BUILDING PERFORMANCE

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Effective until 4 August 2022
Replaced by H1/VM2 First Edition Amendment 1

H1 Energy Efficiency

Verification Method H1/VM2

Energy efficiency for buildings greater than 300 m²

FIRST EDITION | EFFECTIVE 29 NOVEMBER 2021

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

New Zealand Government

Preface

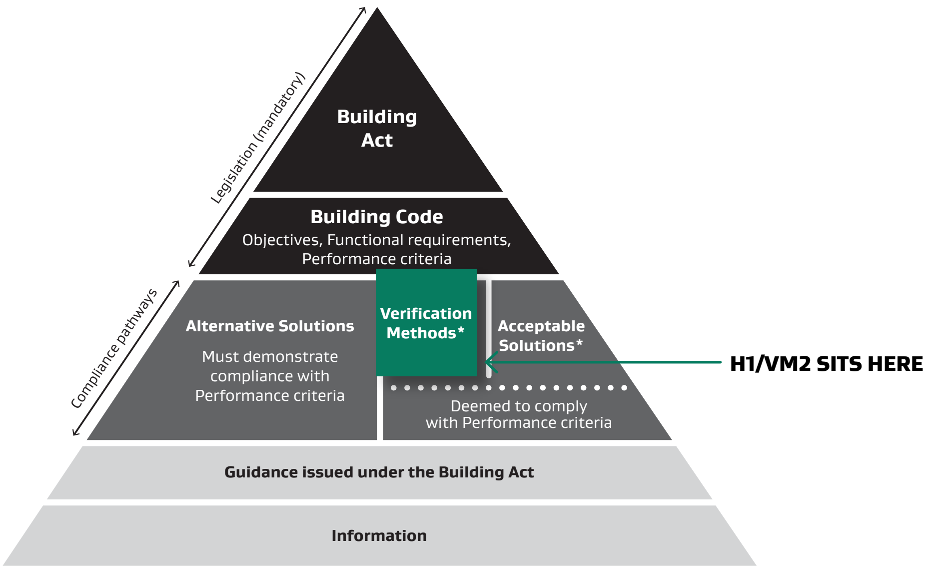
Document status

This document (H1/VM2) is a verification method issued under section 22 (1) of the Building Act 2004 and is effective on 29 November 2021. It does not apply to building consent applications submitted before 29 November 2021. The previous Verification Method H1/VM1 Fourth Edition Amendment 4, can be used to show compliance until 2 November 2022 and can be used for building consent applications submitted before 3 November 2022.

Building Code regulatory system

Each verification method outlines the provisions of the Building Code that it relates to. Complying with an acceptable solution or verification method is a way of complying with that part of the Building Code. Other options for establishing compliance are listed in section 19 of the Building Act.

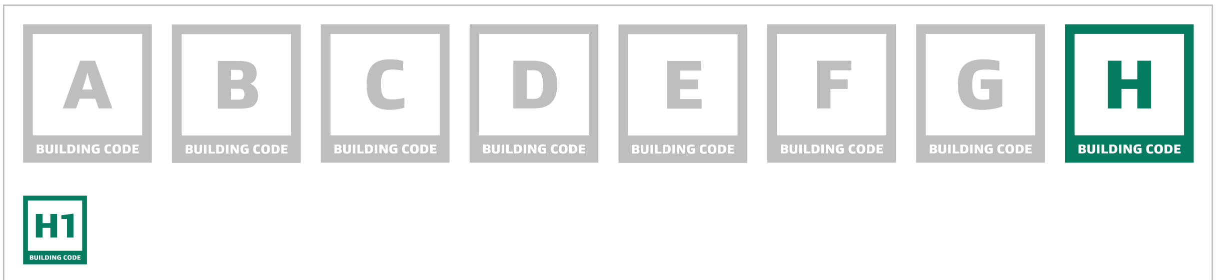
Schematic of the Building Code System



** may include cited standards and information*

A building design must take into account all parts of the Building Code. The Building Code is located in Schedule 1 of the Building Regulations 1992 and available online at www.legislation.govt.nz

The part of the Building Code that this verification method relates to is clause H1 Energy Efficiency. Further information on the scope of this document is provided in Part 1. General.



Further information about the Building Code, the objectives, functional requirements and performance criteria provisions that it contains, and other acceptable solutions and verification methods are available at www.building.govt.nz

Main changes in this version

This is the first edition of H1/VM2. However, prior to its release, similar requirements were previously found within H1/VM1. The main changes from H1/VM1 Fourth Edition Amendment 4 are:

- The scope of H1/VM1 has been reduced to cover only housing, and buildings other than housing less than 300 m². Requirements applicable to large buildings have been combined into the new Verification Method H1/VM2. To reflect the new scope of the documents and the new document layout, a new introduction and scope has been provided in Part 1. General.
- Citation of NZS 4243.1: 2007 "Energy Efficiency – Large Buildings Part 1: Building Thermal Envelope" has been removed from the document. The relevant content from this standard has been adopted into H1/VM2 with permission from Standards New Zealand.
- The minimum *R-values* previously found in NZS 4218 and NZS 4243.1 have been updated with new values found in Part 2. Building.
- The requirements for determining the thermal resistance and construction R-value of building elements have been revised to better reflect the thermal performance of windows, doors, skylights and slab-on-ground floors.
- Portions of text have been re-written to enhance clarity in the document and provide consistent language with other acceptable solutions and verification methods.
- References have been revised to include only documents within the scope of H1/VM2 in Appendix A.
- Additional references have been added to include AS/NZS 4859.1, BS EN 673, ISO 10077-1 and ISO 10077-2, ISO 10211, ISO 10456, ISO 12631, ISO 13370 and ISO 13789 in Appendix A.
- The definitions page has been revised to include all defined terms used in this document in Appendix B.
- The three-zone climate zone map previously found in NZS 4218 and NZS 4243.1 has been replaced with a six-zone climate zone map in Appendix C.
- The computer modelling method for determining the building energy use has been provided in Appendix D.
- A new procedure for calculating the construction R-value of windows, doors, skylights and curtain walling has been added in Appendix E.
- A new procedure for calculating the construction R-value of slab-on-ground floors has been added in Appendix F.

People using this document should check for amendments on a regular basis. The Ministry of Business, Innovation and Employment may amend any part of any acceptable solution or verification method at any time. Up-to-date versions of acceptable solution and verification methods are available from www.building.govt.nz

Features of this document

- For the purposes of Building Code compliance, the standards and documents referenced in this verification method must be the editions, along with their specific amendments listed in Appendix A.
- Words in *italic* are defined at the end of this document in Appendix B.
- Hyperlinks are provided to cross-references within this document and to external websites and appear with a blue underline.
- Classified uses for buildings, as described in clause A1 of the Building Code, are printed in **bold** in this document. These are denoted with classified use icons for:

H	Housing	CR	Commercial	Out	Outbuildings
CR	Communal residential	Ind	Industrial	Anc	Ancillary
CN	Communal non- residential				

- Appendices to this verification method are part of, and have equal status to, the verification method. Figures are informative only and the wording of the paragraphs takes precedence. Text boxes headed 'COMMENT' occur throughout this document and are for guidance purposes only.

Contents

Part 1. General

1.1 Introduction

1.1.1 Scope of this document

CR CN Com 1.1.1.1 This document applies to **communal residential**, **communal non-residential** (assembly care only) and **commercial** *buildings* with a floor area of *occupied space* greater than 300 m^2.

H 1.1.1.2 For all **housing**, and *buildings* other than **housing** with an *occupied space* less than 300 m^2, refer to the Acceptable Solution H1/AS1 or Verification Method H1/VM1 as a means to demonstrate compliance or use an alternative means to demonstrate compliance.

1.1.2 Items outside the scope of this document

1.1.2.1 This verification method does not include the use of foil insulation.

1.1.2.2 This verification method does not include requirements to comply with Building Code clauses H.1.3.1(b), H1.3.4, H1.3.5 or H1.3.6. For these clauses, use an alternative means to demonstrate compliance.

1.1.3 Compliance pathway

1.1.3.1 This verification method is one option that provides a means of establishing compliance with the performance criteria in Building Code clauses H1.3.1 (a), and H1.3.3.

