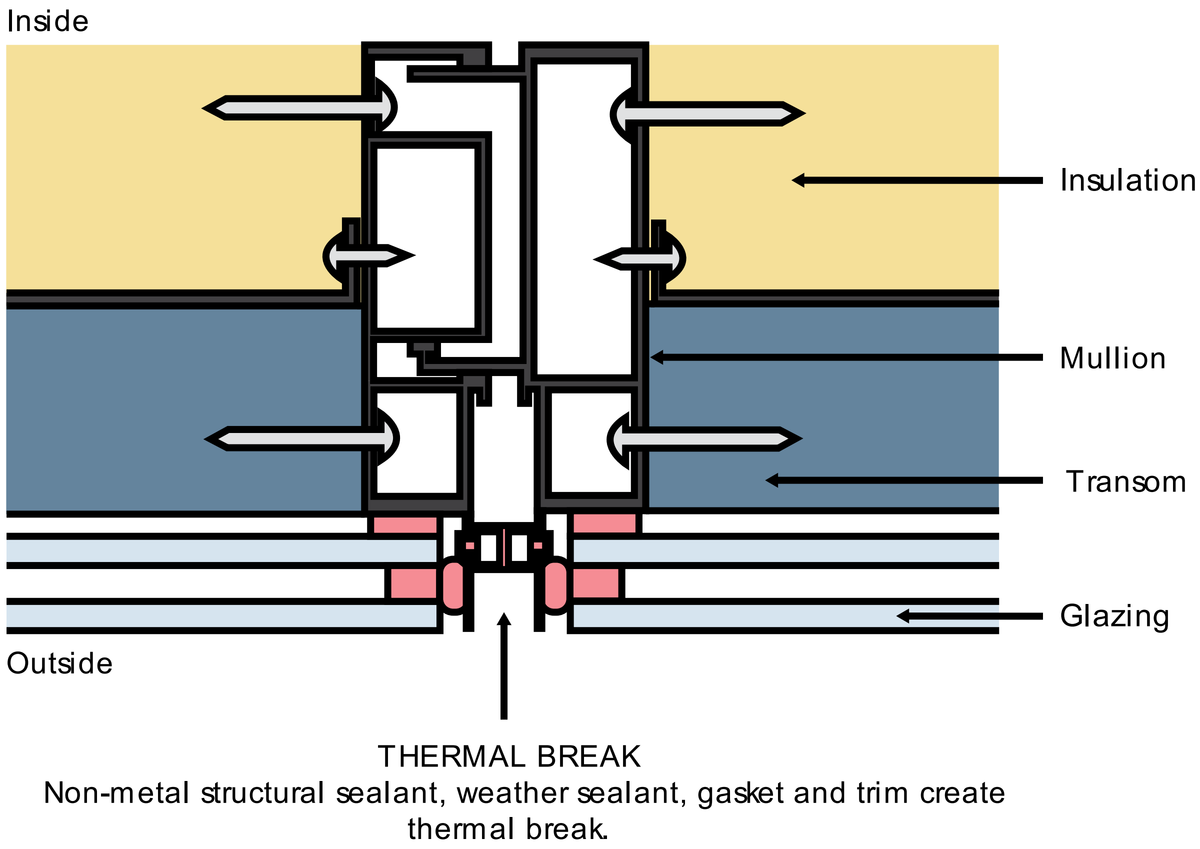
11.9.7 **Spandrel panel thermal performance**

Specification J1.5b describes the methods of determining the thermal performance of spandrel panels using one of two calculation methods.

> ***Reminder:***
>
> Spandrel panels refer to the *opaque* part of a façade in curtain wall constructions which is commonly adjacent to, and integrated with, *glazing*.

As per *glazing*, the thermal performance of a spandrel panel relates to the whole assembly, including the frame, the edge of the spandrel panel that has reduced thermal properties due to the frame, and the centre of the spandrel panel. When insulation is added in a spandrel panel, it is often added along the backside of the panel between the structural parts of the frame. Spandrel panels are typically poor for *thermal bridging* as the frames are generally made from highly conductive materials that allow heat to transfer from the outside into the building. Often insulation is installed on the backside of the panel, however, this does not limit the *thermal bridging* through the frame. Figure 11.19 provides an example of a spandrel panel that uses non-metal elements to create a thermal break.

Figure 11.19 Example of a spandrel panel with thermal break



11.9.7.1 Calculation method 1

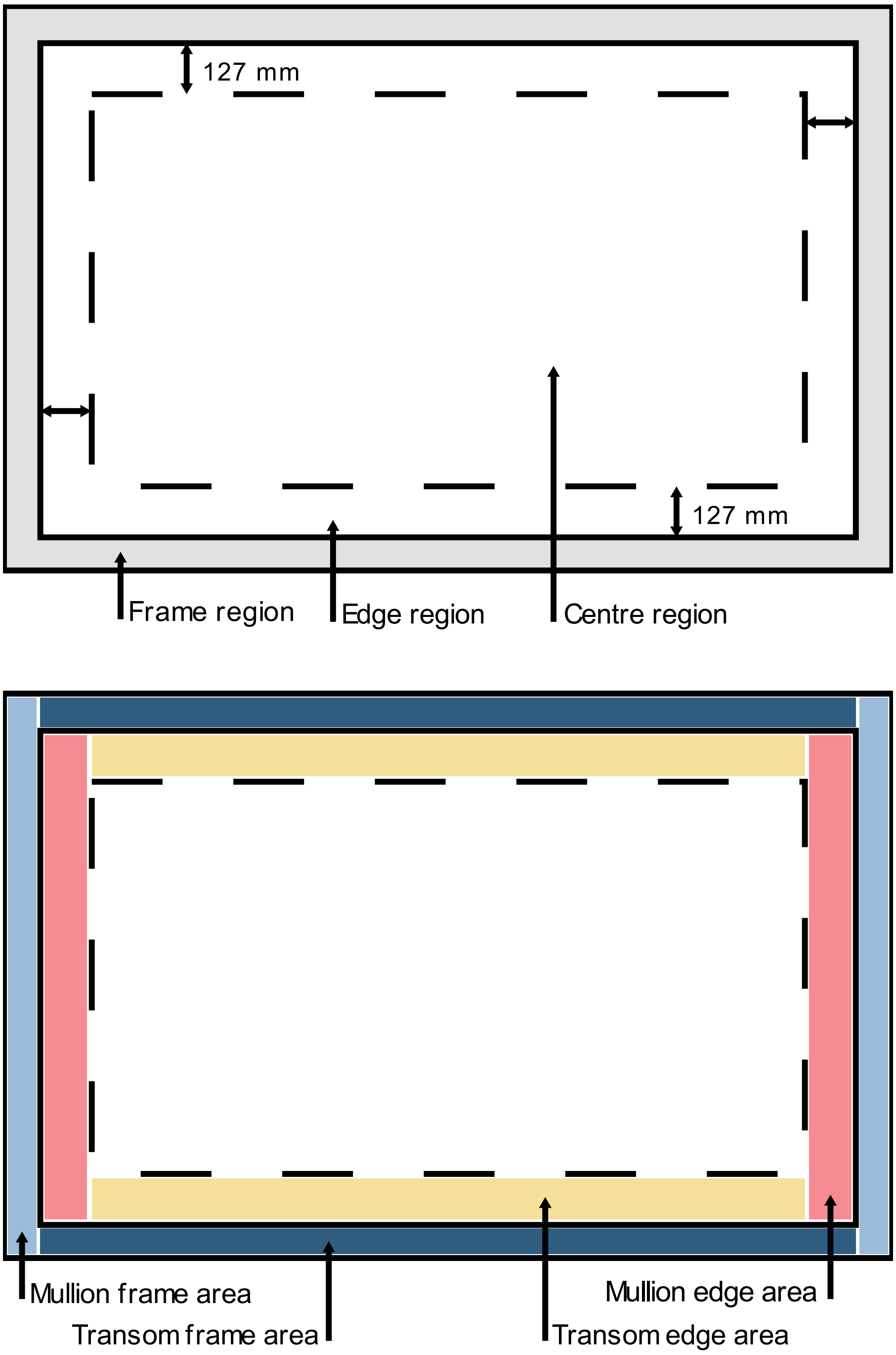
Calculation method 1 is used to detail the *R-Values* to be achieved by common forms of spandrel panels. Four common forms are provided with their thermal properties listed in Table 2 of Specification J1.5b.

11.9.7.2 Calculation method 2

Calculation method 2 is used for the calculation of the *Total System R-Values* of less common forms of spandrel panels. An equation, like that used for *glazing*, is provided to determine the *Total System R-Value*.

Please note that when calculating the area of the frame and edge regions, to avoid double counting, the area of the mullion is to be used with the full height and the area of the transom is to be used with the middle dimension. See Figure 11.20 for details.

Figure 11.20 Spandrel panel frame, edge and centre regions



Example: Method 2 Spandrel panel R-Value

A spandrel panel is 1.5 m wide and 1.2 m high. The spandrel panel has the following U-Values.

Frame region:

Area 1: U=10

Example: Method 2 Spandrel panel R-Value

Area 2: U=11.8

Area 3: U=10

Area 4: U=4.6

Edge region (width of 127 mm):

Area 5: U=1.9

Area 6: U=1.9

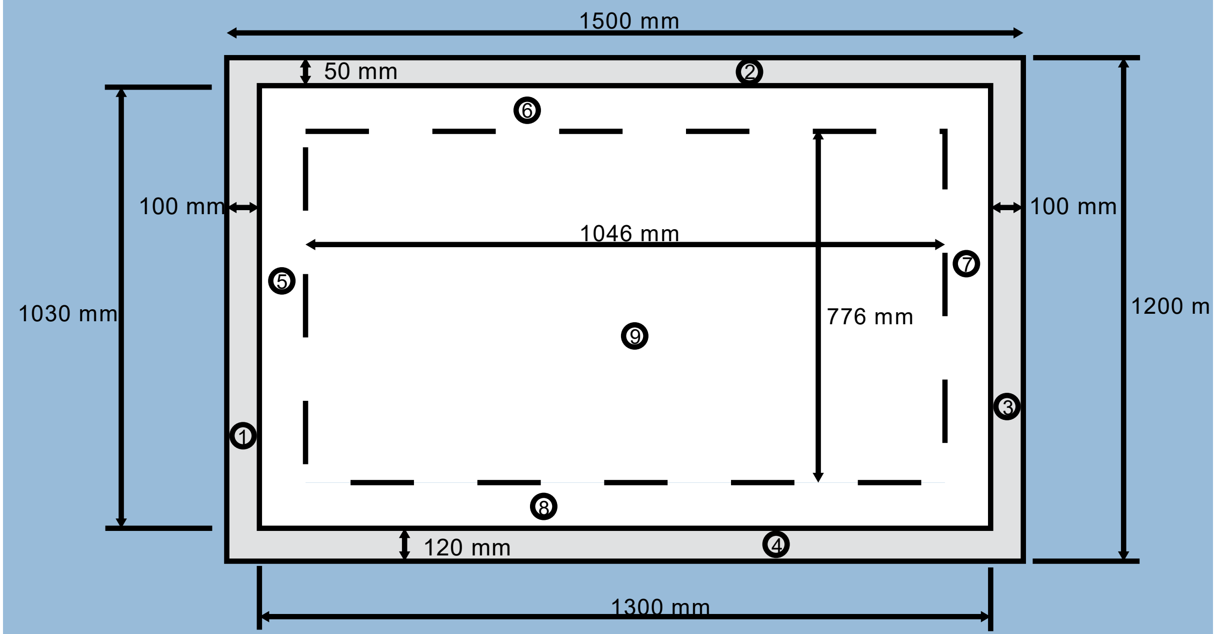
Area 7: U=1.9

Area 8: U=1.6

Centre region:

Area 9: U=0.355

Figure 11.21 Spandrel dimensions



Step 1: Area calculations

Based on the image above, the spandrel panel has the following dimensions

Frame region:

Area 1 = 1200 x 100 = 120000 mm^2 = 0.12 m^2

Area 2 = 1300 x 50 = 65000 mm^2 = 0.065 m^2

Example: Method 2 Spandrel panel R-Value

Area 3 = 1200 x 100 = 120000 mm^2 = 0.12 m^2

Area 4 = 1300 x 120 = 156000 mm^2 = 0.156 m^2

Edge region (width of 127 mm):

Area 5 = 1030 x 127 = 130810 mm^2 = 0.131 m^2

Area 6 = 1046 x 127 = 132842 mm^2 = 0.133 m^2

Area 7 = 1030 x 127 = 130810 mm^2 = 0.131 m^2

Area 8 = 1046 x 127 = 132842 mm^2 = 0.133 m^2

Centre region:

Area 9 = 1046 x 776 = 811696 mm^2 = 0.812 m^2

Step 2: *Total System U-Value*

Based on the U-Values provided and the calculated areas the *Total System U-Value* can be determined for the spandrel panel. First, individual components of the equation will be solved.

$U_{cs}A_{cs}$:

$U_{cs}A_{cs}$ = 0.355 x 0.812 = 0.288

$\sum U_{es}A_{es}$:

$\sum U_{es}A_{es}$ = (1.9 x 0.131) + (1.9 x 0.133) + (1.9 x 0.131) + (1.6 x 0.133)

$\sum U_{es}A_{es}$ = (0.249) + (0.253) + (0.249) + (0.213)

$\sum U_{es}A_{es}$ = 0.964

$\sum U_{fs}A_{fs}$:

$\sum U_{fs}A_{fs}$ = (10 x 0.12) + (11.8 x 0.065) + (10 x 0.12) + (4.6 x 0.156)

$\sum U_{fs}A_{fs}$ = (1.2) + (0.767) + (1.2) + (0.718)

$\sum U_{fs}A_{fs}$ = 3.885

A_{cs}:

A_{cs} = 0.812 m^2

$\sum A_{es}$:

Example: Method 2 Spandrel panel R-Value

$\sum A_{es} = 0.131 + 0.133 + 0.131 + 0.133$

$\sum A_{es} = 0.528\ m^2$

$\sum A_{fs}$:

$\sum A_{fs} = 0.12 + 0.065 + 0.12 + 0.156$

$\sum A_{fs} = 0.461\ m^2$

Result

The above determined values can now be used in the equation provided in Clause 3 of Specification J1.5b to determine the *Total System U-Value* of the spandrel panel.

$$U_{sp} = \frac{U_{cs}A_{cs} + \sum U_{es}A_{es} + \sum U_{fs}A_{fs}}{A_{cs} + \sum A_{es} + \sum A_{fs}}$$

$$U_{sp} = \frac{0.288 + 0.964 + 3.885}{0.812 + 0.528 + 0.461}$$

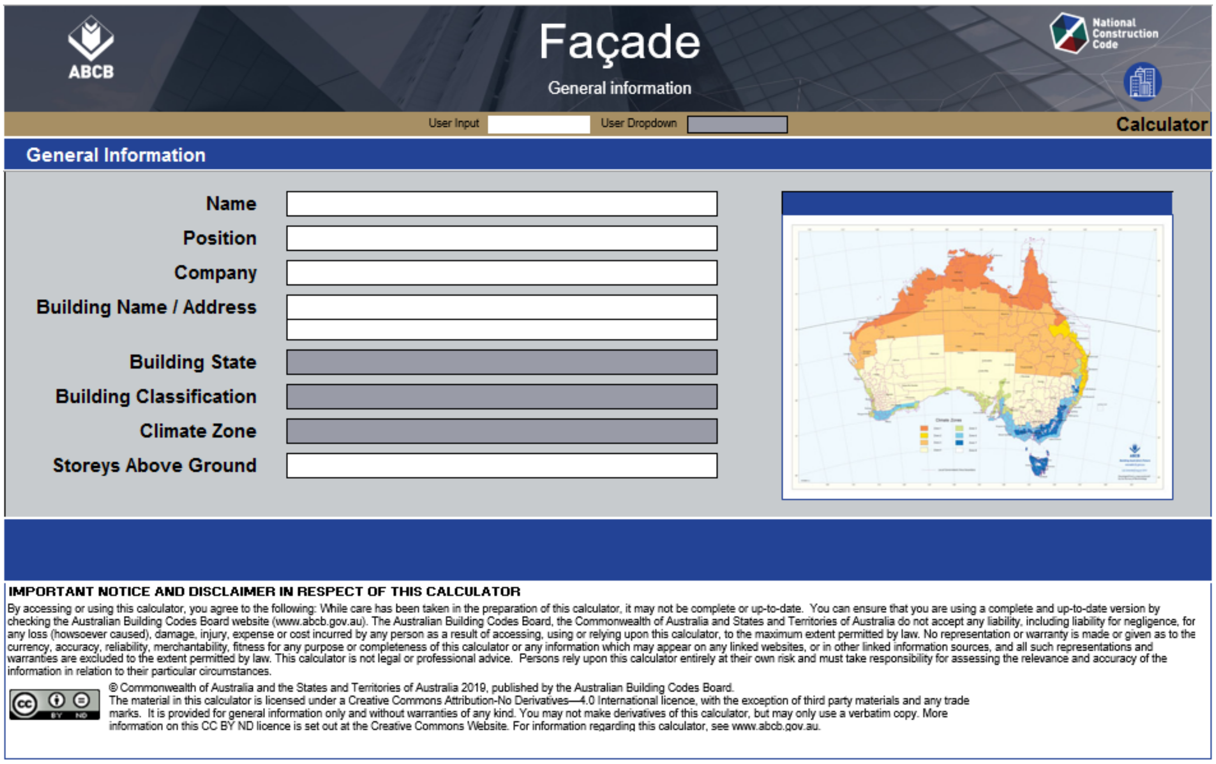
$$U_{sp} = 2.852$$

Calculated in accordance with the formula provided in Clause 3 of Specification J1.5b, the *Total System U-Value* of the spandrel panel is 2.852.

11.9.8 **Facade calculator**

The ABCB has developed a Façade Calculator for NCC users to assist with demonstrating compliance with the NCC wall and *glazing* provisions.

Figure 11.22 Introductory page of the ABCB Façade Calculator



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

11.9.8.1 Calculator ribbon

When the Façade Calculator is first opened, the custom Façade Calculator ribbon will appear, rather than the normal Microsoft Excel menu.

- Worksheets – General Info, Glazing Systems, Wall Systems, Shading Systems, Wall Glazing Area + Results and User Library navigate to the specific sheet.
- Support – Offers a link to the Façade Calculator help guide, Online Enquiry and options to clear data from specific sheets or areas.
- Zoom – Zoom functions for ease of accessibility.

11.9.8.2 General information

- Name, Company, Building Name / Address – Used for identification of the project. This is simply to provide context for the user and will repeated in the report generated at the end.
- Building State – This cell requires a selection of the state where the building is located.
- Building Classification – This cell requires a selection of the building's class type.

- Climate Zone – This cell requires a selection of the climate zone in which the building is located.
- Storeys Above Ground – This cell requires the maximum number of storeys above ground to be entered.

11.9.8.3 Glazing systems

- Glazing Reference – This cell requires a unique reference identifier for each *glazing* system.
- System Type – This cell requires a selection of a default (generic) system type that best represents the design intent, or a user (defined) product located in the User Library. Examples of generic system types include awning, casement or fixed systems.
- Glass Type – This cell requires a selection of a generic *glazing* type that represents the design intent or installation in construction, or a defined *glazing* type located in the User Library. Examples of generic *glazing* types include single *glazing*, single *glazing* – low e or DGU – double low e *glazing*.
- Frame Type – This cell requires a selection of a generic frame type that represents the design intent or installation in construction, or a defined frame type located in the User Library. Examples of generic frame types include aluminium, steel or timber framing.
- Methodology – This cell requires a selection of either AFRC (true module size) or WERS (default module size). Note this is for reporting requirements only, so that a reader of the report will know what method has been followed.
- *Total System U-Value* – This cell requires an input of the *Total System U-Value* (i.e. the thermal transmittance of the composite element allowing for the effect of any airspaces, *thermal bridging* and associated surface resistances).
- *Total System SHGC* – This cell requires an input of the *Total System SHGC* (i.e. the fraction of incident irradiance on a wall-glazing construction or a *roof light* that adds heat to a building's space).

A maximum of 16 Glazing Systems are allowed for any one project, with a Glazing System being a combination of a System Type, Glass Type, Frame Type and Methodology.

11.9.8.4 Wall systems

Wall Systems

- Wall Reference – This cell requires a unique reference identifier for each wall system.
- Wall Type – This cell requires a selection of either spandrel or wall construction.

- Spandrel Methodology – If the Wall Type is selected as a spandrel system, this cell requires a selection of either NCC Specification J1.5b or AFRC Calculations. If the Wall Type is a wall construction, leave blank.
- Wall Construction – This cell requires a selection of a default (generic) wall construction that best represents the design intent, or a user (defined) wall construction located in the User Library.
- If Specification J1.5b Method 1 is used, the spandrel panel can simply be selected from the list of NCC specified spandrel panels within the Wall Construction cell. If Specification J1.5b Method 2 is used, the calculated *Total System U-Value* will be required to be manually added to the User Library as a user (defined) spandrel panel.
- Wall Thickness – This cell requires the wall thickness from the exterior facing surface to the interior facing surface. Wall thickness is used in the reporting function only, to enable better cross referencing of wall build-ups.
- *Total System R-Value* – This cell will automatically fill with the *Total System R-Value* associated with the wall construction. If a defined Wall Construction is added to the User Library, the associated *Total System R-Value* must also be entered. *Total System R-Values* can be generated via the *Total System R-Value* Calculator.
- Solar Absorptance – This cell requires the solar absorptance value of the exterior surface. If the surface is glass, enter the SHGC.

A maximum of 16 Wall Systems are allowed for any one project, with a Wall System being a combination of a Wall Type, Spandrel Methodology, Wall Construction and Thickness.

Total System R-Value Calculator

For a wall construction, details on each layer from the external (Ext – Layer 1) to the internal (maximum of Layer 7) can be entered to determine the *Total System R-Value*.

- Material – This cell requires the selection of either a default (generic) or user (defined) material located in the User Library.
- Thickness – This cell requires the thickness of the layer in mm.
- *Thermal Bridge* – This cell requires a generic or defined definition of the *thermal bridge* in the layer. If steel framing, the framing web and flange thicknesses must be entered.
- Metal Frame, Web – This cell requires the thickness of a metal frame web in mm.
- Metal Frame, Flange – This cell requires the thickness of a metal frame flange in mm.

- Wall Construction – This cell requires a unique reference identifier for the wall construction.
- Once the *Total System R-Value* has been calculated, the *Total System R-Value* will be required to be manually added to the User Library as a user (defined) wall type.

11.9.8.5 Shading systems

- Shading Reference – This cell requires a unique reference identifier for each shading system.
- Shading Type – This cell requires a selection of a horizontal shading system or 'device'. A 'device' must be *capable* of restricting at least 80% of summer solar radiation, and, if adjustable, will operate automatically in response to the level of solar radiation.

P – This cell requires the horizontal distance in metres from the head of the *glazing* to the shadow casting edge of the projection. Refer to Figure 11.17.

G – This cell requires the vertical distance in metres from the head of the *glazing* to the shadow casting edge of the projection. Refer to Figure 11.17.

H – This cell requires the vertical distance in metres from the base of the *glazing* to the shadow casting edge of the projection. Refer to Figure 11.17.

A maximum of 16 Shading Systems are allowed for any one project, with a Shading System being a combination of either a 'device' or P, G and H.

11.9.8.6 Wall Glazing Area + Results

The Wall Glazing Area + Results sheet combines the projects general information, Glazing Systems, Wall Systems, Shading Systems and areas to calculate the J1.5 Wall and *glazing* results as a function of their area.

References specified in Glazing Systems, Wall Systems and Shading Systems can be allocated to four cardinal directions (North, East, South and West). Wall and *glazing* areas are then applied to each *glazing* and wall reference.

As per Specification J1.5a, there are two methods, Method 1 and Method 2, to determine the U-Value and solar admittance of a wall-glazing construction. Method 1 results are presented below each orientation. A summary of both Method 1 and Method 2 results for all orientations are provided in the Results tab at the top of the sheet. The proposed design chart must fall under the DTS reference line in the Method 1 and Method 2 results graphs for both wall-glazing U-Value and solar admittance.

If Method 1 and Method 2 fail to meet the minimum *Performance Requirements*, the *Reference Building* provides Method 1 and Method 2 performance values to be used in JV3 modelling.

The *reference building's* shading can be adjusted to include the proposed shading if caused by the building geometry or exclude the proposed shading if the primary purpose is energy efficiency.

11.9.9 **Façade Calculator Case study**

11.9.9.1 Office building, Brisbane

Case Study 2 focuses on a theoretical office building in Brisbane, Qld. Its aim is to explore different design options to show compliance via Method 1 or 2 while introducing the tool's concepts to the user. User objectives include the following:

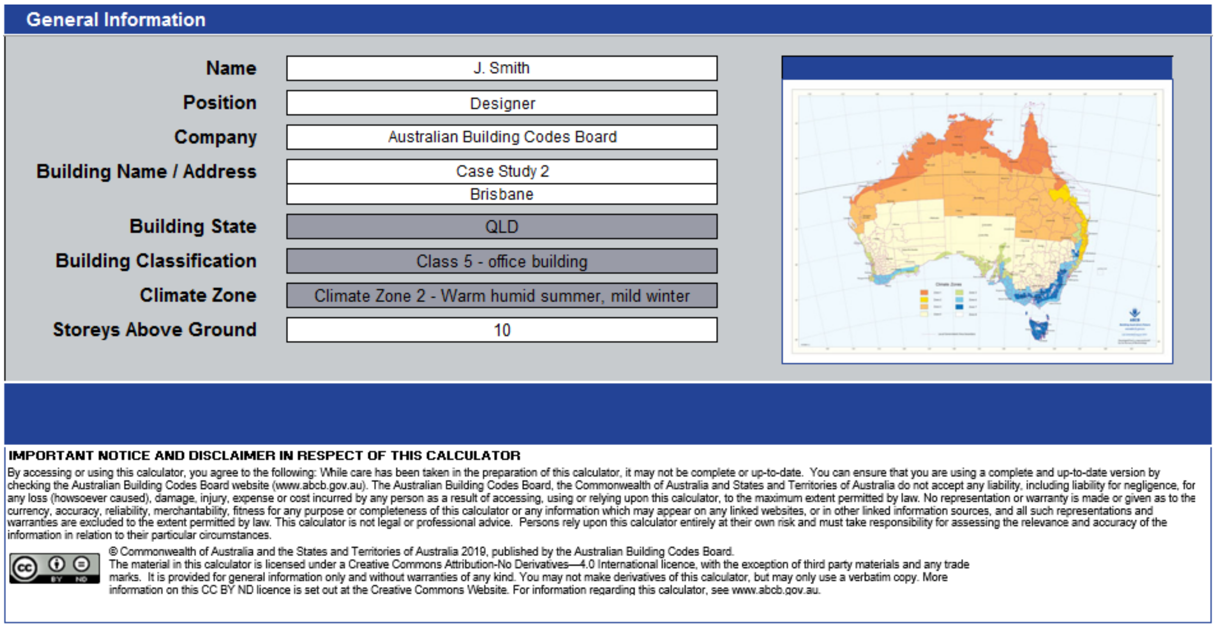
- introduction of spandrel *thermal bridging* and its impact on *Total System R-value* ($m^2K.W$);
- minimum thermal resistance requirements driven by an *R-value* ($m^2K.W$) backstop;
- benefits of improved *glazing* systems to improve Wall-glazing U-Value – $W/m^2.K$ + Solar Admittance; and
- limitations of high *glazing* to façade ratios (too much glass).

The following information has been assumed.

- Class 5, office
- *Climate zone* 2
- Square floor plate, 10 m x 10 m
- 3 m floor/floor, 10 storeys
- 80% *glazing* to façade ratio
- Curtain wall with spandrel panels
- 100% fixed lites

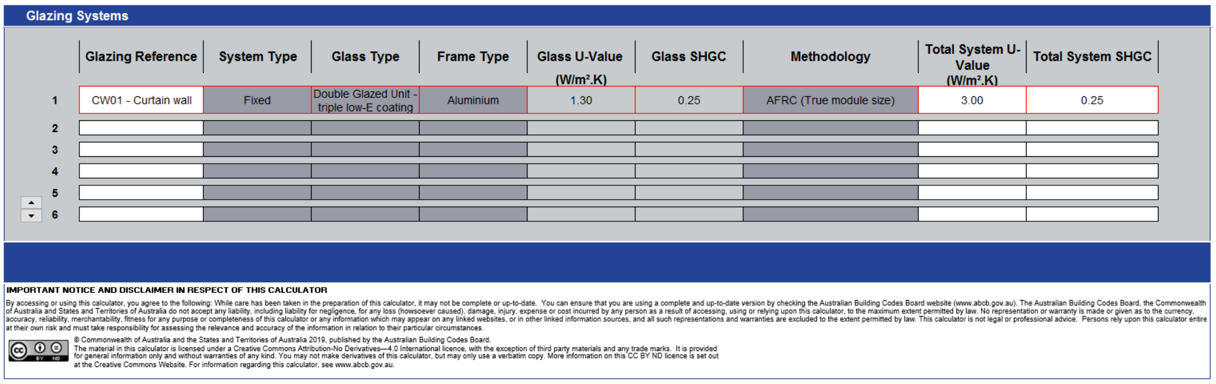
Step 1, entering general information about a building. This includes Building Classification, Climate, Storeys Above Ground and general project specific information. A green tick will appear when a cell has been completed. Once all green ticks have can be seen for each item, proceed to the next worksheet.

Figure 11.23 Case Study 2 – Step 1



Step 2, entering glazing system information. For each *glazing* type, create and enter a unique *glazing* reference (such as using the *glazing* designation in the design brief). In this example, typical System U-Values (W/m².K) and System SHGC have been used for aluminium framed systems (fixed) with high performance, low-e double *glazing*. The tool has a small number of generic *glazing* types available, but it is expected that users will create specific *glazing* types in the User Library and these can be called up as required.

Figure 11.24 Case Study 2 – Step 2



Step 3, entering spandrel (opaque) information to calculate its thermal resistance and the impact of thermal bridging. As below, using the Specification J1.5b, a default double glazed spandrel configuration (Span Config 2 – R2.0 insulation and standard aluminium frame) has been used with a *Total System R-value* of 0.45 m²K.W. Users have the option of either Specification J1.5b (Method 1) or entered the *Total System R-value* in the User Library (User - defined) in line with the Method 2 calculation. A solar absorptance is set using the System SHGC for the vision area, assuming it is the same glass type.

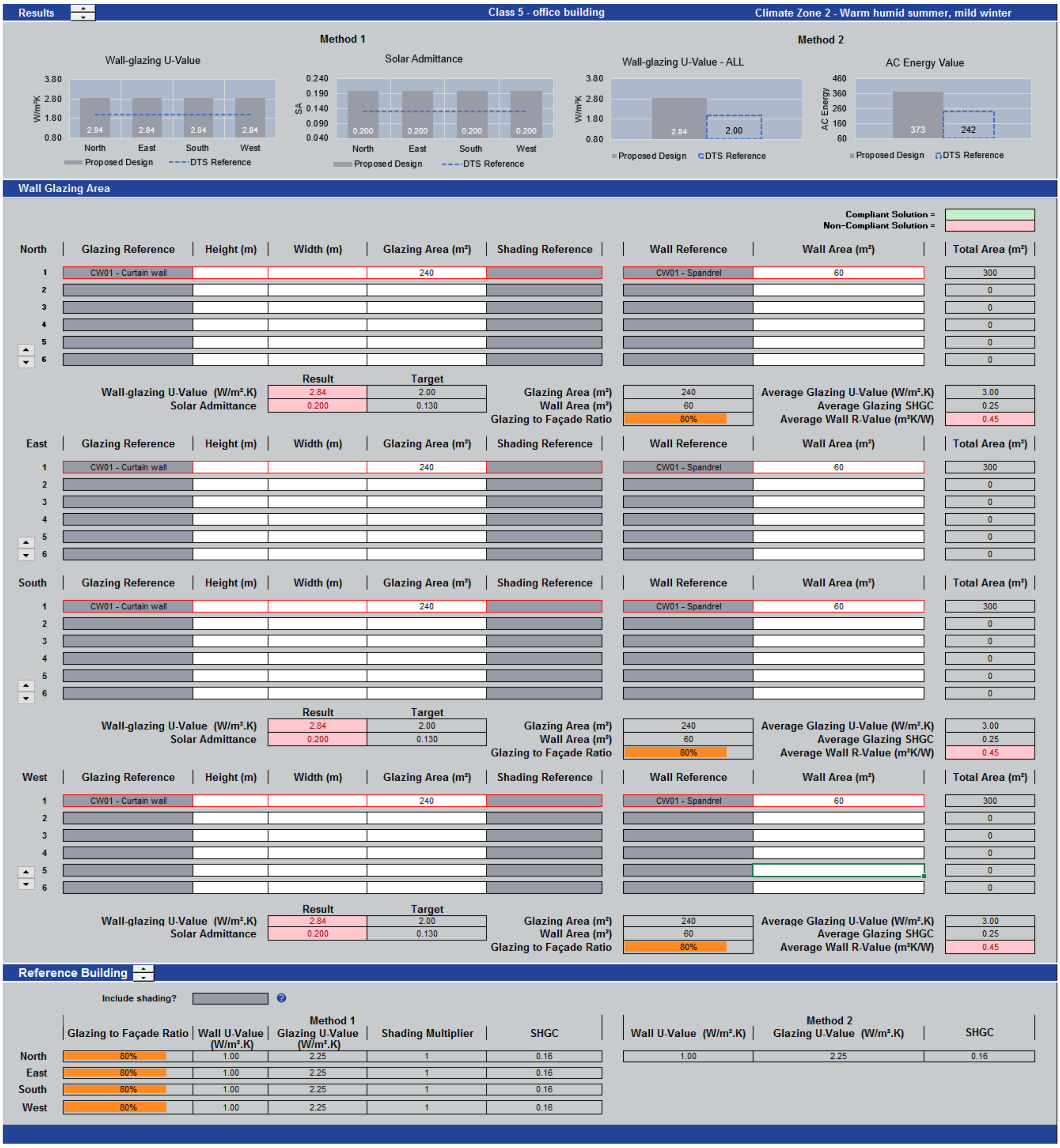
Figure 11.25 Case Study 2 – Step 3

Wall Systems

	Wall Reference	Wall Type	Spandrel Methodology	Wall Construction	Wall Thickness (mm)	Total System R-Value (W/m².K)	Solar Absorptance
1	CW01 - Spandrel	Spandrel	NCC Specification J1.5b	Spandrel Config 2 - R2.0	200	0.45	0.30
2							
3							
4							
5							
6							

Step 4, assess if the design meets minimum thermal resistance requirements. In the Wall Glazing Areas + results tab, areas of both glazed and *opaque* elements of the façade are entered to generate Method 1 (Wall-glazing U-Value – W/m².K + Solar Admittance) and Method 2 (Wall-glazing U-Value ALL– W/m².K + AC Energy Value) results. In this example the initial design has no shading applied. The Results (Average Wall *R-value* (m²K.W) show that *R-value* backstop is not achieved, and the proposed design does not meet minimum thermal resistance requirements.

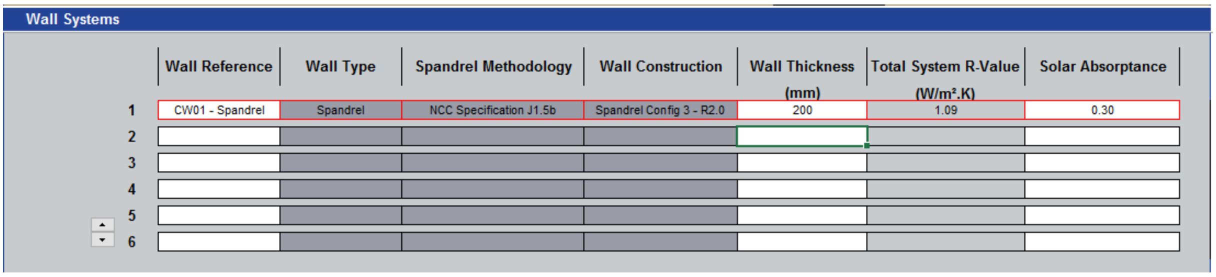
Figure 11.26 Case Study 2 – Step 4



The next steps show how the tool can be used to vary a proposed design to find either a compliant solution against the DTS minimum thermal resistance requirements, or a design that is likely to be able to demonstrate compliance via a JV3 *Verification Method* solution.

Step 5, reduce spandrel *thermal bridging*. Using Specification J1.5b, the default double glazed spandrel configuration (Span Config 2 – R2.0 insulation and standard aluminium frame) has been improved (Span Config 3 – R2.0 insulation and thermally broken aluminium frame) to select a Total System *R-value* of 1.09 m²K.W. The *R-value* backstop of 1.0 m²K.W is now being achieved.

