New Zealand Standard

# Energy Efficiency – Large Buildings

## Part 1: Building Thermal Envelope

Superseding NZS 4243:1996

NZS 4243:Part 1:2007

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## COMMITTEE REPRESENTATION

This Standard was prepared under the supervision of the Energy Efficiency – Large Buildings Committee (P 4243) for the Standards Council established under the Standards Act 1988.

The committee consisted of representatives of the following:

**Nominating Organisations**
Auckland University of Technology
BRANZ Ltd
Department of Building and Housing
Energy Efficiency and Conservation Authority
Glass Association of New Zealand
Illuminating Engineering Society of Australia and New Zealand Limited
Lighting Council of New Zealand

NZS 4243.1:2007 is a revision of NZS 4243:1996 without change to the technical content of the Standard.

## ACKNOWLEDGEMENT

Standards New Zealand gratefully acknowledges the contribution of time and expertise from all those involved in developing this Standard.

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*AMENDMENTS*

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**NZS 4243:Part 1:2007**

New Zealand Standard

# Energy Efficiency – Large Buildings

## Part 1: Building Thermal Envelope



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## NOTES

# CONTENTS

# REFERENCED DOCUMENTS

Reference is made in this document to the following:

## NEW ZEALAND STANDARDS

| | |
|---|---|
| NZS 4214:2006 | Methods of determining the total thermal resistance of parts of buildings |
| NZS 4218:2004 | Energy efficiency – Small building envelope |
| NZS 4220:1982 | Code of practice for energy conservation in non-residential buildings |
| NZS 4243: | Energy efficiency – Large buildings |
| Part 2:2007 | Lighting |
| NZS 4303:1990 | Ventilation for acceptable indoor air quality |

## OTHER PUBLICATIONS

BRANZ Ltd, House Insulation Guide, Second edition, 2005.

Isaacs N., Donn M., Lee J., Bannister P., Guan L., Bassett M., Page I., and Stoecklein A. (1995). A Sensible Step to Building Energy Efficiency: 1995 Revision of NZBC Clause H1; Centre for Building Performance Research, Victoria University of Wellington, 1995.

Judkoff R., and Neymark J. 1995 International Energy Agency Building Energy Simulation Test (BESTEST) and Diagnostic Method; NREL/TP-472-6231 Golden, Colorado, USA; National Renewable Energy Laboratory.

## NEW ZEALAND LEGISLATION

Building Act 2004
Department of Building and Housing, New Zealand Building Code (NZBC) and Compliance Documents

## LATEST REVISIONS

The users of this Standard should ensure that their copies of the above-mentioned New Zealand Standards are the latest revisions. Amendments to referenced New Zealand and Joint Australian/New Zealand Standards can be found on **www.standards.co.nz**.

# RELATED DOCUMENT

BRANZ Ltd, Annual Loss Factor Design Manual (ALF3) (Rev. 3.1.1, 2000)

# REVIEW OF STANDARDS

Suggestions for the improvement of this Standard will be welcomed. They should be sent to the Chief Executive, Standards New Zealand, Private Bag 2439, Wellington 6140.

# FOREWORD

The purpose of this Standard is to provide guidance and details on how to meet minimum acceptable energy efficiency performance requirements for the building envelope and artificial lighting for large buildings. The energy efficiency of heating, ventilation and air-conditioning systems is not addressed in this Standard. This Standard is not a code of good practice but a Standard for minimum requirements. Additional good practice can achieve improved results (NZS 4220 provides further guidance).

NZS 4243:2007 Parts 1 and 2 provide methods for compliance and recognition of climate zoning. NZS 4243:2007 Parts 1 and 2 supersede NZS 4243:1996.

The original version of this Standard specified requirements both for the building thermal envelope and for lighting. With the introduction of a new lighting design Standard (AS/NZS 1680.1:2006) which has replaced NZS 6703:1984 (extensively referenced by NZS 4243:1996), and with significant changes in lamp performance, this revision to NZS 4243:1996 has updated the lighting requirements only. Revision of the building thermal envelope requirements has not been undertaken as part of the revision to NZS 4243:1996.

To simplify the non-concurrent updating of lighting and building thermal envelope requirements, the Standard has been split into two. Part 1 contains the original requirements for the building thermal envelope and is unchanged from the original except where modified wording is necessary as a result of the removal of lighting requirements. The requirements for lighting have been updated and placed in the separate Part 2.

The insulation requirements are based on an economic cost benefit analysis (refer to 'A Sensible Step to Building Energy Efficiency' in Referenced Documents). The minimum insulation level in this Standard is generally the least cost option for the building owner based on current knowledge of insulation, current and forecast energy costs, and heating behaviour.

Energy efficient buildings provide economic comfort and health benefits to the nation, owner and occupants, while retaining or improving on the existing levels of service.

## NOTES

NEW ZEALAND STANDARD

# ENERGY EFFICIENCY – LARGE BUILDINGS

## PART 1: BUILDING THERMAL ENVELOPE

## 1 GENERAL

### 1.1 SCOPE

This Standard specifies performance requirements for large buildings to achieve an adequate level of energy efficiency in their building envelope. Performance requirements for energy efficient artificial lighting in large buildings are set out in NZS 4243 Part 2.