1.1.3.2 Options for demonstrating compliance with H1 Energy Efficiency through the use of acceptable solutions and verification methods are summarised in Table 1.1.3.2. Compliance may also be demonstrated using an alternative solution.

1.2 Using this verification method

1.2.1 Determining the classified use

1.2.1.1 Classified uses for *buildings* are described in clause A1 of the Building Code. Where a specific classified use is mentioned within a subheading and/or within the text of a paragraph, this requirement applies only to the specified classified use(s), and does not apply to other classified uses.

Ind 1.2.1.2 In *buildings* containing both **industrial** and other classified uses, the non-industrial portion shall be treated separately according to its classified use. For example, in a *building* containing both **industrial** and **commercial** classified uses, the **commercial** area shall meet the relevant energy efficiency requirements of the Building Code.

TABLE 1.1.3.2: Demonstrating compliance with H1 Energy Efficiency through acceptable solutions and verification methods

Paragraph 1.1.3.2

Performance clause	Applies to	Relevant acceptable solutions and verification methods
H1.3.1 (a) and (b) *Thermal Envelope*	H **Housing** CR **Communal residential** CN **Communal non-residential** (assembly care only) Com **Commercial**	For **housing**, and *buildings* no greater than 300 m^2: H1/AS1 or H1/VM1 For large *buildings*: H1/AS2 or H1/VM2
H1.3.2E *Building performance index*	H **Housing**	H1/AS1 or H1/VM1
H1.3.3 (a) to (f) Physical conditions	All *buildings*	For **housing**, and *buildings* no greater than 300 m^2: H1/AS1 or H1/VM1 For large *buildings*: H1/AS2 or H1/VM2
H1.3.4 (a) Heating of hot water	All *buildings*	For **housing**, and *buildings* no greater than 300 m^2: H1/AS1 For large *buildings*: H1/AS2
H1.3.4 (b) Storage vessels and distribution systems	Individual storage vessels ≤ 700 L in capacity and distribution systems	For **housing**, and *buildings* no greater than 300 m^2: H1/AS1 For large *buildings*: H1/AS2
H1.3.4 (c) Efficient use of hot water	H **Housing**	H1/AS1
H1.3.5 Artificial lighting	Lighting not provided solely to meet the requirements of Building Code clause F6 in: Com CN **Commercial** and **Communal non-residential** having *occupied space* greater than 300 m^2	H1/AS2
H.1.3.6 *HVAC systems*	Com **Commercial**	H1/VM3

Part 2. Building thermal envelope

2.1 Thermal resistance

2.1.1 Demonstrating compliance

2.1.1.1 The *building envelope* shall be *constructed* to provide *adequate thermal resistance*. This is demonstrated through the use of the *building* energy use modelling method described in Subsection 2.1.2.

COMMENT:

1) To satisfy the Building Code performance requirement E3.3.1 for internal moisture, it may be necessary, depending on the method adopted, to provide more insulation (greater *R-value*) than that required to satisfy energy efficiency provisions alone.

2) Passive measures to prevent overheating from excessive solar heat gains through the *building envelope* should be taken to reduce dependence on active cooling systems. Such measures should include a combination of:

- Providing *adequate thermal resistance* to the *thermal envelope* of the *building*; and
- Avoiding excessive *window areas* (particularly on the east, north and west facing facades); and
- Avoiding excessive *skylight areas*; and
- Selecting glass types with appropriate *solar heat gain coefficients (SHGC)*; and
- Providing external shading for windows and *skylights*; and
- Providing the ability to ventilate the *building* at a sufficient rate to maintain comfortable indoor temperatures in summer.

2.1.2 Modelling method for verification of the design

2.1.2.1 Verification of the design is achieved by demonstrating that the energy use of the *proposed building* design does not exceed the energy use of the *reference building* using computer modelling described in Appendix D.

2.1.2.2 The sum of the calculated annual *heating load* and annual *cooling load* of the *proposed building* shall not exceed that of the *reference building*. The *reference building* shall have *construction R-values* from:

a) For *building elements* that contain embedded heating systems Table 2.1.2.2A; or

b) For *building elements* that do not contain embedded heating systems, Table 2.1.2.2B.

2.1.2.3 The requirements for the *reference building* are separated based on the relevant climate zone for the *building*. A list of the New Zealand climate zones is provided in Appendix C.

2.1.2.4 For *building elements* that contain embedded heating systems, the *proposed building* must, as a minimum, meet the *construction R-values* of Table 2.1.2.2A.

TABLE 2.1.2.2A: Minimum construction R-values for heated roofs, walls or floors

Paragraph 2.1.2.2 a), 2.1.2.4

Building element	Minimum construction R-values (m²·K/W) (1), (2), (3)					
	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6
Heated roof (4)	R6.6	R6.6	R6.6	R6.6	R6.6	R7.0
Heated wall	R2.9	R2.9	R3.0	R3.2	R3.4	R3.6
Heated floor	R2.9	R2.9	R2.9	R3.0	R3.2	R3.4

Notes:

(1) R_{IN}/R-value < 0.1 and R_{IN} is the *thermal resistance* between the heated plane and the inside air.

(2) Floor coverings, for example carpet or cork, will reduce the efficiency of the *heated floor*.

(3) Climate zone boundaries are shown in Appendix C.

(4) In *roofs* with a *roof* space, where the insulation is installed over a horizontal ceiling, the *roof R-value* may be reduced to R3.3 for a distance of up to 500 mm from the outer edge of the ceiling perimeter where space restrictions do not allow full-thickness insulation to be installed.

TABLE 2.1.2.2B: Minimum construction R-values for building elements not containing embedded heating systems

Paragraph 2.1.2.2 a)

Building element	Construction R-values (m²·K/W) (1)					
	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6
Roof (2)	R3.5	R4.0	R5.0	R5.4	R6.0	R7.0
Wall	R2.2	R2.4	R2.7	R3.0	R3.0	R3.2
Floor	R2.2	R2.2	R2.2	R2.4	R2.5	R2.6
Windows and doors	R0.33	R0.33	R0.37	R0.37	R0.40	R0.42
Skylights	R0.42	R0.42	R0.46	R0.46	R0.49	R0.51

Note:

(1) Climate zone boundaries are shown in Appendix C.

(2) In *roofs* with a *roof* space, where the insulation is installed over a horizontal ceiling, the *roof R-value* may be reduced to R3.3 for a distance of up to 500 mm from the outer edge of the ceiling perimeter where space restrictions do not allow full-thickness insulation to be installed.

2.1.3 Determining the thermal resistance of building elements

2.1.3.1 Verification of the *thermal resistance* (*R-values*) of *building elements* is achieved by:

a) For walls, *roofs* and floors other than *slab-on-ground* floors, using NZS 4214; and

b) For windows, doors, *skylights* and *curtain walling*, using Appendix E; and

c) For *slab-on-ground floors*, using Appendix F.

COMMENT: The BRANZ House Insulation Guide provides *thermal resistances* of common *building* components and is based on calculations from NZS 4214. However, the BRANZ House Insulation Guide, 5th edition or earlier, should not be used for determining the *thermal resistances* of *slab-on-ground floors*, windows, and doors due to differences in calculation methods and assumptions compared to Appendix E and Appendix F.

2.1.3.2 The *thermal resistance* (R-values) of insulation materials may be verified by using AS/NZS 4859.1.

2.1.3.3 The *construction R-values* of *building elements* shall be calculated as follows:

a) For walls and *roofs*, the *R-value* is of a typical area of the *building element*; and

b) For framed walls, the *R-value* shall include the effects of studs, dwangs, top plates and bottom plates, but may exclude the effects of lintels, sills, additional studs that support lintels and sills, and additional studs at corners and junctions; and

c) For walls without frames, the *R-value* excludes any attachment requirements for windows and doors; and;

d) For windows, doors and *skylights*, as specified in Appendix E; and

e) For *slab-on-ground* floors, the *R-value* is as specified in Appendix F; and

f) For floors other than *slab-on-ground floors*, the *R-value* is of a typical area of the floor ignoring the effect of floor coverings (including carpets).

Appendix A. References

For the purposes of Building Code compliance, the standards and documents referenced in this verification method must be the editions, along with their specific amendments, listed below.