Figure 11.27 Case Study 2 – Step 5

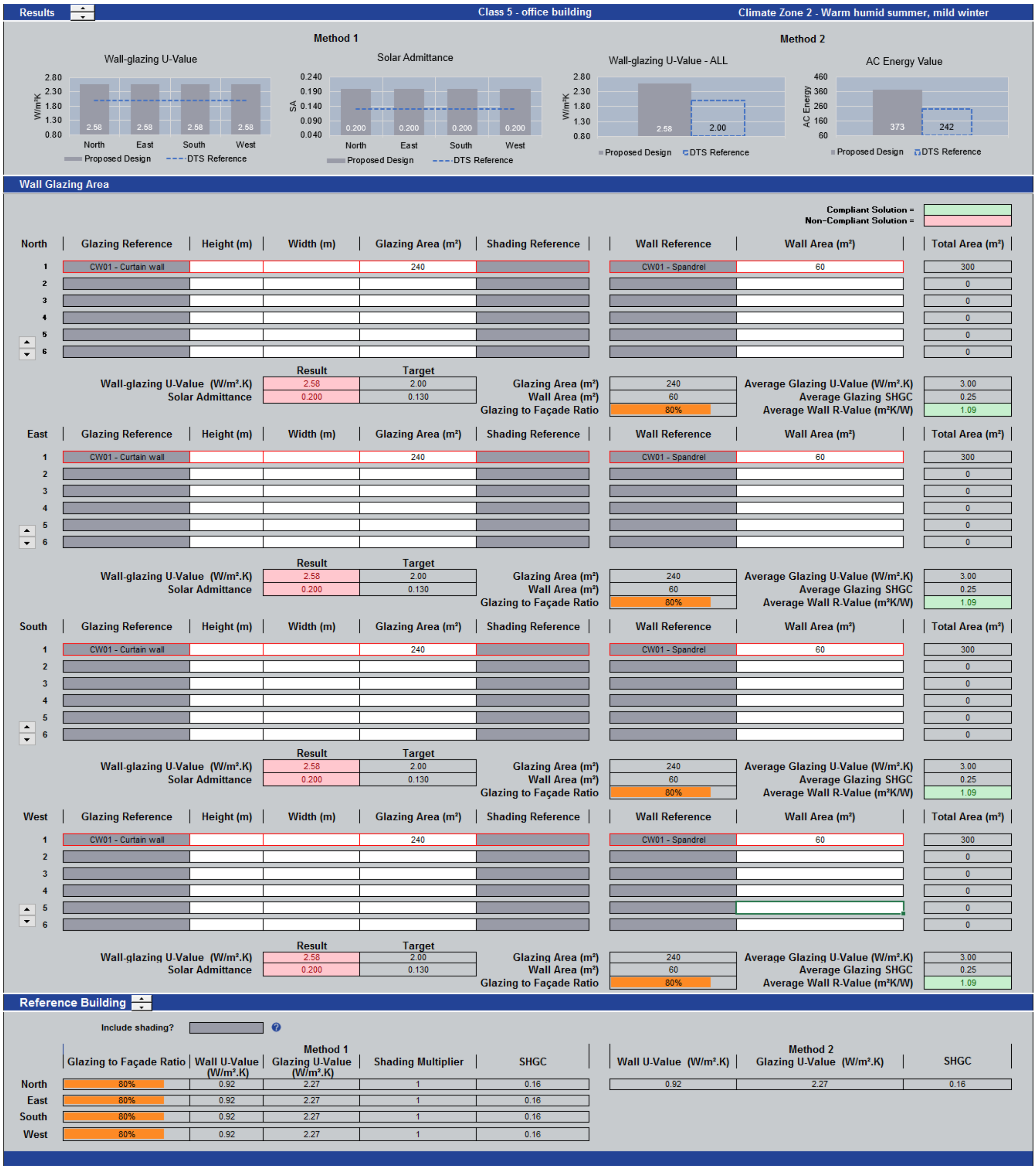


Wall Systems

	Wall Reference	Wall Type	Spandrel Methodology	Wall Construction	Wall Thickness (mm)	Total System R-Value (W/m².K)	Solar Absorptance
1	CW01 - Spandrel	Spandrel	NCC Specification J1.5b	Spandrel Config 3 - R2.0	200	1.09	0.30
2							
3							
4							
5							
6							

Step 6, assess if revised design meets minimum thermal resistance requirements. As per step 5, *R-value* backstop of 1.0 m²K.W has now been met but the minimum *Performance Requirements* of Method 1 (Wall-glazing U-Value – W/m².K + Solar Admittance) and Method 2 (Wall-glazing U-Value ALL– W/m².K + AC Energy Value) are not achieved. JV3 *reference building* fabric remains very high performing and thus a *Performance Solution* is unlikely based on the proposed fabric values.

Figure 11.28 Case Study 2 – Step 6



Step 7, assess if revised design meets minimum thermal resistance requirements. With a Wall-glazing U-Value of 2.5 W/m².K, the minimum thermal resistance requirements of Method 1 (Wall-glazing U-Value – W/m².K + Solar Admittance) and Method 2 (Wall-glazing U-Value ALL– W/m².K + AC Energy Value) are still not achieved. Upgrading the curtainwall to an aluminium thermally broken system with a tinted double glazed unit, a revised *Total System U-Value* and *Total System SHGC* of 2.2 W/m².K and 0.16 SHGC are entered.

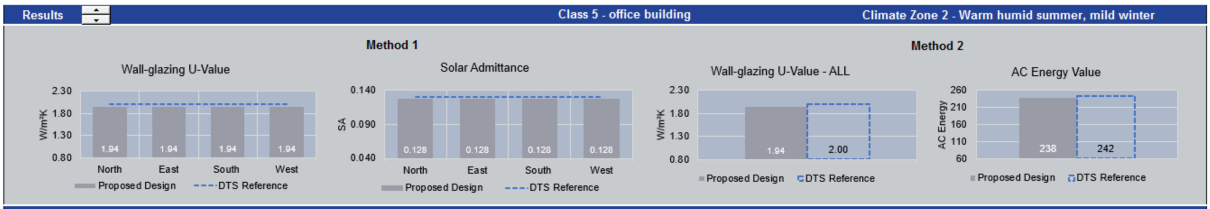
Figure 11.29 Case Study 2 – Step 7

Glazing Systems

	Glazing Reference	System Type	Glass Type	Frame Type	Glass U-Value (W/m².K)	Glass SHGC	Methodology	Total System U-Value (W/m².K)	Total System SHGC
1	CW01 - Curtain wall	Fixed	Double Glazed Unit - triple low-E coating	Aluminium	1.30	0.25	AFRC (True module size)	2.20	0.16
2									
3									
4									
5									
6									

Step 8, assess if revised design meets minimum thermal resistance requirements. Compliance is now met for Method 1 and Method 2 as a result of the combined fabric improvements thought this case study. A reduction of *glazing* to façade ratios are also a major opportunity and would lead to a more economical outcome in addition to better procurement options.

Figure 11.30 Case Study 2 – Step 8



North	Glazing Reference	Height (m)	Width (m)	Glazing Area (m²)	Shading Reference	Wall Reference	Wall Area (m²)	Total Area (m²)
1	CW01 - Curtain wall			240		CW01 - Spandrel	60	300
2								0
3								0
4								0
5								0
6								0

	Result	Target				
Wall-glazing U-Value (W/m².K)	1.94	2.00	Glazing Area (m²)	240	Average Glazing U-Value (W/m².K)	2.20
Solar Admittance	0.128	0.130	Wall Area (m²)	60	Average Glazing SHGC	0.16
			Glazing to Façade Ratio	80%	Average Wall R-Value (m²K/W)	1.09

East	Glazing Reference	Height (m)	Width (m)	Glazing Area (m²)	Shading Reference	Wall Reference	Wall Area (m²)	Total Area (m²)
1	CW01 - Curtain wall			240		CW01 - Spandrel	60	300
2								0
3								0
4								0
5								0
6								0

	Result	Target				
Wall-glazing U-Value (W/m².K)	1.94	2.00	Glazing Area (m²)	240	Average Glazing U-Value (W/m².K)	2.20
Solar Admittance	0.128	0.130	Wall Area (m²)	60	Average Glazing SHGC	0.16
			Glazing to Façade Ratio	80%	Average Wall R-Value (m²K/W)	1.09

South	Glazing Reference	Height (m)	Width (m)	Glazing Area (m²)	Shading Reference	Wall Reference	Wall Area (m²)	Total Area (m²)
1	CW01 - Curtain wall			240		CW01 - Spandrel	60	300
2								0
3								0
4								0
5								0
6								0

	Result	Target				
Wall-glazing U-Value (W/m².K)	1.94	2.00	Glazing Area (m²)	240	Average Glazing U-Value (W/m².K)	2.20
Solar Admittance	0.128	0.130	Wall Area (m²)	60	Average Glazing SHGC	0.16
			Glazing to Façade Ratio	80%	Average Wall R-Value (m²K/W)	1.09

West	Glazing Reference	Height (m)	Width (m)	Glazing Area (m²)	Shading Reference	Wall Reference	Wall Area (m²)	Total Area (m²)
1	CW01 - Curtain wall			240		CW01 - Spandrel	60	300
2								0
3								0
4								0
5								0
6								0

	Result	Target				
Wall-glazing U-Value (W/m².K)	1.94	2.00	Glazing Area (m²)	240	Average Glazing U-Value (W/m².K)	2.20
Solar Admittance	0.128	0.130	Wall Area (m²)	60	Average Glazing SHGC	0.16
			Glazing to Façade Ratio	80%	Average Wall R-Value (m²K/W)	1.09

Reference Building

Include shading?

Method 1

	Glazing to Façade Ratio	Wall U-Value (W/m².K)	Glazing U-Value (W/m².K)	Shading Multiplier	SHGC
North	80%	0.92	2.27	1	0.16
East	80%	0.92	2.27	1	0.16
South	80%	0.92	2.27	1	0.16
West	80%	0.92	2.27	1	0.16

Method 2

Wall U-Value (W/m².K)	Glazing U-Value (W/m².K)	SHGC
0.92	2.27	0.16

11.9.10 **Glazing strategies**

11.9.10.1 The importance of glazing

The importance of glazing in a building's envelope

All elements of a building's *envelope* present opportunities for energy savings. However, in high-rise buildings, there is not the same scope for reducing energy flow through roofs and floors as for low-rise buildings; as there is less roof and floor area exposed to the external environment when compared to external walls/*glazing*.

The energy efficiency requirements emphasise the importance of maintaining the thermal performance of the *envelope*. Engineering systems may be replaced many times over a building's life, but fundamental fabric requirements such as wall insulation, *glazing* size and performance, shading, orientation and air tightness generally remain for the life of the building.

For energy flow through the *envelope*, *glazing* is often the greatest path of heat transfer and, possibly, of infiltration, making it a critical element in achieving energy efficiency.

The importance of glazing generally

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

In summer, sunlight radiates through the *glazing*, bringing unwanted heat into the interior. However, in winter, solar heat gains through the *glazing* can contribute effectively to the energy efficiency of a building where heating is desired. This is less important in non-residential commercial buildings where internal heat loads from lighting, appliances, equipment and people can be high enough to require little or no additional heating in most climates.

The provisions contain requirements for the thermal performance of *glazing* (glass + frame) depending on the *glazing* area, its orientation and the extent of any shading. This attempts to limit unwanted heat gain into the building in hot weather without unduly restricting the potential for solar heat gains in winter.

Glazing – the main opportunity to improve energy efficiency

Poorly designed *glazing* can become the main thoroughfare for unwanted heat gain or heat loss. However, with the correct design, glazed windows and doors may provide an opportunity to achieve greater energy efficiencies within the building 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; and
- providing natural light which can reduce the use of heat-producing artificial lighting in the building during daylight hours.

Design alert:

One of the main considerations in the design of mechanical equipment for a building is the heating or cooling load resulting from the *glazing*. Correctly designed and installed *glazing* may reduce the size and operating load of the mechanical equipment needed to air-condition a building.

It is recognised that for most commercial buildings in most *climate zones*, the predominate mode is cooling. Therefore, there is a greater emphasis on Total System SHGC over *Total System U-Value* in the provisions.

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

11.9.10.2 The effect of sun angles on glazing energy efficiency

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.

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 windows providing heat gains when they may be welcome.

11.9.10.3 The importance of orientation to glazing energy efficiency

The orientation of *glazing* can help to receive beneficial winter sun but not unwanted summer sun.

Generally, during the summer months, *glazing* facing the East and West receives the largest amount of solar gain, while *glazing* facing the North or South receives the least solar gain. This is in relation to the higher sun position on the horizon during the summer months, limiting the amount of solar heat transmitted through the North and South facing *glazing*.

Generally, during the winter months, *glazing* facing the North is the largest source of solar gain. *Glazing* facing the East and West still provide gains, however they are less than that of those available from the North due to the lower sun position during winter months. The South facing orientation provides negligible heat gains during the winter months when they are most desirable.

Combining the summer and winter outcomes shows that *glazing* facing the East and West provides the highest level of unwanted summertime heat gains but less 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 can be most beneficial.

Orientation however is not directly important for conductance. Whether *glazing* faces North, South, East or West, the same amount of heat loss is calculated to occur because the loss depends on the air temperature inside the building 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.

11.10 **Floors**

The requirements for floors apply to all floors that are part of the building *envelope*. These include the floor above or below a plant room, a carpark or the like if it is part of the *envelope*. However, the requirements do not apply to the intermediate floors between *conditioned spaces*.

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

1. Vertical direction – an overall minimum *Total R-Value* is required and in some instances under-slab insulation with a specific *R-Value*; and
2. Horizontal direction – perimeter insulation required with a specific *R-Value.*

11.10.1 **Total R-Value**

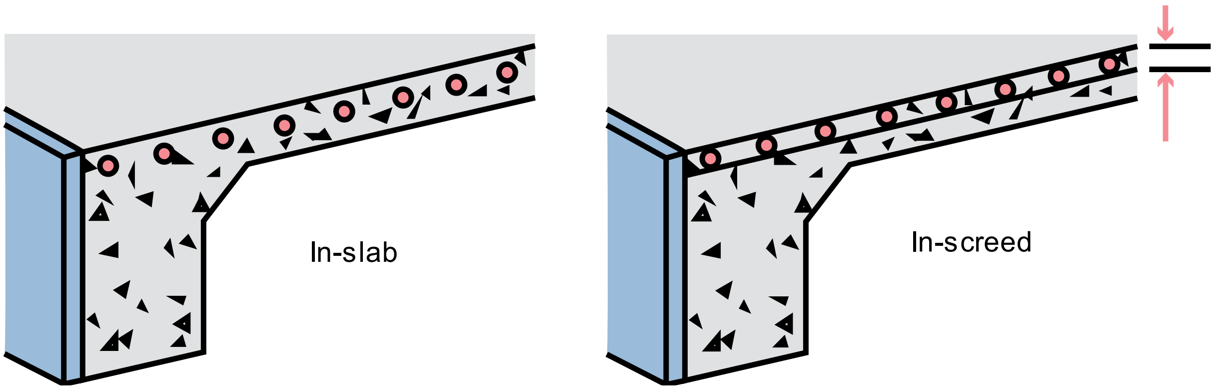
Reminder:

The calculation method used to determine the *Total R-Value* must comply with AS/NZS 4859.2, or Specification J1.6 or Section 3.5 of CIBSE Guide A for soil or sub-floor spaces.

This subclause establishes the requirements for floors that are part of the *envelope*. Table J1.6 specifies minimum *Total R-Values* based on *climate zone* and whether the floor has an in-slab heating or cooling system.

An in-slab or in-screed heating or cooling system is a system where pipes or cables are encased within the concrete slab or screed for the purposes of providing artificial heating and/or cooling. An example of an in-slab and in-screed heating or cooling system is shown in Figure 11.31.

Figure 11.31 Diagram of an in-slab and in-screed heating or cooling system



The note to Table J1.6 details requirements for sub-floor *R-Values*. Sub floor *R-Values* are to be calculated in accordance with Specification J1.6 or Section 3.5 of CIBSE Guide A.

Alert:

CIBSE Guide A is a guide for Environmental Design. Section 3.5 - Thermal properties of building structures covers the determination of heat transmission properties of building elements including walls, floors, roofs, windows. It provides methods of calculation and associated data on the thermal conductivity of materials.

Reminder:

J1.6(a) does not apply to a Class 2 *SOU* or a Class 4 part of a building.

11.10.2 Vertical edge insulation

Subclause J1.6 requires that a concrete slab-on-ground in *climate zone* 8 or a floor with an in-slab or in-screed heating or cooling system must be insulated around the vertical edge of its perimeter to a minimum *R-Value* of 1.0. Floors used solely in a bathroom, amenity area or the like are excluded from floors with an in-slab or in-screed heating or cooling system, as these are typically small areas.

The energy from a heated slab is distributed to all faces of the slab and not just to the surface within the building *envelope*. In a sense, the slab itself acts like a radiator. This means energy is lost from the underside of the slab and at the external edges. To control this heat loss, the slab must be insulated at the vertical edges.

11.10.3 Slab-on-ground

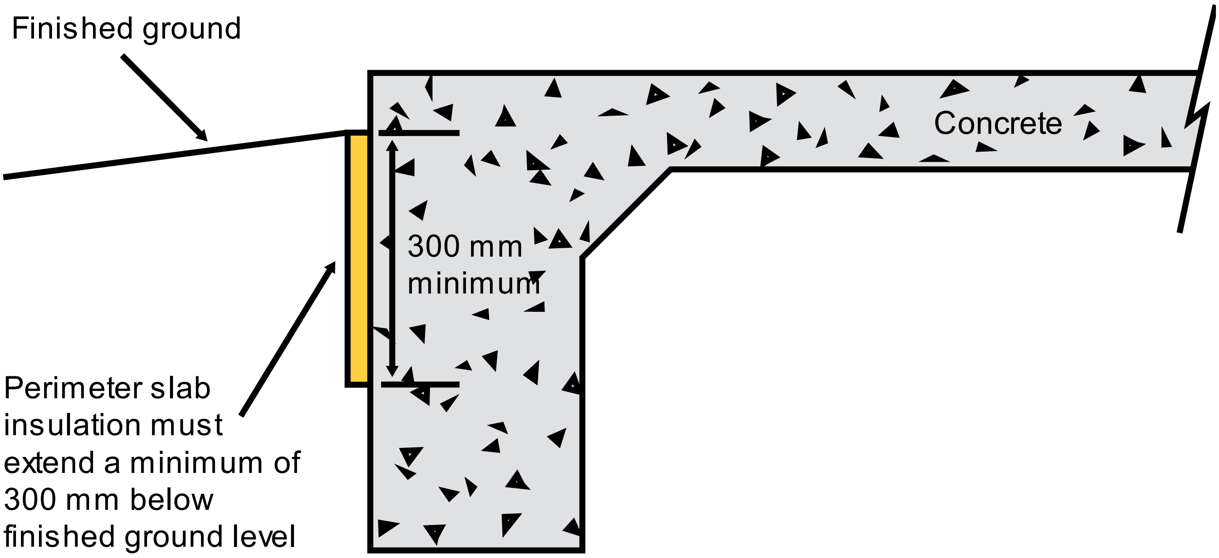
This subclause applies to subclause J1.6(b) for concrete slab-on-ground floors in *climate zone* 8.

Insulation for a slab-on-ground must be suitable for an external environment. In particular, it must be water resistant and still achieve the required *R-Value*. This can be validated by manufacturer's literature on test results.

This subclause also addresses the installation of perimeter slab insulation. The most problematic area is where the slab is in direct contact with the portion of the ground that is subject to significant seasonal or daily temperature variations. Conduction between slab and ground would increase the energy needed to keep the slab at the desired temperature.

To reduce the extent of this problem, the insulation must extend from the adjacent finished ground level to a depth of 300 mm, or for the full depth of the vertical edge of the slab-on- ground if the slab edge is less than 300 mm. Refer to Figure 11.32 for further explanation.

Figure 11.32 Depth of insulation



11.10.4 **Typical constructions**

The figures below outline the thermal performance of some of the more common forms of floor construction. For a material that is not listed in the figure below, other than air, the material *R-Value* may be determined by dividing the thickness of the item in metres by the thermal conductivity in W/m.K (typical values are described in Specification J1.2).

For the purposes of calculating the *Total R-Value* of a floor, the *R-Value* attributable to an in-slab or in-screed heating or cooling system is not included.

Note that it should not be assumed that these figures are representative of all construction scenarios. For example, the spacing of stumps, or the specific type of frame could all affect the actual *Total R-Value* by creating *thermal bridging* between elements or by compressing insulation. If following a DTS compliance pathway, *Total R-Value* must be calculated using the methods prescribed in AS/NZS 4859.2 to properly account for these effects.

Alert:

Examples of typical constructions for low rise construction can be found in the Guide to Volume One.

11.10.5 **Sub-floor thermal performance**

Specification J1.6 provides detail on the thermal performance achieved by sub-floor spaces and soil in direct contact with a floor.

The *R-Values* provided are intended to assist in determining whether and how much additional insulation is required to achieve the minimum *Total R-Values* in Table J1.6. This is provided as an alternative to carrying out a more detailed calculation using Section 3.5 of CIBSE Guide A.

11.10.5.1 Sub-floor thermal performance

Clause 2 of Specification J1.6 details the *R-Values* considered to be achieved by enclosed sub-floor spaces that are mechanically ventilated by 1.5 air changes per hour at most, or are provided with a maximum of 150% of the aggregate sub-floor ventilation required by Part F1 and are not mechanically ventilated.

The *R-Values* are listed in Table 2a of Specification J1.6 and are determined based on the ratio of floor area to floor perimeter in metres.

Where the ratio of floor area to floor perimeter is between the values stated, interpolation may be used to determine the sub-floor space *R-Value*.

11.10.5.2 R-Values

Subclause b of Specification J1.6 details the *R-Values* of the soil for floors that are in direct contact with the ground.

The *R-Values* are listed in Table 2b of Specification J1.6 and are determined based on the ratio of floor area to floor perimeter in metres, as well as the wall thickness.

Where a wall thickness or ratio of floor area to floor perimeter is between the values stated, interpolation may be used to determine the soil *R-Value*.

12 Part J3 – Building sealing

12.1 Introduction

The building sealing *DTS Provisions* of Part J3 have been developed to control unwanted air leakage into and out of the building *envelope*.

As with all other aspects of the NCC *DTS Provisions*, each element within Section J of NCC Volume One is designed to work as a system to ensure the building achieves the desired level of energy efficiency. Building sealing is an integral part of this system and the control of air leakage will have a major impact on the thermal performance of the building, in particular, the capacity to reduce the energy required for artificial heating, cooling and humidity control.

The building sealing provisions have changed little since first introduced into Volume One in 2005, other than to extend their application to other building classifications and to include a provision to seal *evaporative coolers*. However, an issue that does become increasingly important with high-rise buildings is air infiltration. The higher the floor above ground level, the greater the wind pressure and, as a result, the greater the potential for infiltration or leakage.

The introduction of the building *envelope* sealing *Verification Method* JV4 in NCC 2019 (see Chapter 9) provides a method of demonstrating compliance with the building sealing requirements in JP1(e) as an alternative compliance option to the *DTS Provisions* provided herein.

Reminder:

All requirements in Part J3 apply to the *SOUs* of a Class 2 building or Class 4 part of a building. Refer to Chapter 10 (Heating and cooling loads for SOUs in a Class 2 building or a Class 4 part) for more information.

12.2 Scope

The building sealing requirements address the following elements of a building:

- chimneys and flues;
- *roof lights*;
- windows and doors;
- exhaust fans;
- construction of ceilings, walls and floors; and
- *evaporative coolers*.

The requirements have been developed to address conditions most likely to be experienced in the eight *climate zones* adopted by the NCC.

There are many concessions provided and these are described later in this Chapter.

12.3 Intent

The intent of Part J3 is to restrict the unintended leakage of outdoor air into the building and loss of conditioned air from the building.

In addition to unnoticed air leakage, drafts caused by poorly sealed external openings and construction gaps can affect building occupants' sense of comfort, causing them to increase their use of heating and *air-conditioning*. Leakage of humid air into an air-conditioned building can increase energy use for dehumidification.

This Chapter provides details of each of the requirements in Part J3. It discusses important points that should be considered when determining a building's compliance with NCC Volume One *DTS Provisions*.

12.4 DTS Provisions

J3.0 clarifies that the *DTS Provisions* in Part J3 are part of a suite of *DTS Provisions* within Section J that must be applied together to meet the *Performance Requirements*. In simple terms, the building must comply with all the appropriate *DTS Provisions* in Section J to be considered as complying with NCC Volume One.

Accordingly, if there is any variation from the prescribed *DTS Provisions* in one part, then the entire set of energy efficiency requirements for the building will need to be checked to ensure that there is no unintended effect on the other parts because of a *Performance Solution* being adopted for one Part. Refer to A2.2(3) and A2.4(3) of NCC Volume One for details.

12.5 Application

The requirements of Part J3 apply to the elements forming the *envelope* of a Class 2 to 9 building; however, there are many exemptions. These are for:

- buildings in *climate zones* 1, 2, 3 and 5 where *evaporative coolers* are the only means of *air-conditioning*. This concession recognises that the *evaporative cooler* requires external air to be introduced to allow the cooler to work effectively; or
- permanent building openings needed for the safe use of a gas appliance. This may include wall vents and the like. However, the concession is limited to the areas required for the safe operation of that equipment. To determine the appropriate area, evidence should be received from the appliance manufacturer as part of the *building approval* process; or
- a building or space where the *mechanical ventilation* required by Part F4 provides sufficient pressurisation to prevent infiltration, i.e. the ventilating air needs to be relieved.

These concessions are intended to exempt those buildings or parts of buildings that should not be sealed for one reason or another.

Design alert:

How do we know whether a building will be air-conditioned?

Building approval documents should clearly state what *air-conditioning* equipment will be used in the building. It is recommended that this should be listed as a distinct schedule, like a window schedule for ease of assessing compliance with Section J.

What happens if the building has no *air-conditioning*?

The NCC Volume One definition is quite broad in that a "*conditioned space*" includes any space "likely ... to have its temperature controlled by *air-conditioning*". This requires a degree of discretion. The *Appropriate Authority* will be required to assess the future potential for *air-conditioning*.

Design alert:

It would be reasonable to assume that, for employee or customer comfort and product protection, most offices, shops and laboratories, for example, would be air-conditioned.

12.6 Chimneys and flues

A chimney or flue serving an open solid fuel burning appliance is required to have a damper or flap fitted. The damper or flap must be designed so that it can be operated easily 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 in summer months. It is important to note that only appliances with an open face, which burn a solid-fuel such as timber, are required to have a damper.

12.7 Roof lights

12.7.1 What roof lights need to be sealed?

Clause J3.3(a) provides general requirements for sealing of *roof lights* and covers two distinct situations where *roof lights* must be sealed, or *capable* of being sealed. The first is when they serve a *conditioned space*. The second situation is when they are in a habitable room in *climate zones* 4, 5, 6, 7 and 8.

For example, a *roof light* will need to be sealed if it serves a laundry that is air-conditioned. Conversely, it would not require sealing if the laundry was not air-conditioned, because the room is not considered to be a habitable room for the purposes of the NCC.

12.7.2 How are roof lights sealed?

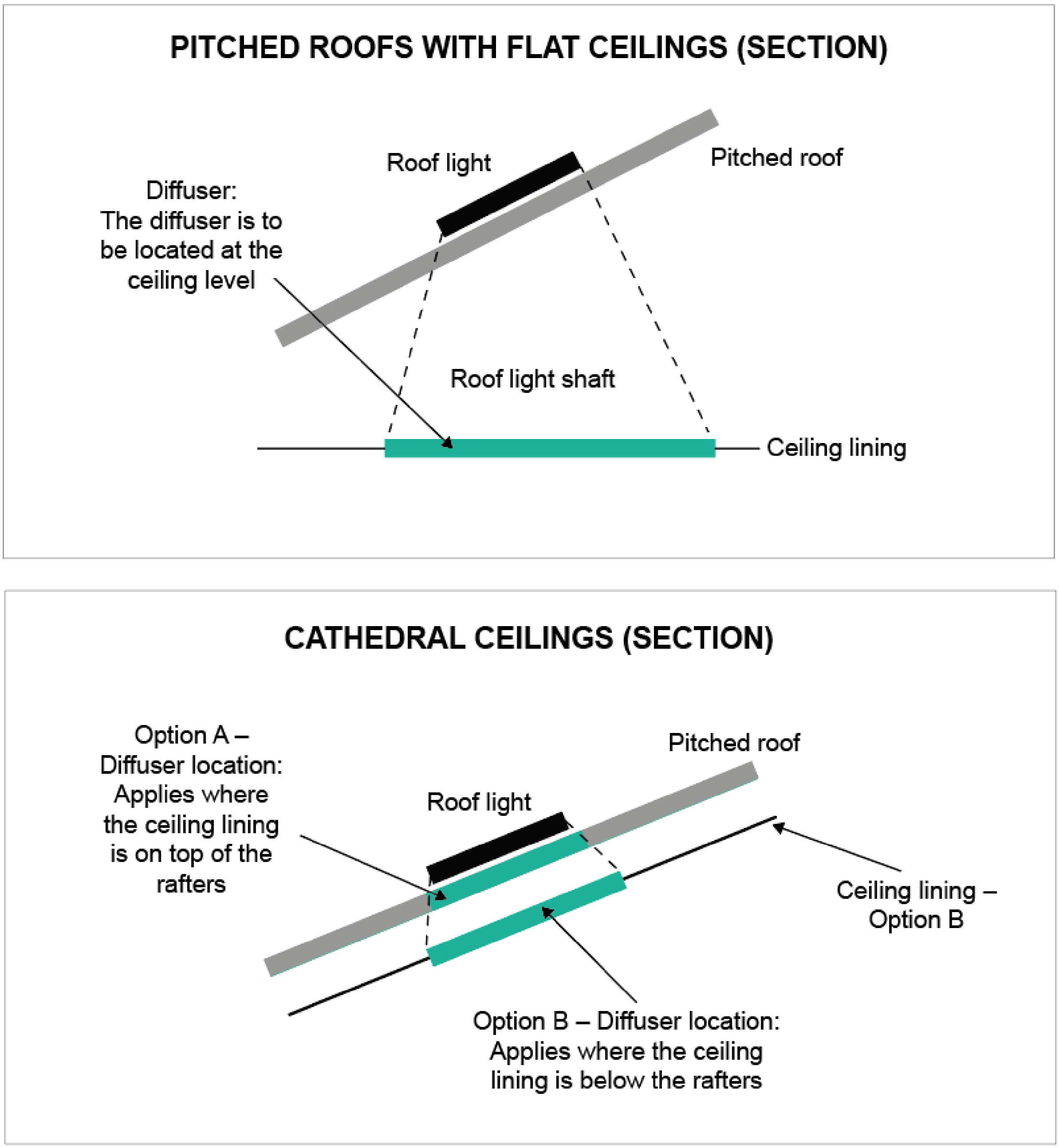
There are three options for achieving an effective seal;

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 the glare from the *roof light*. Refer to Figure 12.1 for suitable ceiling diffuser locations.

2. A weatherproof seal can be installed, and although not mentioned in the clause, the seal could be a foam or rubber compression strip or the like as described in J3.4(c)(ii) 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 ensure the operating mechanisms are easily accessible to the occupant, so they can be readily used.

Figure 12.1 Suitable location of ceiling diffusers



Reminder:

It is important to note that a window becomes a *roof light* only when it is installed at an angle between 0 and 70 degrees, measured from the horizontal plane. Glazed openings that are installed in roofs with a greater angle are considered to be windows and are addressed by clause J3.4 for sealing purposes.

12.8 External windows and doors

External windows and doors must be sealed when they form part of the *envelope* or are in *climate zones* 4, 5, 6, 7 and 8. Reasonable judgement is required when applying sealing to windows and doors, i.e. the seal must be durable with no gaps between a conditioned and non-*conditioned space*.

The application parameters for a habitable room or *conditioned space* are the same as discussed previously in this Chapter for *roof light* sealing.

Clause J3.4(b) details three exemptions:

1. windows that comply with AS 2047 (Windows in buildings – selection and installation) are exempt as the Standard contains acceptable provisions for window sealing.
2. fire or smoke doors, as any seal might compromise the integrity of the door.
3. A roller shutter door, roller shutter grille or other security door or device installed only for out-of-hours security.

Clause J3.4(d) relates to external entry doors leading to a *conditioned space*. An external door opening into a *conditioned space* with a floor area greater than 50 m^2 must be self-closing, have an airlock or be a revolving door to minimise loss of conditioned air. This provision applies to all *climate zones* (refer to Figure 12.2 for further explanation).

Clause J3.4(e) relates to entrances to loading docks. Should a loading dock lead to a *conditioned space*, it must be fitted with a rapid roller door.

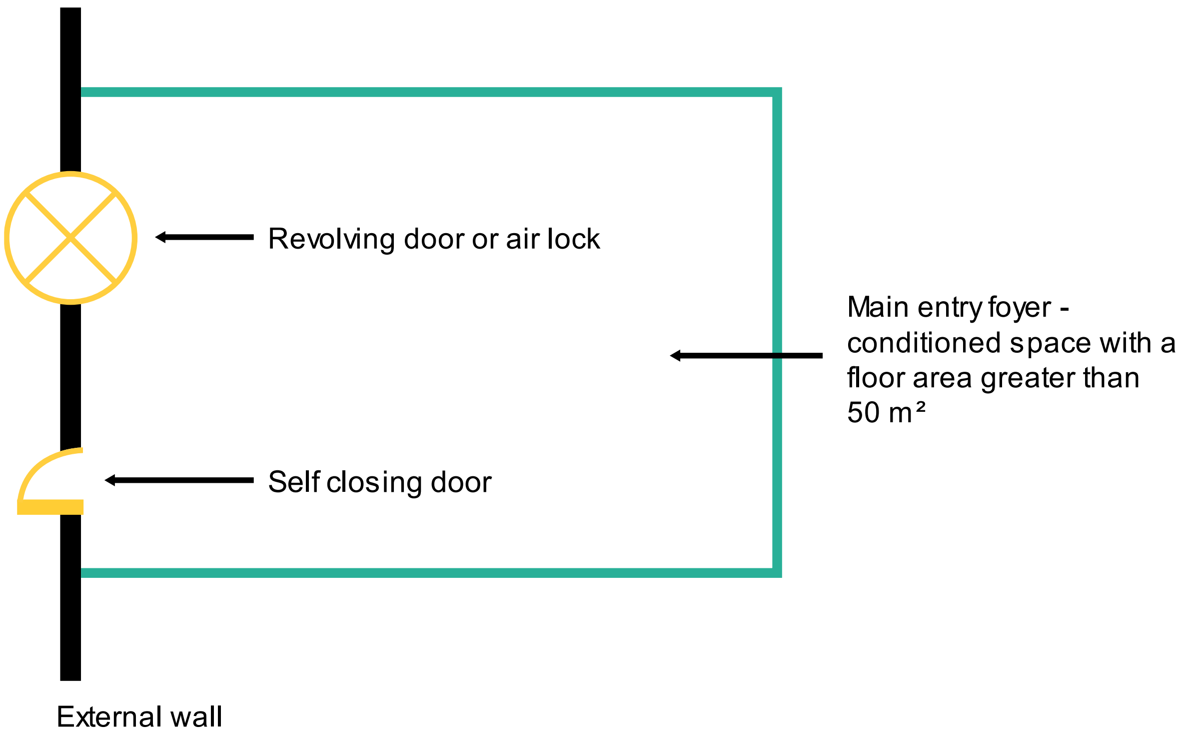
Design alert:

What is the difference between sealing a door and minimising air loss?

Clause J3.4(a) requires most external doors to be provided with a seal, so that closed air is prevented from passing through the gap between the door and door frame.

Clause J3.4(d) requires most entry doors to be designed so that when the door is in use the loss of conditioned air is minimised. This can be achieved by a revolving door, air lock or a self-closer.

Figure 12.2 Entry doors to a conditioned building (plan view)



12.9 **Exhaust fans**

This requirement in J3.5 applies to exhaust fans located in the *envelope* of a *conditioned space* in any *climate zone* or in the external fabric of a habitable room in *climate zones* 4, 5, 6, 7 and 8.

The exhaust fans are essentially openings in the insulated *envelope*, through which conditioned air will escape when they are not operating. Accordingly, the requirement is to restrict the extent of air leakage from intermittently operating fans. This can be achieved by strip damper systems that are readily available for most fan types. Alternatively, a filter system, like that used in kitchen range hoods is acceptable as they significantly restrict the flow of air when the fan is not operating.

Design alert:

What if the exhaust fan is part of a conditioning system?

If the fan was operating as part of the *air-conditioning* system, such as a control return air fan, an additional damper would not be required but, if one is already there for other purposes, it must close on shut down under a provision in Part J5.

12.10 Construction of ceilings, walls and floors

Subclause J3.6 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. It applies to the external fabric elements of the building such as ceilings, walls and floors and any opening in those elements when they form part of the *envelope* in any *climate zone* or in *climate zones* 4, 5, 6, 7 and 8.

In most instances, conventional internal fixing and finishing procedures will be sufficient to comply with the required seal, provided the linings are close fitting and trimmed by skirtings, architraves, cornices and the like.