NZS 4243 Part 1 applies to large buildings that have conditioned spaces. The building thermal envelope requirements apply to all large buildings. This Standard provides three methods of demonstrating compliance. These are set out in the decision flow chart in figure 1.

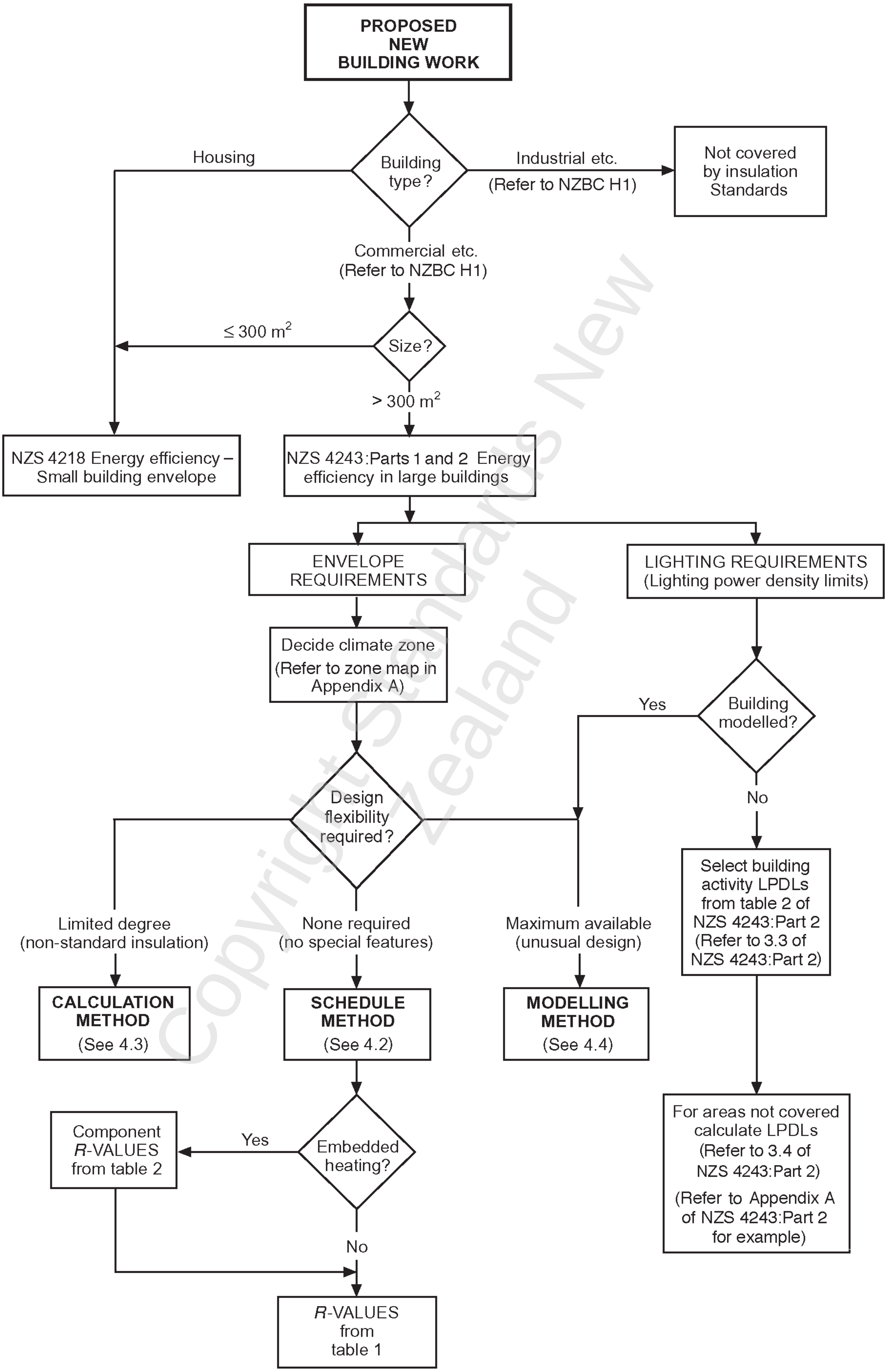


**Figure 1 – Decision flow chart**

## 1.2 DEFINITIONS

For the purposes of this Standard the following definitions shall apply:

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).

BUILDING ENVELOPE COMPONENT. An area of the building envelope, such as roof, wall, floor or glazing of a given construction and to which a single thermal resistance value may be allocated.

BUILDING THERMAL ENVELOPE. The roof, wall, glazing and the floor construction, between unconditioned external spaces and conditioned spaces, enclosing all habitable spaces, bathrooms, kitchens and other rooms in the building likely to require conditioning.

CONDITIONED SPACE. That part of a building within the building thermal envelope, including habitable spaces, that may be directly or indirectly heated or cooled for occupant comfort.