Standards New Zealand		Where quoted
NZS 4214: 2006	Methods of determining the total thermal resistance of parts of buildings	2.1.3.1, Definitions
AS/NZS 4859:	Thermal insulation materials for buildings	
Part 1: 2018	General criteria and technical provisions	2.1.3.2
British Standards Institute		
BS EN 673: 2011	Glass in building – Determination of thermal transmittance (U value) – Calculation method	E.1.2.2 a), E.1.2.4 a), E.2.1.2 a), Equation E.5
International Organization for Standardization		
ISO 10077:	Thermal performance of windows, doors and shutters – Calculation of thermal transmittance	
Part 1: 2017	General	E.1.2.2, E.1.2.4 a), E.1.3.1, E.2.1.2, Equation E.3
Part 2: 2017	Numerical method for frames	E.1.2.2 b), E.1.2.4 b), E.2.1.2 b)
ISO 10211: 2017	Thermal bridges in building construction – Heat flows and surface temperatures – Detailed calculations	F.1.2.3
ISO 10456: 2007	Building materials and products – Hygrothermal properties – Tabulated design values and procedures for determining declared and design thermal values	F.1.2.6
ISO 12631: 2017	Thermal performance of curtain walling – Calculation of thermal transmittance	Equation E.5
ISO 13370: 2017	Thermal performance of buildings – Heat transfer via the ground – Calculation methods	F.1.2.2, F.1.2.3, F.1.2.4, F.1.2.6
ISO 13789: 2017	Thermal performance of buildings – Transmission and ventilation heat transfer coefficients – Calculation method	F.1.2.3

These standards can be accessed from www.standards.govt.nz.

American National Standards Institute		
ANSI/ASHRAE 140: 2017	Standard method of test for the evaluation of building energy analysis computer programs	D.1.3.1

This standard can be accessed from webstore.ansi.org/

References

BRANZ Ltd

BRANZ House Insulation Guide (5th Edition), 1 July 2014	2.1.3.1 Comment, F.1.1.1 Comment

This document can be accessed from www.branz.co.nz.

International Energy Agency

Building Energy Simulation Test (BESTEST) and Diagnostic Method (1995)	D.1.3.1

This document can be accessed from www.nrel.gov

Appendix B. Definitions

These definitions are specific to this verification method. Other defined terms found in italics within the definitions are provided in clause A2 of the Building Code.

Adequate	Means *adequate* to achieve the objectives of the Building Code.
Building	Has the meaning given to it by sections 8 and 9 of the Building Act 2004.
Building element	Any structural or non-structural component or assembly incorporated into or associated with a *building*. Included are *fixtures*, services, *drains*, permanent mechanical installations for access, glazing, partitions, ceilings and temporary supports.
Building envelope	The *building thermal envelope* plus the exterior surface of any spaces not requiring conditioning, e.g. garage, floor space (below insulating layer), *roof* space (above any outer surface defining an attic or when there is no attic above the insulating layer).
Conditioned space	That part of a *building* within the *building thermal envelope* that may be directly or indirectly heated or cooled for occupant comfort. It is separated from *unconditioned space* by *building elements* (walls, windows, *skylights*, doors, *roof*, and floor) to limit uncontrolled airflow and heat loss.
Construct	In relation to a *building*, includes to design, build, erect, prefabricate, and relocate the *building*; and *construction* has a corresponding meaning.
Construction R-value	The total *thermal resistance (R-value)* of a typical area of a *building element*.
Cooling load	The amount of heat energy removed from the *building* to maintain it below the required maximum temperature (the amount of heat removed by the chosen appliances, not the amount of fuel required to run them).
Curtain walling	Part of the *building envelope* made of a framework usually consisting of horizontal and vertical profiles, connected together and anchored to the supporting structure of the *building*, and containing fixed and/or openable infills, which provides all the required functions of an internal or *external wall* or part thereof, but does not contribute to the load bearing or the stability of the structure of the *building*.
Door area (A_{door})	The total area of doors in the thermal envelope, including frames and opening tolerances, and including any opaque panels, glazing, decorative glazing and louvres.
External wall	Any vertical exterior face of a *building* consisting of primary and/or secondary elements intended to provide protection against the outdoor environment
Floor area	In relation to a *building*, means the *floor area* (expressed in square metres) of all interior spaces used for activities normally associated with domestic living.
Glazing Area ($A_{glazing}$)	The total area of vertical windows and doors that include glazing in the *thermal envelope* including transparent or translucent glazing, frames and opening tolerances, decorative glazing, and louvres. This excludes opaque panels, opaque doors, and *skylights*.
Heated roof, wall, or floor	Any *roof*, wall, or floor incorporating embedded pipes, electrical cables, or similar means of raising the temperature of the *roof*, wall, or floor for room heating.
Heating load	The amount of heat energy supplied to the *building* to maintain it at the required temperature (the amount of heat delivered by the chosen appliances, not the amount of fuel required to run them).

HVAC system	For the purposes of performance H1.3.6 and in relation to a *building*, means a mechanical, electrical, or other system for modifying air temperature, modifying air humidity, providing ventilation, or doing all or any of those things, in a space within the *building*.
Insulation plane	The plane within a *building envelope component* where the predominant *R-value* is achieved.
Intended use	In relation to a *building*, — a) includes any or all of the following: i) any reasonably foreseeable occasional use that is not incompatible with the intended use; ii) normal maintenance; iii) activities undertaken in response to *fire* or any other reasonably foreseeable emergency; but b) does not include any other maintenance and repairs or rebuilding.
Occupied space	Any space within a *building* in which a person will be present from time to time during the *intended use* of the *building.*
Persons	Includes— a) the Crown; and b) a corporation sole; and c) a body of *persons* (whether corporate or unincorporated).
Plug load	The electrical load drawn by electrical appliances connected to the *building* electrical reticulation system by way of general purpose socket outlets.
R-value	The common abbreviation for describing the values of both *thermal resistance* and *total thermal resistance*.
Roof	Any *roof*-ceiling combination where the exterior surface of the *building* is at an angle of 60° or less to the horizontal and has its upper surface exposed to the outside.
Shading coefficient (SC)	The ratio of the total *solar heat gain coefficient* (SHGC) through a particular glass compared to the total *solar heat gain coefficient* through 3 mm clear float glass.
Slab-on-ground floors	Floor *construction* consisting of a concrete slab or concrete raft foundation in contact with the ground over its whole area.
Skylight	Translucent or transparent parts of the *roof*, including frames and glazing.
Skylight area ($A_{skylight}$)	The area of *skylights* that are part of the *roof thermal envelope*, including frames and opening tolerances.
Solar Heat Gain Coefficient (SHGC)	The total solar energy entering a *building* through the glazing, that is, the direct transmission of energy from the sun plus the inwards re-radiation of heat from solar radiation that is absorbed in the glass. The SHGC is also known as the solar factor (SF) or g (glazing factor).
Thermal envelope	The *roof*, wall, window, *skylight*, door and floor *construction* between *unconditioned spaces* and *conditioned spaces*.
Thermal mass	The heat capacity of the materials of the *building* affecting *building* heat loads by storing and releasing heat as the interior and/or exterior temperature and radiant conditions fluctuate.
Thermal resistance	The resistance to heat flow of a given component of a *building element*. It is equal to the air temperature difference (K) needed to produce unit heat flux (W/m^2) through unit area (m^2) under steady conditions. The units are $m^2{\cdot}K/W$.

Total thermal resistance	The overall air-to-air *thermal resistance* across all components of a *building element* such as a wall, *roof* or floor. (This includes the surface resistances which may vary with environmental changes eg temperature and humidity, but for most purposes can be regarded as having standard values as given in NZS 4214.)
Total wall area	In relation to a *building,* means the sum (expressed in square metres) of the following: a) the *wall area* of the *building*; and b) the area (expressed in square metres) of all vertical windows and doors in *external walls* of the *building.*
Unconditioned space	Space within the *building envelope* that is not *conditioned space* (for example, this may include a garage, conservatory, atrium, attic, subfloor, and so on). However, where a garage, conservatory or atrium is expected to be heated or cooled these spaces shall be included in the *conditioned space*.
Wall area	The area of walls that are part of the *thermal envelope*, measured on the exterior side and excluding the *door area* and the *window area*.
Window area (A_{window})	The total area of windows in the *thermal envelope*, including transparent or translucent glazing, frames and opening tolerances and decorative glazing and louvres, but excluding glazing in doors and *skylights*.