Design alert:

What does close fitting mean?

If we consider that doors and windows require a compression seal, it is easy to see that the gap around a window or door when closed is not considered acceptable. Accordingly, a reasonable interpretation of “close fitting” would be having a gap less than that between a closed window or door and the associated frame, which is typically 2 mm.

It is noted that some lining systems, such as plasterboard, require gaps to allow for movement of sheeting. In such instances, skirtings will be required to seal the wall and floor junctions where a fitted floor is installed and there are gaps between the subfloor and internal space. However, if the floor was a concrete slab or platform particleboard flooring then no gap would exist between the internal and external spaces and sealing is not necessary. Where it is not possible to have close fitting junctions or penetrations, expanding foam, caulking, rubber compressible strip etc. may be used to seal the gap.

As already mentioned in most instances, this requirement will be addressed by conventional construction practices i.e. no additional requirements 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 if the gaps are considered to be excessive.

12.11 Evaporative coolers

Like 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, this would occur 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 would otherwise leak through the unsealed cooler or its ductwork.

13 Part J5 – Air-conditioning and ventilation

Reminder:

The requirements in Part J5 apply to the *SOUs* of a Class 2 building and the Class 4 part of a building. Refer to Chapter 10 for more information.

13.1 Introduction

Efficient design of *air-conditioning* and ventilation systems is an essential element of building environmental management. As people's expectations for comfortable buildings rises, there is a corresponding demand on artificial internal environment systems to provide this comfort.

Research[5] detailed in a report by the former Department of Climate Change and Energy Efficiency (DCCEE) in 2012 describes building *HVAC* equipment as generally the largest end-use, responsible for 43% of the electricity used by the building's services.

Based on the increasing demands for comfort in buildings and therefore potentially higher energy consumption, there is a need for systems to use energy in an efficient manner. The NCC includes a range of requirements to remove poor practice and mandate efficient system design.

Design alert:

Application of the requirements in Part J5 are likely to require specialist mechanical engineering input in conjunction with manufacturers' data validating the performance of the *air-conditioning* and ventilation plant to enable the *Appropriate Authority* to assess the proposal against the requirements of NCC Volume One.

[5] Pitt & Sherry with input from BIS Shrapnel and Exergy Pty Ltd, for the DCCEE, Baseline Energy Consumption and Greenhouse Gas Emissions – In commercial Buildings in Australia, Part 1 – Report, November 2012 (pg. 7)

Design alert:

Appropriately qualified engineers would ideally be specialists in *air-conditioning*. It may be necessary to validate their expertise before accepting their documentation.

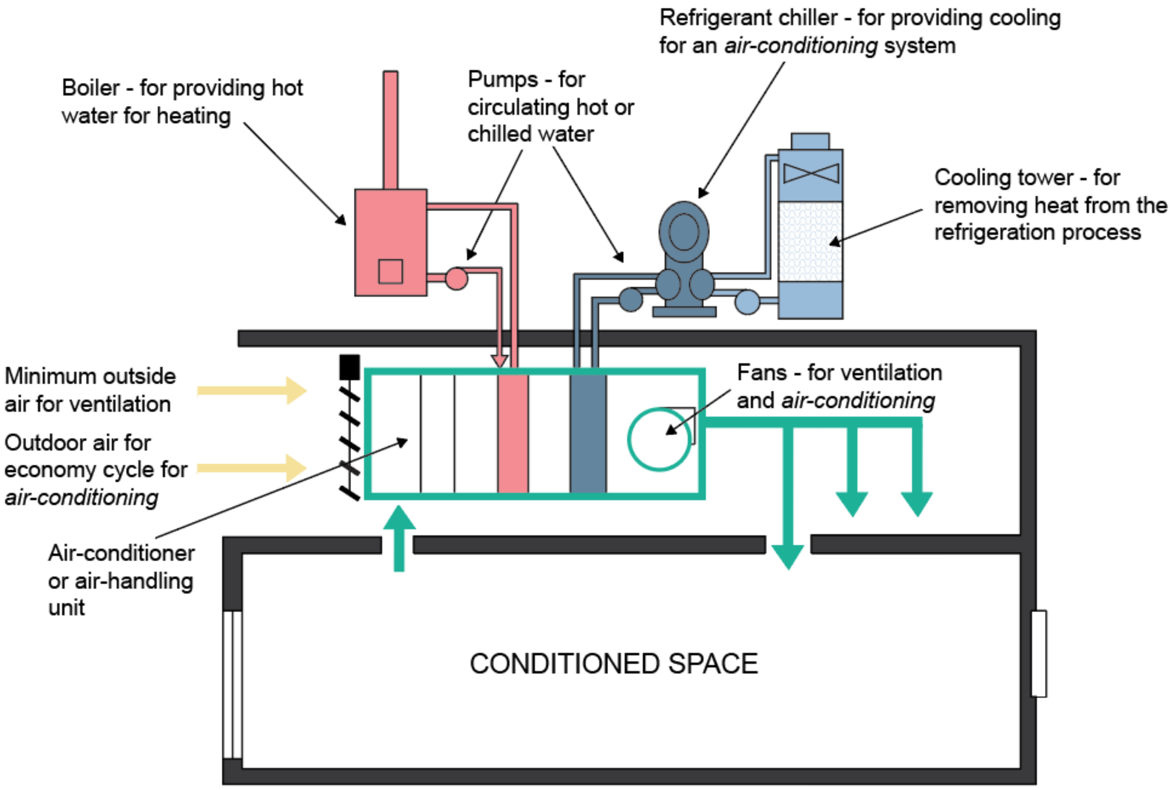
13.1.1 **Types of air-conditioning systems**

Examples of *air-conditioning* systems are listed below:

- central chilled water systems;
- central condenser water loop systems;
- central air-handling units (*AHU*);
- individual unitary systems for heating and cooling; and
- evaporative cooling units or systems.

It is worthwhile noting that this list is not exhaustive and there may be many combinations or variations on these types of systems or others depending upon the building. Figure 13.1 shows a diagram of a typical *AHU* served by a central *HVAC* plant.

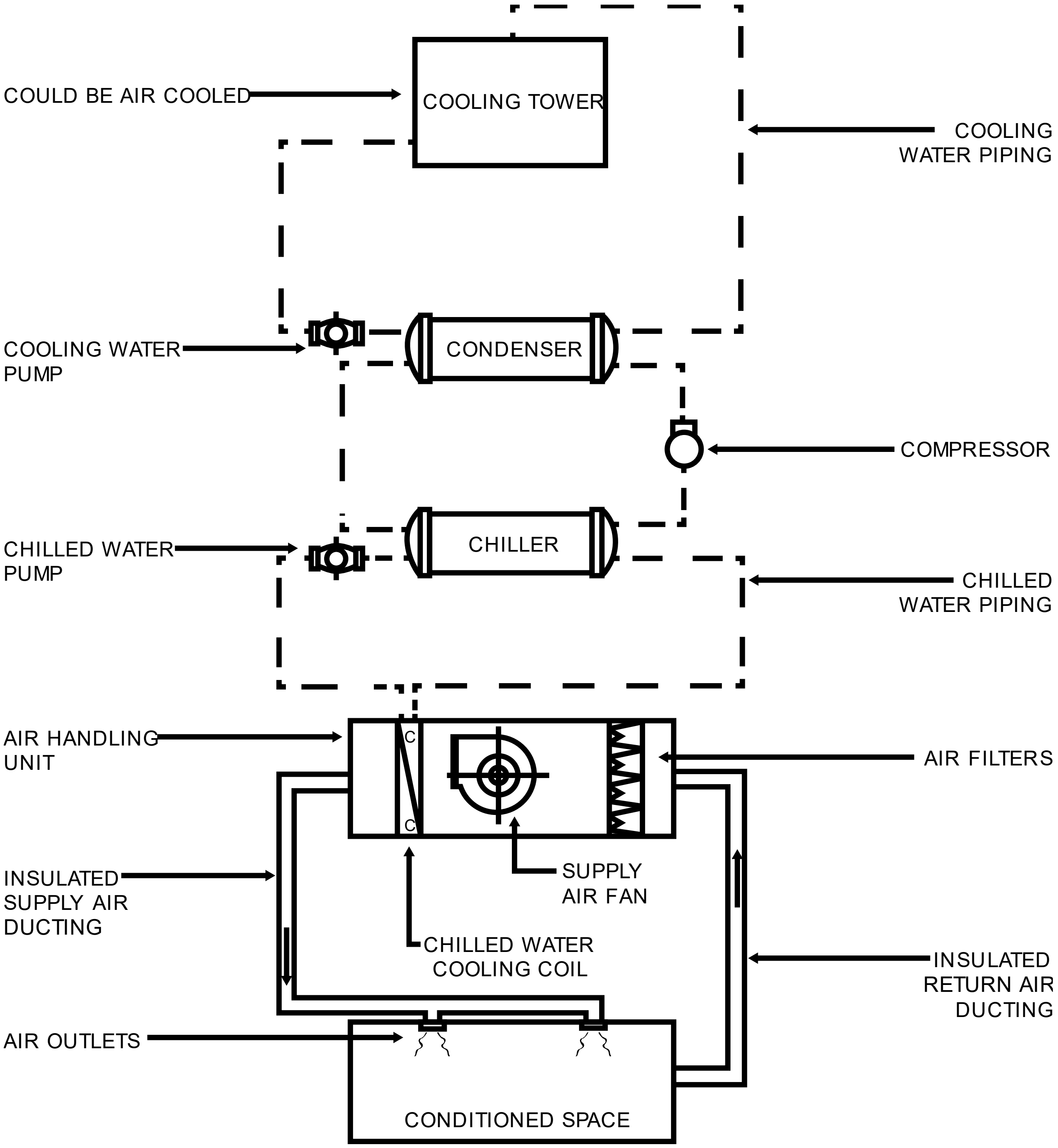
Figure 13.1 Diagram of a typical *AHU* and its central plant connections



13.1.1.1 Central chilled water system

Central chilled water systems provide chilled water as a cooling medium. The chilled water can then be used in a variety of equipment types to provide *air-conditioning*. Chilled water is generated by a refrigerant chiller. The rejected heat is transferred to the atmosphere, either by a cooling tower, directly by an evaporative condenser or by an air-cooled condenser. Refer to Figure 13.2.

Figure 13.2 Typical air-conditioning using a central chilled water system (source – AIRAH)



The *AHU* can be a central system serving more than one area and/or multiple floors, or alternatively, an individual *fan coil unit (FCU*) can be provided for each individual space. For further information, refer to the explanation of *AHU* and *FCU*.

The central *AHU* can contain heating and/or cooling coils that heat and/or cool the air. This heating and/or cooling can also be provided in each individual *FCU*.

The chilled or heated water is circulated through coils within the *AHUs* or *FCUs*. An air stream, consisting of air returned from the *conditioned spaces*, outdoor air or a mixture of the two is passed over the coils. This cools or heats the air to the desired temperature, before being supplied into the *conditioned space.*

There are two main types of central chilled water system; air cooled and water cooled:

1. water cooled means that heat from the chiller is rejected using water as a transfer medium. This water then transfers heat to the external atmosphere using a cooling tower; and
2. air cooled means the heat is rejected by fans that pass air across an outdoor coil containing the refrigerant (like a domestic air-conditioner or refrigerator).

A brief explanation of the refrigerated cooling process is as follows.

Figure 13.2 shows the chiller system as made up of a chiller vessel, a compressor and a condenser vessel. Liquid refrigerant evaporates in the chiller vessel by absorbing heat from the chilled water circulating through the evaporative side of the chiller. This cools the chilled water which is then pumped around the chilled water piping circuit and delivered to various chilled water coils in the building for heat exchange. Figure 13.2 shows this heat exchange taking place with the supply air stream in an *AHU*.

The compressor draws refrigerant gas from the chiller and compresses it. This hot gas passes to the condenser where it is cooled and reliquefied with heat transferred to the cooling water loop. The now liquid refrigerant returns from the condenser to the chiller through a pressure reducing device and the cycle is repeated. Heat from inside the building has been effectively transferred through the system to the outside atmosphere.

13.1.1.2 Central condenser water system

This system uses a cooling tower or other form of cooler and circulates the cooled water to one or more package units. There is no chiller (central or otherwise) used in this system.

The cooling tower cools water for supply to one or more condenser water package units. Each package unit contains its own refrigerant circuit, including a compressor, which discharge the rejected heat to the water and hence to the atmosphere via the cooling tower. The refrigerant then goes to a coil within an indoor unit over which air from the space is passed, conditioned and then recirculated back to the space.

Individual packaged *air-conditioning* units like this can be provided in a variety of applications.

13.1.1.3 Individual air-cooled unitary systems for heating and cooling

Individual air-cooled package units or self-contained units vary in size from a split unit or room air-conditioner, through to larger units which are usually located on the roof.

Packaged systems include indoor (the unit on the wall) and outdoor components with the package units containing:

- a refrigeration circuit, which includes a compressor,
- indoor and outdoor coils; and piping; and
- indoor and outdoor fans.

In cooling mode, the compressor increases the temperature of the refrigerant before an outdoor fan passes ambient air over the outdoor evaporator coil, causing the refrigerant to reject heat to the atmosphere. The cooled refrigerant is then rapidly expanded causing it to cool further before passing through an indoor coil. An indoor fan moves air over the indoor coil and thus recirculates cool air to the space.

In heating mode, the most common system is a heat pump, where the refrigeration system works in a reverse cycle.

Different types of split systems include:

- wall mounted split system;
- floor or under ceiling mounted split: like the wall mounted system, except the indoor unit is on the floor or under the ceiling;
- ceiling cassette: like the wall mounted system, except the indoor unit is inside the ceiling space; and
- ducted split: like the wall mounted system, except the indoor unit is not visible and uses ducts to deliver air to various rooms.

A package system would include:

- a room air-conditioner; and
- a roof top package system: this contains the entire system of fans, compressor and evaporator and condenser coils.

It is worthwhile noting that all individual package units may feature a reverse cycle which would provide heating as well as cooling. The heating can be provided by reversing the refrigeration cycle within the system.

13.1.1.4 Evaporative cooling system

Evaporative cooling systems are typical for residential and industrial buildings and are usually placed on the roof.

Evaporative coolers work best in climates where the air is hot and the humidity is low. They operate by drawing hot outdoor air into the unit through filter pads made wet by a cold water supply. The air temperature of the air drops because of the evaporation, which also increases the humidity of the air stream.

The cooler, humidified air is discharged indoors, before finally leaving the indoor environment through open windows and doors.

13.2 Scope

The provisions of Part J5 apply to the following:

- **Air-conditioning system control**, including:
  - General controls; and
  - Time switches.
- **Mechanical ventilation system control**, including:
  - General controls;
  - Exhaust systems;
  - Carpark exhaust systems; and
  - Time switches.
- **Fan systems**, including:
  - Fans;
  - Ductwork; and

  - Ductwork components in the index run.
- **Ductwork insulation**, including:
  - Ductwork and fittings; and Insulation.
- **Ductwork sealing**
- **Pump systems**, including:
  - Circulator pumps;
  - Other pumps; and
  - Pipework
- **Pipework insulation**, including:
  - Piping, vessels, heat exchangers and tanks containing heating or cooling fluid; and
  - Insulation.
- **Space heating**, including:
  - Energy sources
  - Bathroom electric heaters;
  - Outdoor fixed heating and cooling; and
  - Gas water heaters.
- **Refrigerant chillers**
- **Unitary air-conditioning equipment**, including:
  - Capacity of less than 65 *kWr*; and
  - Capacity of 65 *kWr* or more.
- **Heat rejection equipment**, including:
  - Cooling towers, closed circuit coolers and evaporative condensers
  - Air-cooled condensers

Design alert:

Many central *air-conditioning* systems incorporate a ventilation service to meet the NCC Volume One requirements in Part F4. However, for the purposes of Part J5, an *air-conditioning* system is a service installed in the building for heating or cooling. These services are not required by NCC Volume One, whereas minimum ventilation requirements are. The *air-conditioning* system may or may not incorporate the ventilation required for compliance with Part F4.

For example, the *air-conditioning* system may be a hot water radiator heating system or a passive chilled beam cooling system with no provisions for introducing

Design alert:

outdoor air through the heating or cooling system. Therefore, a separate means of providing ventilation will be needed, be it a *mechanical ventilation* system or openings such as windows. On the other hand, the *air-conditioning* system may have provisions for introducing outdoor air as is the case with most of the larger central *air-conditioning* systems.

A required ventilation system is a system designed to provide *mechanical ventilation* in accordance with NCC Volume One Part F4 for the health of the building occupants. For Part J5, the *mechanical ventilation* air quantity should not exceed by more than 20%, the maximum that is required by Part F4, except in cases where outdoor air economy cycles or energy reclaiming systems are used, or where *mechanical ventilation* is needed to balance the required exhaust or process exhaust.

What are the requirements when the air-conditioning is achieved by a heated water system using heated water radiators to directly heat the room?

The requirements for a heated water system used to heat a building, such as a hydronic heat panel system are addressed by this Part through the requirements for pump energy, *boiler* efficiency and the energy source.

13.3 Intent

The intent of Part J5 is to ensure that *air-conditioning* and ventilation systems have design features that allow the systems to be used in a manner that avoids excessive energy usage. The features themselves, however, do not ensure energy efficiency; as systems must be commissioned, operated and maintained in an effective manner to ensure energy consumption is reduced.

In most instances, the NCC Volume One requirements should prevent poor design, while encouraging considered selection of plant and equipment that could be expected to achieve a reasonable level of energy efficiency.

13.4 DTS Provisions

J5.0 establishes that the *DTS Provisions* in Part J5 are part of an overall energy efficiency solution and each *DTS Provision* within Section J is applied as a package to meet the *Performance Requirements*.

If there is any variation from the prescribed *DTS Provisions* in Part J5, then the entire energy efficiency requirements for the building may need to be assessed as a *Performance Solution*, due to the potential effects created by the interdependency of some of the clauses. This is not to say, however, that the unaffected *DTS Provisions* cannot be used to form part of that *Performance Solution*.

Reminder:

Part E2 of NCC Volume One contains requirements for smoke hazard management in the event of a fire incident.

Part E3 of NCC Volume One contains requirements for the cooling of lift shafts.

Part F4 of NCC Volume One contains requirements for certain rooms contained in buildings to be subjected to ventilation, whether it be via natural or mechanical means.

13.5 Application

Part J5 contains minimum energy efficiency requirements for the major energy consuming components of *HVAC* systems used in buildings.

Class 8 electricity network substations are exempted from Part J5. These substations commonly operate *mechanical ventilation* or *air-conditioning* 24 hours a day to serve high voltage equipment, so manual override or specific design features for energy efficiency could be hazardous.

13.6 Air-conditioning system control

J5.2 relates to a system that provides *air-conditioning*.

It should be noted that the NCC cannot mandate operational or administrative matters such as the set point for temperature control devices, nor would it be practical to do so. It can only require that temperature control devices be installed.

Note that J5.2 relates to *air-conditioning* units and systems so the floor area measured would only be that for the space served by that *air-conditioning* unit or system and not include non-conditioned corridors, toilets, plant rooms and the like.

13.6.1 Control

Clause J5.2(a) relates to the control requirements for *air-conditioning* systems so that the consumption of energy is limited.

Subclause J5.2(a)(i) requires controls to deactivate the *air-conditioning* system when a building or part of a building is unoccupied. The system is intended to deactivate only where the building or part of the building served by the *air-conditioning* system is not occupied. For example, if an *air-conditioning* system serves a whole building, it is only required to be *capable* of being deactivated when the whole building is unoccupied. Similarly, if an *air-conditioning* system only serves a single floor of a building, the system must be *capable* of being deactivated when that floor of the building is unoccupied. It is likely this clause will require the operational arrangements of the *air-conditioning* system to be designed based on logical building layouts.

Subclause J5.2(a)(ii)(A) outlines that when one space has different thermal characteristics to another space, and both are conditioned by the same air-conditioner, it is necessary to provide separate temperature control of each space so as not to increase energy usage due to over heating or cooling.

For example, consider the differing thermal characteristics between a south and east facing room due to the differing solar gains received. If the temperature sensor is in the east facing room it may activate a higher level of cooling than the south facing room may require. This may result in the south facing room being cooler than desired. An additional temperature control device will allow separate control of the space, facilitating reduced energy use.

Subclause J5.2(a)(ii)(B) requires the temperature control of the *air-conditioning* system to not depend on mixing heated and cooled air streams that have been actively conditioned by the plant. This requirement allows the *air-conditioning* system to use no more energy than is necessary.

Subclause J5.2(a)(ii)(C) contains restrictions on reheating the supply air. These requirements are intended to encourage the grouping of areas with similar loads (heating and cooling demand), rather than sub-cooling all the supply air and reheating excessively to achieve the desired temperature. Subclause J5.2(a)(ii)(C)(aa) outlines that where a separate reheat device is provided; the supply air temperature must not increase by more than 7.5 K at the full supply air rate. The 7.5 K limit on temperature rise allows for some trim heating of cold air supply but within reasonable limits.

Reminder:

The kelvin is the primary unit of temperature measurement in the physical sciences and is often used in conjunction with the degree Celsius which has the same magnitude (i.e. an increase of 7.5 K is the same as an increase of 7.5 °C).

Subclause J5.2(a)(ii)(C)(bb) outlines that the allowable temperature rise can be determined by using an inverse relationship between allowable temperature rise and supply air rate. If, during the reheating, the supply air rate is also reduced then the temperature rise can be proportionally increased above 7.5K at the same rate that the supply air rate has been reduced. For example, the reheat temperature could be increased to 10K when the supply air rate is reduced by 25% or increased to 15K if the supply air rate is reduced by 50%.

Subclause J5.2(a)(iii) requires outdoor air economy cycles to be provided, however, buildings in *climate zone* 1 or an area needing humidity control for process applications are exempt. If the air flow rate of an *air-conditioning* system is greater than or equal to the figures in Table J5.2, then this subclause applies. For example, if an *air-conditioning* system in *climate zone* 2 has a total air flow rate equal to or larger than 9000 L/s then an outdoor air economy cycle must be provided. The outdoor air economy cycle is designed to bring in larger quantities of outdoor air for conditioning when the ambient enthalpy conditions are suitable. This typically means that in the summer cooling season during times when the ambient temperature/humidity conditions are lower than the return air condition then outdoor air economy cycle can be used to minimise energy usage to cool the air.

In this case, the *air-conditioning* unit capacity means the capacity of each air-conditioner serving a space, not the combination of all units serving a space, because an outdoor air economy cycle is cost effective only in a unit larger than the stated capacities.

Outdoor air economy cycles can be cost effective in partially occupied Class 6 restaurants or cafes and some Class 9b buildings. However, when the occupancy of a building is less than one person per square metre, the amount of outdoor air required by Part F4 could be so great that an outdoor air economy cycle would admit only a small additional amount of air. Should this be the case, the added cost of the dampers and controls, as well as the added pressure drops, may not be justified for the energy saving returned and a performance-based solution verifying that an outdoor air economy cycle is not required may be appropriate.

An exemption is granted to applications that require humidity control for a specific process related application within the building or a building that is in *climate zone* 1. It is considered the additional cost and energy use of humidification or activation of a dehumidification plant offsets any benefit of free cooling from outdoor air economy cycle. Additionally, the amount of time throughout the year where an outdoor air economy cycle for buildings within *climate zone* 1 would be practical is minimal, due to high temperatures and humidity.

Subclause J5.2(a)(iv) requires the water flow through items such as water heaters, chillers and coils to be stopped when the item is not operating. This is usually achieved by an automatic valve. This requirement applies only when there is more than one water heater, chiller or coil in the *air-conditioning* system. This will reduce the pump energy consumption by preventing water being circulated unnecessarily and reducing energy associated with losses from pumping water through equipment that is not operational. In addition, thermal losses through pipework and components will be reduced.

Subclause J5.2(a)(v) outlines that a variable speed fan must be used when the supply air quantity is *capable* of being varied. This is because a variable speed fan is a more energy efficient method of reducing energy consumption when compared to throttling the air supply with dampers. An *air-conditioning* system with an airflow less than 1000 L/s is exempt.

Subclause J5.2(a)(vi) requires the *air-conditioning* unit or system to stop when a door to a balcony, patio or courtyard of a *SOU* of a Class 3 building is open for more than one minute. This can be achieved by an electric power micro-switch/ reed switch on the door. The one minute timing is to allow for people to open and close the door without the *air-conditioning* stopping and starting each time. However, if the door is left open for more than one minute, it ensures that the *air-conditioning* does not continue to operate and leak conditioned air.

Subclause J5.2(a)(vii) requires *air-conditioning* systems to have coordinated control from central plant through to zone and room controls. The term “direct signals” means that the information comes directly from the components within the building such as temperature sensors or control valves. Direct signals help to regulate the operation and set-points of central plant in coordination with the needs of the building, rather than operating central services as a continuous provision that can be used when required.

Subclause J5.2(a)(viii) requires that the *air-conditioning* system has a control dead band greater than or equal to 2°C. A dead band is the temperature band between the set points for heating and cooling that automatically control the system. Within the dead band the system is not operating, and therefore using no energy. An *air-conditioning* system where a smaller range is required for specialised applications is exempt.

Subclause J5.2(a)(ix) outlines that the maximum design air or fluid flow is achieved but not exceeded by more than 15% above design at each component. If a common control system contains multiple components as required to meet the needs of the system at its maximum operating condition, the maximum design air or fluid flow is achieved but not exceeded by more than 15% above design at each group of components. To meet the requirements of the subclause, balancing dampers and balancing values must be provided. Balancing dampers and valves are designed to regulate airflow within ducts and air-handling equipment. This clause requires designers to consider the inclusion of components that are allow for appropriate commissioning of building *HVAC* systems.

Subclause J5.2(a)(x) requires that airflow can be stopped in independent operating spaces of more than 1000 m^2 and each separate floor of the building without interrupting the remaining areas of the *air-conditioning* system. The system must be *capable* of allowing for different operating times when terminating airflow in independent areas. For example, if an *air-conditioning* system serves a Class 5 office building with different work zones or business on the same floor, the airflow to each business or work zone must be *capable* of stopping without interrupting the *air-conditioning* of the remaining work zones or businesses. This is typically done with dampers and variable speed drives on plant to reduce air flow.

Subclause J5.2(a)(xi) outlines that an *air-conditioning* system's heated water and chilled water circuits must have automatic variable temperature operation. When operated at variable temperature, chillers and *boilers* have the potential for improved efficiency operation. This can be implemented via a temperature reset control strategy.

Subclause J5.2(a)(xii) requires any motorised outdoor air or return air dampers to close when the system is deactivated if it is not being actively closed through the BMS. It does not require that the dampers be motorised, only that if motorised dampers are installed they close. This requirement is to reduce the uncontrolled infiltration of outside air into the building during periods when *air-conditioning* systems are not in operation.

13.6.2 **Same space control**

Subclause J5.2(b) requires that *air-conditioning* systems must use control sequences to prevent the systems from operating in opposing heating and cooling modes when two or more systems serve the same space. This is commonly the case when supplementary systems to suit a fit out are added to base building systems. For example, if two *FCUs* are serving the same teaching room in an education building, controls should be in place to prevent them from operating in opposing modes.

13.6.3 Time switches

J5.2(c) specifies the requirements for time switch control of power supply to *air-conditioning* systems. The intent is to reduce unnecessary energy consumption attributable to the system when it is not being used.

Air-conditioning systems greater than 2 kW and heaters greater than 1 kW used for *air-conditioning* must be provided with time switches that can activate and de-activate the respective system. Controls are readily available with minimal associated cost to suit the requirements of this clause. Many units can be supplied with in-built controllers. At variable pre-programmed times and on variable pre-programmed days, the time switch must be *capable* of switching electric power on and off. Examples where pre-programmed days and times need to be changed may include changes with daylight savings or buildings where the occupancy is variable throughout the year such as for education facilities.

J5.2(c)(iii) grants exemptions for time switches for an *air-conditioning* system serving a single *SOU* in a Class 2, 3 or 9c building or a Class 4 part of a building. This exemption recognises that where a space is served by a small system, the system is likely to be under the control of the occupants who would determine when the system should operate and therefore could effectively control the system manually. There is also an exemption for a building where *air-conditioning* is needed for 24 hour continued use, such as a hospital emergency room.

13.7 Mechanical ventilation system control

J5.3 relates to a system that provides *mechanical ventilation*.

It should be noted that the NCC cannot mandate operational or administrative matters such as the pre-programmed times for time switches, nor would it be practical to do so. It can only require that time switches be installed.

13.7.1 General

J5.3(a) relates to the control requirements for *mechanical ventilation* systems so that the consumption of energy is limited. The *mechanical ventilation* system may be part of an *air-conditioning* system described in J5.2 or may be a separate *mechanical* *ventilation* system such as a carpark *mechanical ventilation* system. The requirements do not apply to a *mechanical ventilation* system that serves only one *SOU* in a Class 2 building or Class 4 part of a building.

J5.3(a)(i) is intended to only apply when the building or part of a building served by the *mechanical ventilation* system is unoccupied. For example, if a *mechanical ventilation* system serves a whole building, it is only required to be *capable* of being deactivated when the whole building is unoccupied. Similarly, if a *mechanical ventilation* system only serves a single floor of a building, the system must be *capable* of being deactivated when that part of the building is unoccupied.

J5.3(a)(ii) contains specific requirements for when a *mechanical ventilation* system serves a *conditioned space*. Periods where evaporative cooling is being used are excluded as there are potential issues with increased humidity.

J5.3(a)(ii)(A) requires that the *mechanical ventilation* system have either an energy reclaiming system that preconditions outdoor air at a minimum sensible heat transfer effectiveness of 60% or demand control ventilation in accordance with AS1668.2.

The required measures for J5.3(a)(ii)(A) are specified in Table J5.3. As an example, if a *mechanical ventilation* system in *climate zone* 3 has an outdoor air flow greater than 1000 L/s, a modulating control device is required.

J5.3(a)(ii)(B) requires that the outdoor air requirement of Part F4 not be exceeded by more than 20% when serving a *conditioned space*. This value is to provide the designers some flexibility when supplying a series of spaces from one system. Where there is a need for more outdoor air for one space, it may be appropriate that a dedicated system be installed for that space. There are many exemptions for requirement J5.3(a)(ii)(B) including:

- situations where additional unconditioned outdoor air is supplied for free cooling as part of an outdoor air economy cycle; or
- situations where *mechanical ventilation* is needed to balance the required exhaust or process exhaust. This may occur in areas such as toilets or bathrooms which have high exhaust rates to remove contaminated air or to balance process exhausts such as those used in a health care building or laboratory; or
- situations where an energy reclaiming system preconditions all outdoor air are exempt.

> ***Reminder:***
>
> Part F4 of NCC Volume One contains requirements for certain rooms contained in buildings to be subjected to ventilation, whether it be via natural or mechanical means.

J5.3(a)(iii) requires a larger *mechanical ventilation* system with a high airflow rate of more than 1000 L/s to have a variable speed fan when the supply air quantity is *capable* of being varied. Varying the fan speed to suit demand will minimise energy consumption. Fans whose airflow is required to be constant by Part F4 are exempt.

13.7.2 **Exhaust systems**

J5.3(b) contains requirements for exhaust systems.

An exhaust system with an air-flow rate of more than 1000 L/s must be *capable* of stopping the motor when the system is not needed to reduce energy consumption.

The requirements do not apply to a miscellaneous exhaust system serving a *SOU* in a Class 2, 3 or 9c building.

Consideration should be given to situations where safety is an issue, such as the exhaust from a chemical storage cabinet. Likewise, it may be more appropriate that fume hoods in some situations operate on a reduced flow, while in other situations operate at full flow. A *Performance Solution* may be considered more appropriate in such situations.

The required minimum ventilation rates take precedence over energy efficiency measures. Therefore, exhaust systems that must balance the intake of outdoor air required for ventilation are exempt. This is because there are no opportunities to stop the motor in these systems.

13.7.3 **Carpark exhaust systems**

J5.3(c) requires that carpark exhaust systems have an atmospheric contaminant monitoring system and control in accordance with AS 1668.2. Monitoring of atmospheric contaminants, typically carbon monoxide, is required to allow for variable speed operation of carpark supply and exhaust fans to provide energy efficient operation of the systems.

Carpark exhaust systems can be controlled in accordance with 4.11.2 or 4.11.3 of AS 1668.2 under J5.3(c). The former requires ventilation rates to be varied in a prescribed manner based on the concentration of atmospheric contaminants in the carpark. The latter provides a simpler method for use with small carparks with 40 or fewer spaces. This ventilation rate variation should be done using a variable speed fan in conjunction with the requirement of J5.3(a)(iii).

13.7.4 **Time switches**

J5.3(d) specifies the requirements for time switch control of power supply to *mechanical ventilation* systems. The intent is to reduce unnecessary energy consumption attributable to the system when it is not being used.

Mechanical ventilation systems with an air flow rate of more than 1000 L/s are required to be provided with a time switch. The time switch is to be *capable* of activating and deactivating the respective system at variable pre-programmed times and days.

J5.3(d)(iii) grants exemptions for time switches for a *mechanical ventilation* system serving a single *SOU* in a Class 2, 3 or 9c building or a Class 4 part of a building. This exemption recognises that the system is likely to be under the control of the occupants who would determine when the system should operate and therefore could effectively control the system manually.

There is also an exemption in J5.3(d)(iii)(B) for a building where *mechanical ventilation* is needed for 24 hour occupancy such as a hospital emergency room or factory. In such cases a time switch would serve no purpose.

13.8 **Fan systems**

J5.4 sets out requirements for fans, ductwork and duct components used as part of an *air-conditioning* system or *mechanical ventilation* system.

13.8.1 **Methods of compliance**

There are two options to demonstrate that a fan system that forms part of an *air-conditioning* or *mechanical ventilation* system is compliant with J5.4.

J5.4(a) outlines the first option. Fans, ductwork and duct components must separately comply with subclauses (b), (c), (d) and (e). In other words, each of the individual components of a fan system must be individually more efficient than the values specified in J5.4.

J5.4(a)(ii) specifies the second option for a whole-of-fan-system compliance. The fan motor input power per unit of flowrate (e.g. W/L/s) must be lower than the fan motor input power per unit of flowrate achieved if the system was designed in accordance with subclauses (b), (c), (d) and (e) together. In other words, the fan system as a whole must be more efficient than a system that is designed to meet the individual component requirements.

Whole-of-system compliance allows for increased flexibility when design constraints prevent individual component level DTS metrics from being met, without the need for a *Performance Solution*.

13.8.2 **Fans**

J5.4(b) outlines the efficiency requirements for a system's fan. Separate options are provided for fans with static pressure above and below 200 Pa to encourage designers to minimise static pressure where suitable, as this contributes to energy savings.

J5.4(b)(i) requires that the overall static efficiency at Best Efficiency Point (BEP) must be more than 13 x In(p) – 30 for fans in systems that have a static pressure of less than 200 Pa. This equation refers to the natural log and the fan's static pressure requirement in pascals. Static pressure is the overall resistance to airflow that the fan is required to overcome. The static efficiency at BEP is the ratio of the fan power output to the power supplied to the fan.

Example: Static efficiency

The fan has a static pressure equal to 150 Pa.

The static efficiency at BEP is therefore equal to:

η_{static} = 13 x ln(p) – 30

η_{static} = 13 x ln(150) – 30

η_{static} = 13 x 5.01 – 30

η_{static} = 35%

For fans with a static pressure above 200 Pa, J5.4(b)(ii) nominates the required efficiency of a fan at the full load operating point. The clause uses a regression formula, based on the fan input power, minimum fan performance grade and two regression coefficients to specify a suitably efficient fan. Table J5.4a, Table J5.4b and Table J5.4c provide the minimum fan performance grade and regression coefficients based on fan type, fan installation arrangement and fan power.

Axial fans use blades rotating around an axis to draw air in parallel to that axis and force air out in the same direction. Axial fans are often used in ductwork as components of return air, exhaust air or supply air systems.

Mixed flow fans incorporate elements of axial fans and centrifugal fans so that the air flows in both axial and radial direction relative to the shaft. These are commonly used in smaller ventilation systems.

Centrifugal fans are a mechanical device that increases the volume of an airstream by impellers, a series of blades mounted on a circular hub, which in turn accelerates air radially and alters the direction of the outward flowing air, typically by 90 degrees. These are commonly used in scenarios where a higher static pressure is required, such as *AHUs*.