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).

DEFAULT VALUE. Value(s) to be used for modelling purposes, unless the designer can demonstrate that a different assumption better characterises the building's use over its expected life.

FLOOR AREA. The rentable floor area of a building or tenancy as defined by the Property Council of New Zealand less any uncovered outdoor areas such as balconies.

GLAZING AREA. The total area of glazing and doors in the total wall area of the building thermal envelope, including frames and opening tolerances.

GLAZING. A transparent or translucent area in a building envelope component.

GROSS FLOOR AREA. The area obtained from measurements taken around the external face of the building at floor level(s).

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).

INSULATION PLANE. The plane within a building envelope component where the predominant *R*-value is achieved.

LARGE BUILDING. Any building of floor area exceeding 300 $m^2$ but excluding housing, industrial and ancillary buildings, and non-habitable outbuildings.

LIGHTING POWER DENSITY LIMIT (LPDL). The limit that the lighting load shall not exceed. It is set in terms of watts per square metre of lit area and based on recommended maintained illuminances and other factors.

PLUG LOAD. The electrical load drawn by electrical appliances connected to the building electrical reticulation system by way of general purpose socket outlets.

REFERENCE BUILDING. A building design, with identical dimensions and functions to the proposed building, which in all respects is compliant with the requirements of the sections and tables laid down in the calculation or modelling method.

*R*-VALUE (TOTAL THERMAL RESISTANCE). The value of thermal resistance of a building element (e.g. wall, floor or roof) which is the sum of the surface resistances on each side of a building element and the thermal resistances of each component of the building element including any cavities in the element. It is determined by calculation or measuring the temperature difference between the internal air on one side and the external air on the other side of a building component, when there is unit heat flow in unit time through unit area using internal and external conditions considered as typical for buildings ($m^2$ °C/W).

NOTE – Thermal resistances for materials forming parts of building elements are often quoted excluding surface resistances. *R*-values for whole building elements, and for glazing, are normally quoted including surface resistances.

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 total solar heat gain through glass or a window system, with or without integral shading devices, to that through unshaded 3 mm clear float glass.

SKYLIGHT AREA. The area of skylight where it interrupts the insulation plane, including window frames and opening tolerances. (A total area less than 0.6 $m^2$ may be ignored for calculation purposes.)

SOLAR APERTURE (*V*). The fraction of total solar radiation received on the vertical wall (opaque and glazed) that actually enters the perimeter space being considered.

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. A measure of the resistance to heat flow through a uniform homogeneous material of given thickness. It can be determined by measuring the temperature difference between the hot and cold surfaces when there is unit heat flow in unit time through unit area ($m^2$ °C/W).

TOTAL ROOF AREA. Any roof area including skylights.

TOTAL WALL AREA. For the purposes of calculation, the total wall area is deemed to be the wall area plus the glazing area (see also WALL AREA).

UNCONDITIONED SPACE. That part of a building that would not be normally conditioned for occupant comfort (e.g. garage, conservatory).

WALL. Any vertical or near vertical part of the building envelope that is not part of the glazed area and is at an angle from the horizontal greater than 60°.

WALL AREA. For the purposes of calculation, the area of the wall is deemed to be the area of the internally exposed external wall, excluding glazing area (see also TOTAL WALL AREA).

WINDOW TO WALL RATIO (*WWR*). The ratio of the glazed area to the total wall area.

### 1.3 INTERPRETATION

**1.3.1** For the purposes of this Standard, the word 'shall' refers to requirements that are essential for compliance with the Standard, while the word 'should' refers to practices that are advised or recommended.

**1.3.2** The terms 'Normative' and 'Informative' have been used in this Standard to define the application of the Appendix to which they apply. A 'Normative' Appendix is an integral part of a Standard whereas an 'Informative' Appendix is only for information and guidance.

## 2 GENERAL REQUIREMENTS

### 2.1 GENERAL

Methods of measuring or calculating the thermal resistance of building envelope components, and the listing of thermal resistances of common building construction methods, are covered in NZS 4214.

This Standard is not concerned with minimum thermal resistances that may be required for other purposes, such as the avoidance of internal moisture problems or the avoidance of discomfort. These requirements may impose additional limits to the thermal resistance of building envelope components.

### 2.2 GROUPS OF BUILDINGS

A joined group of buildings that are not housing, which together have a total floor area greater than 300 $m^2$, may be treated as a single large building if each building has at least 25 % of its total wall or roof/floor area in common with one or more of the other buildings in the group.

### 2.3 INTEGRITY OF THERMAL INSULATION

**2.3.1** Insulation shall be installed to achieve and maintain its intended *R*-value.

NOTE – Construction methods shall not compromise the integrity of the building thermal insulation. The BRANZ House Insulation Guide provides useful guidance.

**2.3.2** In all circumstances the requirements of the specific insulation product should be followed.

**2.3.3** Insulation shall be carefully inspected for correct installation before cavities are enclosed.

NOTE – Incorrect installation of bulk insulation materials, particularly lack of continuity in the insulation envelope and over-compaction, can seriously compromise the actual insulation levels achieved in practice.