Appendix C. New Zealand climate zones

C.1 Climate zones

C.1.1 Climate zone boundaries

C.1.1.1 There are six climate zones. The climate zone boundaries are based on climatic data taking into consideration territorial authority boundaries.

C.1.1.2 A list of the climate zones for each territorial authority is provided in Table C.1.1.2 and illustrated in Figure C.1.1.2. The list in the table takes precedence over the figure.

TABLE C.1.1.2: Climate zones by territorial authority
Paragraph C.1.1.2

North Island/Te Ika-a-Māui	
Territorial authority	**Climate zone**
Far North District	1
Whangarei District	1
Kaipara District	1
Auckland	1
Thames-Coromandel district	1
Hauraki District	2
Waikato District	2
Matamata-Piako District	2
Hamilton City	2
Waipa District	2
Ōtorohanga District	2
South Waikato District	2
Waitomo District	2
Taupo District	4
Western Bay of Plenty District	1
Tauranga City	1
Rotorua District	4
Whakatane District	1
Kawerau District	1
Ōpōtiki District	1
Gisborne District	2
Wairoa District	2
Hastings District	2
Napier City	2
Central Hawke's Bay District	2
New Plymouth District	2
Stratford District	2
South Taranaki District	2
Ruapehu District	4
Whanganui District	2
Rangitikei District (north of 39°50'S (-39.83))	4
Rangitikei District (south of 39°50'S (-39.83))	3
Manawatu District	3
Palmerston North City	3
Tararua District	4
Horowhenua District	3
Kapiti Coast District	3
Porirua City	3
Upper Hutt City	4
Lower Hutt City	3
Wellington City	3
Masterton District	4
Carterton District	4
South Wairarapa District	4

South Island/Te Waipounamu	
Territorial authority	**Climate zone**
Tasman District	3
Nelson City	3
Marlborough District	3
Kaikoura District	3
Buller District	4
Grey District	4
Westland District	4
Hurunui District	5
Waimakariri District	5
Christchurch City	5
Selwyn District	5
Ashburton District	5
Timaru District	5
Mackenzie District	6
Waimate District	5
Chatham Islands	3
Waitaki District (true left of the Otekaieke river)	6
Waitaki District (true right of the Otekaieke river)	5
Central Otago District	6
Queenstown-Lakes District	6
Dunedin City	5
Clutha District	5
Southland District	6
Gore District	6
Invercargill City	6

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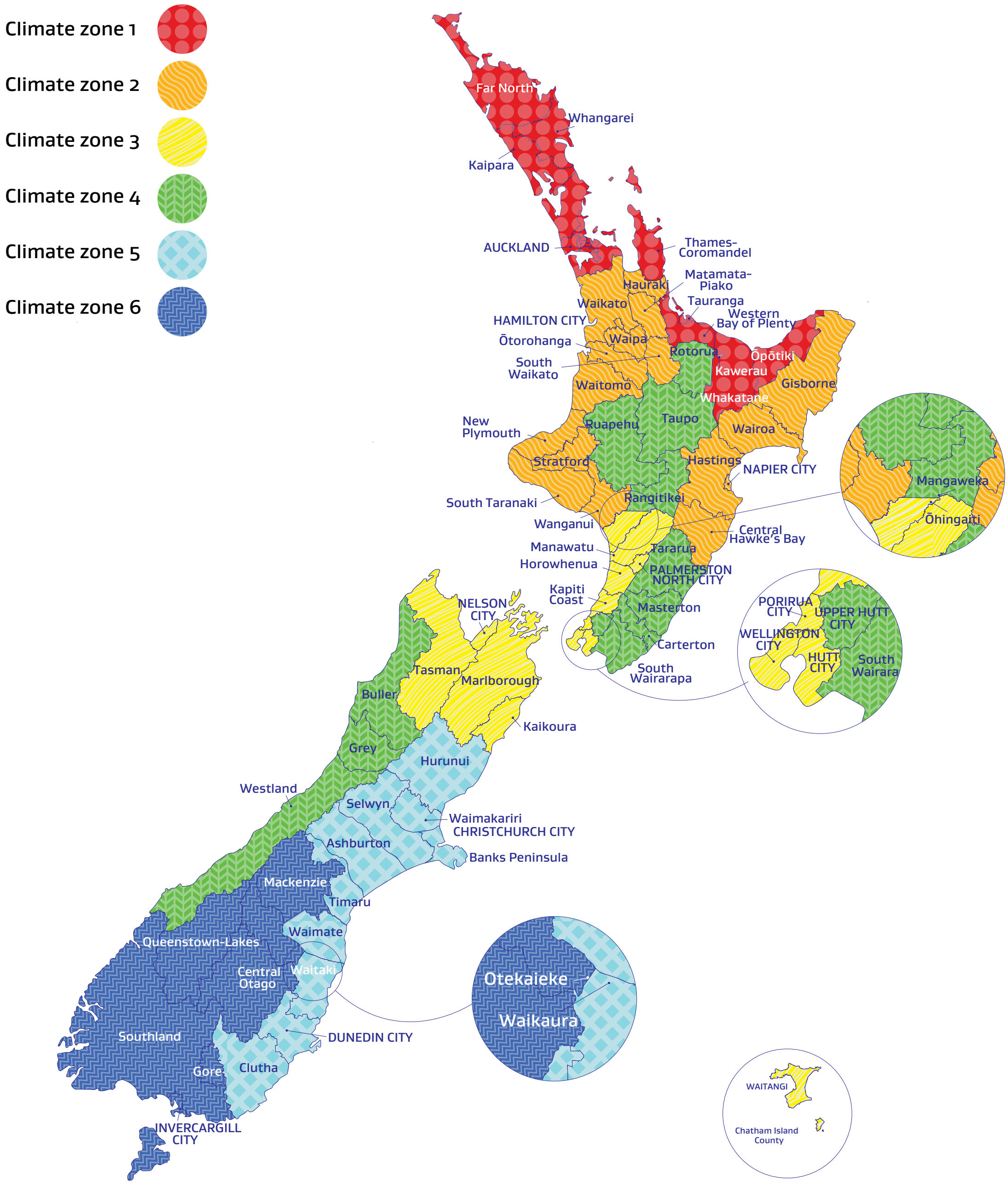
FIGURE C.1.1.2: Map of New Zealand Climate zones

Paragraph C.1.1.2



Appendix D. Modelling method – Building energy use comparison

D.1 Modelling requirements

D.1.1 Overview

D.1.1.1 This modelling method is used to assess the energy performance of a proposed *building* by using a simulation of the *building* to predict its space *heating loads* and *cooling loads*. This is compared with the space *heating loads* and *cooling loads* of a reference *building* that is the same shape, dimensions, and orientation as the proposed *building*, but has *building elements* with *construction R-values* from:

a) For *building elements* that contain embedded heating systems Table 2.1.2.2A; or

b) For *building elements* that do not contain embedded heating systems, Table 2.1.2.2B.

D.1.1.2 Both *buildings* shall be simulated using the same method.

D.1.2 Modelling principles

D.1.2.1 The proposed *building* and reference *building* shall both be analysed using the same techniques and assumptions except where differences in energy efficiency features that are specified in this appendix require a different approach.

D.1.2.2 The specifications of the proposed *building* used in the analysis shall be as similar as is reasonably practicable to those in the plans submitted for a building consent.

D.1.2.3 The reference *building* shall have the same number of storeys, floor area for each storey, orientation and three dimensional form as the proposed *building*. Each floor shall be orientated exactly as the proposed *building*. The geometric form shall be the same as the proposed *building*.

D.1.2.4 Features that may differ between the proposed *building* and the reference *building* are:

a) Wall *construction R-value* and *thermal mass*; and/or

b) Floor *construction R-value*; and/or

c) *Roof construction R-value* and *thermal mass*; and/or

d) Window size and orientation, *construction R-value*, *solar heat gain coefficient* (*SHGC*), and external shading devices; and/or

e) Heating, cooling, and ventilation plant (sizing only).

D.1.2.5 The results of the thermal modelling should not be construed as a guarantee of the actual energy use of the *building*.