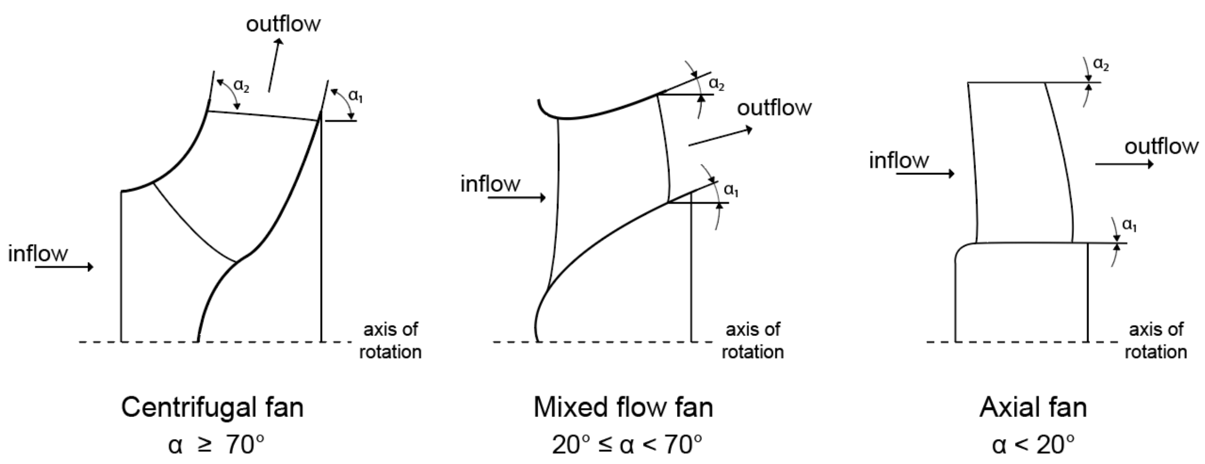
Centrifugal forward-curved fans have impellers with forward blades that are curved in the direction of wheel rotation.

Centrifugal radial bladed fans have impellers with multiple equally spaced flat blades that extend in a perpendicular direction to wheel rotation.

Centrifugal backward-curved fans have impellers with blades that are curved in the direction opposite to wheel rotation. Plug in fans are typically backward curved centrifugal fans.

FPREN 17166 2019, the standard for Fans – Procedures and methods to determine the energy efficiency for the electrical input power range of 125 W up to 500 kW, provides further clarification on the differentiation of fan types described in Figure 13.3 below.

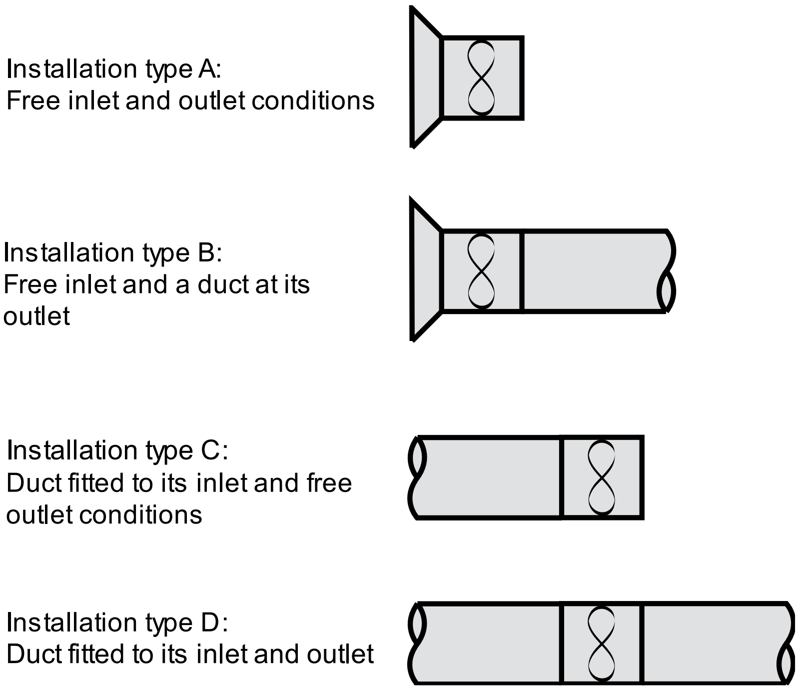
Figure 13.3 Fan type differentiation by angles



There are 4 installation types in J5.4(b) that affect the calculation of the minimum efficiency: A, B, C and D.

- Installation type A refers to an arrangement where the fan is installed with free inlet and outlet conditions.
- Installation type B refers to an arrangement where the fan is installed with a free inlet and a duct at its outlet.
- Installation type C refers to an arrangement where the fan is installed with a duct fitted to its inlet and with free outlet conditions respectively.
- Installation type D refers to an arrangement where the fan is installed with a duct fitted to its inlet and outlet.

Figure 13.4: Installation types A, B, C and D



Installation types A and C require a minimum required system static efficiency, while installation types B and D require a minimum required system total efficiency.

Example: Full load efficiency

A centrifugal backward curved fan is installed with free inlet and outlet conditions. The fan installation type is therefore type A.

The motor input power of the fan is 10 kW.

$P = 10$ kW

As the fan is a centrifugal backward curved fan with installation type A, the minimum performance grade of 64 is determined from Table J5.4a.

$N = 64$

The regression coefficients a and b are obtained from Table J5.4b and J5.4c respectively.

Example: Full load efficiency

From Table J5.4b it is determined that for a centrifugal backward curved fan with a motor input power ≥10 kW the regression coefficient a is equal to 1.1.

From Table J5.4c it is determined that for a centrifugal backward curved fan with a motor input power ≥10 kW the regression coefficient b is equal to 2.6.

a = 1.1
b = 2.6

Using the coefficients determined above, the minimum efficiency at the full load operating point is calculated using the following formula.

η_{min} = 0.85 x (a x ln(P) - b + N) / 100
η_{min} = 0.85 x (1.1 x ln(10) – 2.6 + 64) / 100
η_{min} = 0.85 x (1.1 x ln(10) – 2.6 + 64) / 100
η_{min} = 54%

Result

In this instance, the minimum required static efficiency is equal to 54%.

J5.4(b)(iii) exempts fans that are required to be explosion proof from the requirements of J5.4(b)(i) and J5.4(b)(ii). Examples of fans that are required to be explosion proof may include fans located in dangerous goods areas. In these cases, safety overrides energy efficiency requirements.

13.8.3 **Ductwork**

J5.4(c)(i) nominates that the average pressure drop for flexible ductwork and straight segments of rigid ductwork in the index run of a fan system must not exceed 1 Pa/m. The index run is the path within the air duct system with the greatest pressure drop. As the requirement is for the average pressure drop, localised sections may exceed 1 Pa/m if these gains are traded off with lower losses elsewhere in the system. For this calculation, the pressure drop of flexible ductwork sections may be calculated as if the flexible ductwork is in a straight configuration, i.e. 6m of flexible ductwork with bends is equal to 6m of flexible ductwork laid straight.

J5.4(c)(ii) limits flexible ductwork to a maximum of 6 m in length in any duct run. The excessive use of flexible ductwork can introduce the risk of a heightened pressure drop.

J5.4(c)(iii) disallows ductwork bends, elbows and tees in the index run that have a smaller effective diameter than the upstream duct section they are connected to. Such fittings have substantial pressure drops. Reducing bends are permissible.

J5.4(c)(iv) requires rigid ductwork elbows of 90 degrees or less (e.g. a sharp 45 degree bend) include turning vanes, except where turning vanes would present a fouling risk (i.e. potential for particulates to build up affecting the characteristics of the duct) or where it is a long radius bend in accordance with AS 4254.2. Turning vanes assist the airflow in making a smoother and more gradual change in direction, reducing energy lost due to abrupt changes in direction.

13.8.4 Ductwork components in the index run

J5.4(d), Table J5.4d and Table J5.4e specify the maximum allowable pressure losses of components in a ductwork system. For ease of clarification, these have been simplified into Table 13.1 below.

Table 13.1 Maximum allowable pressure losses of components in a ductwork system

Subclause	Location	Maximum pressure drop (Pa)	Clarifications
J5.4(d)(i)	Across a coil	Specified in Table J5.4d	
J5.4(d)(i)	(1 row)	30	
J5.4(d)(i)	(2 rows)	50	
J5.4(d)(i)	(4 rows)	90	
J5.4(d)(i)	(6 rows)	130	
J5.4(d)(i)	(8 rows)	175	
J5.4(d)(i)	(10 rows)	220	
J5.4(d)(ii)(A)	HEPA air filters	200	When clean

Subclause	Location	Maximum pressure drop (Pa)	Clarifications
J5.4(d)(ii)(B)	HEPA air filters at an air velocity of 1.5 m/s	Filter design pressure drop	When clean
J5.4(d)(iii)(A)	Filters other than a HEPA filter	Specified in Table J5.4e	
J5.4(d)(iii)(A)	MERV = 9	55	When clean
J5.4(d)(iii)(A)	MERV = 11	65	When clean
J5.4(d)(iii)(A)	MERV = 13	95	When clean
J5.4(d)(iii)(A)	MERV = 14	110	When clean
J5.4(d)(iii)(B)	Filters other than a HEPA filter at an air velocity of 2.5 m/s	Filter design pressure drop	When clean
J5.4(d)(iv)(A)	Single stage intake louvres	30	
J5.4(d)(iv)(B)	Two stage intake louvres	60	
J5.4(d)(iv)(C)	Acoustic intake louvres	50	
J5.4(d)(iv)(D)	Non-weatherproof intake louvres	30	
J5.4(d)(v)(A)	VAV boxes for units with electric reheat	100	
J5.4(d)(v)(B)	VAV boxes for other units	25	Not including coil pressure losses
J5.4(d)(vi)	Rooftop cowls	30	
J5.4(d)(vii)	Attenuators	40	Use of multiple attenuators in series is not permitted
J5.4(d)(viii)	Fire dampers	15	When open
J5.4(d)(ix)	Balancing and control dampers in the index run	25	When in a fully open position
J5.4(d)(x)	Supply air diffusers and grilles	40	
J5.4(d)(xi)	Exhaust grilles	30	
J5.4(d)(xii)	Transfer ducts	12	
J5.4(d)(xiii)	Door grilles	12	
J5.4(d)(xiv)	Active chilled beams	150	

Where the pressure loss of a component exceeds the allowance provided in J5.4(d), compliance using J5.4(a)(ii) may be demonstrated through another section’s pressure drop being below its allowance by an equivalent amount. For example, throw diffusers are likely to have a higher pressure drop than specified in J5.4(d), and can therefore be offset by savings elsewhere. AS1324 and AS1668.2 provide pressure drop values that may be used as the basis of a *Performance Solution* or subclause 5.4(a)(ii).

Note that the allowances for grilles do not include any balancing dampers that may be included within the grille.

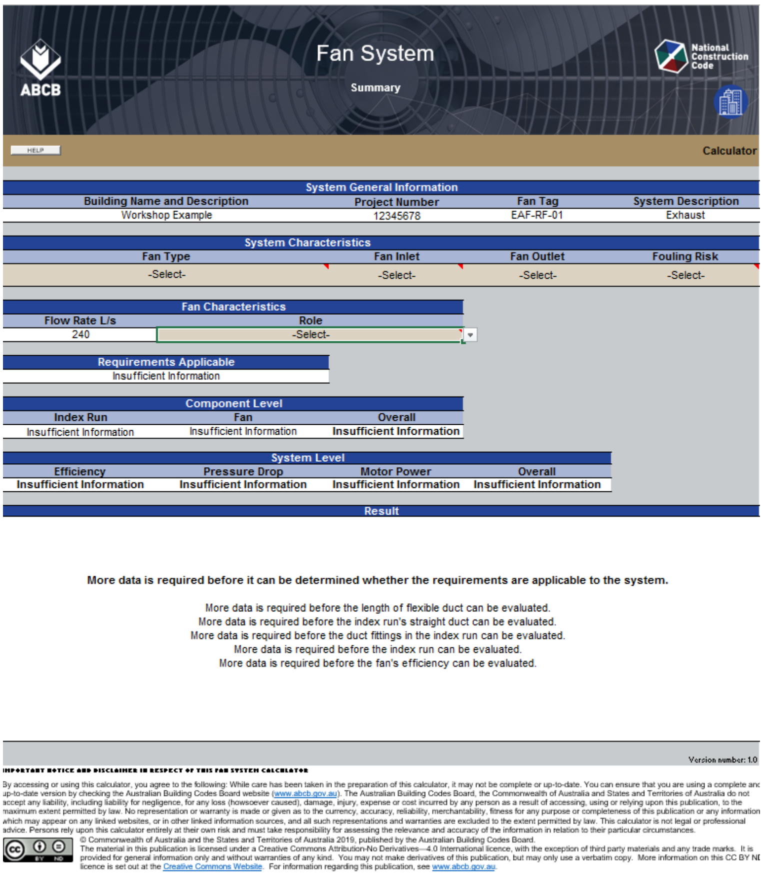
13.8.5 **Exemptions**

There are some exemptions to subclauses (a), (b), (c) and (d), as the requirements are not appropriate for all fan systems. These exemptions include fans in an *air-conditioning* system that is unducted and has a supply air capacity smaller than 1000 L/s, kitchen exhaust systems and the power for process-related components. Smoke spill fans are also exempt, except in cases where they are used for *air-conditioning* or ventilation. In these cases, other requirements take precedence over energy efficiency.

13.8.6 **Fan System Calculator**

The ABCB has developed a Fan System Calculator for NCC users to assist with demonstrating compliance with the NCC fan system provisions.

Figure 13.5 Introductory page of the ABCB Fan System Calculator



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

Calculator ribbon

When the Fan System Calculator is first opened, the custom Fan System Calculator ribbon will appear, rather than the normal Microsoft Excel menu.

- System Select – Brings down a list of fan tags. Clicking on a fan tag will change the active system to that fan.
- Navigation – All Systems, Summary, Index Run and Fan Details navigates to that sheet for the system which is active. Worksheet provides a space for notes and calculations.
- Reporting – The report sheet brings together the summaries for all systems and can be printed.
- Help – A link to the Fan System Calculator help guide.
- Zoom – Zoom functions for ease of accessibility.

All Systems

- Building Name and Description, Project Number, Designer and Company – Used for identification of the project. This is simply to provide context for the user and will repeated in the report generated at the end.
- System Description, Fan Tag and Flow Rate – Creates a schedule of each fan system. Systems can be added (+), removed (-), copied (C) and pasted (P) until all systems are recorded.

13.8.6.1 Summary

The Summary sheet holds specific configuration information and builds the results for the fan system.

System General Information:

- Building Name, Project Number, Fan Tag and System Description – Used for identification of the project and fan systems. These will be automatically filled based on the information in All Systems.

System Characteristics:

- Fan Type – This cell offers a selection of fan types as per Table J5.4a.
- Fan Inlet – This cell requires a selection of either a free or ducted inlet.
- Fan Outlet – This cell requires a selection of either a free or ducted outlet. The inlet and outlet conditions used determine the installation type.
- Fouling Risk – This cell requires a selection of either yes or no as to whether a fouling risk is associated with the system. Fouling risks are where particulates may build up and affect the characteristics of the duct. They are often associated with kitchen, workshop or lab exhaust systems however can also occur in other applications.

Fan Characteristics:

- Role – This cell requires a selection of the roll of the fan system. Some types of fans are exempt from the requirements of J5.4(e).

13.8.6.2 Index Run

Index Run Details

- Each row represents one segment of a system (i.e. a straight run of duct, a bend or a coil).
- Description – Segment of system for identification.

- Duct Shape – This cell requires a selection of either rectangular, circular or circular flexible duct. If a rectangular shape is selected, then a width and height cell will become available to edit. Similarly, if a circular shaped duct is selected, a diameter cell will become available to edit.
- Component Type – This cell requires a selection of either straight duct, duct fitting (loss coefficient - Kt) or duct fitting (pressure drop - PD).
- Temperature – System air temperature in °C.
- Flow Rate – Rate of air flow in L/s.
- Roughness – Material roughness (mm) is documented in industry guidance materials including AIRAH DA03 or the ASHRAE handbook, or from suppliers and other sources.

Segments can be added (+), removed (-), copied (C) and pasted (P) until all systems are recorded. The default (D) button sets a particular row as default, when adding a new row, it will be a copy of the default row.

Once the appropriate level of information has been entered, the editable cells will be highlighted in green or red to identify compliance. The Calculator will determine the pressure drop through the straight segment of pipe and compare it with the requirement of J5.4(c)(i). It will also check the pressure drop of each individual fitting and sum these up as a total to see if compliance can be achieved through J5.4(c)(ii). Therefore, even if compliance isn't met on a component level, it could be achieved on a whole-of-system level.

13.8.6.3 Fan Details

External Static Pressure:

- Calculated Static Pressure – The calculated static pressure is based on the details listed in the Index Run sheet.
- Design Static Pressure – This cell requires the designed static pressure. The Calculated Static Pressure can be used as a guide however, designers should ensure to allow for any system contingencies.

Fan Details:

- Motor Input Power – This cell requires the motor input power in kW.
- System Total Efficiency – This cell requires the fan's efficiency at the full load operating point (%).

The efficiency required to comply on a component level will be calculated based on the entered information.

13.8.6.4 Results

Results are found on the Summary sheet. The Summary sheet will compile the results and informs if compliance can be met for both the fan and index run components of the J5.4 requirement under J5.4(a)(i). If compliance is not met with J5.4(a)(i), compliance will be checked on a whole of system level J5.4(a)(ii).

Figure 13.6 Example of Summary page in the ABCB Fan System Calculator showing non-compliance

Component Level		
Index Run	Fan	Overall
Part J5.4 Not Satisfied	Part J5.4 Not Satisfied	**Part J5.4 Not Satisfied**

System Level			
Efficiency	Pressure Drop	Motor Power	Overall
+17.1%	+39.0%	+62.8%	Part J5.4 Not Satisfied

Result
The fan system does not satisfy the DTS Provisions of Part J5.4.
The length of flexible duct in the index run satisifes Part J5.4. The pressure drop through the straight duct in the index run does not satisfy the DTS Provisions on a component level. One or more duct fittings in the index run exceed the maximum pressure drops allowed under the DTS Provisions on a component level. Considering these elements, the index run does not satisfy the DTS Provisions of Part J5.4 on a component level. The fan's efficiency does not satisfy the DTS Provisions of Part J5.4 on a component level.
Consider increasing the size of the straight duct. Sections which are non-satisfactory are highlighted red on the Index Run sheet. Fittings whose pressure drop exceeds allowed values are highlighted red on the Duct Details sheet. Consider increasing the duct sizes or using less lossy fitings for these components. This calculator does not check whether the upstream connections to ductwork bends, elbows and tees in the index run have an equivalent diameter to the connected duct per J5.4(c)(iii). Ensure you check whether your system satisfies this provision, and if not, make suitable allowances in systemic energy usage calculations for the pressure drop differences which would result. The entered system design pressure drop is less than that calculated from the duct data provided. This is abnormal. For systems which do not satisfy the DTS Provisions, a JV3 or other Performance Solution may provide a suitable pathway.

13.8.6.5 Reporting

- The 'All Systems' sheet provides a quick summary of each system.
- The 'Go To' Report button on the ribbon generates a more complex report on the whole project.

Example:

Consider a workshop that requires an in-duct supply fan and a roof mounted exhaust fan.

The following details apply to both the supply and exhaust fans:

- Axial fan not as a component of an *AHU* or *FCU* (i.e. other)
- Fan inlet = ducted
- Fan outlet = ducted
- Motor input power = 0.4 kW

Example:

- System efficiency = 70%
- Air flow rates = 240 L/s
- Static pressure = 150 Pa
- Fouling risk = yes

Supply fan index run components:

- Duct run 1 (3 m in length, 300 x 250 mm, 0.49 Pa/m pressure drop)
- Duct run 2 (3 m in length, 300 x 250 mm, 0.49 Pa/m pressure drop)
- Louvre (single stage, 20 Pa pressure drop)
- Contraction (2.74 Pa pressure drop)
- Expansion (13.70 Pa pressure drop)
- Fire damper 1 (15 Pa pressure drop)
- T branch (1.92 Pa pressure drop)
- Fire damper 2 (15 Pa pressure drop)
- Turn (0.21 Pa pressure drop)
- Flexible ductwork (1 m, 200 mm diameter, 0.88 Pa/m pressure drop)
- Diffuser (10 Pa pressure drop)

Note the pressure drop across each component has been calculated using a duct friction loss chart.

Exhaust fan index run components:

- Duct run 1 (3 m in length, 300 x 250 mm, 0.49 Pa/m pressure drop)
- Duct run 2 (3 m in length, 300 x 250, 0.49 Pa/m pressure drop)
- Turn (1.85 Pa pressure drop)
- T branch (1.64 Pa pressure drop)
- Louvre (single stage, 20 Pa pressure drop)
- Contraction (2.74 Pa pressure drop)
- Expansion (13.70 Pa pressure drop)
- Fire damper 1 (15 Pa pressure drop)
- Fire damper 2 (15 Pa pressure drop)
- Roof cowl (25 Pa pressure drop)

Example:

Note the pressure drop across each component has been calculated using a duct friction loss chart.

As per J5.4(a), fans, ductwork and duct components that form part of an *air-conditioning* system or *mechanical ventilation* system must either separately comply with the requirements of J5.4(b), (c), (d) and (e) or achieve whole of system compliance (i.e. the proposed fans, ductwork and duct components achieve a fan motor input power lower than that of a system designed to meet the DTS requirements of J5.4(b), (c), (d) and (e)).

The following example will be checked at a component level. Please note the Fan System Calculator determines if compliance is met at both a component and system level.

For the purposes of this example it is assumed that the upstream connections to ductwork bends, elbows and tees in the index run have an equivalent diameter to the duct they are connected to.

Step 1: Fans

J5.4(b) details fan requirements that must be met to achieve component compliance (i.e. J5.4(a)(i)).

Variable speed control:

Since the airflow for both fans is less than 1000 L/s, variable speed control is not required.

Minimum efficiency:

Since the static pressure of both fans is less than 200 Pa (i.e. 150 Pa), the minimum overall static efficiency must be more than 13 x ln(Pa) – 30 as per J5.4(b)(ii).

$13 \times \ln(Pa) - 30 = 13 \times \ln(150) - 30 = 35.1\%$

Example:

Since the total system efficiency (70%) is more than the calculated minimum efficiency (35.1%), the requirements of J5.4(b)(ii) are met.

Step 2: Ductwork

J5.4(c) details requirements for the ductwork that must be met to achieve component compliance (i.e. J5.4(a)(i)).

For the purposes of this calculation, only the index run will be checked. Please note that in all duct runs flexible duct must not be longer than 6 m in length.

Index run pressure drop:

Supply fan-

The straight sections of rigid and all sections of flexible ductwork in the supply fan include duct run 1, duct run 2 and the flexible ductwork.

As the total length of the straight duct is 7 m (3 m + 3 m + 1 m), the maximum allowable pressure drop is 7 Pa.

Summing the calculated pressure drops across the straight ducts gives:

(0.49 Pa/m x 3 m) + (0.49 Pa/m x 3 m) + (0.88 Pa/m x 1 m) = 3.82 Pa

As 3.82 Pa is less than the allowable pressure drop of 7 Pa, the sections of straight duct in the supply fan meet the requirements of J5.4(c)(i).

Exhaust fan-

The straight sections of rigid and all sections of flexible ductwork in the supply fan include duct run 1 and duct run 2.

As the total length of the straight duct is 6 m (3 m + 3 m), the maximum allowable pressure drop is 6 Pa.

Example:

Summing the calculated pressure drops across the straight ducts gives:

(0.49 Pa/m x 3 m) + (0.49 Pa/m x 3 m) = 2.94 Pa

As 2.94 Pa is less than the allowable pressure drop of 6 Pa, the sections of straight duct in the supply fan meet the requirements of J5.4(c)(i).

Flexible ductwork:

The flexible ductwork in the supply fan is at a length of 1 m. Therefore, the requirements of J5.4(c)(ii) are met as the flexible ductwork does not account for more than 6 m in length.

Upstream connections:

As the upstream connections to ductwork bends, elbows and tees in the index run have an equivalent diameter to the duct they are connected to, compliance is met with J5.4(c)(iii)

Please note that the Fan System Calculator does not check whether upstream connections to ductwork bends, elbows and tees in the index run have the same diameter to the connected duct.

Turning vanes:

As the fan system is serving a workshop, there is a fouling risk within this example. Therefore, turning vanes are not required in all rigid ductwork elbows of 90° or less in the index run.

Step 3: Ductwork components in the index run

J5.4(d) details requirements for the index run that must be met to achieve component compliance (i.e. J5.4(a)(i)).

Please note not all components listed in J5.4(d) are included in this example. Only the specific battery room index run components will be examined.

Example:

Intake louvres:

Supply and exhaust fans: Since the single stage louvre pressure drop (20 Pa) is less than that of the requirement J5.4(iv)(A) (30 Pa), the DTS requirements are met.

Fire dampers:

Supply and exhaust fans: Since the fire damper pressure drop (15 Pa) is not more than that of the requirements in J5.4(vii) (15 Pa). This requirement is met.

Supply air diffusers:

Supply fan: Since the diffuser pressure drop (10 Pa) is less than that of the requirement J5.4(x) (40 Pa), the DTS requirements are met.

Roof cowl:

Exhaust fan: Since the roof cowl pressure drop (25 Pa) is less than that of requirement J5.4(vi) (30 Pa), the DTS requirements are met.

Contraction:

The requirements for contractions are not specified in J5.4(d). Therefore, they are deemed compliant.

Expansion:

The requirements for expansions are not specified in J5.4(d). Therefore, they are deemed compliant.

T branch:

The requirements for T branches are not specified in J5.4(d). Therefore, they are deemed compliant.

Turn:

The requirements for turns are not specified in J5.4(d). Therefore, they are deemed compliant.

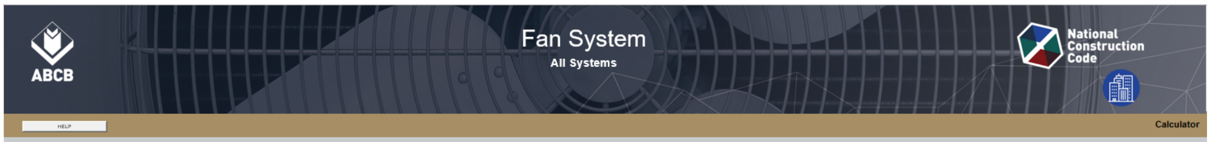
Example:

As all components of the fan system meet the compliance requirements of J5.4(b), (c) and (d), the fan system complies on a component level.

Where there are large numbers of different fans, ductwork and duct components, or the system does not meet individual component compliance but may meet whole of system compliance, the ABCB Fan System Calculator can aid in undertaking the calculations.

The figures below are images of the Calculator for the example above.

Figure 13.7 Fan System Calculator 'All Systems' page



Project Information			
Building Name and Description	Project Number	Designer	Company
Workshop Example	12345678	A.Designer	ABCB

Colour Guide				
Input	Calculated	N/A	Compliant	Non-compliant
Gold	White	Grey	Green	Red

Controls	ID	System Description	Fan Tag	Flow Rate (L/s)	Configuration		Straight Duct PD (Pa) Calculated	Straight Duct PD (Pa) Allowable		Fitting PD (Pa) Calculated	Fitting PD (Pa) Allowable		Efficiency (%) Calculated	Efficiency (%) Allowable		Motor Input Power (kW) Calculated	Motor Input Power (kW) Allowable		Summary
+ - C P D	1	Supply	SAF-GF-01	240	Complete	Go To	3.8	7.0	Go To	78.6	118.6	Go To	70.0%	35.1%	Go To	0.05	0.16	Go To	Satisfies Part J5.4
+ - C P D	2	Exhaust	EAF-RF-01	240	Complete	Go To	2.9	6.0	Go To	93.9	108.9	Go To	70.0%	35.1%	Go To	0.05	0.12	Go To	Satisfies Part J5.4

Notice for new users:

The Fan System Calculator uses a custom ribbon for navigation. For more guidance on this tool, please click the Help button on the ribbon above.

Notice for all users:

The Fan System Calculator is not a compliance tool, nor a Verification Method. It is provided solely to aid practitioners in developing their understanding of the NCC.
The accuracy of the Calculator's output is based entirely on the accuracy of the data entered by the user.

Supply fan:

Figure 13.8 Fan System Calculator 'Summary' page – supply fan

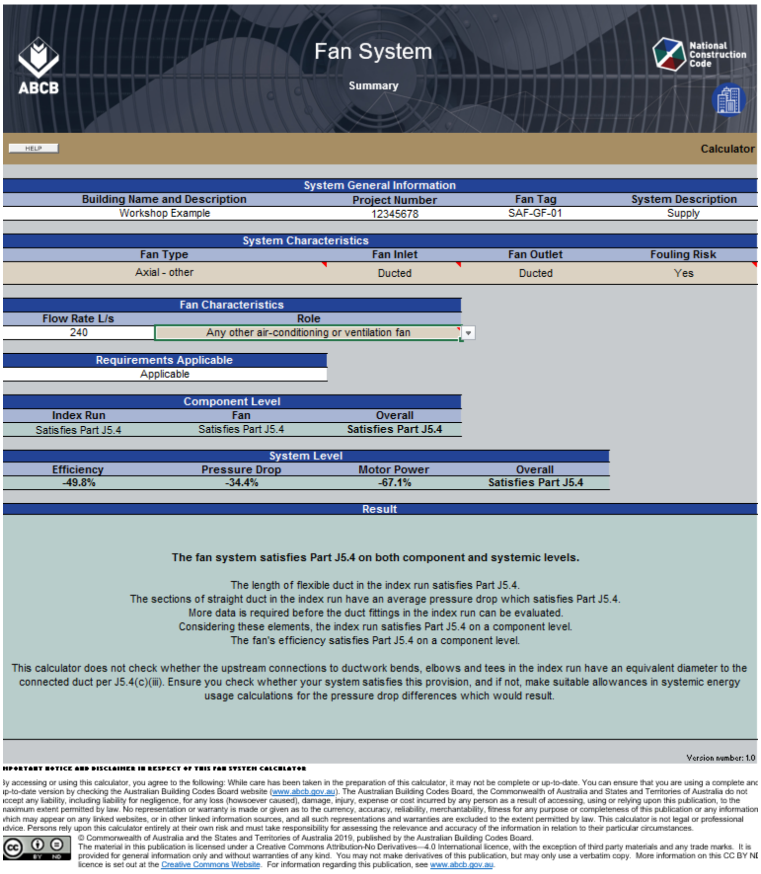


Figure 13.9 Fan System Calculator 'Index Run' page – supply fan

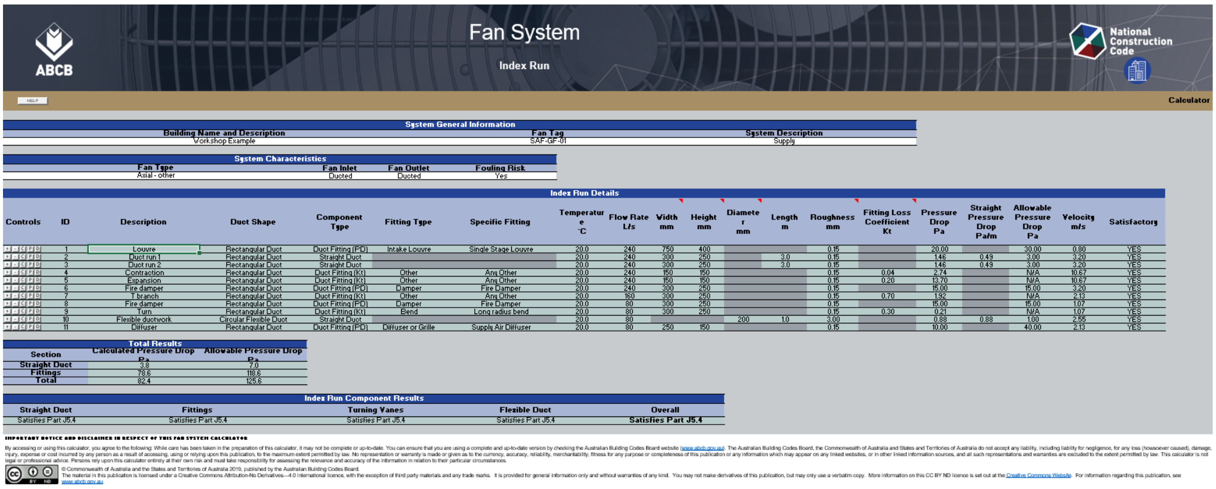
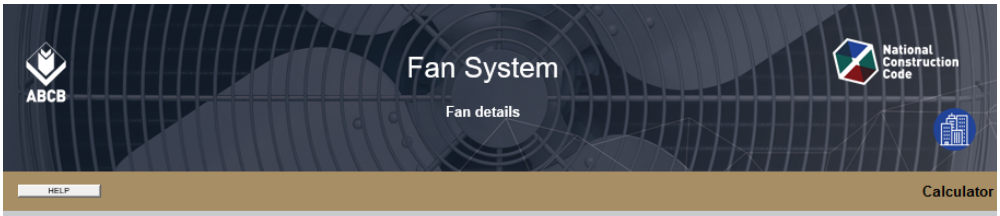


Figure 13.10 Fan System Calculator 'Fan Details' page – supply fan



System General Information		
Building Name and Description	**Fan Tag**	**System Description**
Workshop Example	SAF-GF-01	Supply

System Characteristics			
Fan Type	**Fan Inlet**	**Fan Outlet**	**Fouling Risk**
Axial - other	Ducted	Ducted	Yes

Fan Characteristics	
Flow Rate L/s	**Role**
240	Any other air-conditioning or ventilation fan

External Static Pressure		
Calculated Static Pressure Pa	**Design Static Pressure Pa**	**Note:** The design static pressure will likely exceed that calculated through allowances for dirty filters, inlet/outlet losses, safety factors etc. Ensure that these items are accounted for in your design static pressure calculations.
82.4	150	

Fan Details		
Motor Input Power kW	**System Total Efficiency %**	**Note:** The fan's efficiency should be presented at the full load operating point.
0.40	70.0%	

Component Level Compliance	
Required Efficiency %	**Efficiency Result**
35.1%	**Satisfies Part J5.4**

Exhaust fan:

Figure 13.11 Fan System Calculator 'Summary' page – exhaust fan

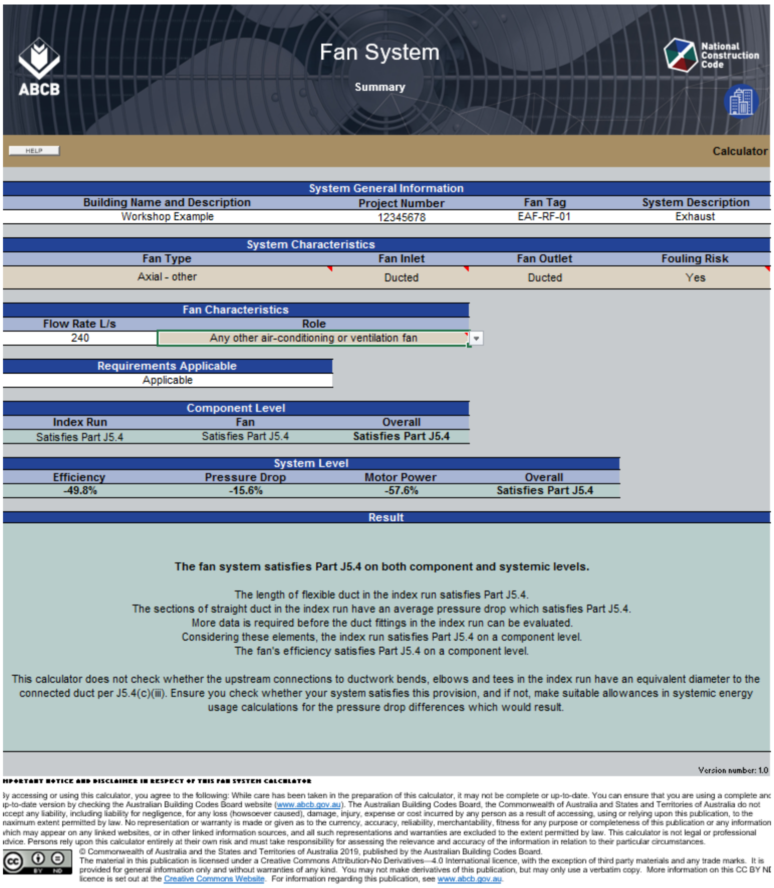


Figure 13.12 Fan System Calculator 'Index Run' page – exhaust fan

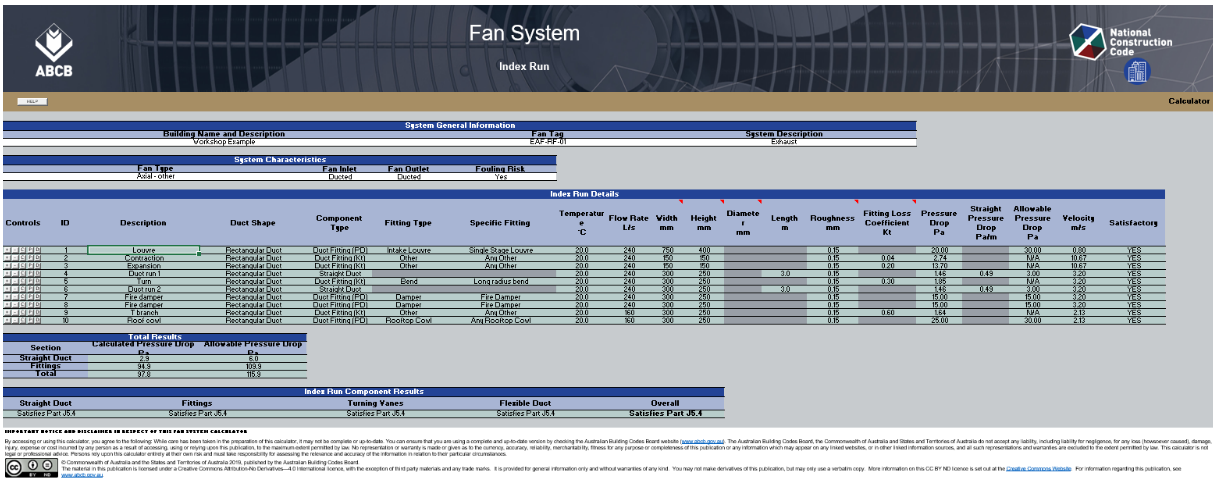
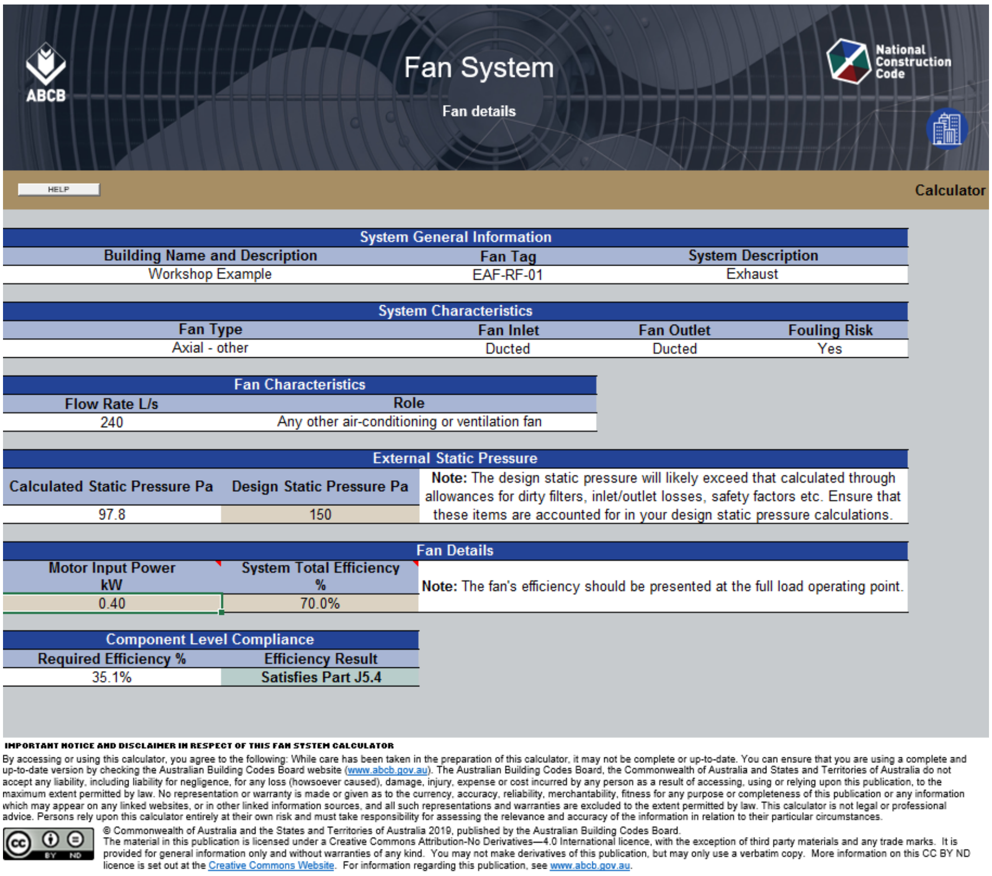


Figure 13.13 Fan System Calculator 'Fan Details' page – exhaust fan



13.9 Ductwork insulation

To reduce energy loss, ductwork and fittings in an *air-conditioning* system need to be insulated. The insulating requirements do not apply to ventilation ductwork where the air is not heated or cooled (such as the return air), as the temperature of this air does not need to be maintained.