### 2.4 CONSERVATORIES, OUTBUILDINGS AND ATRIA

An unconditioned space attached to the building, e.g. atrium, conservatory, garage etc. may be considered outside the building thermal envelope providing there is a separating wall, roof or floor between it and the rest of the building. The wall, roof or floor (inclusive of transparent components) between the space and the rest of the building forms part of the building thermal envelope and shall meet the requirements for minimum thermal resistance required by this Standard. Where such a space is conditioned, it shall be treated as being within the building thermal envelope.

# 3 COMPLIANCE REQUIREMENTS

To achieve an adequate level of energy efficiency, the building shall comply with the methods in 4.2 or 4.3 or by using the modelling method in 4.4.

# 4 COMPLIANCE METHODS

## 4.1 GENERAL

**4.1.1** All large buildings shall meet the minimum building thermal envelope performance requirements for compliance with this Standard.

**4.1.2** Compliance may be demonstrated by using the schedule method, calculation method, or the modelling method.

## 4.2 SCHEDULE METHOD

**4.2.1** Building envelope components between conditioned and exterior or unconditioned spaces shall have minimum *R*-values according to table 1 or table 2.

**4.2.2** The floor *R*-value shall be determined from the inside air to the outside air.

NOTE – NZS 4214 provides a calculation for the floor component alone, which in the case of a suspended floor does not include the effect of a sub-floor perimeter wall. The thermal resistance of the sub-floor perimeter may therefore be added to the floor component *R*-value as calculated from NZS 4214 in appropriate cases for the purposes of compliance with this Standard. Values for sub-floor perimeters may be calculated using BRANZ House Insulation Guide. Section 4.2.2 places suspended floors on the same *R*-value basis as slab-on-ground floors.

**4.2.3** Table 1 provides minimum *R*-values and applies to buildings that have a Window to Wall Ratio (*WWR*) of less than or equal to 50 %. If the *WWR* is greater than 50 %, the calculation method or the modelling method shall be used.

**Table 1 – Minimum *R*-values for schedule method (*WWR* ≤ 50 %)**

| Building thermal envelope component | Minimum *R*-values ($m^2$ °C/W) | |
|---|---|---|
| | Climate zone 1 | Climate zones 2 & 3 |
| Roof (average including glazing) | *R* 1.9 | *R* 1.9 |
| Wall | *R* 0.3 | *R* 1.2 |
| Floor | No requirement | *R* 1.3 |
| Glazing | No requirement | No requirement |

NOTE –

(1) The *R*-values given in this table are those applicable to the reference building as described in this Standard.

(2) Carpets or floor coverings are not included in the floor *R*-value. The floor *R*-value is met by concrete slab-on-ground and suspended floors with continuous enclosed perimeter with 100 mm drooped foil. Exposed floors will require additional treatment, e.g. office building with open car parking under.

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

**4.2.4** Table 2 applies to building envelope components that contain embedded heating systems irrespective of the *WWR* (see also 4.2.1).

**Table 2 – *R*-values for building with heated walls, ceilings and floors**

| **Building thermal envelope component** | **Minimum values** ($m^2$ °C/W) |
|---|---|
| Heated ceiling ($R_{OUT}$) | *R* 3.0 |
| Heated wall ($R_{OUT}$) | *R* 2.2 |
| Heated floor ($R_{OUT}$) | *R* 1.7 |

Where:

$R_{IN} / R_{OUT} \leq 0.1$

and

$R_{IN}$ is the thermal resistance between the heated plane and the inside air;

$R_{OUT}$ is the thermal resistance between the heated plane and the outside air.

NOTE –

(1) Carpets or floor coverings are not included in the floor *R*-value. Floor coverings, e.g. carpet or cork, will reduce the efficiency of the heated floor.

(2) This table is applicable for all climate zones.



## 4.3 CALCULATION METHOD

**4.3.1** This method allows for increased flexibility in proposed wall construction such as more than one type of wall construction, a mix of glazing types, a range of thermal resistances, any *WWR*, or a combination of these.

**4.3.2** The thermal performance of the proposed building wall, as defined by the total wall thermal resistance ($R_{Total}$) and the solar aperture ($V$), shall be at least equal to the reference building wall.

**4.3.3** Building thermal envelope components with *R*-values and conditions different from those given in 4.2 (schedule method) may be used providing the heat loss, as calculated by 4.3.6, of the proposed building is less than or equal to the heat loss of the reference building for the relevant climate zone. For compliance:

$$HL_{Proposed} \leq HL_{Reference} \quad \text{.......... Equation 1}$$

where

$HL_{Proposed}$ is the heat loss of the proposed total wall

$HL_{Reference}$ is the heat loss of the reference total wall

and the proposed solar aperture shall be less than or equal to 0.5.

**4.3.4** $HL_{Reference}$ shall be calculated from Equation 2 in 4.3.6 using the thermal resistance and conditions from 4.2 (schedule method), as appropriate, with glazing *R*-values of 0.18. $HL_{Proposed}$ shall be calculated from Equation 2, using the actual proposed areas and *R*-values as defined in 4.3.2, 4.3.5 and 4.3.7.