D.1.3 Modelling software

D.1.3.1 If the application for which the software is to be used has been documented according to the ANSI/ASHRAE Standard 140 procedure, then the method shall pass the ANSI/ASHRAE Standard 140 test. If the application for which the software is to be used has not been documented according to the ANSI/ASHRAE Standard 140 procedure, the method shall be tested to BESTEST and pass the BESTEST.

D.1.4 Default values

D.1.4.1 The *default values* and schedules included in this appendix shall be used unless the designer can demonstrate that different assumptions better characterise the *building's* use over its expected life. Any modification of default assumptions shall be used in simulating both the proposed *building* and the reference *building*.

D.1.4.2 Other aspects of the *building's* performance for which no *default values* are provided may be simulated according to the designer's discretion as is most appropriate for the *building*, but they must be the same for both the proposed *building* and the reference *building*.

D.1.4.3 In all the following cases, modelling is to be identical for both the proposed *building* and the reference *building*. Some of these items have limitations on the input values and others have default schedules that may be used when actual figures are not known. In all cases these values shall be reasonable approximations of the requirements of the *building* and its use during its expected life:

a) Heating set-points, and schedules; and
b) Cooling set-points, and schedules; and
c) Ventilation set-points, and schedules; and
d) Fresh air ventilation air change rates and schedules; and
e) Internal gains loads and schedules; and
f) Occupancy loads and schedules; and
g) Lighting schedules; and
h) The location and *R-value*s of carpets and floor coverings; and
i) Incidental shading; and
j) Heating, cooling and ventilation plant, type and modelling method.

D.1.5 Climate data

D.1.5.1 Both the proposed *building* and the reference *building* shall be modelled using the same climate data. The analysis shall use the closest climate data available for the location in which the *building* project is to be *construct*ed. The climate data shall represent an average year for the location.

> i
>
> COMMENT: Using the relevant NIWA Typical Meterological Year climate files is one way to achieve this requirement.

D.1.6 Thermal zones

D.1.6.1 The model of the proposed *building* and the reference *building* shall be identically and suitably divided into separate thermal zones.

D.1.6.2 Spaces that are likely to have significantly different space conditioning requirements shall be modelled as separate zones.

D.1.6.3 The *conditioned space* shall be divided into a minimum of three thermal zones.

D.1.6.4 *Roof* spaces and enclosed subfloor spaces shall be modelled as thermal zones.

D.1.6.5 The model shall have a representation of internal conductive heat flows between thermal zones. Internal partitions between thermal zones require modelling and shall be described in terms of their location, surface area, pitch, and *construction R-value*.

D.1.6.6 The same internal partitions as modelled in the proposed *building* shall be modelled in the reference *building*.

D.1.6.7 Internal partitions within a thermal zone which may affect the thermal performance of the *building* shall be modelled.

D.1.6.8 Airflow between thermal zones need not be modelled unless desired.

D.1.7 Unconditioned space

D.1.7.1 An *unconditioned space* attached to the *building* (e.g. conservatory, atrium, car park, storage, plant room etc.) may be considered outside the *building thermal envelope* providing there is a separating wall between it and the rest of the *building*. The wall (inclusive of any windows) between it and the rest of the *building* forms part of the *building thermal envelope* and in the reference *building* it shall meet the requirements of Subsection 2.1.2.

D.1.7.2 An *unconditioned space* outside the *building thermal envelope* need not be modelled.

D.1.8 Units and group buildings

D.1.8.1 Walls and other surfaces that separate occupied units may be assumed to have no heat transfer.

D.1.9 Thermal mass

D.1.9.1 The *thermal mass* may either be modelled:

a) The same way for both the proposed *building* and the reference *building*; or

b) As proposed for the proposed *building* and modelled as lightweight for the reference *building*.

D.1.10 Thermal mass of contents

D.1.10.1 The *thermal mass* of the contents shall be the same for both models, and may be regarded as zero for modelling purposes.

D.1.11 Shading

D.1.11.1 Exterior attached shading such as fins and overhangs should be modelled as proposed in the proposed *building* but need not be modelled in the reference *building*.

D.1.11.2 No account shall be taken of internal shading devices such as blinds, drapes and other non-permanent window treatments.

D.1.12 Incidental shading

D.1.12.1 Shading by structures and terrain that have a significant effect on the *building* shall be modelled in the same way for the proposed *building* and the reference *building*.

D.1.12.2 No account shall be taken of trees or vegetation.

D.1.13 Infiltration

D.1.13.1 Infiltration assumptions for proposed *building*s and the reference *building* shall be the same, and shall be reasonable for the *building construction*, location, and use.

D.1.14 Internal air flows

D.1.14.1 Interzone air flow does not require modelling.

D.1.15 Internal doors

D.1.15.1 Internal doors need not be modelled.

D.2 Thermal envelope

D.2.1 Thermal envelope building elements

D.2.1.1 All *building element*s shall be described in terms of surface area, orientation, pitch, and *construction R-value*. *Glazing areas* shall have their *solar heat gain coefficient* (*SHGC*) specified.

D.2.1.2 The solar absorption of external *building elements*, except as specified in Paragraph D1.11.2, shall be modelled in both the proposed *building* and reference *building* as proposed. If solar absorption is not specified, they shall be modelled in both the proposed *building* and reference *building* as 0.7.

D.2.1.3 When the modelling program calculates and adds its own surface resistances to the input *thermal resistance*, the input *thermal resistances* shall be the *construction R-values* derived as specified in this method less the standardised surface resistances of 0.03 $m^2 \cdot K/W$ outside and 0.09 $m^2 \cdot K/W$ inside (0.12 $m^2 \cdot K/W$ total). The same method of calculation shall be used for the proposed *building* and the reference *building*.

D.2.2 External walls

D.2.2.1 *External wall*s of the proposed *building* shall be modelled as proposed.

D.2.2.2 *External wall*s for the reference *building* shall have an *R-value* equal to the values specified in Paragraph 2.1.2.2.

D.2.2.3 *External walls* for the reference *building* shall have the same orientation, tilt and area as the proposed *building*, except as provided in Paragraph D.2.6.3.

D.2.3 Internal walls

D.2.3.1 Walls separating different thermal zones or *conditioned space* and *unconditioned space*s of the proposed *building* and reference *building* shall be modelled as proposed. Other internal walls need not be modelled.

D.2.3.2 The same internal walls as modelled in the proposed *building* shall be modelled in the reference *building*. Other internal *wall*s need not be modelled. In the reference *building*, the *construction R-value*s of walls between *conditioned space* and *unconditioned space*s shall be those specified in Paragraph 2.1.2.2.

D.2.4 Roofs

D.2.4.1 *Roof*s of the proposed *building* shall be modelled as proposed.

D.2.4.2 *Roof*s for the reference *building* shall have the same area as those for the proposed *building* except where *skylight areas* are modified according to Subsection D.2.7.

D.2.4.3 In all cases the total *roof area* shall be the same as for the proposed *building*.

D.2.4.4 The *roof* of the reference *building* shall have an *R-value* equal to the value specified in Paragraph 2.1.2.2.

D.2.4.5 The *roof*s of the proposed *building* and reference *building* shall have the same solar absorption (0.7 is an acceptable *default value*).

D.2.5 Floors

D.2.5.1 Floors for the proposed *building* shall be modelled as proposed.

D.2.5.2 Floors for the reference *building* shall have the same area as those in the proposed *building* but shall be modelled with a *construction R-value* as specified in Paragraph 2.1.2.2.

D.2.5.3 Floors for the reference *building* shall be of the same type as for the proposed *building*. For example, floors in contact with the ground may not be substituted with suspended floors or vice versa.

D.2.5.4 Carpets and other floor coverings shall be the same in both the proposed *building* and reference *building* and shall be modelled if present. Any *thermal resistance* provided by carpets or floor coverings shall be in addition to the *R-value*s specified in Paragraph 2.1.2.2.