13.9.1 Ductwork and fittings

J5.5(a) outlines the basic requirements for insulation. Under J5.5(a)(i), insulation must comply with the requirements of AS/NZS 4859.1 which covers the technical requirements for insulation.

> ***Alert:***
>
> AS 4859.1 is the Australian standard for, "General criteria and technical requirements of materials for the thermal insulation of buildings" and covers testing,

Alert:

installation and calculations. The Standard specifies requirements and methods of test for materials that are added to, or incorporated in, *opaque* envelopes of buildings and building services, including ductwork and pipework, to provide thermal insulation by moderating the flow of heat through these envelopes and building services. *DTS Provisions* are based on AS 4859.1 calculation methods.

J5.5(a)(ii) specifies the minimum material *R-Values* of flexible ductwork, cushion boxes and other ductwork and fittings. A lower *R-Value* is allowed for flexible ductwork to account for the greater practicality of insulating solid ductwork. As the amount of flexible ductwork in a system is limited by J5.4(c)(ii), it will only have a small impact upon the system as a whole. Cushion boxes and other ductwork requires the insulation levels listed in Table J5.5. These vary depending on the conditions that the ductwork is exposed to, indicating that there are greater energy losses in more severe conditions (i.e. when exposed to sunlight).

Note that the insulation levels in Table J5.5 are minimum material *R-Values* of the added insulation only. The *R-Values* are based on the location and *climate zone* of the installed ductwork and fittings.

13.9.2 **Integrity of the insulation barrier**

J5.5(b) outlines the specific requirements of the ductwork insulation.

J5.5(b)(i) specifies that the insulation must be protected against the effects of weather and sunlight. A typical design life of insulation is between 5 to 10 years. Lack of protection to the effects of weather and sunlight will drastically reduce the design life, and in turn its insulating properties. This protection may be achieved by ensuring that the insulation is enclosed in protective sheathing such as formed metal sheeting, external grade plastics or other similar material.

J5.5(b)(ii) requires insulation to be installed so that it forms a continuous barrier by abutting adjoining insulation. This limits heat loss or gain through any gaps in the insulation. The insulation should also maintain its position and thickness other than at flanges and supports. Any compression of insulation can reduce its effectiveness.

J5.5(b)(iii)(A) requires a vapour barrier (such as duct tape or other impervious seals) to be installed around the insulation on ductwork that carries cold air. This vapour barrier controls the level of condensation resulting from the cold surface. Condensing moisture can saturate the insulation, which reduces its effectiveness and causes it to deteriorate.

J5.5(b)(iii)(B) states that where the vapour barrier is used as a membrane, it must overlap by 50 mm and be bonded or taped together to ensure the vapour barrier membrane can function as intended.

13.9.3 **Exemptions**

J5.5(c) exempts situations where ductwork and fittings do not need to be in accordance with the requirements of J5.5(a) as there are cases where it may be impractical or pointless to do so.

Design alert: Combustibility of duct materials

NCC Volume One - Specification C1.10, clause 5 requires flexible ductwork to comply with the fire hazard properties set out in AS 4254.1 and AS 4254.2. Compliance with these Standards should be validated by appropriate test reports in accordance with Clause A2.2 of the NCC.

J5.5(c)(i) exempts the insulation requirements from ductwork and fittings located within the only room or last room served. It is implied that the heating or cooling effect is intended for that room anyway and therefore insulation in unnecessary. However, if a room where the ductwork is not insulated is sub-divided, the insulation will then need to be added to the ductwork that passes through the first sub-divided room to serve the second sub-divided room. Examples where this should be considered are parts of a building or storey likely to be sub-divided as part of a fit-out such as an office.

J5.5(c)(ii) exempts fittings that form the interface with the *conditioned space* as there would be minimal heat transfer occurring from these fittings. Examples include air registers, diffusers, outlets and grilles. This however, does not exempt cushion boxes, which are specifically included by J5.5(a)(ii)(B).

J5.5(c)(iii) exempts the minimum insulation requirements from return air ductwork in, or passing through, a *conditioned space*. There would be no heat transfer across the ductwork in these areas as the air temperature would be the same in both the duct and the *conditioned space*.

J5.5(c)(iv) exempts ductwork containing unconditioned outdoor air or exhaust air ductwork where the air is to be discarded. There would be no benefit gained, in terms of reducing energy consumption, by requiring insulation to be installed on this ductwork as the air is to be discarded and not reused. In some cases, designers may choose to insulate this ductwork to reduce condensation, but this is at their discretion and outside the scope of the energy efficiency requirements.

J5.5(c)(v) exempts the floor of an in-situ *AHU* from the insulation requirements of J5.5(a) on the basis that the heating or cooling effect is intended for that location anyway.

J5.5(c)(vi) exempts *air-conditioning* equipment that complies with *MEPS*.

Reminder:

MEPS means the *Minimum Energy Performance Standards*.

J5.5(c)(vii) exempts flexible fan connections.

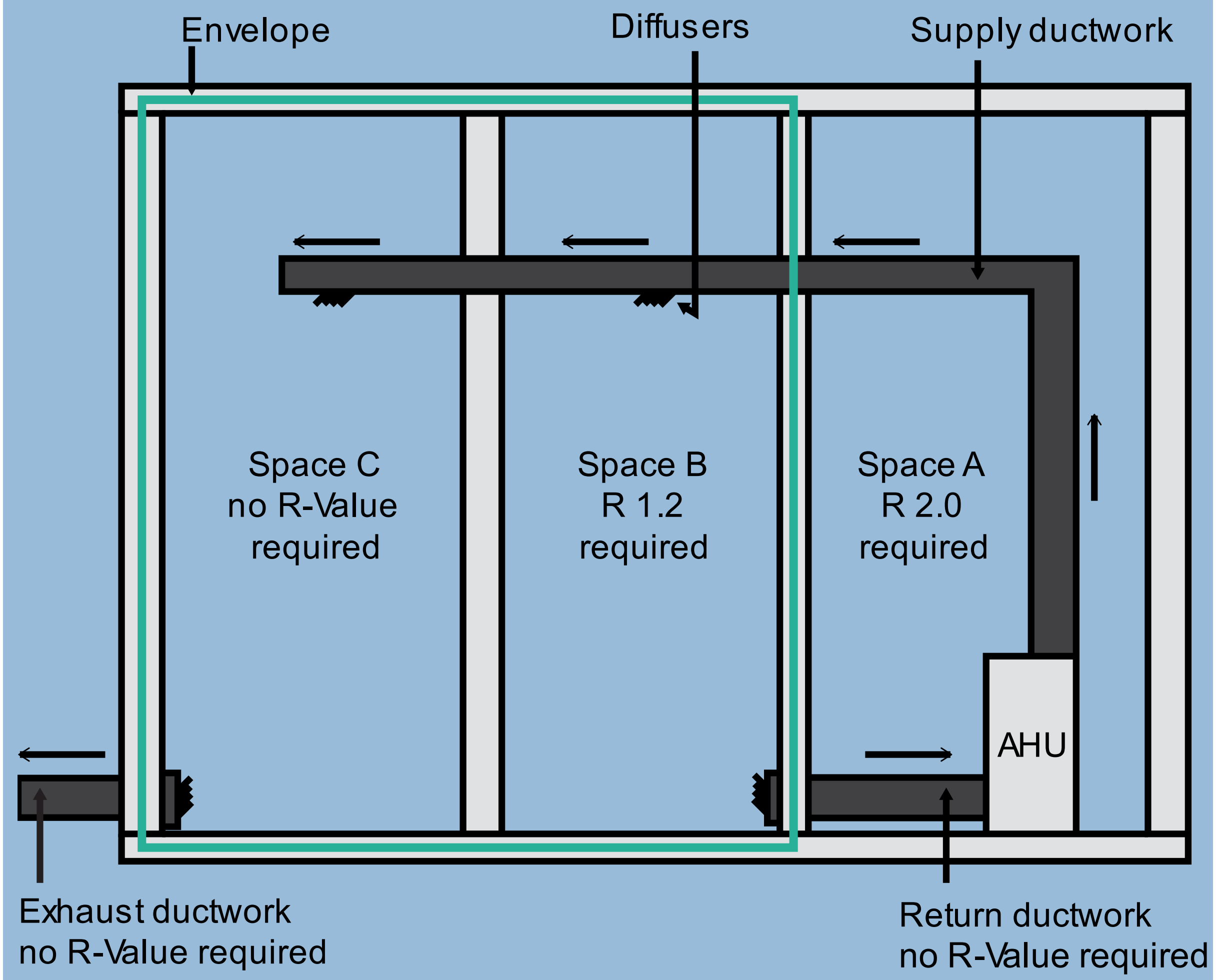
Design alert:

Note that air-handling ductwork must also comply with Clause 5 of Specification C1.10 in NCC Volume One, which requires the fire hazard properties of ductwork to comply with AS 4254.1 and AS 4254.2.

The application of the ductwork insulation requirements is shown in the following example.

Example: Ductwork insulation

Table 13.2 Ductwork section



The building is in *climate zone* 5 and the ductwork is greater than 3 m in length.

Space A is not conditioned; therefore, insulation must be installed to the supply and return ductwork with a minimum *R-value* of R 2.0 as per Table J5.5.

Space B is a *conditioned space*; therefore, insulation with a minimum added *R-Value* of R 1.2 from Table J5.5 is required to be installed on the supply ductwork. No insulation is needed for the return ductwork in Space B as it is exempted by J5.5(c)(iii).

Example: Ductwork insulation

Space C is a *conditioned space*. Since it is the last room served by the system, the insulation requirements of J5.5(a) do not apply to the ductwork.

In Space B and C, the diffuser forms the interface with the *conditioned space* and is therefore exempt from the insulation requirements of J5.5(a) by J5.5(c)(ii).

The exhaust ductwork is exempt from the insulation requirements of J5.5(a) by J5.5(c)(iv).

Note that the requirements of Section C - Fire resistance in NCC Volume One may also apply.

13.9.4 **Fittings**

For the purposes of J5.5(a), (b) and (c), ‘fittings’ includes passive or static components of a ductwork system and excludes active components of a ductwork system such as those used in an *AHU*.

Passive or static components of a ductwork system include items such as plenums, bends, branches, transitions, reducers, offsets, spigots, cushion heads, attenuators and fixed air balance dampers. These passive or static components of a ductwork system must therefore meet the insulation requirements of section J5.5.

Active components may include VAV boxes, electric duct heaters, actuated volume control dampers, access panels and doors, fire and smoke dampers, fans or humidifiers. These components often move or require regular access which would make insulation on the components impractical. Therefore, active components of a ductwork system are exempt from the insulation requirements of section J5.5.

13.10 **Ductwork sealing**

Unsealed joints in *air-conditioning* ductwork allows heated or cooled air to leak. J5.6 requires that ductwork must be sealed in accordance with AS 4254.1 and AS 4254.2

for the static pressure in the system. Sealing methods include adhesives, mastics, sealants, gaskets or the like. These requirements do not apply to ventilation ductwork where the air is not heated or cooled.

Alert:

AS 4254 is the Australian standard for, “Ductwork for air-handling systems in buildings”. Part One of the standard includes requirements for materials, construction and installation, including some aspects of performance, for flexible duct for air-handling systems in buildings and facilities.

The requirements only apply to duct systems with a capacity of 3000 L/s or greater.

The duct leakage tests of clause 2.2.4 of AS 4254.2 are included in this requirement. The key purpose of this is to ensure that there are no major leaks, such as uncapped spigots or similar, in the system. Construction errors of this nature can cause extreme leakage rates in some systems, severely compromising system performance.

13.11 Pump systems

J5.7 specifies two options for demonstrating compliance for pump systems that form part of an *air-conditioning* system.

One option is to demonstrate that each individual component within the pump system is individually more efficient than the values specified in J5.7. This allows for a relatively simple comparison against a DTS efficiency value for each component of the pump system.

Alternatively, demonstrating that the pump system (as a whole) is more efficient than a comparative pump system (also as a whole) designed to meet all individual DTS requirements. This allows for increased flexibility when design constraints prevent the individual component level metrics from being met, without the need for a JV3 calculation or other *Performance Solution*.

13.11.1 General

The two options for demonstrating compliance are specified in J5.7(a).

J5.7(a)(i) specifies the option for component-level compliance and requires compliance with each of J5.7(b), (c) and (d).

J5.7(a)(ii) outlines the option for whole-of-system compliance. The designed pump motor power per unit of flowrate (e.g. W/L/s) of the pump in the system must be lower than that as if the system was designed in accordance with J5.7(b), (c) and (d). In other words, the pump system (as a whole) must be more efficient than a system designed to meet the individual component requirements. If a pump system is compliant with J5.7(a)(ii), it does not need to comply with J5.7(b), (c) or (d). For situations where certain reticulation configurations do not meet the requirements of J5.7(a)(i), this method would be appropriate.

13.11.2 Circulator pumps

J5.7(b) specifies the efficiency requirements for circulator pumps that form part of an *air-conditioning* system. J5.7(b) is a requirement if the component-level compliance option of J5.7(a)(i) is used.

J5.7(b) applies to glandless impeller pumps used in a closed loop system with a rated hydraulic power output below 2.5 kW. The clause specifies that the glandless impeller pump must have an energy efficiency index (EEI) of less than or equal to 0.27. The EEI must be calculated in accordance with European Union Commission Regulation No. 622/2012.

The EEI compares the weighted average power with a calculated reference. This reference is calibrated such that only 20% of circulators or a certain type have an EEI less than or equal to 0.20. The lower the EEI, the less energy the circulator uses. The EEI is a characteristic of the pump, and so should be included in the data provided by pump manufacturers.

A Pump System Calculator has been developed by the ABCB to aid in the EEI calculations. See a detailed description of the Calculator in Chapter 13.11.2.

Alert:

The European Union Commission Regulation No. 622/2012 is the regulation for eco-design requirements for glandless standalone circulators and glandless circulators integrated in products. It provides the calculation methods to determine the EEI for circulator pumps.

13.11.3 **Other pumps**

J5.7(c) nominates the efficiency requirements of other pumps that form part of an *air-conditioning* system. J5.7(c) is a requirement if the component-level compliance option of J5.7(a)(i) is used.

The clause applies to pumps not covered by J5.7(b). The clause specifies that the pump must have a Minimum Efficiency Index of at least 0.4. The Minimum Efficiency Index must be calculated in accordance with European Union Commission Regulation No. 547/2012.

The Minimum Efficiency Index is a dimensionless comparator which indicates the minimum efficiency required for a pump. The Minimum Efficiency Index does not directly correlate to an efficiency value, but to the value of a constant within an equation in European Commission Regulation No. 547/2012 which then determines the minimum efficiency. Unlike the EEI for circulator pumps, a greater Minimum Efficiency Index indicates a greater efficiency and thus less energy use.

A Pump System Calculator has been developed by the ABCB to aid in the Minimum Efficiency Index calculations. See a detailed description of the Calculator in Chapter 13.11.2.

It is intended that almost all pumps are covered by either European Union Commission Regulation No. 622/2012 or No. 547/2012. If a pump is not covered, a *Performance Solution* may be appropriate. The methodology of J5.7(a)(ii) could serve as a starting point for such a *Performance Solution*.

13.11.4 Pipework

J5.7(d) specifies the maximum allowable pressure losses for straight segments of pipework that form part of an *air-conditioning* system. J5.7(d) is a requirement if the component-level compliance option of J5.7(a)(i) is used.

J5.7(d)(i) specifies the allowable pressure losses attributable to straight segments of pipework, that do not have branches and have a constant flowrate through the entire pipe network (i.e. a non-distributive pipework system). Pressure losses for constant speed systems are listed in Table J5.7b and pressure losses for variable speed systems are listed in Table J5.7c.

J5.7(d)(ii) specifies the allowable pressure losses attributable to straight segments of pipework in other pipework systems (i.e. distributive pipework systems). Pressure losses for constant speed systems are listed in Table J5.7d and pressure losses for variable speed systems are listed in Table J5.7e.

The variance of requirements for pressure drops across different types of systems indicate the differences in energy use from these systems. Systems which operate for a shorter period have a smaller aggregate energy use, and so have loosened requirements. Incorporating variable speed control into a system will also reduce the aggregate energy use and allow for a similar loosening of requirements.

References such as CIBSE Guide C (Section 4.4 Water flow in pipes) and AIRAH Design Application Manual DA01 Centrifugal Pumps provide details of pump system design that could be used in preparing a *Performance Solution*.

13.11.5 Exemptions

J5.7(e)(i) exempts the requirements of J5.7(d) from valves and fittings. This is because the average pressure drop in these are largely determined by the functional requirements of the system.

J5.7(e)(ii) exempts the requirements of J5.7(d) from the smallest compliant pipework with a velocity of 0.7 m/s or less. This does not refer to the smallest pipework within the proposed design, the exemption refers to the smallest pipework allowable in proposed the design. See the example below for further clarification.

Example: J5.7(e)(ii) exemption check

An *air-conditioning* system operates for less than 5000 hours/annum. The system is a distributive (i.e. has branches), variable speed system. A segment of pipe within the index run of the *air-conditioning* system has a flow rate of 6 L/s and a diameter of 150 mm.

Pressure drop

The pressure drop requirements for the distributive, variable speed system is found in Table 5.7d. Therefore, for any pipe size in the index run of this system, the maximum pressure drop is 400 Pa/m.

Velocity

First the velocity of the proposed segment of pipe is determined. The segment of pipe analysed is a copper Type B to AS1432 pipe, with a water temperature of 6°C. The surface roughness of the copper pipe is 0.0015 mm. Based on these characteristics, and the known flow rate of 6 L/s and diameter of 150 mm, the velocity of liquid in the segment of pipe is 0.35 m/s.

Note that the ABCB's Pump System Calculator can calculate the velocity of each segment of pipe within the index run.

Determining smallest compliant pipe size

The diameter of the segment of pipe can be decreased until the pressure drop no longer complies with the requirements of J5.7(d), which for this example is found Table 5.7d.

150 mm diameter:	9.3 Pa/m pressure drop and 0.35 m/s velocity
125 mm diameter:	22.1 Pa/m pressure drop and 0.50 m/s velocity
100 mm diameter:	66.5 Pa/m pressure drop and 0.79 m/s velocity
90 mm diameter:	128.7 Pa/m pressure drop and 1.05 m/s velocity
80 mm diameter:	277.7 Pa/m pressure drop and 1.44 m/s velocity
65 mm diameter:	651.6 Pa/m (above maximum allowable pressure drop)

Example: J5.7(e)(ii) exemption check

Therefore, the smallest pipe size compliant with J5.7(d) is 80 mm. However, when the smallest pipe size is chosen, the velocity is above 0.70 m/s (1.44 m/s).

Result

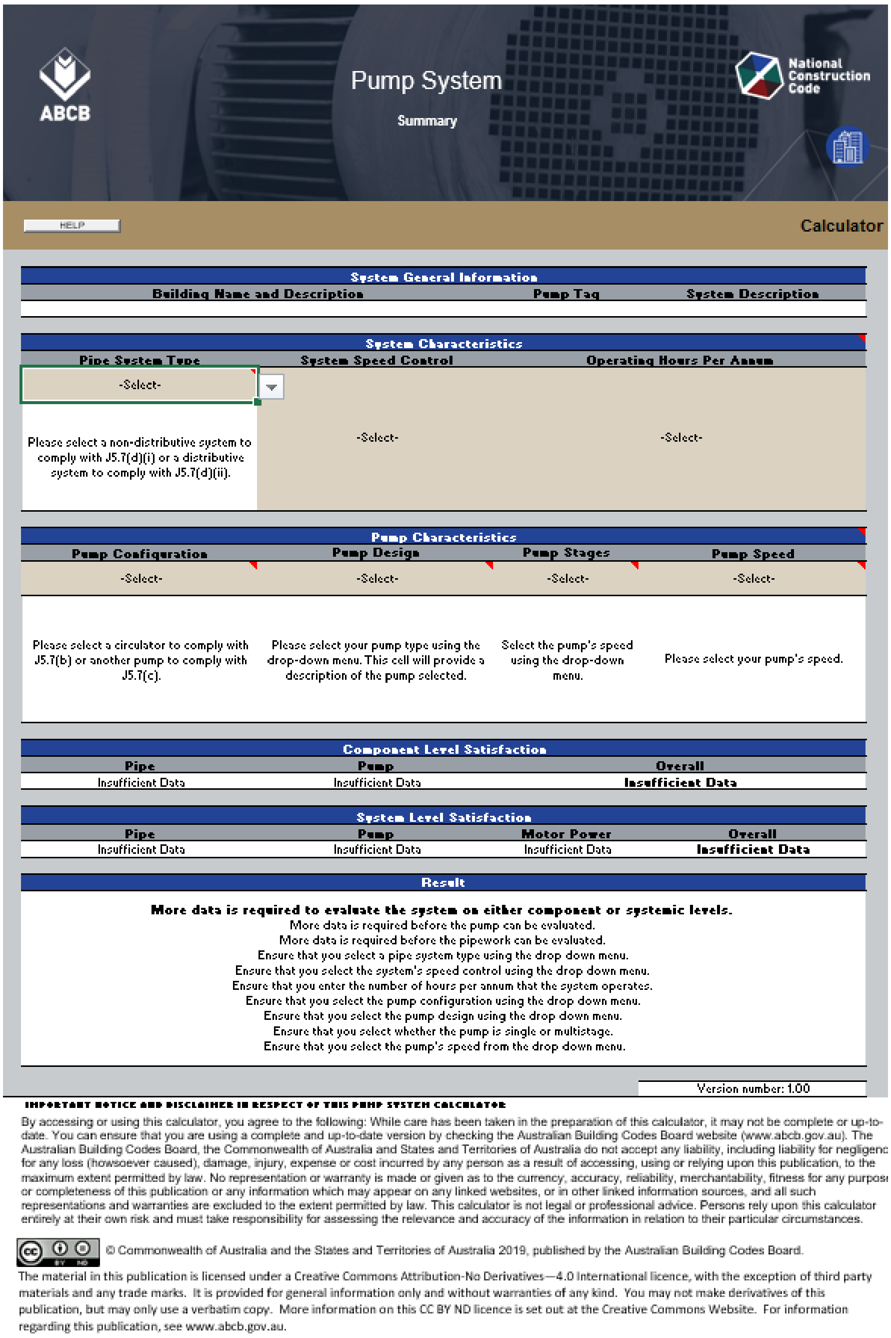
Therefore, while the proposed velocity of the pipe is less than 0.70 m/s, this segment of pipework is not exempt from the requirements of J5.7(d) as the smallest compliant pipe size results in a velocity greater than 0.70 m/s.

Note that the ABCB's Pump System Calculator automatically calculates whether segments of pipe will meet the requirements of J5.7(e).

13.11.6 **Pump System Calculator**

The ABCB has developed a Pump System Calculator to assist with demonstrating compliance with the NCC pump system provisions.

Figure 13.14 Introductory page of the ABCB Pump System Calculator



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

Calculator ribbon

When the Pump System Calculator is first opened, the custom Pump System Calculator ribbon will appear, rather than the normal Microsoft Excel menu.

- System Select – Brings down a list of pump tags. Clicking on a pump tag will change the active system to that pump tag.
- Navigation – All Systems, Summary, Pipe Details and Pump Details navigates to that sheet for the system which is active. Worksheet provides a space for notes and calculations.
- Reporting – The report sheet brings together the summaries for all systems and can be printed.
- Help – A link to the Pump System Calculator help guide.
- Zoom – Zoom functions for ease of accessibility.

All Systems

The 'All Systems' sheet functions as a schedule of pumps and summarises information about the project and each system within.

- Building Name and Description, Project Number, Designer and Company –Used for identification of the project. This is simply to provide context for the user and will repeated in the report generated at the end.
- System Description and Pump Tag – Creates a schedule of each pump system. Systems can be added (+), removed (-), copied (C) and pasted (P) until all systems are recorded. The default (D) button sets a particular system as default, when adding a new system, it will be a copy of the default system.

13.11.6.1 Summary

The Summary sheet functions as a hub for system information and storing results.

System General Information:

- Building Name, Pump Tag and System Description – Used for identification of the project and pump systems. These will be automatically filled based on the information in All Systems.

System Characteristics:

- Pipe System Type – This cell requires the selection of either a non-distributive system (per J5.7(d)(i)), or a distributive system (per J5.7(d)(ii)).
- System Speed Control – This cell requires a selection of either constant or variable speed. This determines whether you need to comply with (A) or (B) within J5.7(d)'s sub-clauses.
- Operating Hours Per Annum – This cell requires the number of hours per annum the system operates. This can be computed by considering a typical period and

extrapolating to the year. The number of hours per annum is used within Table J5.7b to Table J5.7e.

Pump Characteristics:

- Pump Configuration – This cell requires a selection of either a circulator pump (per J5.7(b)) or 'other' pumps (per J5.7(c)). Most pumps come under the 'other' category, unless this is specifically a circulating system.
- Pump Design – This cell offers a selection of pump designs from the options contained within EU Commission Regulation No. 547/2012. If the pump is a circulator type pump, the design may not be listed in the options given, in this case, select other.
- Pump Stage – This cell requires the selection of a single or multistage pump. If the pump has multiple series impellers, then then the pump is a multistage pump, otherwise, it is a single stage pump.
- Pump Speed – Unless the pump is a circulator pump, this cell must match the allowed pump designs of EU Commission Regulation No. 547/2012. The Calculator's results will inform if an invalid speed is selected.

Links to the EU Commission Regulations regarding Circulators and Other Pumps are provided in the Chapter 17: References.

13.11.6.2 Pipe Details

System Characteristics:

- The system characteristics provided in the Summary are listed for reference.
- Use Simple Method – The simple method is intended for designers who have already calculated the average pressure drop through the design process.
- Use Complex Method – The complex method models the system and calculates the pressure drop.

Simple Method:

- Diameter Present – A list of pipe diameters included in Tables J5.7a to J5.7d. Tick the checkbox if it is included within the system, untick if it is not.
- Average Pressure Drop – The system's average pressure drop, in Pa/m, and is determined from the designer's calculations.

Complex Method:

The complex method builds the index run of the pipe system and determines whether it complies with J5.7(d).

- Description – Piping system for identification.

- Material – This cell requires a choice of copper, light, medium and heavy steel and PVC to Australian Standard or a custom material.
- Temperature – System fluid temperature in °C.
- Flow Rate – Rate of water flow in L/s.
- Diameter – If a material is selected to Australian Standards, a nominal diameter will automatically fill this cell. However, if a custom material is entered this cell will need to be filled manually.
- Length – Length of piping in metres.

Piping details can be added (+), removed (-), copied (C) and pasted (P) until all systems are recorded. The default (D) button sets a particular row as default, when adding a new row, it will be a copy of the default row.

- Roughness – Material roughness (mm) from historic testing is documented in many industry guidance materials, including for example AIRAH DA16, the AIRAH handbook or the ASHRAE handbook.

Once the above details are entered, the Calculator will determine the pressure drop of each section of pipe and compare it to the requirement of J5.7(d), and also apply the velocity check of J5.7(e)(ii) to each section of pipe and account for this. These results determine the average pressure drop through the lengths of pipe provided in the index run. The average pressure drop is then compared with the pressure drop allowed in J5.7(d). The Calculator will then determine whether the piping complies with J5.7(d) on a component level.

13.11.6.3 Pump Details

The pump details sheet will change depending on selections in the summary sheet.

For circulator type pumps:

- EEI and hydraulic power – Both the pump's EEI and hydraulic power should be available from the pump supplier.

For other pumps:

- Simple Method – This cell requires the pump's Minimum Efficiency Index. This is usually available with a supplier's pump selections. Using the simple method will determine whether the pump complies at a component level, however if a system wide check is required under J5.7(a)(ii), the alternate method must be used.

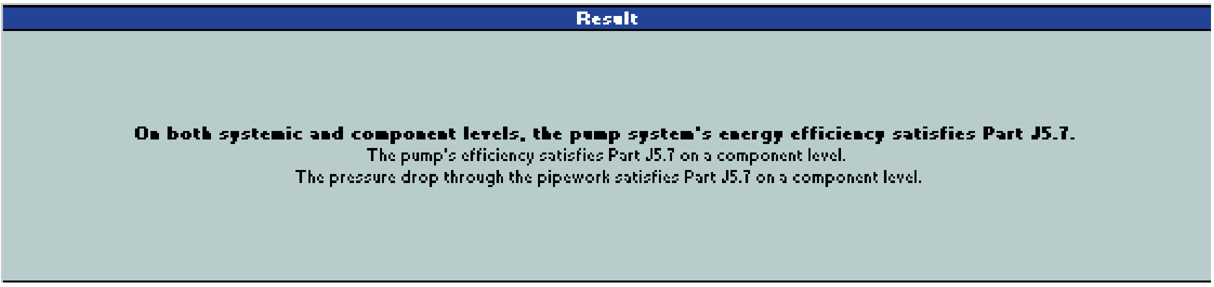
- Use Alternate Method – The alternate method uses the procedure within EU Commission Regulation No. 547/2012 to compute the required efficiency and compare it with the actual efficiency.
- Water Flow Rate – Rate of water flow at the BEP.
- System Head – System head at the BEP.
- Efficiency – Efficiency of the pump at the BEP.

The calculator will determine the efficiency required to comply with the Minimum Efficiency Index and compare that with the pump, to determine if the selection complies with J5.7(c) on a component level.

13.11.6.4 Results

Results are found on the Summary sheet. The Summary sheet will compile the results of each component, to determine if compliance with (b), (c) and (d) is met under J5.7(a)(i). If compliance is not met at a component level under J5.7(a)(i), and all the data has been provided the calculator will also check compliance on a system level under J5.7(a)(ii). To check compliance on a system level within the calculator, the Alternate Method for ‘other’ pumps must be used. This method requires more information than the Simple Method including the water flow rate, system head, number of pump impellers and the efficiency.

Figure 13.15 Example of Summary page in the ABCB Pump System Calculator showing compliance



13.11.6.5 Reporting

- The ‘All Systems’ sheet provides a quick summary of each system.
- The ‘Go To Report’ button on the ribbon generates a more complex report on the whole project.

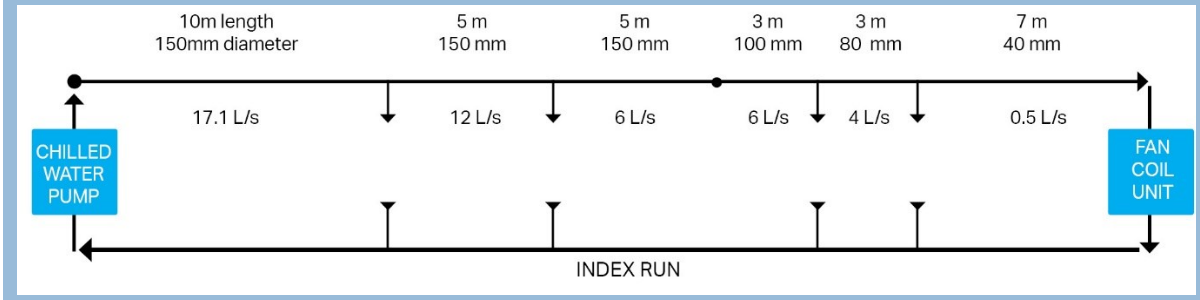
Example:

Consider a chilled water pump located in a university. The chilled water pump operates for approximately 12 hours a day with a fluid temperature of 6°C. The pumps water flow rate is 17.1 L/s. The system head is 300 kPa and the efficiency at the BEP is 75%.

The Minimum Efficiency Index of the pump is equal to 0.55 when calculated in accordance with European Union Commission Regulation No. 547/2012.

The pipe system is a variable speed, distributive system. The straight segments of pipework along the index can be represented with the following diagram.

Figure 13.16 Straight pipework in index run



Straight segments of pipework along the index run include:

1: Copper Type B to AS1432, 150 mm diameter, 10 m length, 0.0015 mm roughness, 17.1 L/s flow rate, 60.1 Pa/m pressure drop

2: Copper Type B to AS1432, 150 mm diameter, 5 m length, 0.0015 mm roughness, 12 L/s flow rate, 31.9 Pa/m pressure drop

3: Copper Type B to AS1432, 150 mm diameter, 5 m length, 0.0015 mm roughness, 6 L/s flow rate, 9.3 Pa/m pressure drop

4: Copper Type B to AS1432, 100 mm diameter, 3 m length, 0.0015 mm roughness, 6 L/s flow rate, 66.5 Pa/m pressure drop

5: Copper Type B to AS1432, 80 mm diameter, 3 m length, 0.0015 mm roughness, 4 L/s flow rate, 134.8 Pa/m pressure drop

6: Copper Type B to AS1432, 40 mm diameter, 7 m length, 0.0015 mm roughness, 0.5 L/s flow rate, 104.8 Pa/m pressure drop

Example:

7: Copper Type B to AS1432, 40 mm diameter, 7 m length, 0.0015 mm roughness, 0.5 L/s flow rate, 104.8 Pa/m pressure drop

8: Copper Type B to AS1432, 80 mm diameter, 3 m length, 0.0015 mm roughness, 4 L/s flow rate, 134.8 Pa/m pressure drop

9: Copper Type B to AS1432, 100 mm diameter, 3 m length, 0.0015 mm roughness, 6 L/s flow rate, 66.5 Pa/m pressure drop

10: Copper Type B to AS1432, 150 mm diameter, 5 m length, 0.0015 mm roughness, 6 L/s flow rate, 9.3 Pa/m pressure drop

11: Copper Type B to AS1432, 150 mm diameter, 5 m length, 0.0015 mm roughness, 12 L/s flow rate, 31.9 Pa/m pressure drop

12: Copper Type B to AS1432, 150 mm diameter, 10 m length, 0.0015 mm roughness, 17.1 L/s flow rate, 60.1 Pa/m pressure drop

Please note the pressure drop across each component has been calculated using a pipe friction loss chart.