**4.3.5** The reference building window and wall areas are determined by the proposed building window to wall ratio assuming the following:

(a) If the proposed building *WWR* is less than or equal to 50 % (i.e. proposed window area ≤ proposed wall area) then the reference window and wall areas are as proposed.

(b) If the proposed building *WWR* is greater than 50 % (i.e. proposed window area > proposed wall area) then the reference wall and window areas are both equal to half the total wall area.

NOTE – Where *WWR* > 50 %, then 4.3.5(b) limits $R_{Reference}$ to 0.23 in climate zone 1 and 0.31 in climate zones 2 and 3, and *V* is limited to 0.5.

**4.3.6**

The heat flow (*HL*) through the total wall shall be shown by the building heat loss (*HL*) in Equation 2:

$$HL = \frac{A_{Total}}{R_{Total}} = \frac{A_{Wall}}{R_{Wall}} + \frac{A_{Glazing}}{R_{Glazing}} \quad \text{.......... Equation 2}$$

where

$A_{Wall}$ is the wall area ($m^2$)
$A_{Glazing}$ is the glazing area ($m^2$)

and

$R_{Wall}$ and $R_{Glazing}$ are the proposed or reference *R*-values ($m^2$ °C/W) of the corresponding building thermal envelope components.

NOTE –

(1) The total wall area used shall be the same for both the proposed and reference building in the equation except as in 4.3.5 (b).

(2) Appendix B provides a worked example.

**4.3.7** Where a building thermal envelope component is proposed to have two or more methods of construction with different thermal resistances, the corresponding term in the proposed building thermal characteristic shall be expanded to suit.

For example, $\sum \frac{A_{Wall}}{R_{Wall}}$ becomes $\frac{A_{Wall(1)}}{R_{Wall(1)}} + \frac{A_{Wall(2)}}{R_{Wall(2)}}$ .................. etc.

**4.3.8**

The solar aperture (*V*) of the proposed wall is given by Equation 3:

$$V = \frac{\sum SC_{Glazing} A_{Glazing}}{\sum A_{Wall} + \sum A_{Glazing}} \quad \text{.......... Equation 3}$$

where

*SC* is the shading coefficient.

NOTE – The reference wall has a maximum *WWR* of 50 % with a glazing area *R*-value of 0.18, a shading coefficient of 1.0, and opaque *R*-values from table 1.

## 4.4 MODELLING METHOD

**4.4.1** Building envelope components do not need to comply with the requirements of 4.2 or 4.3 providing the energy use of the proposed building design does not exceed the energy use of the reference building.

**4.4.2** A proposed building design is modelled, and its energy use calculated, using an evaluated computer modelling method. This is compared with the energy use of a reference building design. The reference building shall be modelled using the same method and shall have the same size and shape as the proposed building design, but shall have thermal characteristics and conditions according to 4.2.

**4.4.3** The computer modelling and calculation method used shall be satisfactorily evaluated by the International Energy Agency's 'Building Energy Simulation Test and Diagnostic Method (BESTEST)'. Other methods approved by a suitable authority (e.g. the Department of Building and Housing) may also be used.

**4.4.4** Appendix C provides requirements for the modelling inputs and outputs.

# APPENDIX A
# CLIMATE ZONES

(Normative)

**A1**

The climate zone boundaries are based on climatic data taking into consideration territorial authority boundaries, providing for three zones (see figure A1).

**A2**

Zone 1 comprises the Coromandel District, Franklin District and all districts north of these.

**A3**

Zone 2 comprises the remainder of the North Island excluding Taupo District, Ruapehu District and the northern part of the Rangitikei District.

**A4**

Zone 3 comprises the remainder of the country, i.e. Taupo District, Ruapehu District, northern part of Rangitikei District, South Island and all other islands not in zone 1.


**Figure A1 – Climate zones**

# APPENDIX B
# WORKED EXAMPLES – BUILDING THERMAL ENVELOPE

(Informative)

**Examples**

The following provides information by way of worked examples (see table B1) for a proposed building with two wall types in climate zone 2. A similar principle may be used for the solar aperture calculation. Consider the following proposed building:

**Table B1 – Worked examples**

| **Example 1** | **Area** ($m^2$) | ***R*-value** $m^2$ °C/W | **Example 2** | **Area** ($m^2$) | ***R*-value** $m^2$ °C/W |
|---|---|---|---|---|---|
| $Wall_{(1)}$ | 100 | 1.0 | $Wall_{(1)}$ | 100 | 1.0 |
| $Wall_{(2)}$ | 50 | Unknown | $Wall_{(2)}$ | 50 | Unknown |
| Glazing (single) | 60 | 0.18 | Glazing (single) | 160 | 0.18 |



**Example 1**

$$WWR = \frac{60}{210} = 29\,\%$$

29 % < 50 % use table 1 (see 4.2.3)

From Equation 2 ........................ $HL_{Reference} = \frac{150}{1.2} + \frac{60}{0.18} = 458.3$

From Equation 1 ........................ $HL_{Proposed} \leq HL_{Reference}$

Using Equations 1 and 2 ........... $\frac{100}{1} + \frac{50}{R_{Wall(2)}} + \frac{60}{0.18} \leq 458.3$

$R_{Wall(2)} \geq 2$ ( i.e. $Wall_{(2)}$ requires insulation to a minimum *R*-value of 2.0).