D.2.5.5 When using a modelling program that uses inputs for describing the *thermal resistance* of *slab-on-ground floors* that are different to the *construction R-value* of *slab-on-ground floors* as defined in Paragraph 2.1.3.3 e) (e.g. not from the inside air to the outside air):

a) In the reference *building*, any *slab-on-ground floor* shall be modelled with a construction type selected from Tables F.1.2.2A to F.1.2.2X in Acceptable Solution H1/AS2 Appendix F. For the slab area-to-perimeter ratio, *external wall* cladding type and *external* wall effective thickness of the reference *building*, the selected construction type must have a *construction R-value* that is equal to or greater than the minimum *R-value* for *slab-on-ground floors* specified in Paragraph 2.1.2.2.; and

b) In the proposed *building*, using the methods specified in Appendix F, any *slab-on-ground* floor must, as a minimum, meet the *construction R-value* for *slab-on-ground floors* in:

i) For floors that contain embedded heating systems, Table 2.1.2.2A; or

ii) For floors that do not contain embedded heating systems, Table 2.1.2.2B.

D.2.6 Window and doors

D.2.6.1 Windows and doors that are part of the *thermal envelope* in the proposed *building* shall be modelled as proposed.

D.2.6.2 Windows and doors that are part of the *thermal envelope* in the reference *building* shall have the same distribution, orientation, tilt, and area, as the proposed *building* except as provided in Paragraph D.2.6.3.

D.2.6.3 The *glazing area* of the reference *building* shall equal that of the proposed *building* unless the proposed *building* has *glazing area* which exceeds 50% of the *total wall area*, in which case the reference *building* shall use a *glazing area* of 50% of the *total wall area*. The glazing distribution shall be modelled as equal to the distribution in the proposed *building* or shall constitute an equal percentage of *wall area* for each zone and orientation's *external wall*.

D.2.6.4 Glazing for the reference *building* shall assume a *shading coefficient* of 0.8 and a site shading of 0.7.

D.2.6.5 In the reference *building*, windows and doors that are part of the *thermal envelope* shall be modelled with *construction R-values* as specified in Table 2.1.2.2B.

D.2.7 Skylights

D.2.7.1 *Skylights* of the proposed *building* shall be modelled as proposed. A total *skylight area* of less than 0.6 m² may be ignored for calculation purposes.

D.2.7.2 *Skylights* and *roof*s for the reference *building* shall be modelled such that the total *R-value* of the *roof* is equivalent to a *roof* meeting the requirements specified in Paragraph 2.1.2.2.

D.2.7.3 The total *R-value* of the *roof* shall be determined in accordance with Equation D.1:

$$\text{Equation D.1: } R_{roof,\ total} = \frac{A_{roof} + A_{skylight}}{\frac{A_{roof}}{R_{roof}} + \frac{A_{skylight}}{R_{skylight}}}$$

where: $R_{roof,total}$ is the total *R-value* of the *roof* including *skylights* in the reference *building thermal envelope* ($m^2 \cdot K/W$) and
A_{roof} is the *roof* area of the reference *building* (m^2); and
R_{roof} is the *construction R-value* of the *roof* in the reference *building thermal envelope* ($m^2 \cdot K/W$); and
$A_{skylight}$ is the *skylight area* of the reference *building* (m^2); and
$R_{skylight}$ is the *construction R-value* of the *skylight*(s) in the reference *building thermal envelope* ($m^2 \cdot K/W$).

D.2.7.4. This shall be achieved while the *R-value* and *shading coefficient* of the glass remain the same as that proposed. This provision effectively limits the amount of *skylight* that can be included in the reference *building*.

D.3 Space conditioning

D.3.1 Control temperatures

D.3.1.1 In all cases temperatures modelled shall be the same for the proposed *building* and the reference *building*.

D.3.1.2 This specification does not deal specifically with internal conditions, and it is for the designer to judge what appropriate comfort conditions are. It is advisable that the designer considers the maximum acceptable temperature and checks that this is not exceeded. A temperature of between 20°C and 24°C is often used for air-conditioned **commercial** *building*s during occupied hours.

D.3.1.3 Unless a different schedule can be justified as a likely schedule for the foreseeable life of the *building*, occupancy for **commercial** *building*s shall be 10 hours per day, 5 days per week or as provided for:

CR CN Com

a) **Communal residential** including hotels, motels, and health consultancies in Table D.5.1.2A; and

b) **Communal non-residential** assembly care including schools in Table D.5.1.2B; and

c) **Commercial** including offices, restaurants, and retail shops in Table D.5.1.2C.

D.3.2 Fresh air ventilation

D.3.2.1 The fresh air ventilation rate and schedule shall be the same for both the proposed *building* and the reference *building*.

D.3.2.2 Constant ventilation may be modelled.

D.3.2.3 The minimum ventilation rate should be according to G4/AS1 or G4/VM1.

D.3.2.4 Ventilation may be provided mechanically or by natural means.

D.3.3 Conditioning system modelling

Com D.3.3.1 For **commercial** *buildings*, *HVAC systems* shall be simulated in an identical manner in both the proposed *building* and the reference *building* and be consistent with the requirements of Verification Method H1/VM3. Sizing is the only feature that may be changed in response to load requirements.

D.3.3.2 The type of plant in the proposed *building* should represent the type of system proposed. Where such a model is unavailable, use the closest that is available.

D.3.3.3 Plant type shall be the same for both the reference *building* and proposed *building*. All devices that supply space heating or ventilation shall be accounted for. Assumptions made must be clearly and fully stated. The program shall be suitable for the type of system proposed.

D.3.3.4 Sizing of plant (for modelling purposes) shall be according to the automatic sizing if this feature is provided by the software. Alternatively the plant should be of sufficient capacity to meet loads without incurring significant energy penalty due to prolonged part-load operation.

D.3.3.5 Modelling shall use reasonable assumptions as to equipment performance and control.

D.3.3.6 Sufficient information shall be input to describe the proposed *building*'s plant to permit modelling by the program.

D.4 Internal loads

D.4.1 Lighting

D.4.1.1 For the proposed *building*, the connected lighting load shall be modelled as proposed.

D.4.1.2 For the reference *building*, the connected lighting load shall be modelled as the lighting load permitted in NZS 4243 Part 2. Alternatively, the lighting load of the proposed *building* may be used if this is less than the load permitted by NZS 4243 Part 2. The load from lighting not covered by *lighting power density limits* specified in NZS 4243 Part 2 shall be the same in the proposed *building*.

D.4.1.3 The lighting use schedule shall be the same for both the proposed *building* and the reference *building*. Any assumption regarding the proportion of lights in use shall be reasonable, and shall be recorded. The default lighting schedule is 90% of total lighting connected load during hours of occupancy, and 10% of total connected lighting load on during other hours. Hours of occupancy for the *building* shall be a reasonable approximation of how the *building* is expected to be used. *Default value* is ten hours per day, five days per week for commercial *building*s.

D.4.1.4 Lighting schedules shall use the same references throughout for both the proposed *building* and the reference *building*. Lighting schedules are provided for:

CR a) **Communal residential** including hotels, motels, and health consultancies in Table D.5.1.2A; and

CN b) **Communal non-residential** assembly care including schools in Table D.5.1.2B; and

CR c) **Commercial** including offices, restaurants, and retail shops in Table D.5.1.2C.

D.4.1.5 The lighting schedule may be altered to reflect the type of controls in the proposed *building*, but both the proposed *building* and reference *building* lighting schedules shall be identical. No credit shall be given for the use of any controls, automatic or otherwise.

D.4.1.6 Thermal simulations shall include the heat released into the proposed *building* and reference *building* from lighting. The same loads and schedules as the modelled lighting shall be used in each case.

D.4.2 Domestic hot water

D.4.2.1 Hot water systems shall not be modelled.

D.4.3 Occupants and plug loads

D.4.3.1 The maximum power densities into a *building* from occupants and *plug loads* is provided in Table D.5.1.1 and is modified to provide default values for heat release at different times of day. The modification factors are provided for:

a) **Communal residential** including hotels, motels, and health consultancies in Table D.5.1.2A; and
b) **Communal non-residential** assembly care including schools in Table D.5.1.2B; and
c) **Commercial** including offices, restaurants, and retail shops in Table D.5.1.2C.

D.4.3.2 These values should be used unless other suitable parameters specific to the *building*'s use can be shown to be more appropriate. These internal loads shall be the same for both the proposed *building* and reference *building*. All internal loads are regarded as sensible heat.

D.4.3.3 *Unconditioned space* shall be assigned zero internal loads.

D.4.4 Process loads

D.4.4.1 Process loads are those heat loads that result from the production of goods within a *building*.