As per J5.7(a), pumps and pipework that form part of an *air-conditioning* system must either separately comply with the requirements of J5.7(b), (c) and (d) or achieve whole of system compliance (i.e. the proposed pumps and pipework achieve a pump motor input power lower than that of a system designed to meet the DTS requirements of J5.7(b), (c) and (d)).

The following example will be checked at a component level. Please note the Pump System Calculator determines if compliance is met at both a component and system level.

Step 1: Circulator pumps

J5.7(b) details requirements for the EEI for circulator pumps that must be met to achieve component compliance (i.e. J5.7(a)(i)).

Circulator pumps are glandless impeller pumps used in a closed loop system with a rated hydraulic power output below 2.5 kW.

Example:

The EEI must be calculated in accordance with European Union Commission Regulation No. 622/2012. The ABCB's Pump System Calculator calculates the EEI using this method.

However, as the specified pump in the example is not a circulator pump this requirement is not relevant.

Step 2: Other pumps

J5.7(c) details requirements for the Minimum Efficiency Index of other pumps that must be met to achieve component compliance (i.e. J5.7(a)(i)).

Other pumps refer to pumps not covered by J5.7(b) (i.e. pumps that are not circulator pumps).

The Minimum Efficiency Index must be calculated in accordance with European Union Commission Regulation No. 547/2012. The ABCB's Pump System Calculator calculates the Minimum Efficiency Index using this method.

As the Minimum Efficiency Index (0.55) is greater than that specified in J5.7(c) (0.4), compliance is met with J5.7(c).

Please note the Pump System Calculator will determine the Minimum Efficiency Index in accordance with European Union Commission Regulation No. 547/2012 for component level compliance. However, if a whole of system check is required under J5.7(a)(ii), an alternate method is used. This method uses the procedure within EU Commission Regulation No. 547/2012 to compute the required efficiency and compare it with the actual efficiency.

Example:

Step 3: Pipework

J5.7(d) specifies average maximum pressure drops for straight segments of pipework along the index run that must be met to achieve component compliance (i.e. J5.7(a)(i)).

As the pipework system is distributive and variable speed, the pressure drop of straight segments of pipework must not be more than the values nominated in Table J5.7e.

The operating hours per annum for a system that operates for approximately 12 hours a day fall between 2000 and 5000 hours (multiply the operating hours per day by the number of days in operation to determine the number of hours per annum).

Table J5.7e specifies that all nominal pipe diameters for the above range in hours have an average maximum allowable pressure drop of 400 Pa/m.

As pipes 1 to 6 have pressure drops below that specified in Table J5.7e (400 Pa/m), compliance is evidently met with the requirements of J5.7(d). If the segments of pipework do not all meet the requirements of the maximum allowable pressure drop, the average pressure drop is calculated by summing the pressure drop (Pa) of each segment of pipe and dividing this by the total length of all segments; as follows:

$$\frac{2 \times \left((60.1 \times 10) + (31.9 \times 5) + (9.3 \times 5) + (66.5 \times 3) + (134.8 \times 3) + (104.8 \times 7)\right)}{2 \times (10 + 5 + 5 + 3 + 3 + 7)}$$

$$Average\ pressure\ drop = 65.0\ Pa/m$$

Step 4: Exemptions

Valves and fittings are exempt from the pipework requirements (d).

Example:

The smallest pipe size compliant with J5.7(d) for each segment pipework would result in a velocity of greater than 0.7 m/s. Therefore, no segments of pipework are exempt from the requirements of J5.7(d).

Result

As the components of the pump system meet the compliance requirements of J5.7(c) and (d) (excluding J5.7(b) as the pump is not a circulator pump) the pump system complies on a component level.

Where the system is considered complex or does not meet individual component compliance but may meet whole of system compliance, the ABCB Pump System Calculator can provide a quicker way to undertake the calculations.

The figures below are images of the Calculator for the example above.

Figure 13.17 Pump System Calculator 'All Systems' page

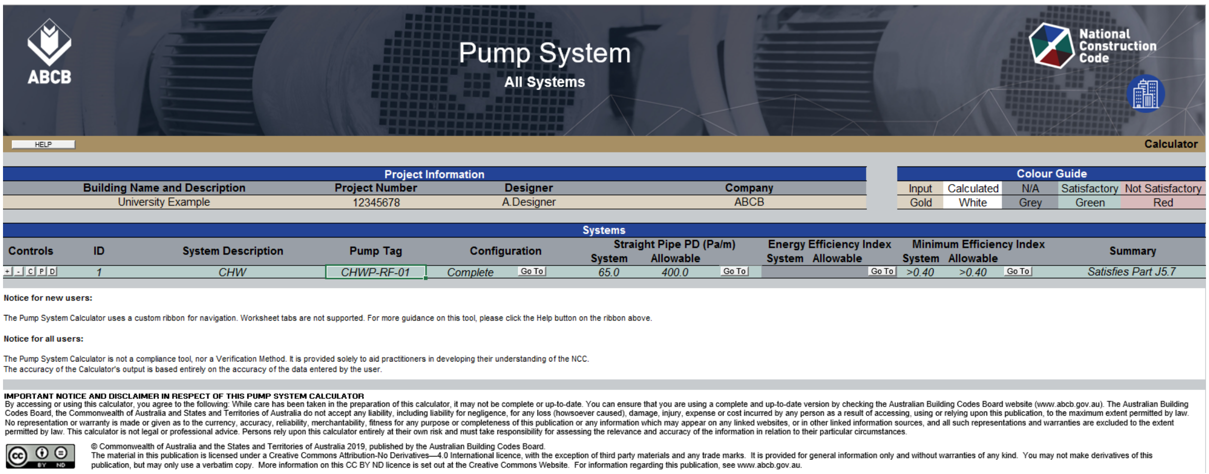


Figure 13.18 Pump System Calculator 'Summary' page

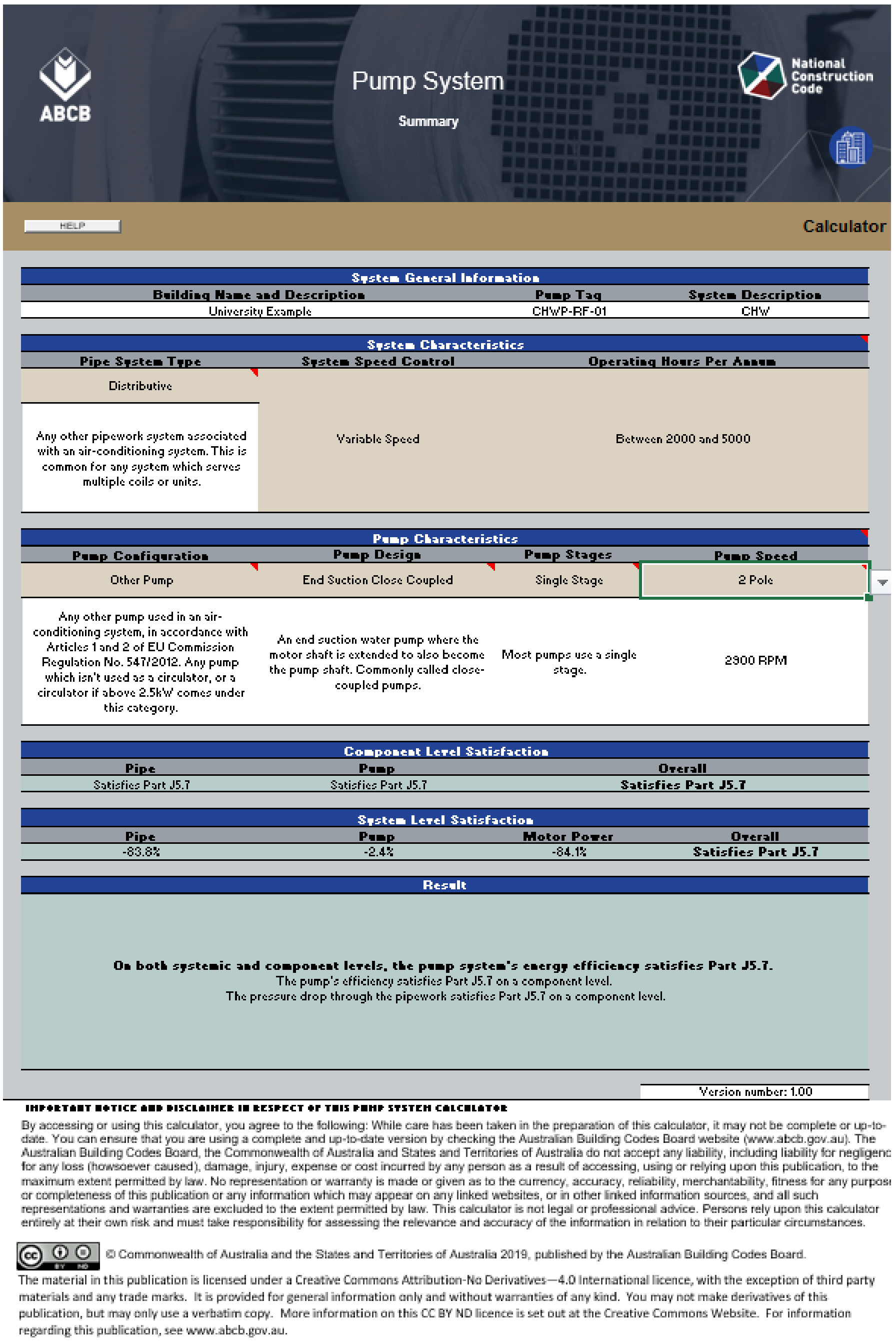
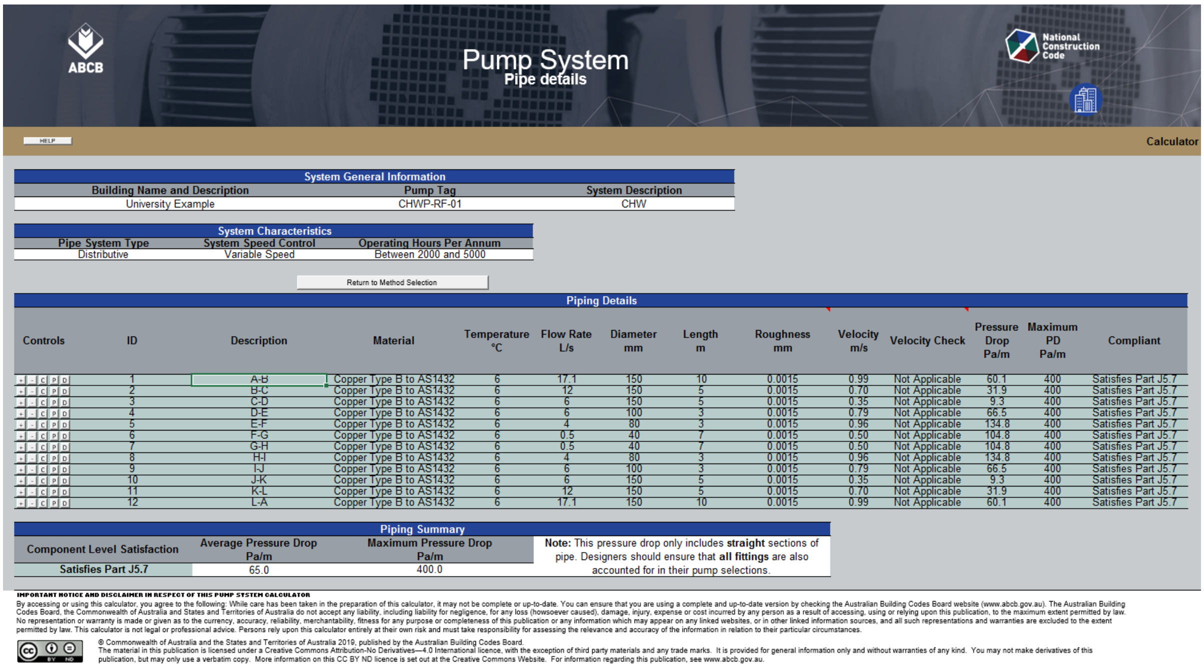


Figure 13.19 Pump System Calculator 'Pipe Details' page



System General Information		
Building Name and Description	Pump Tag	System Description
University Example	CHWP-RF-01	CHW

System Characteristics		
Pipe System Type	System Speed Control	Operating Hours Per Annum
Distributive	Variable Speed	Between 2000 and 5000

Piping Details

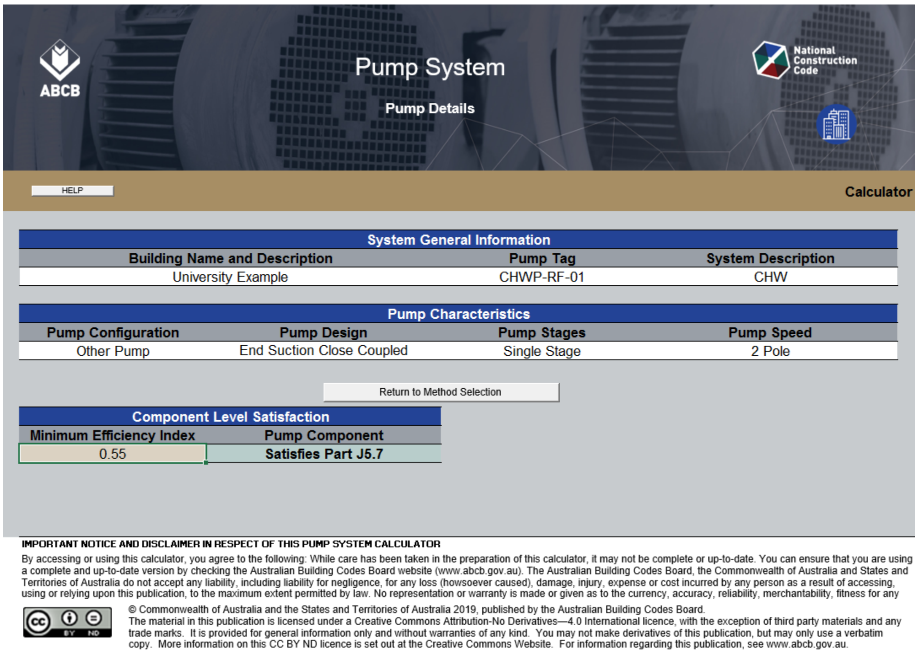
Controls	ID	Description	Material	Temperature °C	Flow Rate L/s	Diameter mm	Length m	Roughness mm	Velocity m/s	Velocity Check	Pressure Drop Pa/m	Maximum PD Pa/m	Compliant
+ - C P D	1	A-B	Copper Type B to AS1432	6	17.1	150	10	0.0015	0.99	Not Applicable	60.1	400	Satisfies Part J5.7
+ - C P D	2	B-C	Copper Type B to AS1432	6	12	150	5	0.0015	0.70	Not Applicable	31.9	400	Satisfies Part J5.7
+ - C P D	3	C-D	Copper Type B to AS1432	6	6	150	5	0.0015	0.35	Not Applicable	9.3	400	Satisfies Part J5.7
+ - C P D	4	D-E	Copper Type B to AS1432	6	6	100	3	0.0015	0.79	Not Applicable	66.5	400	Satisfies Part J5.7
+ - C P D	5	E-F	Copper Type B to AS1432	6	4	80	3	0.0015	0.96	Not Applicable	134.8	400	Satisfies Part J5.7
+ - C P D	6	F-G	Copper Type B to AS1432	6	0.5	40	7	0.0015	0.50	Not Applicable	104.8	400	Satisfies Part J5.7
+ - C P D	7	G-H	Copper Type B to AS1432	6	0.5	40	7	0.0015	0.50	Not Applicable	104.8	400	Satisfies Part J5.7
+ - C P D	8	H-I	Copper Type B to AS1432	6	4	80	3	0.0015	0.96	Not Applicable	134.8	400	Satisfies Part J5.7
+ - C P D	9	I-J	Copper Type B to AS1432	6	6	100	3	0.0015	0.79	Not Applicable	66.5	400	Satisfies Part J5.7
+ - C P D	10	J-K	Copper Type B to AS1432	6	6	150	5	0.0015	0.35	Not Applicable	9.3	400	Satisfies Part J5.7
+ - C P D	11	K-L	Copper Type B to AS1432	6	12	150	5	0.0015	0.70	Not Applicable	31.9	400	Satisfies Part J5.7
+ - C P D	12	L-A	Copper Type B to AS1432	6	17.1	150	10	0.0015	0.99	Not Applicable	60.1	400	Satisfies Part J5.7

Piping Summary		
Component Level Satisfaction	Average Pressure Drop Pa/m	Maximum Pressure Drop Pa/m
Satisfies Part J5.7	65.0	400.0

Note: This pressure drop only includes **straight** sections of pipe. Designers should ensure that **all fittings** are also accounted for in their pump selections.

- The Complex Method for Pipe Details was used in the example as per Figure 13.19. The Complex Method was chosen as the average pressure drop was not known. The complex method models the system and calculated the pressure drop.

Figure 13.20 Pump System Calculator 'Pump Details' page – Simple Method



System General Information		
Building Name and Description	Pump Tag	System Description
University Example	CHWP-RF-01	CHW

Pump Characteristics			
Pump Configuration	Pump Design	Pump Stages	Pump Speed
Other Pump	End Suction Close Coupled	Single Stage	2 Pole

Component Level Satisfaction	
Minimum Efficiency Index	Pump Component
0.55	Satisfies Part J5.7

Figure 13.20 shows the Pump System Calculator evaluating the pump compliance using the Simple Method. The Simple Method is used when the pump's Minimum

Efficiency Index is known, but can only be used for component level compliance as per J5.7(a)(i).

Figure 13.21 Pump System Calculator 'Pump Details' page – Alternate Method

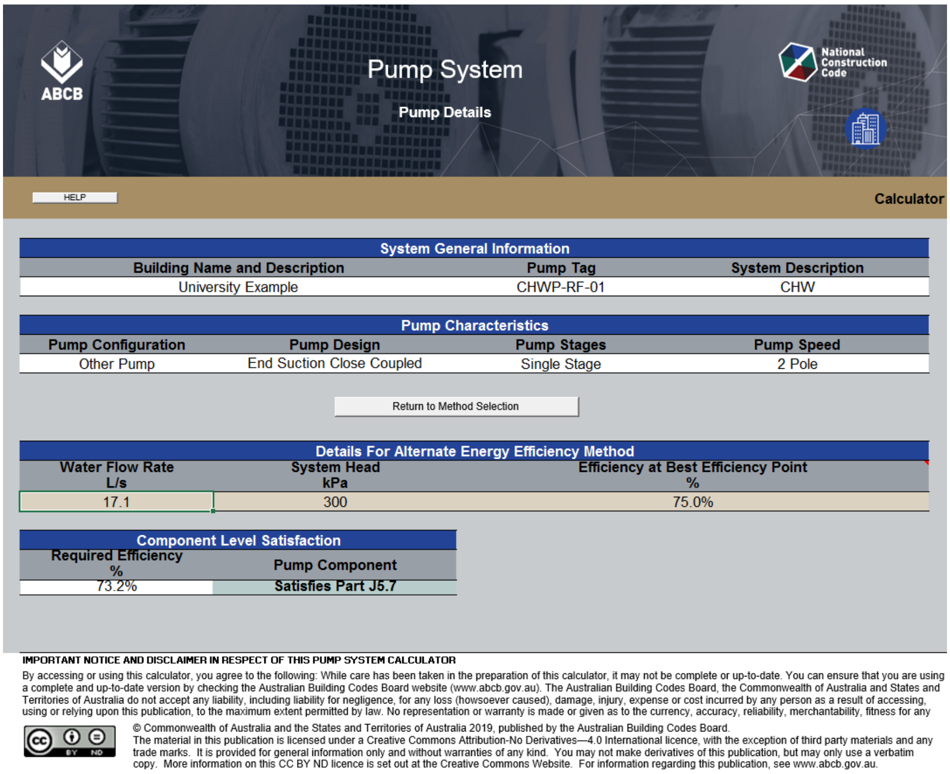


Figure 13.21 shows the Pump System Calculator evaluating the pump compliance using the Alternate Method for Pump Details. The Alternate Method requires more information than the Simple Method, however it can analyse the system, for compliance with either J5.7(a)(i) or J5.7(a)(ii).

13.12 Pipework insulation

J5.8 requires piping, vessels, heat exchangers and tanks that contain heating and cooling fluids that are part of an *air-conditioning* system to be insulated. Heating fluids include heated water, steam and condensate. Cooling fluids include refrigerant, chilled water, brines and glycol mixtures; but do not include condenser cooling water. Piping, vessels, heat exchangers and tanks that are covered by *MEPS* are exempt from these requirements.

J5.8(a)(i) specifies that insulation must comply with the requirements of AS/NZS 4859.1.

Alert:

AS 4859.1 is the Australian Standard for, “General criteria and technical requirements of materials for the thermal insulation of buildings”. The Standard specifies requirements and methods of test for materials that are added to, or incorporated in, *opaque* envelopes of buildings and building services, including ductwork and pipework, to provide thermal insulation by moderating the flow of heat through these envelopes and building services. *DTS Provisions* are based on AS 4859.1 calculation methods.

J5.8(a)(ii) specifies the insulation requirements for piping of heating and cooling fluids. Table J5.8a outlines minimum total insulation *R-Values* based on fluid temperature and a nominal diameter of the water piping. The single required *R-Value* for each pipe diameter is intended to allow for straightforward installation on-site and compliance to be achieved.

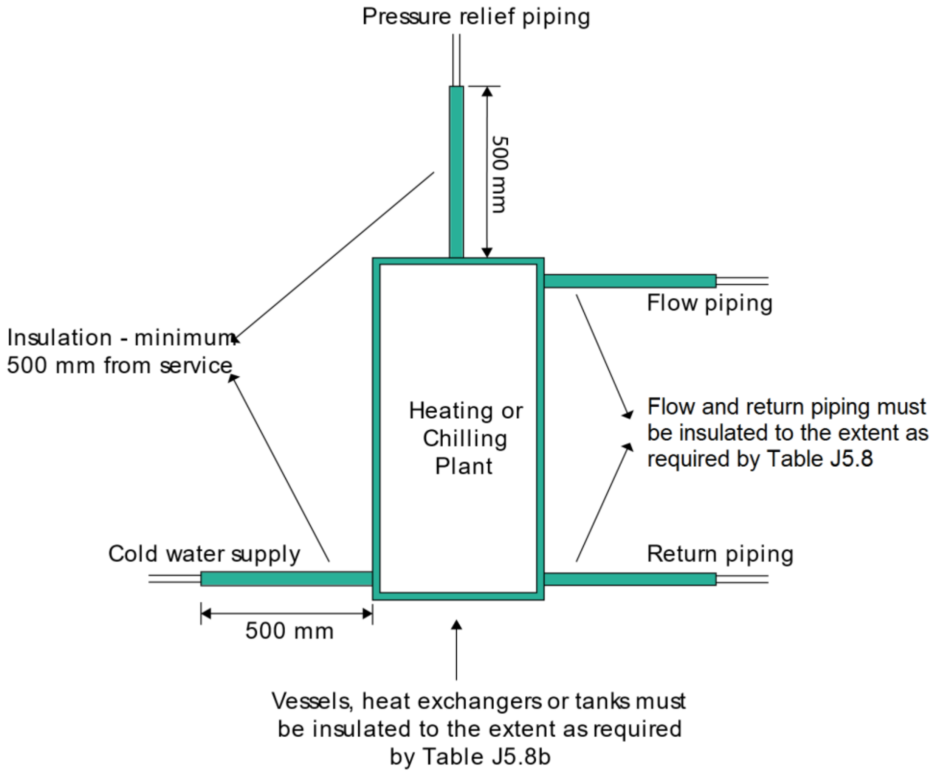
For example, a pipe with a diameter of less than 40 mm carrying a chilled fluid of a temperature above 2°C requires a minimum *R-Value* for pipework insulation of 1.0, as specified in Table J5.8a.

The note to Table J5.8a outlines scenarios where the required insulation *R-Value* may be halved. The concession recognises the practical and physical limitations of installing thick insulation to small diameter piping where the pipework penetrates a structural member. Where the pipework penetrates a structural member, piping is only required to have insulation installed that is half of the added *R-Value* required by Table 2a.

J5.8(a)(iii) outlines that insulation requirements for vessels, heat exchangers and tanks are in Table J5.8b. This table specifies minimum insulation *R-Values* based on the fluid temperature range.

J5.8(a)(iv) specifies that insulation requirements apply to refill and pressure relief piping within 500 mm of the connection to the *air-conditioning* system. The piping must have an *R-Value* equal to the required *R-Value* of the pipe, vessel or tank connected to the piping.

Figure 13.22 Insulation of piping serving a heating or cooling system



As an example, pressure relief piping is connected to a 40 mm diameter pipe carrying low temperature chilled water ≤2 °C. The pipe requires a minimum insulation *R-Value* of 1.3 and therefore the pressure relief piping, to 500 mm from the connection also requires insulation with *R-Value* of 1.3.

Note the *R-Value* is the material *R-Value* of the insulation and not the *Total R-Value* of the pipe, air film and insulation. However, where piping has a significant inherent *R-Value*, it may be subtracted from the material *R-Value* required. The inherent *R-Value* of most piping materials, such as copper and steel, is however not sufficient to satisfy the requirements in Table J5.8a.

The insulation types in the following table are typical examples of materials that can be used to insulate piping. The *R-Values* provided are to be used for guidance only. The *R-Values* are calculated in accordance with AS/NZS 4859.1 as per the requirement in J5.8(a)(i).

Table 13.3 Typical pipe insulation and corresponding R-values

Insulation	R-Value
13 mm of closed cell polymer	0.6
19 mm of closed cell polymer	0.9
25 mm of closed cell polymer	1.3
25 mm of glass wool	1.3

13.12.1 Weather and temperature protection

J5.8(b)(i) requires insulation to be protected from the effects of weather and sunlight, as these may reduce the insulating properties. A typical design life of insulation is between 5 to 10 years. Lack of protection from the effects of weather and sunlight will drastically reduce the design life, and in turn its insulating properties. This protection may be achieved by ensuring that the insulation is enclosed in protective sheathing such as formed metal sheeting, external grade plastics or other similar material.

J5.8(b)(ii) requires insulation to be able to withstand the temperatures within the piping, vessel, heat exchanger or tank, otherwise degradation of the insulation's thermal performance may occur.

13.12.2 Integrity of the insulation barrier

J5.8(c) requires insulation to be protected by a vapour barrier if the piping, heat exchanger or tank contains a cooling fluid.

A vapour barrier helps to reduce the likelihood of condensation problems. Condensation problems can occur when the internal temperature of the piping, heat exchanger or tank is below the dew point of the external air.

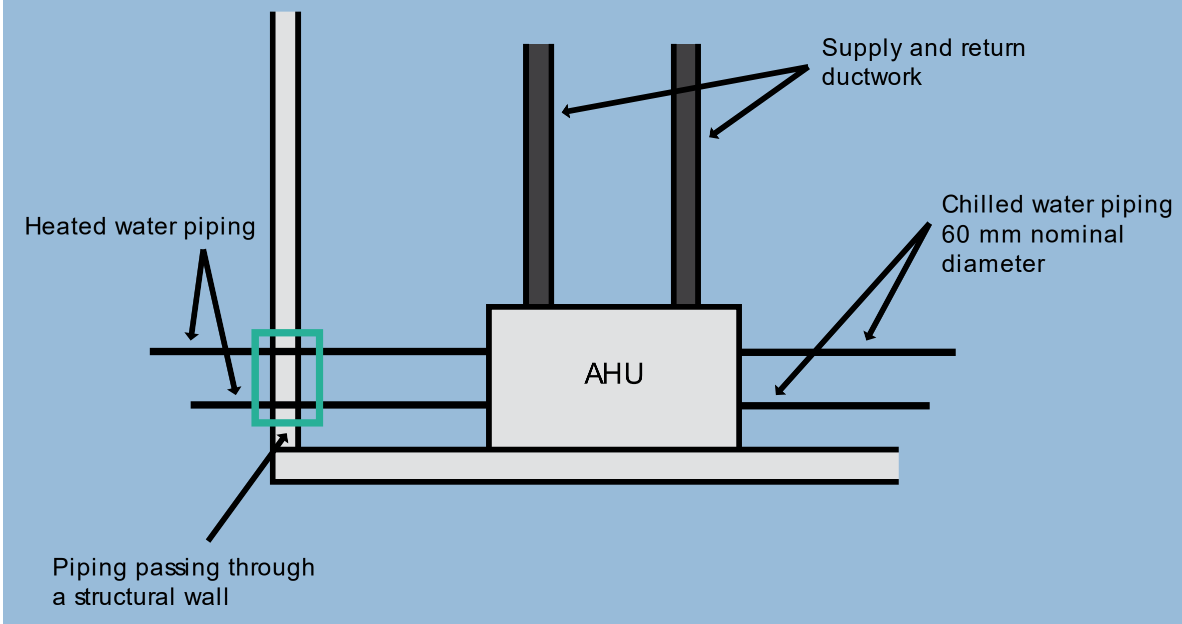
13.12.3 Exemptions

J5.8(d) outlines circumstances when piping, vessels and heat exchangers are exempt from meeting the requirements of J5.8(a) and (b). Exemptions include:

- Piping, vessels and heat exchangers located within the last space being heated or cooled as the heating or cooling effect is intended for that space anyway;

- Piping, vessels and heat exchangers in a slab or panel that is specifically designed as a heating or cooling system, such as an in-slab or in-screed heating or cooling system. This is because the insulation would contradict the aim of the heating or cooling from the piping;
- Piping, vessels and heat exchangers that are supplied as part of an item of plant such as a chiller or *boiler*; or
- Piping, vessels and heat exchangers inside an item of plant such as an *AHU*, *FCU* or the like.

Figure 13.22: Piping insulation requirements



The piping insulation requirements would be as follows:

For heated water piping, insulation with a material *R-Value* of 1.7 would be required to be installed. However, for the heated water piping section that passes through a structural wall, a concession is available as described in the note to Table J5.8a. This results in a minimum required insulation *R-Value* of 0.85 for the section of supply and return piping.

The chilled water supply and return piping has a 60 mm nominal diameter. This means an added *R-Value* of 1.5 is required to be installed on this piping as per Table J5.8a.

13.12.4 Heating and cooling fluid definitions

J5.8(e) provides clarification on heating and cooling fluids for the purposed of J5.8(a), (b), (c) and (d). Heating fluids include refrigerant, heated water, steam and condensate, while cooling fluids include refrigerant, chilled water, brines and glycol mixtures. Cooling fluids do not include condenser cooling water.

Condenser cooling water is exempt from the minimum insulation requirements of this clause due to the limited temperature difference between the piping contents and the surrounding space. This means there would likely be small energy savings achieved compared to the costs of insulation in these circumstances. However, insulation may be installed for reasons other than energy efficiency such as for acoustics, or to minimise the risk of condensation forming.

13.13 Space heating

13.13.1 Energy sources

Energy sources that may be used for heating a space directly are listed in J5.9(a). All forms of heating described in J5.9(a)(i) to (a)(v) can be used in combination so as not to restrict heating to only one type. This recognises that a combination of heating options may be the most appropriate and cost-effective heating solution and may include a limited amount of electric resistance heating.

J5.9(a)(i) to (iii) permit solar heaters, gas heaters or heat pump heaters to be used for *air-conditioning* or as a part of an *air-conditioning* system.

J5.9(a)(iv) allows reclaimed heat from another process such as from a refrigeration plant and bio-fuels to be used. This reclaimed energy can be used in conjunction with one or more heaters allowed under J5.9.

Electric heating can be used in specific circumstances only as outlined in J5.9(a)(v)(A). A small amount of electric resistance heating is allowed for the floor area of the *conditioned space* of up to 10 W/m^2 *for climate zone* 1 and 40 W/m^2 for *climate zone* 2. The small allowances for *climate zone* 1 and 2 recognise the likely limited heating required for these mild climates.

J5.9(a)(v)(A)(cc) allows larger electric heating allowances in situations where reticulated gas is not available at the allotment boundary. This recognises the likely limited heating options in areas where natural gas is not readily available. The maximum values are specified in Table J5.9 and are again *climate zone* based. This recognises the limited heating required in temperate climates, compared to cool climates.

J5.9(a)(v)(B) allows a further exemption for relatively small electric heaters in *climate zones* 1 to 5 if the annual energy consumption for this heating is not more than 15 kWh/m^2 of the floor area of the *conditioned space*.

J5.9(a)(v)(C) places limits on the amount of reheat allowed for an in-duct heater in line with J5.2(a)(ii)(C).

Reminder:

Subclause J5.2(a)(ii)(C) contains restrictions on reheating the supply air. These requirements are intended to encourage the grouping of areas with similar loads (heating and cooling demand), rather than sub-cooling all the supply air and reheating excessively to achieve the desired temperature.

J5.2(a)(ii)(C)(aa) outlines that where a separate reheat device is provided; the supply air temperature must not increase by more than 7.5 K at the full supply air rate. The 7.5 K limit on temperature rise allows for some trim heating of cold air supply but within reasonable limits.

Subclause J5.2(a)(ii)(C)(bb) outlines that the allowable temperature rise can be determined by using an inverse relationship between allowable temperature rise and supply air rate. If, during the reheating, the supply air rate is also reduced then the temperature rise can be proportionally increased above 7.5 K at the same rate that the supply air rate has been reduced. For example, the reheat temperature could be increased to 10 K when the supply air rate is reduced by 25% or increased to 15 K if the supply air rate is reduced by 50%.

13.13.2 Bathroom electric heaters

J5.9(b) permits a small electric heater in a bathroom of a Class 2, Class 3 or Class 9c aged care building. The system must have a heating capacity of 1.2 kW or less. Typically, this would include small electric heaters such as a 3-in-1 heater, exhaust fan and light system. The heater must be fitted with a means to ensure it will not run excessively when the bathroom is not in use, such as a timer.

13.13.3 Outdoor fixed heating or cooling

J5.9(c) is specifically for fixed outdoor heating and cooling appliances. The clause requires that the appliance must be *capable* of automatic shutdown when:

- nobody is occupying the space;
- a period of one hour has elapsed since the heater was last activated; or
- the space has reached the required temperature.

This may be achieved by an outdoor temperature sensor, timer, motion detector or the like. The requirement aims to limit energy consumption when the service is not needed.

13.13.4 Gas water heaters

J5.9(d) specifies the efficiencies required for a gas fired heater that heats a space via water. Examples of these include units such as a *boiler*.

The minimum thermal efficiencies are based on the rated gas consumption of the *boiler* in MJ/hour. There are many testing standards that can be used to demonstrate a unit's gross thermal efficiency, including BS 7190, ANSI/AHRI 1500 and AS/NZS 5263.1.2. Larger *boilers* are required to have a greater gross thermal efficiency as they have both greater energy consumption and economies of scale able to reduce the relative cost of achieving higher efficiencies.

It is important that test conditions mirror the expected, typical operating conditions for every test used to determine the unit's thermal efficiency. This is especially important for condensing *boilers*, where the inlet/outlet temperature of water will greatly impact the overall efficiency.

Alert:

BS7190 is the British Standard for the "Method for assessing thermal performance of low temperature hot water *boilers* using a test rig". The Standard specifies a procedure for assessing the thermal performance of low temperature hot water *boilers* which are intended for central heating or indirect hot water supply and which are fired with solid, liquid or gaseous fuels.

13.14 Refrigerant chillers

J5.10 covers the requirements for refrigerant chillers. The Clause specifies that a refrigerant chiller, that is part of an *air-conditioning* system, must have an EER complying with Table J5.10a or Table J5.10b. Refrigerant chillers must also comply with the *MEPS* efficiency requirements.

The tables are like tables in ASHRAE 90.1 2016. Table J5.10a (Option 1) contains higher full-load performance values. These performance values are applicable to chillers which are more likely to operate at full load. Table J5.10b (Option 2) contains higher part-load performance values. These performance values are applicable to chillers which are more likely to operate at part load.

A designer may choose whether to comply with Table J5.10a (Option 1) or Table J5.10b (Option 2). The choice of tables gives designers scope to use the most appropriate chiller depending on building operation (i.e. full load or part load).

Generally, full load can be simplified to operating at greater than 90% of the rated capacity for most of its run time, and part load can be simplified to operating at less than 90% of the rated capacity for most of its run time.

The EER must be determined by testing in accordance with the American Air-Conditioning, Heating & Refrigeration Institute (AHRI) Standard,
AHRI 551/591. This standard requires chillers to be tested at full load and at a series of part loads, which are then integrated into a single number part-load efficiency.