**Example 2**

$$WWR = \frac{160}{310} = 52\ \%$$

48 % < 50 % $R_{Reference}$ is 0.31 in zones 2 and 3 (see 4.3.5)

From Equation 2 .................... $HL_{Reference} = \frac{310}{0.31} = 1000$

From Equation 1 .................... $HL_{Proposed} \leq HL_{Reference}$

Using Equations 1 and 2 ....... $\frac{100}{1} + \frac{50}{R_{Wall(2)}} + \frac{160}{0.18} \leq 1000$

$R_{Wall(2)} \geq 4.5$ (i.e. $Wall_{(2)}$ requires insulation to a minimum *R*-value of 4.5).

NOTE – A wall *R*-value of 4.5 is extremely high and a practical solution may be to review the *R* 1.0 section of $Wall_{(1)}$, improve the glazing, or reduce the glazing area.

# APPENDIX C
# MODELLING METHOD – BUILDING ENERGY USE COMPARISON

(Normative)

## C1 MODELLING REQUIREMENTS

### C1.1 OVERVIEW

**C1.1.1**

The energy performance of a proposed building may be assessed by using a simulation of the building to predict its energy use. This is compared with the energy use of a reference building that is the same shape and size as the proposed building, but has thermal characteristics according to 4.2 of this Standard. Both buildings shall be modelled using the same simulation method.

**C1.1.2**

To comply with this Standard the proposed building need not comply with the schedule method or the calculation method, provided the proposed building has an annual assessed energy use which is no more than that of the reference building when modelled as described in this Standard.

### C1.2 MODELLING PRINCIPLES

**C1.2.1**

Where specified, the modelling techniques and assumptions prescribed in this Standard shall be used; however, in many areas the proper exercise of professional judgment is required. Two rules shall be used in meeting this requirement. Firstly, the proposed building and reference building shall both be analysed using the same techniques and assumptions except where differences in energy efficiency features require a different approach. Secondly, simplifying assumptions that may reduce the energy use of the proposed building in relation to the reference building are not permitted.

**C1.2.2**

The modeller shall use professional judgement to check that the modelling method and assumptions used provide a reasonably accurate representation of the expected energy use of the building. However, due to the number of assumptions that are necessary, the results of the analysis shall not be construed as a guarantee of the actual performance of the building.

**C1.2.3**

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

### C1.3 MODELLING RESTRICTIONS

**C1.3.1**

The proposed and the reference buildings shall be the same as each other and modelled in the same manner using the same assumptions, except with respect to energy efficiency changes such as are allowed for in this Standard.

**C1.3.2**

Features that may differ between the proposed building and the reference building are:

(a) Wall *R*-value and thermal mass;

(b) Floor *R*-value;

(c) Roof *R*-value and thermal mass;

(d) Window size and orientation, *R*-value, shading coefficient, and external shading devices;

(e) Lighting power density and lighting heat load;

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

## C1.4 DEFAULT VALUES

**C1.4.1**

The given default values shall be used unless the designer can demonstrate that a different assumption better characterises the building's use over its expected life. Any modification of a default assumption shall be used in modelling both the proposed building and the reference building.

**C1.4.2**

Other aspects of the building's performance may be modelled according to the designers' discretion as is most appropriate for the building, but they shall be the same for both the proposed building and the reference building. (Often these features are ones that are likely to change over the life of the building and thus no credit is given for them.)

**C1.4.3**

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

(a) Heating, setpoints and schedules;

(b) Cooling, setpoints and schedules;

(c) Ventilation, setpoints and schedules;

(d) Fresh air ventilation, air change rate and schedules;

(e) Internal gains loads and schedules;

(f) Occupancy loads and schedules;

(g) Lighting schedules;

(h) The location and *R*-values of carpets and floor coverings;

(i) Incidental shading; and

(j) Heating, cooling and ventilation plant, type and modelling method.

## C1.5 THE BUILDING'S ENERGY PERFORMANCE

**C1.5.1**

If the purpose of carrying out thermal modelling is to demonstrate compliance with the New Zealand Building Code, it should be noted that compliance with this Code represents attainment of an adequate level of energy efficiency. It does not represent good design or energy-efficient design. Most designers will find considerable scope for improving energy performance of buildings beyond the level of these requirements. The modelling methods described could be extended to assist in improving the energy efficiency of the design, but this is not the purpose of this Standard.

**C1.5.2**
The building is to be modelled as it is intended to be used. It is recognised that it is possible to add energy efficiency measures after completion of the building, but the cost of doing so is almost invariably higher than meeting the code requirements at the time of construction.