D.4.4.2 Only in circumstances where process loads are significant, and it can be shown that they will continue for the expected life of the *building*, may modelling occur. Process loads shall be the same in both the proposed *building* and reference *building*.

D.5 Reference building

D.5.1 Schedules

The default power densities for internal gains from occupants and *plug loads* are provided in Table D.5.1.1.

TABLE D.5.1.1: Default power densities for internal gains from occupants and plug loads
Paragraph D.5.1.1

Classified use	Applies to[1]	Occupancy (W/m^2)	Plug load (W/m^2)
CR	Community service – hotels and motels	2.9	2.7
	Community care – Unrestrained – such as health/institutional	3.6	10.7
CN	Assembly care – schools	9.7	5.4
Com	Office	2.7	8.1
	Restaurant	7.3	1.1
	Retail shop	2.4	2.7
	Car park	N/A	N/A

Note:
(1) If an activity for the proposed *building* is not specifically described, use the nearest description for both the proposed *building* and the reference *building*.

D.5.1.2 The default schedules for occupancy and *plug loads* are provided for:

a) **Communal residential** including hotels, motels, and health consultancies in Table D.5.1.2A; and
b) **Communal non-residential** assembly care including schools in Table D.5.1.2B; and
c) **Commercial** including offices, restaurants, and retail shops in Table D.5.1.2C.

TABLE D.5.1.2A: Default schedules for occupancy, plug loads and lighting – Percentage of maximum load or percentage of power density for communal residential

Paragraphs D.3.1.3 a), D.4.1.4 a), D.4.3.1 a), D.5.1.2 a)

Community service – hotels and motels					
Occupancy	**12 am – 8 am**	**8 am – 11 am**	**11 am – 6 pm**	**6 pm – 10 pm**	**10 pm – 12 am**
Week	90	40	20	70	90
Saturday	90	50	30	60	70
Sunday	70	70	30	60	80
Plug load and lighting					
Week	10	40	25	60	60
Saturday	10	40	25	60	60
Sunday	10	30	30	50	50
Community service – residential care such as retirement village					
Occupancy	**12 am – 8 am**	**8 am – 11 am**	**11 am – 6 pm**	**6 pm – 10 pm**	**10 pm – 12 am**
Week	70	90	90	85	70
Saturday	70	90	90	85	70
Sunday	70	90	90	85	70
Plug load and lighting					
Week	20	90	85	80	20
Saturday	20	90	85	80	20
Sunday	20	90	85	80	20
Community care – Health/ medical specialist					
Occupancy	**12 am – 8 am**	**8 am – 11 am**	**11 am – 6 pm**	**6 pm – 10 pm**	**10 pm – 12 am**
Week	0	80	80	30	0
Saturday	0	40	40	0	0
Sunday	0	5	5	0	0
Plug load and lighting					
Week	10	90	90	30	10
Saturday	10	40	40	10	10
Sunday	5	10	10	5	5

TABLE D.5.1.2B: Default schedules for occupancy, plug loads and lighting – Percentage of maximum load or percentage of power density for communal non-residential – assembly care

Paragraphs D.3.1.3 b), D.4.1.4 b), D.4.3.1 b), D.5.1.2 b)

Schools					
Occupancy	**12 am – 8 am**	**8 am – 11 am**	**11 am – 6 pm**	**6 pm – 10 pm**	**10 pm – 12 am**
Week	0	95	95	10	0
Saturday	0	10	10	0	0
Sunday	0	0	0	0	0
Plug load and lighting					
Week	5	95	95	30	5
Saturday	5	15	15	5	5
Sunday	5	5	5	5	5

TABLE D.5.1.2C: **Default schedules for occupancy, plug loads and lighting – Percentage of maximum load or percentage of power density for commercial buildings**

Paragraphs D.3.1.3 c), D.4.1.4 c), D.4.3.1 c), D.5.1.2 c)

Office					
Occupancy	**12 am – 8 am**	**8 am – 11 am**	**11 am – 6 pm**	**6 pm – 10 pm**	**10 pm – 12 am**
Week	0	95	95	5	0
Saturday	0	10	5	0	0
Sunday	0	5	5	0	0
Plug load and lighting					
Week	5	90	90	30	5
Saturday	5	30	15	5	5
Sunday	5	5	5	5	5
Restaurant					
Occupancy	**12 am – 8 am**	**8 am – 11 am**	**11 am – 6 pm**	**6 pm – 10 pm**	**10 pm – 12 am**
Week	0	5	50	80	35
Saturday	0	0	45	70	55
Sunday	0	0	20	55	20
Plug load and lighting					
Week	15	40	90	90	50
Saturday	15	30	80	90	50
Sunday	15	30	70	60	50
Retail shop					
Occupancy	**12 am – 8 am**	**8 am – 11 am**	**11 am – 6 pm**	**6 pm – 10 pm**	**10 pm – 12 am**
Week	0	60	70	40	0
Saturday	0	60	80	20	0
Sunday	0	10	40	0	0
Plug load and lighting					
Week	5	90	90	50	5
Saturday	5	90	90	30	5
Sunday	5	40	40	5	5

D.6 Documentation

D.6.1 Documentation of analysis

D.6.1.1 Documentation of computer modelling analysis shall contain:

a) The name of the modeller; and

b) The thermal modelling program name, version number, and supplier; and

c) Technical detail on the proposed *building* and reference *building* designs and the differences between the designs; and

d) The sum of the *heating load* and *cooling load* for the proposed *building* and reference *building*; and

e) Where possible, the *heating load* and *cooling load* for the proposed *building* and the reference *building*; and

f) The calculated annual energy consumption for space heating, space cooling, ventilation/fans, and lighting.

Appendix E. Windows, doors, skylights, and curtain walling

E.1 Vertical windows and doors

E.1.1 Methods for determining construction R-values

E.1.1.1 The *construction R-values* for vertical windows and doors shall be determined using one of the following methods:

a) Calculation of the *construction R-value* of each individual window and door that is part of the *thermal envelope*, in accordance with Section E.1.2; or

b) Calculation of the representative *construction R-value* of all windows and doors that are part of the *thermal envelope* of the proposed *building*, which is then deemed to apply to all windows and doors of the proposed *building*, in accordance with Section E.1.3.

> COMMENT: The window size and frame material have a major impact on the *construction R-value* of a window as a *building element*. Often the *thermal resistances* of the glazing and the frames are dissimilar. For large windows, the *thermal resistance* of the glazing will have more impact on the overall window *construction R-value* than in a small window, which is dominated by the frame performance. This means that the *construction R-values* of two differently-sized windows consisting of identical frame and glazing materials will usually be dissimilar.

E.1.2 Calculation of the construction R-value of each individual window and door that is part of the thermal envelope

E.1.2.1 For each window that is part of the *thermal envelope* of the proposed *building*, the window *construction R-value* (R_W) shall be calculated in accordance with Equation E.1. The *construction R-value* shall be rounded down to no less than two significant figures.

Equation E.1: $R_w = \frac{1}{U_w}$

where:

R_W is the *construction R-value* of the window ($m^2{\cdot}K/W$); and

U_W is the thermal transmittance of the window ($W/(m^2{\cdot}K)$), determined in accordance with Paragraph E.1.2.2.

E.1.2.2 The thermal transmittance (U_W) of each vertical window that is part of the *thermal envelope* of the proposed *building* shall be determined in accordance with ISO 10077-1, with:

a) The thermal transmittance of the glazing (U_g) determined using BS EN 673; and

b) The thermal transmittance of the frame (U_f) determined using ISO 10077-2. For frames with special extensions overlapping the wall or other *building elements*, such as frames with flanges to the cladding, the following deviations from ISO 10077-2 Section 6.3.1, are permitted:

   i) special extensions may be disregarded or included in the calculation model, but shall be disregarded when determining the projected width of the frame section (b_f) as per ISO 10077-2: 2017 Appendix F; and

   ii) window reveal liners that are integral with the window unit may either be disregarded or included in the calculation model.

E.1.2.3 For each door that is part of the *thermal envelope* of the proposed *building*, the door *construction R-value* (R_D) shall be calculated in accordance with Equation E.2. The *construction R-value* shall be rounded down to no less than two significant figures.