Alert

HRI 551/591 is the American Air-Conditioning, Heating & Refrigeration Institute standard for the "Performance rating of water-chilling and heat pump water-heating packages using the vapour compression cycle". The standard specifies the requirements for water-chilling and water-heating packages using the vapour compression cycle including test requirements, rating requirements, minimum data requirements, marking and nameplate data and conformance conditions.

Note that the use of flow and return temperatures applied during the testing of chillers to AHRI 551/591 (a 6°C flow and 12°C return) may not be appropriate to allow for a pumping system compliant with J5.7.

Comparison to the European Union MEPs (EUROVENT)

The European Union (EU) has developed a minimum energy performance requirement for chillers used within its borders: EU Eco-design Lot 21. Systems certified under this scheme may be used as the basis of a *Performance Solution* with the approval of the *Appropriate Authority*.

13.15 Unitary air-conditioning equipment

A unitary air-conditioner is a modular factory assembled *air-conditioning* unit. These units are self-contained and include within the unit all the components for heating and/or cooling; such as fans, controls, a refrigeration system, heating coil and sometimes the heater. Split systems, packaged air-conditioners, variable refrigerant flow and variable refrigerant volume air-conditioners are all types of unitary air-conditioners.

13.15.1 Capacity less than 65 kWr

Unitary *air-conditioning* equipment with a capacity of less than 65 *kWr* must comply with *MEPS*. For these small systems, no further improvements above this level are required.

Reminder:

MEPS means the *Minimum Energy Performance Standards*.

13.15.2 **Capacity of 65 kWr or more**

J5.11(a) and (b) specify the efficiency required for water and air cooled packaged *air-conditioning* systems when tested in accordance with AS/NZS 3823.1.2 at test condition T1.

AS/NZS 3823.1.2 has various test conditions, so this clause requires the equipment to be tested at condition T1, which provides standard cooling capacity rating conditions for moderate climates. The standard covers the performance of electrical appliances, air-conditioners and heat pumps. Part 1.2 covers ducted air-conditioners and air-to-air heat pumps - testing and rating for performance.

Alert:

AS/NZS 3823.1.2 is the Australian and New Zealand standard for the, “Performance of electrical appliances - air-conditioners and heat pumps”, specifically “Ducted air-conditioners and air to-air heat pumps – testing and rating for performance”. The standard specifies the standard conditions for capacity and efficiency ratings of ducted, air-cooled air-conditioners and ducted air-to-air heat pumps

J5.11(a) specifies the efficiency required for water-cooled packaged *air-conditioning* equipment. The *air-conditioning* equipment must have a minimum EER of 4.0 W_r / $W_{input\ power}$.

J5.11(b) specifies the efficiency required for air-cooled packaged *air-conditioning* equipment. The *air-conditioning* equipment must have a minimum EER of 2.9 W_r / $W_{input\ power}$.

These systems must also comply with *MEPS*.

Alert:

The input power includes both compressor and fan input power.

13.16 **Heat rejection equipment**

13.16.1 **Cooling towers, closed circuit coolers and evaporative condensers**

J5.12(a) outlines that the requirements for a fan that forms part of a cooling tower, closed circuit cooler or an *evaporative cooler* that is part of an *air-conditioning* system, are in Table J5.12. The maximum fan motor power allowed is dependent on whether the system is an induced or forced draft. Induced draft is more efficient than forced draft, using a draw-through arrangement as opposed to blowing air from the bottom of the cooling system.

The Note to Table J5.12 specifies that a closed circuit, forced draft cooling tower must not be used as a *DTS Solution* as these systems are extremely inefficient. However, if a closed circuit forced draft cooling tower is required within the design, a *Performance Solution* may be used to demonstrate compliance.

The performance of cooling tower fans, closed circuit cooler fans and evaporative condenser fans can be determined using any nationally or internationally accepted standard. For example, Cooling Technology Institute's (CTI) Standard CTI STD-201RS(13) and Acceptance Testing Code (ATC) ATC-105(00) can be used to determine the performance of cooling tower fans. CTI STD-201RS(13) and ATC-105S(11) can be used for closed circuit cooler fans and ATC-106(11) can be used to determine the performance of evaporative condenser fans.

13.16.2 **Air-cooled condenser**

J5.12(b) specifies the requirements for a self-contained, air-cooled condenser fan motor that is part of an *air-conditioning* system. An air-cooled condenser fan is used as part of the refrigeration cycle to cool refrigerant from its vapour phase to its liquid phase. The fan motor must not use more than 42 *watts* of fan motor power for each kW of heat removed from the refrigerant.

Air-cooled condensers not part of a package air-conditioner or split unit are exempt from the requirements of J5.12(b). These air-cooled condensers are typically associated with larger plant installations. The requirements of J5.12(b) are also not intended to capture a condenser covered by *MEPS*.

14 Part J6 – Artificial lighting and power

14.1 Introduction

The NCC requirements for artificial lighting and power are designed to curb unreasonable energy use in lighting systems, and the power to certain equipment, including vertical transport for nearly all building classifications including the *SOUs* in a Class 2 building and a Class 4 part of a building.

Research[6] indicates that lighting is estimated to be responsible for 26 percent of the electricity used in an office building. Lighting inefficiencies have a compounding effect in warmer climates because the extra electrical load for lighting may translate to waste heat that increases the load on the *air-conditioning* system.

Additionally, power consumption of lifts and escalators can be excessive if inefficient systems are in place or if they are not configured to save energy when not in use.

14.2 Scope

The provisions apply to all buildings, including within the *SOU* of a Class 2 building and a Class 4 part of a building. This is consistent with the philosophy adopted for NCC Volume Two, that both economic and human comfort benefits are achieved by having a dwelling designed with greater levels of energy efficiency. However, there are specific exemptions for certain classes of building, such as Class 8 electricity network substations.

The requirements in Part J6 cover the following:

- limits on the efficiency or power consumption rate of artificial lighting installations, both internal and external.
- control of switching arrangements for lighting and power, including automated cut off in some cases, depending on the building class and the size of the lighting installation

[6] Pitt & Sherry with input from BIS Shrapnel and Exergy Pty Ltd, for the DCCEE, Baseline Energy Consumption and Greenhouse Gas Emissions – In commercial Buildings in Australia, Part 1 – Report, November 2012 (pg. 7)

- control of interior decorative and display lighting;
- time switches for boiling water and chilled water storage units;
- limits on the efficiency and power consumption of lifts and lift artificial lighting; and
- control and efficiency of escalators and moving walkways.

The specification to Part J6 contains further information on appropriate design requirements for lighting and power control devices, including:

- lighting timers;
- time switches;
- motion detectors; and
- daylight sensors and dynamic lighting control devices.

14.3 Intent

14.3.1 Requirements

The intent of Part J6 is to enable artificial lighting and electric power to be used in a responsible manner, thereby avoiding excessive energy use.

Lighting used in buildings, particularly commercial buildings, is a high consumer of electric power, which is usually a high source of GHG emissions. Accordingly, there are significant gains to be achieved by introducing requirements which encourage more efficient use of power for lighting.

In line with the requirements of NCC Volume Two, there are provisions for the use of artificial lighting in Class 2 *SOUs* and a Class 4 part of a building, as well as the common areas of a Class 2 building.

These provisions intend to limit where lighting is often installed far in excess of the lighting needed for the task, or where inefficient fittings are used. For example, ambient lighting installed for aesthetic or mood purposes is not generally required for safety or operational purposes so there are opportunities to save energy by restricting excessive usage. Shops, in particular, often use bright, welcoming lighting designs to attract customers.

Similarly, the provisions applicable to lifts, escalators and moving walkways intend to ensure that energy use is not excessive. Escalators and moving walkways are configured to save energy when not in use and lifts with high frequency usage are designed to be the most efficient.

14.3.2 **Control devices**

Specification J6 provides more explicit technical requirements for the operation and location of control devices such as time switches and motion detectors. This information is not readily available in documents such as Australian Standards and, accordingly, has been developed for use with the NCC requirements.

This Chapter provides a detailed analysis of each of the clauses in J6 – Artificial lighting and power and Specification J6 – Lighting and power control devices.

The analysis discusses important points that should be considered when designing or assessing a building for compliance with the NCC Volume One *DTS Provisions*.

14.4 **DTS Provisions**

This requirement establishes that the *DTS Provisions* in Part J6 are part of an overall energy efficiency solution and each *DTS Provision* within Section J must be applied to meet the *Performance Requirements*.

In simple terms, the building must comply with all the appropriate *DTS Provisions* in Section J to be considered as complying with NCC Volume One using this *Assessment Method*.

Accordingly, if there is any variation from the prescribed *DTS Provisions* in one part, then the entire energy efficiency requirements for the building will need to be checked to ensure that there is no unintended effect on the other parts because of a *Performance Solution* being adopted for one part. Refer to Section A of NCC Volume One for further information.

14.5 **Application**

Part J6 contains minimum energy efficiency requirements for lighting used in buildings.

Class 8 electricity network substations are exempt from Parts J6.2, J6.3 and J6.5(a)(ii), due to operational safety factors as these substations commonly operate 24 hours a day.

14.6 Artificial lighting

14.6.1 SOUs in a Class 2 building or Class 4 part of a building

J6.2(a) is concerned with controlling the lighting energy used in dwellings, i.e. the *SOU* of a Class 2 building or a Class 4 part of a building.

J6.2(a)(i) specifies the different allowances for the maximum lamp power density or illumination power density for various areas of a *SOU* i.e. the allowance within the *SOU* is 5 W/m^2 and the allowance for a verandah, balcony or the like attached to the *SOU* is 4 W/m^2.

Due to the defined terms lamp power density and illumination power density, the requirements only apply to permanently wired artificial lights. Therefore, portable lamps and lights connected by plugs to general electricity power outlets are exempt.

To determine the values, it is necessary to identify the total power in *watts (W)* of the proposed lamps to be installed and then divide this value by the total floor area of the space the lamps serve in square metres (m^2).

J6(a)(ii) provides an alternative approach for dwellings with control devices. Suitable control devices are listed in Table J6.2b. These control devices further reduce the energy used, so an increase to the allowance is given.

This approach provides flexibility in meeting the minimum requirements by recognizing the energy saving properties of devices such as motion sensors and time switches.

J6.2(a)(iii) requires the power of the proposed lighting installation to be used when designing the lamp power density or illumination power density for a *SOU* in a Class 2 building or Class 4 part of building. This may mean the light fittings need to be specified to the building occupants, or some other administrative condition be used.

This may pose an administrative issue for the building official who might need to require actual fittings to be installed or only provide conditional approval to occupants who may want to change or install specific light fittings.

J6.2(a)(iv) requires halogen and fluorescent lamps to be separately switched. This enables the more efficient fluorescent lamps to be used routinely and the less efficient halogen lamps to be used only when needed.

14.6.2 **Buildings other than a SOU of a Class 2 building or a Class 4 part of a building**

Subclause J6.2(b) relates to lighting in buildings other than *SOUs* in a Class 2 building or a Class 4 part of a building and applies to Class 3 and Class 5-9 buildings. Requirements for these types of buildings are more detailed than the requirements for *SOUs* in Class 2 buildings or a Class 4 part, to satisfy the greater range of applications. Like J6.2(a)(ii), this clause sets a lighting power allowance in terms of the illumination power density. This includes for power losses in ballasts and control devices.

Only illumination power density can be used to measure compliance for building types other than Class 2 and Class 4 part of a building. LED lighting is becoming increasing popular for non-residential and the updated illumination power density values reflect this shift to LED technology.

J6.2(b)(i) explains that the individual load allowance for a space is calculated by multiplying the area of that space by the appropriate maximum illumination power density value from Table 6.2a.

The maximum illumination power density values in Table J6.2a have been based on a lighting design complying with the acceptable lighting level recommendations of AS 1680 Interior and workplace lighting - Part 1 General principles and recommendations, for the nature of the task, including an allowance for a safety margin in design and the physical limitations in placing a discrete number of fittings in a uniform array. Table 14.1 shows how some of the values in Table J6.2a correspond to the lighting levels of AS 1680.

J6.2(b)(ii) specifies that the aggregate design illumination power load is the sum of the design illumination power loads in each of the spaces served. The aggregate design illumination must not exceed the individual load allowance calculated in J6.2(b)(i).

J6.2(b)(iii) provides a solution to calculating the design illumination power load in (i) where there are multiple lighting systems serving the same space. The design illumination power load is based on the highest illumination power load where the highest illumination power load is multiplied by the area of the space served; or is determined by the following formula:

$$[H \times T/2 + P \times (100 - T/2)] / 100$$

Where:

H = the highest illumination power load;

T = the time for which the maximum illumination power load will occur, expressed as a percentage of time in which the lights operate within nominated hours;

P = the predominant illumination power load.

Example: Illumination power load for a small laboratory

A laboratory is 5 m by 7 m, therefore its floor area is 35 m^2 and the perimeter is 24 m. The ceiling is 2.6 m high. The lighting design has a proposed aggregate design illumination power load (load for all lighting fittings) of 300 W which includes all ballasts. The design incorporates a programmable dimming system which operates all the lights as a single block.

Design:

The design illumination power load is 300 W.

Allowance:

From Table J6.2a, the maximum illumination power density allowed for a laboratory is 6 W/m^2.

Example: Illumination power load for a small laboratory

Adjustment factors:

From Table J6.2b, the illumination power density adjustment factor for a programmable dimming system that controls at least 75 percent of the floor area is 0.85.

From Table J6.2a Note 3, the adjustment factor for room size depends upon the room aspect ratio (see J6.2a, below for more detail on room aspect ratio adjustments):

$$room\ aspect\ ratio = \frac{A}{H \times C}$$

Where:

A = the area of the enclosed space

H = the height of the space measured from the floor to the highest part of the ceiling

C = the perimeter of the enclosed space

Therefore, the room aspect ratio is:

$$= \frac{35}{(2.6 \times 24)}$$

= 0.56

Since the room aspect ratio is less than 1.5, Note 2 of Table J6.2a allows an adjustment factor for room aspect. The factor is calculated as:

$$Adjustment\ factor = 0.5 + \frac{room\ aspect\ ratio}{3}$$

$$= 0.5 + \frac{0.56}{3}$$

$$= 0.69$$

To determine the new allowance the maximum illumination power density for a laboratory from Table J6.2a is divided by the adjustment factor calculated above.

Example: Illumination power load for a small laboratory

This means 6 W/m^2 is divided by 0.69 to give 8.70 W/m^2.

Note 3 of Table J6.2a allows the adjustment factor from Table J6.2b for the manual dimming system to be applied in addition to the adjustment for room aspect. The new allowance then becomes:

$$8.7 / 0.95 = 9.15 \text{ W/m}^2$$

The illumination power load allowance is space area x maximum illumination power density, which is 35 x 9.15 = 320.4 W

Result

As the aggregate design illumination power load of 300 W is less than the illumination power load allowance of 320.4 W, the design complies.

14.6.3 Exemptions

The energy efficiency provisions in J6.2(a) and J6.2(b) are not always appropriate depending upon the use of a space; and there are situations when life safety must take precedence. J6.5(c) lists exemptions which take account of such situations. The following paragraphs describe these exemptions.

Emergency lighting as required by NCC Volume One Part E4 is exempt, as life safety takes precedence over energy efficiency.

Lighting associated with signage, lighting within display cabinets, and lighting for cases that are fixed in place are all exempt. This concession applies to both external and internal signage and, includes lighting that highlights signs. Regarding display cases, the lighting must be within the fixed cabinet or display case to be exempted, but this cabinet does not necessarily need to be enclosed.

Lighting installed in the accommodation areas of detention centres such as jails and remand centres are also exempt as lighting requirements may differ due to safety reasons. Accommodation should be interpreted as the area specifically set aside for the detainees. Ancillary areas, such as staff common rooms and administrative areas do not receive this concession.

Lighting used for heating, such as a bathroom using heat radiated from special purpose lamps to warm room occupants are exempt. In simple terms, a higher number of *watts* means more heat is radiated. The use of such a system should be nominated on the *building approval* documents.

Lighting used for a specialised process such as lighting used for specific medical procedures, lighting in a fume cupboard or *clean workstation* are usually separate from the general overhead lighting and are often built into specialised equipment. Therefore, they are exempt.

Lighting used for performances such as theatrical or sporting events, which are often separately switched from any general overhead lighting, are also exempt.

Lighting used for the permanent display and preservation of works of art or objects in a museum or gallery other than those for retail sale, purchase or auction are exempt, as these lights are used to *facilitate* and enhance the viewing of the works of art.

Lighting installed solely to provide photosynthetically active radiation for indoor plant growth on green walls and the like often requires specific light intensities and colours to support different plant growth. Therefore, they are exempt.

14.6.4 **Control devices**

Subclause J6.2(d) identifies control devices in Table J6.2b that must comply with Specification J6. The control devices include lighting timers, motion detectors, daylight sensors and dynamic lighting control devices. See Specification J6 for an explanation on the technical requirements for lighting and power control devices.

In total, 5 adjustment factors can be applied to the maximum illumination power density. These include:

- Room Aspect Ratio;
- a maximum of two control devices from Table J6.2b;
- Colour Rendering Index (CRI) adjustment factor from Table J6.2c; and
- Correlated colour temperature (CCT) adjustment factor from Table J6.2c.

Example: Adjustment factors

A conference room is 8 m by 6 m, therefore its floor area is 48 m^2 and the perimeter is 28 m. The ceiling is 2.8 m high. The lighting design has a proposed aggregate design illumination power load (load for all lighting fittings) of 700 W.

The board room is used infrequently and is in an area that receives large amounts of natural light. Therefore, the board room has incorporated a motion detector and a daylight sensor. The board room is fitted with LED lighting with a CRI of 90 and a CCT of 3000 K.

Design:

The design illumination power load is 700 W.

Allowance:

From Table J6.2a, the maximum illumination power density allowed for a conference room is 5 W/m^2.

Adjustment factors:

Room Aspect Ratio:

From Table J6.2a Note 3, the adjustment factor for room size depends upon the room aspect ratio:

$$room\ aspect\ ratio = \frac{A}{H \times C}$$

where:

A = the area of the enclosed space

H = the height of the space measured from the floor to the highest part of the ceiling

C = the perimeter of the enclosed space

Therefore, the room aspect ratio is

Example: Adjustment factors

$$= \frac{48}{(2.8 \times 28)}$$

= 0.61

Since the room aspect ratio is less than 1.5, Note 2 of Table J6.2a allows an adjustment factor for room aspect. The factor is calculated as:

$$Adjustment\ factor = 0.5 + \frac{room\ aspect\ ratio}{3}$$

$$= 0.5 + \frac{0.61}{3}$$

$$= 0.70$$

Therefore, the room aspect ratio adjustment factor is 0.70.

Table J6.2b adjustment factors:

Note 3 of Table J6.2a allows adjustment factors from Table J6.2b for control devices.

Three adjustment factors apply for the board room including the factors for:

- motion detectors where a group of light fittings serving less than 100 m^2 is controlled;
- daylight sensor (Class 5 building); and
- lumen depreciation dimming.

As per note 1, a maximum of two adjustment factors for a control device can be applied to an area using the following formula:

A x (B + [(1 - B) / 2])

Where:

A is the lowest applicable adjustment factor; and

B is the second lowest applicable adjustment factor.

The two lowest applicable adjustment factors are for the motion detectors and daylight sensors, both equal to 0.6.

Example: Adjustment factors

Therefore, in combination, the control device adjustment factor is calculated as:

0.6 x (0.6 + [(1 – 0.6) / 2]) = 0.48

Therefore, the control device adjustment factor is 0.48.

Table J6.2c adjustment factors:

Two adjustment factors can be applied from Table J6.2c based on the board room lighting design. As the CRI is equal to 90 an adjustment factor of 0.9 can be applied, and as the CCT is less than 3500 K an adjustment factor of 0.8 can also be applied.

Maximum illumination power density calculation:

All adjustment factors can now be applied to the illumination power density of 5 W/m^2 specified in Table J6.2a. The new allowance then becomes:

5 / 0.70 / 0.48 / 0.9 / 0.8 or;
5 / (0.70 x 0.48 x 0.9 x 0.8) = 20.67 W/m^2

The illumination power load allowance is space area x maximum illumination power density, which is 48 x 20.67 = 992 W

Result

As the aggregate design illumination power load of 700 W is less than the illumination power load allowance of 992 W, the design complies.

14.6.5 **Maximum illumination power density**

The base (pre-adjustment) illumination power density values in Table J6.2a have been set at a level that can be achieved with reasonable surface reflectance, high efficacy light sources, low loss control devices and high efficiency luminaires.

AS 1680.1 includes scenarios where it may be appropriate for higher illumination levels. Where higher illumination levels are required, a *Performance Solution* based on the notes to Table J6.2a could be developed.

There are two levels for offices. General open areas that are lit to more than 200 lx may use 4.5 W/m^2. For offices lit to less than 200 lx, where task lighting is intended to supplement the general lighting, the maximum for the general lighting is only 2.5 W/m^2.

Note 1 of Table J6.2a provides values for applications not specifically listed in the table.

Note 2 of Table J6.2a is a concession for small enclosed spaces. This is because walls absorb light energy which means that less illumination would be available at the working surface level unless some compensation is permitted. A formula is given for calculating the allowable increase to the maximum illumination power density permitted and is based on a Room Aspect Ratio. The Room Aspect Ratio is a ratio of the area of the enclosed space to the height and perimeter of the enclosed space. See the worked example for a laboratory, above to show how this is calculated.

Note 3 of Table J6.2a allows an increase to the maximum illumination power density if a suitable control device is used for Table J6.2b and Table J6.2c. These adjustment factors are explained below.

Table 14.1 details the relationship of the maximum illumination power density values in Table J6.2a to AS 1680 illuminance levels.

Table 14.1 Recommended illuminance levels and corresponding illumination power densities for space types

Space	AS 1680 recommended illuminance (Lux)	Illumination power density (W/m^2)
Auditorium, church and public hall	160	8
Board room and conference room	240	5
Carpark – general	40	2
Carpark – entry zone (first 15 m of travel) during the daytime	800	11.5

Space	AS 1680 recommended illuminance (Lux)	Illumination power density (W/m²)
Carpark – entry zone (next 4 m of travel) during the day	160	2.5
Carpark – entry zone (first 20 m of travel) during night time	160	2.5
Common rooms, spaces and corridors in a Class 2 building	160	4.5
Control room, switch room and the like – intermittent monitoring	160	3
Control room, switch room and the like – constant monitoring	240	4.5
Corridors	240	5
Courtroom	320	4.5
Entry lobby from outside the building	160	9
Health-care - infants' and children's wards and emergency department	240	4
Health-care - examination room	400	4.5
Health-care - examination room in intensive care and high dependency ward	400	6
Health-care - all other patient care areas including wards and corridors	240	2.5
Kitchen and food preparation area	240	4
Laboratory - artificially lit to an ambient level of 400 lx or more	400	6
Library - stack and shelving area	240	2.5
Library - reading room and general areas	320	4.5
Lounge area for communal use in a Class 3 or 9c building	240	4
Museum and gallery - circulation, cleaning and service lighting	240	2.5
Office - artificially lit to an ambient level of 200 lx or more (maintained average)	320	4.5
Office - artificially lit to an ambient level of less than 200 lx (maintained average)	160	2.5
Plant room where an average of 160 lx vertical illuminance is required on a vertical panel such as in switch rooms	160	4

Space	AS 1680 recommended illuminance (Lux)	Illumination power density (W/m²)
Plant rooms with a horizontal illuminance target of 80 lx	80	2
Restaurant, café, bar, hotel lounge and a space for the serving and consumption of food or drinks	80	14
Retail space including a museum and gallery whose purpose is the sale of objects	160	14
School - general purpose learning areas and tutorial rooms	320	4.5
SOU in a Class 3 or 9c building	160	5
Storage	80	1.5
Service area, cleaner's room and the like	80	1.5
Toilet, locker room, staff room, rest room and the like	80	3
Wholesale storage area with a vertical illuminance target of 160 lx	160	4
Stairways, including fire-isolated stairways	80	2
Lift cars	160	3

14.6.6 **Control device illumination power density adjustment factor**

It is recognised that there are variables in lighting that limit the ability to achieve the maximum illumination power density limits specified in Table J6.2a. To provide flexibility in meeting the requirements, a series of adjustment factors have been included in Table J6.2b that provide credit for using additional energy limiting devices.

The adjustment factors are applied to the illumination power density allowance in Table J6.2a for the space. This means that, if a designer selects a less efficient light source or luminaire, compliance can still be achieved by including a supplementary control device such as an occupancy sensor or photoelectric device.

Occupancy sensors represent an efficient way of tailoring the lighting to the functional needs of the space. The fewer lights that are controlled by an individual sensor, the greater the potential energy saved, however there is less cost saving on the energy to offset the cost of each sensor. Therefore, there is a graduated scale of adjustment factors for the area of lights controlled.

A designer can look at the relative cost/benefit ratio of each option for the project. The cost/benefit may not be a simple balance of the cost of the control device versus the potential energy saving. For example, the preference may be to provide surplus illumination power density allowances to offset another area.

Motion detectors turn on lighting in response to movement and are therefore applicable in areas that are not constantly occupied such as toilets and change rooms.

Programmable dimming systems are where pre-selected scenes or levels are automatically selected by the time of day, photoelectric cell or occupancy sensor. Examples of buildings or spaces where this may be beneficial are university buildings and classrooms. Timetables enable occupancy to be pre-determined and for lighting to be switched on in these times.

Fixed dimming is where lights are controlled to a level and that level cannot be adjusted by the user. For example, where drivers are factory set to a dimmed output to limit the light output.

Lumen depreciation dimming occurs over the lifespan of the light source. Put simply, lighting gets dimmer over time. LED or fluorescent lighting fixtures have much longer lifespans than other lighting fixtures. Therefore, this factor does not apply to tungsten, halogen or other incandescent sources to encourage the use of more efficient lighting sources.

Two stage sensor: The illumination power density adjustment factor for two stage sensor equipped lights with minimum power of 30 percent of peak power refers to both sensors integrated into the lighting system and standalone sensors as part of the lighting control system.

Daylight sensors turn off lighting when sufficient natural light from a window or *roof light* is present. Sensors for artificial lights located adjacent to *roof lights* are to be located at the discretion of the electrical engineer/lighting designer.

Dynamic dimming systems are where the lighting level is varied automatically by a photoelectric cell to either proportionally compensate for the availability of daylight or the lumen depreciation of the lamps.

Note 1 of Table J6.2b specifies that two adjustment factors for a control device can be applied to the maximum illumination power density for an area. Where more than one adjustment factor is applied they are to be combined using the formula below.

$$A \times (B + [(1 - B) / 2])$$

Where:

A is the lowest applicable adjustment factor; and
B is the second lowest applicable adjustment factor.

Note 2 specifies that the adjustment factors do not apply to tungsten halogen or other incandescent sources for programmable dimming systems, fixed dimming systems, lumen depreciation dimming, and daylight sensors and dynamic lighting control devices.

Note 3 specifies that the adjustment factors apply to luminaires with a pre-programmed function which provides one-stage dimming (dimming from ON to OFF) for fixed dimming controls.

Note 4 specifies that adjustment factors for daylight sensors are only applicable to lighting that is on during the day. In other words, daylight sensors for lighting on during the night would not be applicable.

14.6.7 Light colour illumination power density adjustment factor

Table J6.2c provides allowances based on light colour. The maximum illumination power density may be increased by dividing it by the illumination power density adjustment factor. There are two possible adjustments for light colour, one regarding CRI and one regarding CCT.

CRI is the measurement of how colours look under a light source when compared with sunlight and is measured from 0-100. A CRI of 100 means that the colours appear the same as they would under sunlight. For lighting with a CRI greater than or equal to 90, the maximum illumination power density will increase once divided by the adjustment factor of 0.9.

CCT defines the colour appearance and is defined in degrees Kelvin. A warm light is approximately 3500 K and below, moving to brighter, whiter and 'cooler' as the degrees increase. A warmer light is favoured in the DTS requirements. For example, for lighting with a CCT ≤ 3500 K the maximum illumination power density will increase once divided by the adjustment factor of 0.8. Contrastingly, for lighting with a CCT ≥ 4,500K, the maximum illumination power density will decrease once divided by the adjustment factor of 1.1.

Colour tuneable luminaires provide the ability to deliver varying light colours and may meet multiple categories in Table J6.2d. If tuneable luminaires achieve both ≤3,500 K and ≥4,500 K, the ≤3,000 K adjustment factor would be appropriate. The intent of this clause is to prevent designers using cool/blue-tinge daylight luminaires to achieve energy efficiencies. Tuneable luminaires are top of the range and most preferable because they adapt to user requirements and are optimal for circadian rhythms. Therefore, tuneable luminaires should be rewarded for the capacity achieving ≤3,500 K and not penalised for the capacity being ≥4,500 K.

14.7 Lighting Calculator

The ABCB has produced a calculator in excel to assist users in assessing compliance with J6.2.

The following describes key cells in the Lighting Calculator to explain its use. Additional advice can be found in the Help Screen of the Calculator.

14.7.1 Building parameters

- Building Name/Description – This cell is used to identify the building or parts of the building that is being assessed by this spreadsheet- for example the street address.
- Classification – This cell requires the nomination of the Class of building that are being assessed by the spreadsheet.

14.7.2 **Lighting details**

- ID – The calculator can display up to 500 rows. Not all 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 500). You can use these numbers or any preferred code to identify each space.
- Description – Input any desired description of the room or space. This is an optional input for the convenience of the user and the assessor.
- Floor area of the space – This is the floor area of the space that the lights serve in square metres.
- Perimeter of the space – The perimeter is the measurement of the enclosing walls or zone edge (if un-walled) at floor level and is measured in metres. The perimeter of the spaces can be entered into these cells if applicable to increase the allowable wattage for that space. This concession is called a Room Aspect Ratio and applies to small enclosed spaces. The spreadsheet will automate the ratio calculation required using both the perimeter and floor to ceiling height. The concession is given because in these small spaces less illumination would be available at the working level surface as the walls absorb some of the light.
- Floor to ceiling height – The height in metres from the floor to the ceiling. The floor to ceiling height of the spaces can be entered into these cells if applicable to increase the allowable wattage for that space. See description of Room Aspect Ratio above.
- Design illumination power load – This cell is where the total sum of the power (in *watts*) for a space is entered into the spreadsheet.
- Space – This cell is used to select the type of space under assessment. Each space has a different power allowance depending upon the function and use of the space. Select the appropriate option from the dropdown box.
- 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 white 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.
- Adjustment Factor Two – This column is like 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.
- Light colour – This cell requires the selection of the colour range applicable to the lighting. If the colour is outside of the ranges listed, leave the cell blank. Certain colour ranges can both increase and decrease the allowable maximum illumination power density.

14.7.3 **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.

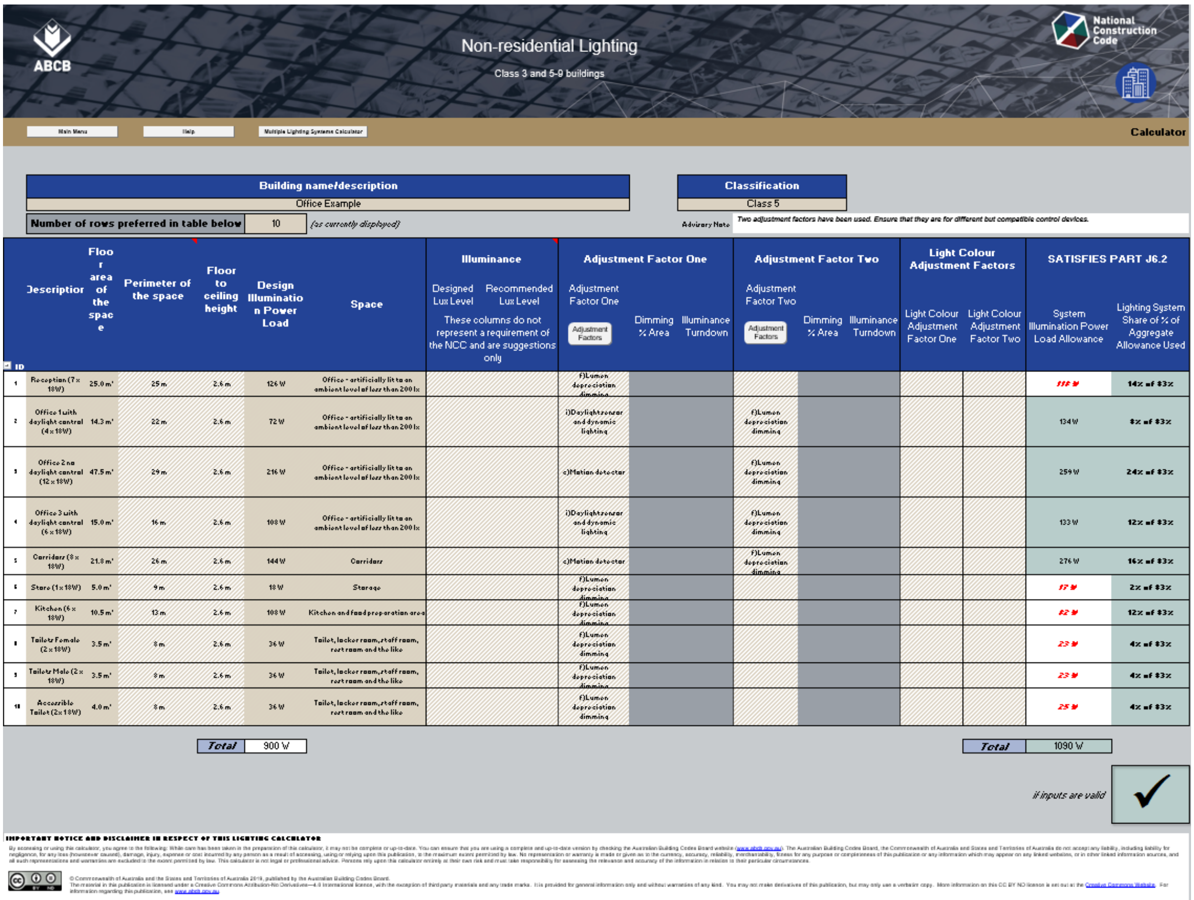
The calculated outcomes are not displayed until all input issues have been resolved. These issues will be highlighted by formatting or advisory messages.

- System Illumination Power Load 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.
- Lighting 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.
- Compliance indicator – The box below the calculated outcomes indicates whether the proposed lighting design meets the requirements of J6.2. 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.

Figure 14.1 shows a screenshot of the Lighting Calculator

Figure 14.1 Example of the Lighting Calculator



14.8 Interior artificial lighting and power control

These requirements cover the switching and control of lighting in various building classes and for automatic control of lighting and power in a *SOU* of a Class 3 building. The intention is to ensure that rooms are not unnecessarily using artificial lighting or power when unoccupied.

14.8.1 Individual lighting controls for each space

Subclause J6.3(a) requires lighting in each room or space within a building to be operated separately from other rooms or spaces. In simple terms, lighting in each space must be switched by its own light switch or group of switches, a control device, or a combination of a switch and a control device. The requirement prevents the use of a master light switch to operate all lights in several rooms or spaces.

Design alert:

The term 'space' may apply to a separate activity area within a larger room and is not necessarily defined by walls. An example would be a TV area within a larger recreational room. These spaces should be defined on the architectural/electrical plans.

14.8.2 **Occupant activated light and power switch**

Subclause J6.3(b) requires each *SOU* within a Class 3 building, except one accommodating the aged or people with a disability, to have a device to cut off power to artificial lighting, *air-conditioning*, local exhaust fans and bathroom heating when unoccupied.

The device must be activated by the presence of occupants. It can, for example, be operated by a motion detector or a security card reader which turns power off when the card is removed.

14.8.3 **Lighting switch location and area of operation**

Subclause 6.3(c) requires that a lighting switch be in a visible position in the room where the lighting is being switched or in an adjacent room where 90 percent of the lighting being switched is visible. It also limits the area of lighting that a single switch can control. The area permitted varies according to the class of the building and the size of the space being artificially lit.

14.8.4 **Lighting controls**

Subclause J6.3(d) requires that 95 percent of the light fittings in a building or storey of a Class 5 to 9 building which is larger than 250 m^2 be controlled by a device which can turn lighting off when unoccupied. The device can include a time switch or an occupant sensing device such as a motion detector complying with Specification J6, or a security card reader that registers a person entering and leaving the building.

14.8.5 Separation of switching

Subclause J6.3(e) requires that, a Class 5, 6 or 8 building with a floor area greater than 250 m^2 must have separate controls for artificial lighting in the natural lighting zone adjacent to windows, and for general lighting not in the natural lighting zone. There are exemptions for small spaces (20 m^2 or less), natural lighting zones with less than four light fittings, or where most (70 percent) of the light fittings in the room are in the natural lighting zone adjacent to windows.

14.8.6 Fire-isolated stairway, passageway or ramp lighting controls

Subclause J6.3(f) requires that artificial lighting in a fire-isolated stairway, passageway or ramp must be controlled by a motion detector in accordance with Specification J6.