## C1.6 ORIENTATION AND SHAPE

**C1.6.1**
The proposed building model shall have the same shape and orientation as the proposed building.

**C1.6.2**
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.

## C1.7 CLIMATE DATA

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 constructed. The climate data shall represent an average year for the location.



## C1.8 THERMAL ZONES

**C1.8.1**
The model of the proposed and reference buildings shall be identical and suitably divided into separate thermal zones.

**C1.8.2**
Spaces that are likely to have significantly different space conditioning requirements shall be modelled as separate zones.

**C1.8.3**
The model shall have a representation of internal conductive heat flows between thermal zones. The only internal partitions requiring modelling are those between thermal zones.

**C1.8.4**
Airflow between thermal zones need not be modelled unless desired.

## C1.9 UNCONDITIONED SPACES

**C1.9.1**
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 transparent components) 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 4.2.

**C1.9.2**
An unconditioned space outside the building thermal envelope need not be modelled.

### C1.10 UNITS AND GROUP BUILDINGS

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

### C1.11 THERMAL MASS

The thermal mass of the proposed building structure may be lightweight. The thermal mass of the reference building shall be equal to or less than that of the proposed building.

### C1.12 THERMAL MASS OF CONTENTS

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

## C2 THERMAL ENVELOPE

### C2.1 ENVELOPE COMPONENTS

**C2.1.1**

Every envelope component that separates the conditioned space from outdoors or unconditioned space shall be accounted for in the model and should be described in terms of its surface area, orientation, and *R*-value. Glazing areas should also have their shading coefficient specified. The thermal mass and/or solar absorption of external surfaces may be specified, but are not required input (see C2.2.3).

**C2.1.2**

*R*-values should be calculated as in the rest of this Standard; that is, using a standardised surface thermal resistance of 0.03 $m^2$ °C/W outside and 0.09 $m^2$ °C/W inside (0.12 $m^2$ °C/W total), and thermal bridging effects calculated as specified in NZS 4214 except as provided for in C2.1.3. (The BRANZ House Insulation Guide provides tables of standard construction types calculated in this manner.)

**C2.1.3**

When the modelling program calculates and adds its own surface resistances to the input resistance, the input resistances shall be the *R*-values derived as specified in this Standard less the standardised surface resistances. The same method of calculation shall be used for the proposed building and the reference building.

### C2.2 EXTERIOR WALLS

**C2.2.1**

Exterior walls of the proposed building shall be modelled as proposed.

**C2.2.2**

Exterior walls for the reference building shall have an *R*-value equal to the values required by 4.2 and have the same orientation, tilt and area as the proposed building, except as provided in C2.6.3.

**C2.2.3**

Walls for the reference building and proposed buildings shall have the same solar absorption. In the absence of specific documentation 0.7 should be used as a default.

**C2.2.4**
Thermal mass of the exterior walls of the proposed building structure may be lightweight. The thermal mass of the walls of the reference building shall be equal to or less than that of the proposed building.

## C2.3 INTERNAL WALLS

**C2.3.1**
Walls separating different thermal zones or conditioned space and unconditioned spaces of the proposed and reference buildings shall be modelled as proposed. Other internal walls need not be modelled.

**C2.3.2**
The same internal walls as modelled in the proposed building shall be modelled in the reference building. Other internal walls need not be modelled. In the reference building, the effective *R*-values of walls between conditioned and unconditioned spaces shall be those required for the thermal envelope in 4.2.

**C2.3.3**
The thermal mass of internal walls of the proposed building structure may be lightweight. The thermal mass of the walls of the reference building shall be equal to or less than that of the proposed building.

## C2.4 ROOFS

**C2.4.1**
Roofs of the proposed building shall be modelled as proposed.

**C2.4.2**
Except where skylight areas are modified according to C2.7, roofs for the reference building shall have the same area as those for the proposed building. In all cases the total roof area shall be the same as for the proposed building.

**C2.4.3**
The roof of the reference building shall have an *R*-value equal to the value shown in 4.2.

**C2.4.4**
The roofs of the proposed and reference buildings shall have the same solar absorption (0.7 is an acceptable default).

**C2.4.5**
The thermal mass of the roof of the proposed building structure may be lightweight. The thermal mass of the roof of the reference building shall be equal to or less than that of the proposed building.

## C2.5 FLOORS

**C2.5.1**
Floors for the proposed building shall be modelled as proposed.

**C2.5.2**
Floors for the reference building shall have the same area as those in the proposed building but shall be modelled with an *R*-value according to 4.2.

**C2.5.3**
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.

**C2.5.4**
Carpets and other floor coverings shall be the same in both the proposed and reference buildings and shall be modelled if present. Any thermal resistance provided by carpets shall be in addition to the *R*-values required by 4.2.

## C2.6 VERTICAL GLAZING

**C2.6.1**
Vertical glazing of the proposed building shall be modelled as proposed.

**C2.6.2**
Vertical glazing for the reference building shall have the same orientation, tilt, and area, as the proposed building except as provided in C2.6.3.