Equation E.2: $R_D = \frac{1}{U_D}$

where:

R_D is the *construction R-value* of the door (m²·K/W); and

U_D is the thermal transmittance of the door (W/(m²·K)), determined in accordance with Paragraph E.1.2.4.

> COMMENT: The door *construction R-value* (R_D) includes the effects of the frame, any glazing and any opaque panels.

E.1.2.4 The thermal transmittance (U_D) of each door that is part of the *thermal envelope* of the proposed *building* shall be determined in accordance with ISO 10077-1, with:

a) The thermal transmittance of any glazing (U_g) determined using BS EN 673; and

b) The thermal transmittance of the frame (U_f) determined using ISO 10077-2. For frames with special extensions overlapping the wall or other building elements, such as frames with flanges to the cladding, the following deviations from ISO 10077-2 Section 6.3.1, are permitted:

   i) special extensions may be disregarded or included in the calculation model, but shall be disregarded when determining the projected width of the frame section (b_f) as per ISO 10077-2 Appendix F; and

   ii) door reveal liners that are integral with the door unit may either be disregarded or included in the calculation model.

E.1.3 Calculation of the representative construction R-value of all windows and doors that are part of the thermal envelope

E.1.3.1 The representative window and door *construction R-value* (R_{WD}) shall be calculated in accordance with Equation E.3. The *construction R-value* shall be rounded down to no less than two significant figures.

Equation E.3: $R_{WD} = \frac{\Sigma A_W + \Sigma A_D}{\Sigma \frac{A_W}{R_W} + \Sigma \frac{A_D}{R_D}}$

where:

R_W is the *construction R-value* of each vertical window that is part of the *thermal envelope* of the proposed *building* (m²·K/W), calculated in accordance with Section E.1.2.1; and

A_W is the window area of each vertical window that is part of the *thermal envelope* of the proposed *building* (m^2), calculated in accordance with ISO 10077-1 Section 6.3.1; and

R_D is the *construction R-value* of each door that is part of the *thermal envelope* of the proposed *building* (m²·K/W), calculated in accordance with Section E.1.2.3.; and

A_D is the *door area* of each door that is part of the *thermal envelope* of the proposed *building* (m^2), calculated in accordance with ISO 10077-1 Section 6.3.1.

E.2 Skylights

E.2.1 Construction R-values

E.2.1.1 The *construction R-values* for *skylights* ($R_{skylight}$) shall include the effects of both the glazing materials and the frame materials and shall be calculated in accordance with Equation E.4. The *construction R-value* shall be rounded down to no less than two significant figures.

Equation E.4: $R_{skylight} = \frac{1}{U_w}$

where:

$R_{skylight}$ is the *construction R-value* of the *skylight* (m²·K/W); and

U_w is the thermal transmittance of the *skylight* (W/(m² K)), determined in accordance with Paragraph E.2.1.2.

E.2.1.2 The thermal transmittance (U_w) of a *skylight* shall be determined in accordance with ISO 10077-1, with:

a) The thermal transmittance of the glazing (U_g) determined using BS EN 673, considering the effects of horizontal or angled glazing on the heat transfer; and

b) The thermal transmittance of the frame (U_f) determined using ISO 10077-2.

E.3 Curtain walling

E.3.1 Construction R-value

E.3.1.1 The *construction R-values for curtain walling* (R_{CW}) shall be calculated in accordance with Equation E.5. The *construction R-value* shall be rounded down to no less than two significant figures.

Equation E.5: $R_{CW} = \frac{1}{U_{CW}}$

where:

R_{CW} is the *construction R-value* of the *curtain walling* (m²·K/W); and

U_{CW} is the thermal transmittance of the *curtain walling* (W/(m² K)), determined in accordance with ISO 12631, with the thermal transmittance of the glazing (U_g) determined using BS EN 673.

Appendix F. Thermal resistance of slab-on-ground floors

F.1 Construction R-values

F.1.1 Methods for determining construction R-values for slab-on-ground floors

F.1.1.1 The *construction R-values* for concrete *slab-on-ground floors*, including floors of basements that contain *conditioned* spaces, shall be determined using:

a) The calculation method described in Section F.1.2; or

b) The performance tables in Acceptable Solution H1/AS2 Appendix F.

> COMMENT:
>
> 1. The *thermal resistances* for *slab-on-ground floors* provided in the BRANZ House Insulation Guide, 5th edition or earlier, should not be used for determining compliance with the requirements of this verification method. This is because they are based on a different calculation method and different assumptions than those specified in this Appendix.
> 2. Where a concrete floor is only partially in contact with the ground, with other parts being suspended, the part that is in contact with the ground shall be treated as a slab-on-ground floor, and the other part be treated as a suspended floor.

F.1.2 Calculating slab-on-ground floor R-values

F.1.2.1 The *construction R-value* of *slab-on-ground floors* shall be calculated from the inside air to the outside air. The effect of floor coverings (including carpets) shall be ignored.

F.1.2.2 The calculation shall be based on a three-dimensional numerical calculation in accordance with ISO 13370 Section 5.2a), or a two-dimensional numerical calculation in accordance with ISO 13370 Section 5.2b). The formulae provided in ISO 13370 Section 7 and Annex D shall not be used for determining the *construction R-value* of *slab-on-ground floors*.

F.1.2.3 When using a two-dimensional numerical calculation in accordance with ISO 13370 Section 5.2b), a geometrical model in accordance with ISO 10211 Sections 7.3, 12.4.1 and 12.4.2 shall be used. The model shall have a floor width equal to half the characteristic dimension of the floor. The characteristic dimension of the floor shall be determined using overall internal dimensions (ignoring internal partitions, as per ISO 13789).

> COMMENT:
>
> 1. The characteristic dimension of the floor (B as defined in ISO 13370) equals the area of the floor divided by half the perimeter of the floor.
> 2. Paragraph F1.2.3. requires a two-dimensional geometrical model with a floor width equal to half the characteristic dimension of the floor. This represents a floor that is infinitely long and has a width equal to the characteristic dimension of the floor.

F.1.2.4 For *slab-on-ground floors* of inhomogeneous *construction*, such as concrete raft foundation floors, the results of any two-dimensional numerical calculation in accordance with ISO 13370 Section 5.2b) shall be validated by three-dimensional numerical calculations in accordance with ISO 13370 Section 5.2a).

> COMMENT: ISO 13370 Sections 5.2 a) and b) specify that the result of a three-dimensional numerical calculation is applicable only for the actual floor dimensions modelled, whereas the result of a two-dimensional numerical calculation is applicable to floors having the characteristic dimension that was modelled. Therefore, the result of a two-dimensional numerical calculation can have wider application, but, depending on the floor *construction*, may need to be validated by comparing the result against the result of a three-dimensional numerical calculation. This should be done for a sample across a range of floor dimensions that the resulting *construction R-value* is to be applied to.

F.1.2.5 The *external wall* shall be included in the model and extend 500 mm above the internal floor surface. For framed walls, the only framing member to be included in the model shall be the bottom plate.

F.1.2.6 The calculation shall use the default values for the thermal properties of the ground from ISO 13370 Table 7 category 2 (thermal conductivity λ=2.0 W/(m·K), heat capacity per volume $\rho c = 2.0 \times 10^6$ J/(m³·K)). For other materials, thermal conductivity values from ISO 10456 shall be used and, for materials used below ground level, reflect the moisture and temperature conditions of the application. Values of surface resistance shall conform to ISO 13370 Section 6.4.3.

F.1.2.7 The *construction R-value* of the *slab-on-ground floor* shall be calculated according to Equation F.1. The *construction R-value* shall be rounded down to no less than two significant figures.

Equation F.1: $R_{floor} = \frac{1}{U}$

where:

R_{floor} is the *construction R-value* of the *slab-on-ground floor* (m²·K/W); and

U is the temperature-specific heat flux through the internal floor surface of the two- or three-dimensional geometrical model, with the internal floor surface extending from the internal surface of the *external wall* to the cut-off plane of the floor (W/(m²·K)), determined by a numerical calculation as per F.1.2.1 to F.1.2.6.

> COMMENT: A commonly used two-dimensional heat-transfer analysis software tool is THERM, developed at the Lawrence Berkeley National Laboratory (LBNL). When using THERM, the temperature specific heat flux U (required by Equation F.1) is the ‘U-factor’ of the internal floor surface of the two-dimensional geometrical model.

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