14.8.7 Foyer, corridor and circulation space lighting controls

Subclause J6.3(g) requires that lighting of more than 250 W within a single zone and located adjacent to windows must be controlled by a daylight sensor and dynamic lighting control device in accordance with Specification J6 for foyers, corridors and other circulation spaces.

14.8.8 Carpark lighting controls

Subclause J6.3(h) requires that the first 19 m of travel in a carpark entry zone lighting must be controlled by a daylight sensor in accordance with Specification J6. 19 m is consistent with AS1680.1 and applied for safety reasons to allow eyes to adjust when travelling from bright to dark spaces.

14.8.9 Exemptions

Like Part J6.2 there is an exemption in subclause J6.3(i) for emergency lighting required by Part E4. There are also exemptions for spaces where artificial lighting is needed for 24 hour occupancy such as for a manufacturing process, parts of a hospital, an airport control tower or within a detention centre.

Subclause J6.3(j) exempts from J6.3(d) any lighting whose sudden loss would create a safety risk. Areas where lighting loss would cause a safety risk include, among others, lighting installations in the patient care areas of a Class 9a or a Class 9c building, a plant room or lift motor room; or a workshop where power tools are used. Heaters where the heater also emits light, such as in bathrooms, are also exempt under this clause.

14.9 Interior decorative and display lighting

The provisions of this clause cover decorative and display lighting inside a building and window display lighting. The interior lighting, such as for a foyer mural or art display, must:

- be separately controlled from other artificial lighting; and
- have separate manual switching for each area that operates during different periods, except where operating times coincide such as in a museum or art gallery; and
- have a separate time switch, in accordance with Specification J6, for display lighting uses more than 1 kW.

Subclause (b) requires window display lighting (usually on the internal perimeter of the building) to be controlled separately from other display lighting.

14.10 Exterior artificial lighting

J6.5 requirements cover external lighting attached to or directed at the façade of a building. Therefore, external lighting such as garden lighting, pathway lighting and the like are exempt from the NCC, however they should comply with Australian Standards and any applicable local laws. External lighting, attached or directed at the façade, must be controlled by a daylight sensor or a programmable time switch control.

If the total lighting load exceeds 100 W, LED lighting must be used for 90 percent of the total load, be controlled by a motion detector in accordance with Specification J6 or have a separate time switch in accordance with Specification J6 when used for decorative purposes.

Subclause J6.2(b) exempts emergency lighting required by Part E4 and lighting around a detention centre from the requirements of (a)(ii) but not from (a)(i). This means that artificial lighting attached to or directed at the façade of a building in these circumstances must be controlled by a daylight sensor or a time switch.

14.11 Boiling water and chilled water storage units

A time switch is required for boiling water and chilled water storage units that continually maintain water at temperature; as energy can be wasted when not used for long periods of time, such as overnight. The time switch used must be in accordance with Specification J6. The requirement does not apply to instantaneous units that heat or chill water as it is being drawn off.

14.12 Lifts

New provisions regarding the minimum energy efficiency of lifts have been introduced into J6.7 of NCC Volume One in 2019. These measures prescribe both operational and standby/idle lift operation energy efficiency measures. A lower energy rating has been allowed for dedicated goods lifts, this is in recognition that these lifts have different requirements to passenger lifts. Dedicated goods lifts are lifts used for carrying goods or materials and in which only the attendant and the persons required to load and unload are intended (or permitted) to travel. Lifts that are intended as passenger lifts, that occasionally carry goods or materials do not fall under this category.

Subclause J6.7(a) specifies that any lifts forming part of a project must have lighting and ventilation systems that are able to be turned off if the lift is not used for more than 15 minutes.

Subclause J6.7(b) requires that any lift must achieve the idle and standby energy performance levels in Table 6.7a. For example, if the rated load is less than or equal to 800 kg, the maximum idle standby energy performance level is 2. Note that Table 6.7a applies to the standby power used after 30 minutes.

Subclause J6.7(c) specifies that any lift must achieve the energy efficiency class in Table 6.7b. The intent of this provision is that lifts that are travelling further have a higher frequency and are more efficient, and that low traffic lifts have a lower target. Dedicated goods lifts are exempt and are to achieve the energy efficiency class D in accordance with ISO 25745-2.

Alert:

ISO 25745 is the Standard for the Energy performance of lifts, escalators and moving walks – Part 2: Energy calculation and classification for lifts. The Standard provides methods to estimate energy consumptions for lifts and methods for energy classification of new, existing or modernised lifts.

14.13 Escalators and moving walkways

If escalators and/or moving walkways are provided as part of a development, they must be *capable* of either stopping completely or slowing to at least 0.2 m/s when not used for more than 15 minutes. Note that this clause does not preclude escalators/ and or moving walkways stopping completely out of hours.

14.14 Lighting and power control devices

Specification J6 contains the technical requirements for any lighting and power control devices that are required by Part J6.

Compliance with the requirements of this specification should be verified and substantiated by manufacturer's data sheets during the *building approval* process. Verification would be like current approval processes for emergency lighting where details of the intended systems form an integral part of the approval process and approved documentation.

Specification J6 provides specific requirements for the operation and capability of the following electrical equipment:

- lighting timers;
- time switches;
- motion detectors; and

- daylight sensors and dynamic lighting control devices.

14.14.1 Lighting timers

A lighting timer is installed so that artificial lighting needed only for transiting between occupied parts of a building will operate on demand before turning off automatically after a reasonable time has passed. The provisions within clause 2 in Specification J6 are intended to provide a reliable and safe switching and lighting arrangement, without running unnecessarily.

The provisions specify that a timer switch needs to be available within 2 m of every entry door and visible when the space is not artificially lit. The area controlled by a single push button timer is limited to 100 m^2 to avoid wasteful energy use. Even so, at least 5 percent of lights in areas larger than 25 m^2 must operate separately from the timer to allow a constant low level of lighting for people to enter the space safely. The 5 percent of lighting that can remain active can usually be achieved by an exit sign or similar fitting. The percentage applies to numbers of lights and not to the energy used or illumination produced by the lighting.

The lighting timer must be *capable* of maintaining artificial lighting for more than 5 minutes and less than 12 hours if the timer is reset. The lighting timer must be *capable* of maintaining artificial lighting while the timer is reset.

> ***Design alert:***
>
> Where the corridor or space is part of an exit or other space defined under Part F4.4, the artificial lighting levels should comply with F4.4.

14.14.2 Time switches

Time switches are intended to turn off the power automatically. Subclause (a) in Clause 3 of Specification J6 specifies time switches to be programmed to accommodate the needs of the specific occupancy. However, the program must be *capable* of turning off the system after normal occupation has finished.

Subclause (b) requires a manual switch or occupant sensing device that overrides time switches for internal lighting by turning the lights on. The override period is to be up to 2 hours. If there is no further presence detected after 2 hours, the time switch must resume control. An alternative solution is to have occupant sensing devices such as security card readers or remote controls that override the time switch upon entry and returns control to the time switch upon exiting.

Subclause (c) specifies a time switch for external lighting to be configured to limit the systems on hours from 30 minutes before sunrise to 30 minutes after sunset, including any pre-programmed periods between these times, and be *capable* of being overridden for up to 8 hours by a manual switch, remote control or a security access system.

Subclause (d) requires a time switch for boiling water and chilled water storage units to be *capable* of being overridden by a manual switch or a security access system that detects a person's presence. If there is no further presence detected after 2 hours the time switch must resume control.

Design alert:

The term 'normal occupation' would, for example, also include suitable allowance for after-hours cleaning and other building functions outside the traditional 9am to 5pm operation of business premises.

14.14.3 **Motion detectors**

Motion detectors have many advantages over other control devices. For example, a person entering a space does not need to find the button to switch on the lights. The motion detector requirements for lighting include movement sensing means, detection thresholds, maximum areas that an individual detector can control, maximum number of lights that can be controlled by a detector, how long they can operate the lights after activation, and override facilities. Clause 4 in Specification J6 separates these requirements into four applications, for:

- a Class 2, 3 or Class 9c building, other than within a *SOU*;
- a Class 5, 6, 7, 8, 9a and 9b non-residential building;
- outside a building, and
- fire-isolated stairways, fire-isolated passageways or fire-isolated ramps.

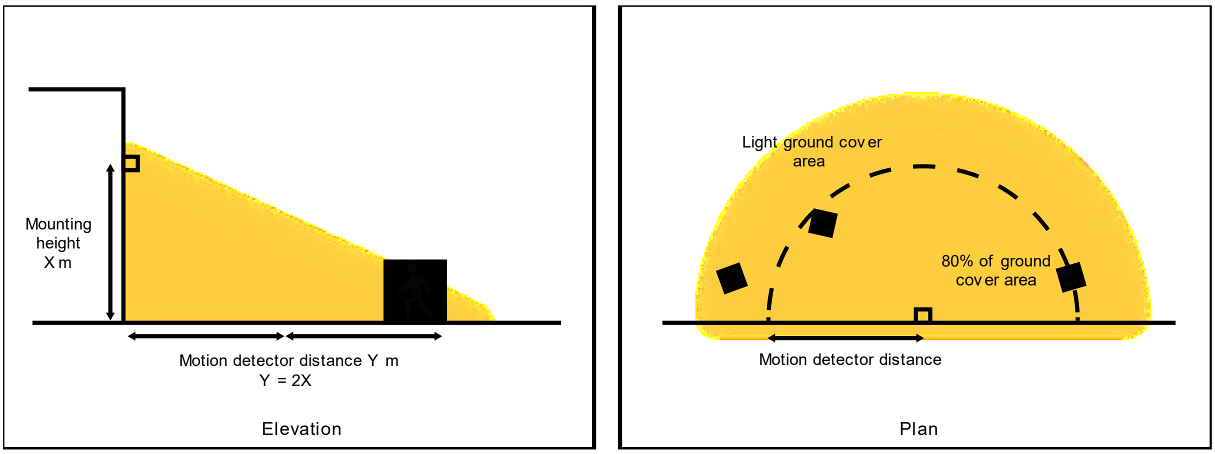
There are no specific requirements for a Class 4 part of a building.

Subclause (a) applies to Class 2, 3 or 9c buildings other than within a *SOU*. Within these buildings motion detectors must detect a person before they are 1m into the space through infra-red, ultrasonic or microwave detection. Other than within a *SOU* of a Class 3 building, the motion detectors must not control more than 100 m^2 to avoid wasteful energy use. Even so, at least 5 percent of lights in areas larger than 25 m^2 must operate separately from the timer to allow a constant low level of lighting for people to enter the space safely. Additionally, the motion detector must be configured so that the lights turn on after 15 minutes of the space being unoccupied and be *capable* of being overridden by a manual switch.

Subclause (b) applies to Class 5, 6, 7, 8, 9a or 9b buildings. Within these buildings a motion detector must detect a person before they are 1 m into the space and any movement within the space of 500 mm through infra-red, ultrasonic or microwave detection. The motion detector must not control more than 500 m^2 or more than 75 percent of the lights using high intensity discharge (Metal halides, high pressure sodiums, mercury vapour lamps) to avoid wasteful energy use. Additionally, the motion detector must be configured so that the lights turn off after 15 minutes of the space being unoccupied and be *capable* of being overridden by a manual switch.

Subclause (c) applies to areas outside of a building. Motion detectors must be *capable* of detecting a person from at least twice the distance of the mounting height or within 80 percent of the ground area covered by the light through pressure, infra-red, ultrasonic or microwave detection. The distances are explained in the diagrams below.

Figure 14.2 Motion detector spatial requirements of Specification J6 subclause (c)



When outside a building, the motion detector must control less than or equal to 5 lights to avoid wasteful energy. The motion detector must use time switches to ensure the lighting does not operate during the day. Additionally, the motion detector must be configured so that the lights turn off after 15 minutes of the space being unoccupied and be *capable* of being overridden by a manual switch which is reset after a period of less than 4 hours.

Subclause (d) applies to fire-isolated stairways, fire-isolated passageways and fire isolated ramps. Motion detectors must detect a person before they are 1 m into the space and movement of 500 mm through infra-red, ultrasonic or microwave detection. For safety reasons these lights must be configured so that the lights dim to a 30 percent peak power or less (they can go to zero) if the space has been unoccupied for 15 minutes.

14.14.4 **Daylight sensor and dynamic lighting control devices**

The daylight and dynamic lighting sensors are designed to respond to changes in the illumination levels within a designated area. The provisions define essential operational parameters for the sensors. These details can be verified from manufacturer’s data.

The provisions in Clause 5 of Specification J6 require the sensor or control device to be designed to operate only the artificial lighting.

Subclause (a) requires daylight sensors and dynamic control devices to be *capable* of adjusting the switching level set point between 50 and 1000 lux for switching on and off. Additionally, the devices must have a delay of more than 2 minutes and a differential of more than 100 lux for a sensor controlling high pressure discharge lighting, and 50 lux for a sensor controlling other than high pressure discharge lighting. Either dimmed or stepped switching is acceptable, provided the process complies with the arrangements in subclause (a)(ii), so that the system is *capable* of reducing the power consumed to continuously less than 50 percent of full power or at least 4 steps down to a power consumption that is less than 50 percent of full power and the technical requirements of this clause can be verified by manufacturer’s data.

Subclause (b) places limits on any manual override switch for sensors or dynamic control devices. It cannot bypass the controls or switch the lights permanently on, independently of the dimming arrangements. The limitation reduces the amount of time the override can be in place.

15 Part J7 – Heated water supply and swimming pool and spa pool plant

15.1 Introduction

These requirements have been developed to minimise the amount of energy used in providing sanitary heated water supply to a building and any pool or spa heating and pumping. The sanitary heated water supply is different to heated water used for space heating, which is covered by Part J5 of NCC Volume One and Chapter 13 of this Handbook.

A heated water supply system is a significant user of energy in a building and, although there is only limited data on pools and spas, their energy use is also significant.

As part of the consolidation of NCC heated water energy efficiency provisions for NCC 2014, some provisions which previously appeared in Part J7 have been relocated to Part B2, Heated water services of NCC Volume Three – PCA. While these provisions now appear in NCC Volume Three, they are still discussed in this Chapter.

15.2 Scope

The provisions are limited to the following-

- heated water supply systems for food preparation and sanitary purposes, except for solar heated water supply systems in *climate zones* 1, 2 and 3 (located in Part B2 of NCC Volume Three);
- swimming pool heating and pumping; and
- spa pool heating and pumping.

Design alert:

Is a heated water system that directly heats a building considered to be a service which needs to comply with Part J5?

The requirements for a heated water system used to directly heat a building, such as a hydronic heat panel system, are addressed by Part J5. Part J7 applies to drinking water delivered for food preparation or for hygiene and amenity purposes, as well as swimming pool and spa plant.

15.3 Intent

These requirements have been developed to control the loss of energy from sanitary or bathing water systems.

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, requirements have been introduced to reduce the amount of heat loss from these units, which in turn will provide tangible reductions in non-*renewable energy* use and GHG emissions. Another aspect of these provisions is the requirement to insulate heated water supply pipes irrespective of whether the pipes are fitted to a storage or instantaneous water heater. Note that solar water heaters in *climate zones* 1, 2 and 3 are exempt from this provision because ambient temperatures in these zones are generally high; reducing the need for pipe insulation, and an electric booster is unlikely to be used. This exemption is as per NCC Volume Three, where a solar heated water supply system for food preparation and sanitary purposes, where installed in a new building, is not required to comply with Section 8 of AS/NZS 3500.4.

The intent of the *DTS Provisions* relevant to swimming pools and spas is to:

- limit the energy supply to a less GHG intensive source, e.g. not resistive heating by electricity;
- limit the amount of energy used; and
- limit the loss of heat by conduction and convection.

This Chapter provides a detailed analysis of each of the clauses in Part J7 of NCC Volume One and Part B2 of NCC Volume Three.

The analysis discusses important points that should be considered when designing and assessing a building for compliance with these requirements.

15.4 DTS Provisions

This clause establishes that the *DTS Provisions* in Part J7 are part of an overall energy efficiency solution and each *DTS Provision* within Section J must be applied together to meet the *Performance Requirements.*

In simple terms, the building must comply with all the appropriate *DTS Provisions* in Section J to be considered as complying with NCC Volume One.

Accordingly, if there is any variation from the prescribed *DTS Provisions* in one part, then the entire set of energy efficiency requirements for the building will need to be checked to ensure that there is no unintended effect on the other Parts because of a *Performance Solution* being adopted for one Part. Refer to Chapter 3.

15.5 Heated water supply

As mentioned previously, the requirements of subclause J7.2 Heated water supply, are now located in NCC Volume Three. The current text directs the user to the requirements in NCC Volume Three.

NCC Volume One J7.2 Heated water supply

A heated water supply system for food preparation and sanitary purposes must be designed and installed in accordance with Part B2 of NCC Volume Three – Plumbing Code of Australia.

15.5.1 NCC Volume Three – Part B2 Heated water services

The requirements of B2 in NCC Volume Three contain the heated water requirements previously located in NCC Volume One. B2 sets out the requirements for the design, construction, installation, replacement, repair, alteration and maintenance of any part of *heated water service* of a property that is connected to the *drinking water* supply. It covers from the *point of connection* to the points of discharge. This section also specifies the minimum energy efficiency of a heater water system in a heated water supply system, but only for Class 1 and 10 (residential) buildings.

15.5.2 **NCC Volume Three B2.9 General Requirements**

The insulation of heated water service pipes for all Classes of building are covered by B2.9, General requirements. This provision states; the design, construction, installation, replacement, repair, alteration and maintenance of a heated water service must be in accordance with AS/NZS 3500.4.

AS/NZS 3500.4. specifies insulation requirements for heated water installations. The requirements in the Standard are intended to reduce heat loss from heated water supply system piping. In most instances, this is achieved by insulation and heat traps, which involve specific pipe configurations.

The heat trap controls energy loss by utilising gravity and the density of the heated water to limit the movement of heated water, thereby greatly reducing convection in the piping. In other words, the heated water is prevented from rising in the piping where its heat would be lost.

It should be noted that some heated water systems have internal heat traps concealed within the unit cabinet. Confirmation of such a heat trap arrangement can be obtained from the manufacturer.

Note The Standard characterises climates more broadly than the NCC *climate zones*. This results in the Standard having three climate regions where the NCC has eight *climate zones*. The climate regions within the Standard are larger than the NCC *climate zones* because the insulation levels that are economically justifiable are similar over a larger range of conditions. This reduces the need for more complex climate zoning and more graduation in the requirements.

15.6 Swimming pool heating and pumping

The first subclause J7.3(a) requires the heating for a swimming pool to be from any one of five 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.

Minimum efficiencies have been introduced for gas heating systems; so that larger systems require greater efficiency. This is particularly important for condensing *boilers*, as the inlet/outlet temperature of water will greatly impact the overall efficiency.

When a gas heater or a heat pump provides the heating, subclause J7.3(b) requires a pool cover regardless of the pool location with a minimum *R-value* of 0.05; and a time switch to control the operation of the heater. Requirements for a time switch are described in Specification J6 which is discussed in detail in Chapter 14.

Subclause (c) requires the time switch to operate the pump to reduce the amount of time and associated energy consumed when the pump is operating when not needed.

A time switch required by either subclause (b) or (c), must be *capable* of switching electric power on and off to a pre-programmed schedule (subclause (d)); which must allow both different times to be scheduled as well as different days. E.g. the swimming pool is used during the week from 7am to 7pm and on weekends from 9am to 5pm. Programming this schedule into the time switch must be possible.

Insulation requirements, covered in Chapter 13 apply to pipework carrying heated or chilled water for a swimming pool.

The sixth subclause J7.3(f) clarifies that this clause is about swimming pools and not about spa pools. Spa pools are covered by Clause J7.4.

15.7 Spa pool heating and pumping

Subclause J7.4(a) restricts the heating sources for a spa pool to the same ones permitted for a swimming pool where it shares a water reticulation system with a swimming pool.

The second subclause J7.4(b) requires a spa pool cover, regardless of the spa location, with a minimum *R-value* of 0.05; 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 in accordance with Specification J6 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.

As for swimming pools, a time switch required by either subclause (b) or (c), must be *capable* of switching electric power on and off to a pre-programmed schedule (subclause (d)); which must allow both different times to be scheduled as well as different days (e.g. the swimming pool is used during the week from 7am to 7pm and on weekends from 9am to 5pm). Programming this schedule into the time switch must be possible.

Insulation requirements outlined in Chapter 13 apply to pipework carrying heated water for a spa pool.

16 Part J8 – Facilities for energy monitoring

16.1 Introduction

Since the inception of a performance-based BCA in 1996, the obligation to maintain building safety requirements to ensure their ongoing performance has been expressed through the inclusion of Performance Statements in BCA Volume One through Section I – Maintenance. However, obligations to ensure ‘proper performance’ have existed in some State and Territory legislation since as early as 1945.

The introduction of a performance-based BCA also brought a desire to develop national maintenance requirements and in early 2000, work was undertaken to recognise the specific obligations imposed by state and territory legislation in the BCA. The relevant *DTS Provisions* or ‘what’ needs to be maintained were identified in Section I of BCA 2004.

However, many administrative issues on which maintenance standards and schedules rely (such as competencies of personnel, monitoring, reporting and auditing of servicing and maintenance systems) were not considered as being appropriate for inclusion in the BCA at this time. The BCA (known as NCC from 2011) therefore did not prescribe ‘how to maintain’ building requirements and jurisdictional approaches continued to apply and evolve individually in relevant legislation and Australian Standards.

As the requirements of Section I remained general in nature i.e. directing users to the relevant *DTS Provisions* to be used for determining compliance, it did not prescribe methods, or frequency for which safety requirements need to be maintained. This meant that most jurisdictions chose to replicate or supplement the Section I requirements.

Owing to concerns over the ability for Section I to be applied to multiple systems, schedules and standards, and the tension of applying the NCC beyond initial certification, a decision was taken that Section I be removed from NCC Volume One in 2014.

Furthermore, J8.2 - Access for maintenance and JP2 have been removed from NCC Volume One. However, designers and regulators still need to consider the need for access for maintenance of *air-conditioning*, ventilation, heated water supply, artificial lighting, vertical transport and the like. The need for these considerations is reflected in A5.0 - Suitability of NCC Volume One which states that every part of a building must be constructed and installed in an appropriate manner to achieve the requirements of the NCC, using materials and construction being fit for the purpose.

Reminder:

The removal of Section I and JP2 from NCC Volume One does not change or diminish obligations to maintain buildings to ensure ongoing performance in accordance with the general requirements expressed through State or Territory legislation. The ABCB has produced a non-mandatory handbook, Maintenance of Safety Measures, Equipment and Energy Efficiency Installations, that considers maintenance which is available from the ABCB website (abcb.gov.au).

Another important aspect of the initial construction is the installation of metering or other monitoring equipment to enable energy auditors or maintenance staff to determine, from the measured energy consumption, whether a system is operating efficiently. This is addressed through the requirements of Part J8.

16.2 Scope

The scope of the facilities required for energy monitoring varies from recording the total electricity and gas consumption of a relatively small building to individual monitoring of the major services in a larger building.

16.3 Intent

The intent of this Part is to ensure the building is designed to enable energy monitoring to be carried out easily. Building owners and designers should appreciate that effective design is concerned not only with the needs of the building occupants but also with the ongoing operation of the building infrastructure. The intent of requiring monitoring facilities is to enable information on the energy consumption of the building or its main services to be provided to identify and rectify any excessive use of energy.

16.4 DTS Provisions

This clause establishes that the *DTS Provisions* in Part J8 are part of an overall energy efficiency solution and each *DTS Provision* within Section J must be applied together to meet the *Performance Requirements.*

In simple terms, the building must comply with all the appropriate *DTS Provisions* in Section J to be considered as complying with NCC Volume One.

Accordingly, if there is any variation from the prescribed *DTS Provisions* in one part, then the entire set of energy efficiency requirements for the building will need to be checked to ensure that there is no unintended effect on the other Parts because of a *Performance Solution* being adopted for one Part.

16.5 Application

The requirements of Part J8 apply to all buildings except within a *SOU* of a Class 2 building or a Class 4 part of a building. They do not apply to Class 8 electricity network substations. This is because the power monitoring procedures for Class 8 electricity network substations have inherent and critical characteristics that either supersede or vary from the procedures adopted and applied to other buildings.

16.6 Facilities for energy monitoring

All buildings with a floor area greater than 500 m^2 must have a means of recording the consumption of gas and electricity. This includes all *SOUs* as these can include either residential buildings or suites of rooms, such as doctors' suites, which may have floor areas greater than 500 m^2. This does not mean recording of the electricity and gas consumption is required by the NCC, but rather that the ability to record is available. For buildings with a floor area no larger than 2,500 m^2, this need only be whole-of-building metering such as an electricity supply meter and/or a gas supply meter (whichever service is provided).

Most smaller buildings would have such meters supplied by the utilities company but, in the case of a campus style complex, such as a hospital, school or university, the utility company might provide only a single meter for the site.

Once a building exceeds 2,500 m^2, additional provisions apply in subclause (b). Buildings with a floor area greater than 2,500 m^2 must also have the means to record individually the energy consumption of nominated main services. The services include,

- *air-conditioning* plant including, where appropriate, heating plant, cooling plant and air handling fans;
- artificial lighting;
- appliance power;
- central heated water supply;
- internal transport devices including lifts, escalators, and moving walkways where there is more than one system serving the building; and
- other ancillary plant.

Note, it is not the intent of this provision to require the sub-metering of services within any *SOUs* within a building, or those related to the separate metering of a tenancy from a common area, only those that operate building wide.

The sub-meters monitoring the main services do not require the ability to record the data individually, however the ability to record, analyse and review the time-of-use energy consumption of these services is required in a single interface monitoring system (i.e. in 15, 30 or 60 minute intervals). This should form part of the building solution documentation. The intent of requiring time-of-use data is to allow maintenance personal to see an energy use profile that shows energy over the course of a day or at a specific time. Therefore, excess energy (for example after hours, on hot days) can be identified and remedied. This monitoring system may take the form of a Building Management System which is likely to be used, in any case, for effective management of the building services. However, other suitable facilities to perform this function are available.

There is an exemption in subclause (d) for Class 2 buildings with a floor area of more than 2,500 m^2 where the total area of the common areas is less than 500 m^2, to recognise instances where most of the floor area is occupied by dwellings, which are likely to be individually metered. However, the requirements of (a) still apply which means that the facility to record the consumption of gas and/or electricity must still be provided.

17 References

Pitt & Sherry with input from BIS Shrapnel and Exergy Pty Ltd, for the DCCEE, Baseline Energy Consumption and GHG Emissions – In Commercial Buildings in Australia, Part 1 – Report, November 2012 (pg. 7)

Emissions breakdown in Australia (ASBEC, 2017)

Commission Regulation (EU) No 622/2012, as referenced in J5.7(b)

Commission Regulation (EU) No 547/2012, as referenced in J5.7(c)

National Construction Code Volume Two, BCA Class 1 and Class 10 Buildings

National Construction Code Volume Three, Plumbing Code of Australia

18 Further reading

The following reference documents are recommended if further information is required regarding the energy efficiency provisions of NCC Volume One.

Each document, or information about the document, is available from the ABCB upon request:

ABCB (2018) Energy Efficiency for commercial buildings; Regulation Impact Statement for decision.

Energy Action (2018), Modelling and Sensitivity Analysis.

NSW Office of Environment and Heritage (2017) Handbook for estimating NABERS ratings

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 the 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*.

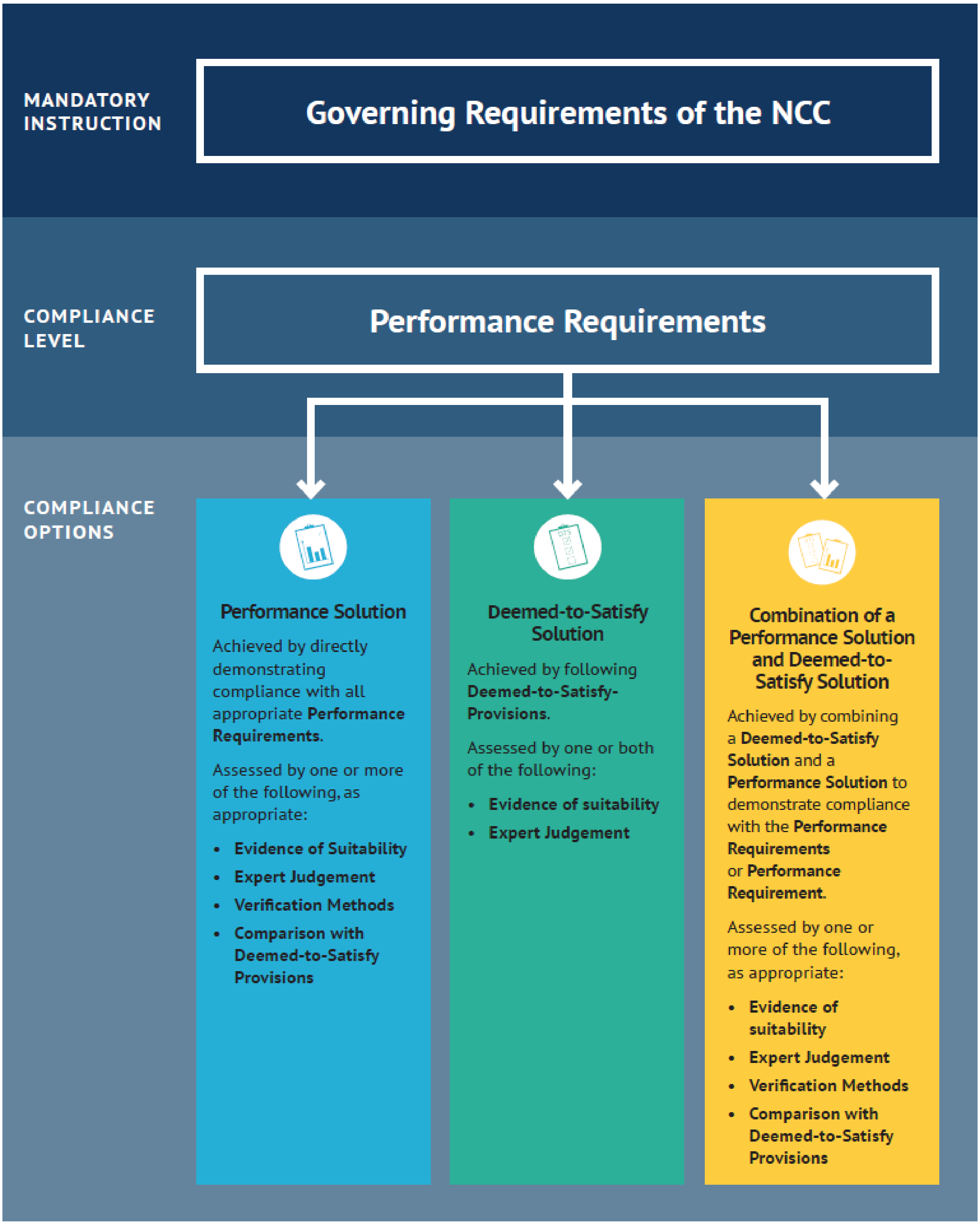
All compliance options must be assessed using one or a combination of the following *Assessment Methods*, as appropriate:

- 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
AFRC	Australian Fenestration Rating Council
AHRI	American Air-Conditioning, Heating & Refrigeration Institute
AIRAH	Australian Institute of Refrigeration Air conditioning and Heating
AS	Australian Standard
ASHRAE	The American Society for Heating, Refrigeration and Air-Conditioning Engineers
ANSI	American National Standards Institute
AHU	Air-handling unit
BCA	Building Code of Australia
BEP	Best Efficiency Point
BPIC	Building Products Innovation Council
CCT	correlated colour temperature
CDB	degree(s) Celsius Dry Bulb
COAG	Council of Australian Governments
COP	Coefficient of Performance
CRI	colour rendering index
DCCEE	Department of Climate Change and Energy Efficiency (Australian Government)
DTS	Deemed-to-Satisfy
EEI	energy efficiency index
EER	Energy Efficiency Ratio
FCU	Fan coil unit

Acronym/Symbol	Meaning
FMAANZ	Fan Manufacturing Association of Australia and New Zealand
GBCA	Green Building Council of Australia
GHG	Greenhouse gas
HEPA	High efficiency particulate arrestance
HVAC	Heating, Ventilation and Air-Conditioning
IGA	Inter-government agreement
MEPS	Minimum Energy Performance Standards
NABERS	National Australian Built Environment Rating System
NatHERS	Nationwide House Energy Rating Scheme
NEPP	National Energy Productivity Plan
NCC	National Construction Code
NZS	New Zealand Standard
PBDB	Performance-based Design Brief
PCA	Plumbing Code of Australia
PMV	Predicted Mean Vote
SHGC	Solar Heat Gain Coefficient
SOU	sole-occupancy unit
VAV	Variable-air volume
WHS	Workplace Health and Safety

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.

Air Handling Unit (AHU) means an item of plant that moves air by mechanical means using fans. It also often contains filtration devices and coils for heating and cooling. It is often located in a plant room or on the roof.

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 is used in the *Functional Statement* and is important, as energy consumption in a building is highly dependent on how the building is used. Energy efficiency cannot be assured simply by appropriate requirements into the building 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 services installed. Many buildings are constructed with a minimum of services provided; allowing the occupants or tenants to install their own preferred services at a later stage. As such, the NCC Volume One energy efficiency requirements must be *capable* of catering for these services after the base building is constructed.

Clean workstation means an environment, usually used in manufacturing of medical products, scientific research or engineering applications, with low levels of environmental pollutants.

Evaporative cooler means an *air-conditioning* system that utilises the evaporation or water to cool air.

Facilitate is used in *Performance Requirement* JP1 to highlight that the installation of energy efficiency features gives the building the ability to reduce energy consumption. However, reduced energy consumption may only be achieved if the building is operated, managed and maintained correctly.

Fan Coil Units (FCU) can be considered a small *AHU* and contains a circulation fan, one or more coils for heating/cooling and; possibly, an air filter. An *FCU* may be used alone or in conjunction with an *AHU*. For example, an *AHU* may handle the fresh make-up air for many *FCUs* which are then located either in or adjacent to the *conditioned spaces. FCUs* are often located in ceiling spaces above the areas served.

Functional Statement: means a statement providing guidance on how a building achieves the *Objectives*. It is found in The Guide to Volume One.

Greenhouse gas intensity is the average emission rate of a given pollutant from a given source relative to the intensity of a specific activity; for example grams of carbon dioxide released per megajoule of energy produced (g CO_2-e/ MJ). It is used in the Modelling Parameters Specification JVb.

HVAC (Heating, Ventilation and Air-Conditioning) describes all systems in a building which condition air by heating or cooling or which move it through the building. A simple split *air-conditioning* unit is part of an *HVAC* system as much as is a more complex centralised *air-conditioning* system involving chillers, *boilers* and air handling plant.

kW_r means kilowatts of refrigeration and is a metric or SI unit (International System of Units) with the additional abbreviation ‘r’ referring to the cooling capacity of refrigeration plant.

$kW_{heating}$ means kilowatts of heating and is a SI unit with the additional word ‘heating’ referring to the capacity of heating plant.

Mechanical ventilation applies to the provision of ventilation using mechanical fans; typically exhaust and/or supply air fans. The ventilation requirement may be integrated into an *air-conditioning* system or be a standalone system. It includes the *mechanical ventilation* required by Part F4.

Natural ventilation is the process of supplying and removing air from an indoor space without the use of *mechanical ventilation* systems. Strategic placement of openings can help to move air through a building at an increased rate and in the desired direction, by creating high and low pressure or taking advantage of naturally rising warm air.

Objective means a statement providing guidance on the community expectations of requirements in the NCC. It is found in The Guide to Volume One.

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.

Both *opaque* building materials such as walls, and transparent or translucent elements considered as *glazing* are under Part J1 – Building Fabric.

Permanent is used to describe features which will have a long term impact on the exposure of the building to climatic effects. *Permanent* features could include natural landscape forms, such as mountains and escarpments, while *permanent* man-made features would include buildings that are likely to be in place for a long period of time, relative to the building being considered.

Thermal bridge is an area or component of the fabric which has higher thermal conductivity than the surrounding materials, creating a path of least resistance for heat transfer. A *thermal bridge* is also called a cold bridge or heat bridge. *Thermal bridges* can significantly reduce the thermal performance of a facade, increasing energy use from a building's heating and cooling systems. If not accounted for, they can also cause unwanted condensation and comfort issues in a building.

Thermal mass is the ability of a material to absorb and store heat as energy. *Thermal mass* can moderate internal temperatures by storing solar energy during the day and re-radiating the heat energy at night.

To the degree necessary is referred to in the *Performance Requirements* because:

- there may be a minimum energy consumption below which it is unnecessary or impractical to regulate;
- there may be some building types for which it is unnecessary or impractical to regulate; and
- some of the features may not be appropriate for some building types.

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.

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.

Watt/(W/L/s) is a measure of the amount of energy used in moving a litre of air (by fans) or of water (by pumps) in one second for purposes of providing building services. The higher the wattage, the more power the fan or pump uses to move the air or water and the lower its energy efficiency.

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
- state emergency risk management policies.