**C2.6.3**
The glazing area of the reference building shall equal that of the proposed building unless the proposed building has glazing 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.

**C2.6.4**
Glazing for the reference building shall assume single glazing with an *R*-value of 0.18 $m^2$ °C/W and a shading coefficient of 1.0. A site shading of 0.75 shall be assumed.

## C2.7 SKYLIGHTS

**C2.7.1**
Skylights of the proposed building shall be modelled as proposed.

NOTE – A total area of skylights of less than 0.6 $m^2$ may be ignored for calculation purposes.

**C2.7.2**
Skylights and roofs for the reference building shall be modelled such that the total *R*-value of the roof is equivalent to a roof meeting the requirements of 4.2. 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.

### C2.8 EXTERNAL DOORS

**C2.8.1**
The distribution of doors in the reference building shall be identical to the distribution of doors in the proposed building.

**C2.8.2**
Doors in the reference building shall have an *R*-value of 0.18 $m^2$ °C/W.

### C2.9 SHADING

**C2.9.1**
Exterior attached shading such as fins and overhangs should be modelled as suggested in the proposed building but need not be modelled in the reference building.

**C2.9.2**
No account shall be taken of internal shading devices such as blinds, drapes and other non-permanent window treatments.

### C2.10 INCIDENTAL SHADING

Incidental shading shall be the same for the reference building and the proposed building. Shading by permanent structures and terrain that have a significant effect on the building shall be taken into account. A permanent structure is one that is likely to remain for the life of the proposed building design. No account shall be taken of trees or vegetation.

### C2.11 INFILTRATION

Infiltration assumptions for reference and proposed buildings shall be the same, and shall be reasonable for the building construction and use.

### C2.12 INTERNAL AIR FLOWS

Interzone air flow does not require modelling.

### C2.13 INTERNAL DOORS

Internal doors need not be modelled.



## C3 LIGHTING

**C3.1** The connected lighting load in the proposed building shall be modelled as shown.

**C3.2** 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 and the reference building.

**C3.3** The connected lighting load in the reference building 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.

**C3.4** 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 buildings.

**C3.5** Lighting schedules in either C3.4 or table C2 may be used, but the same references shall be used throughout for both reference and proposed buildings.

**C3.6** The lighting schedule may be altered to reflect the type of controls in the proposed building, but both the proposed and reference buildings lighting schedules shall be identical. No credit shall be given for the use of any controls, automatic or otherwise.

**C3.7** Thermal simulations shall include the heat released into the reference and proposed buildings from lighting. The same loads and schedules as the modelled lighting shall be used in each case.



## C4 INTERNAL LOADS

**C4.1** Internal loads from lighting shall be as defined in C3.

### C4.2 DOMESTIC HOT WATER

Hot water systems shall not be modelled.

### C4.3 OCCUPANTS AND PLUG LOADS

**C4.3.1**

Table C1 gives values for the maximum likely rates of heat release into a building from occupants and plug loads. These are modified by the factors from the relevant part of table C2 to provide default values for heat release at different times of day. 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 and reference buildings. All internal loads are regarded as sensible heat.

**C4.3.2**

Spaces defined as unconditioned shall be assigned zero internal loads.

## C4.4 PROCESS LOADS

**C4.4.1**

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

**C4.4.2**

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 and reference buildings.

# C5 CONDITIONING SYSTEM MODELLING

**C5.1** This Standard has no requirements for the performance of heating, cooling and ventilating equipment. Thus no credit can be given for a high performance system, and no system requirements are made. Equipment shall be modelled in an identical manner in both models. Sizing is the only feature that may be changed in response to load requirements.

NOTE – Future revisions of this Standard may include requirements for plant and the subsequent credit for high performance equipment.

**C5.2** 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.

**C5.3** 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.

**C5.4** 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.

**C5.5** Modelling shall use reasonable assumptions as to equipment performance and control.

**C5.6** Sufficient information shall be input to describe the proposed building's plant to permit modelling by the program.

## C5.7 VENTILATION

**C5.7.1**
The fresh air ventilation rate and schedule shall be the same for both the proposed building and the reference building.

**C5.7.2**
Constant ventilation may be modelled.

**C5.7.3**
The minimum ventilation rate should be according to NZS 4303.

**C5.7.4**
Ventilation may be provided mechanically or by natural means.

## C5.8 CONTROL TEMPERATURES

**C5.8.1**
In all cases temperatures modelled shall be the same for the proposed building and the reference building.

**C5.8.2**
A minimum temperature of 18 °C from 7 am – 11 pm and 16 °C overnight is required to be modelled in all residential situations. Higher temperatures can be modelled if desired.

**C5.8.3**

This specification does not deal specifically with internal conditions, and it is for the designer to judge what are appropriate comfort conditions. 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 domestic and commercial buildings during occupancy.

**C5.8.4**

Occupancy for commercial buildings should be 10 hours per day, 5 days per week or as shown in the relevant part of table C2, unless a different schedule can be justified as a likely schedule for the foreseeable life of the building.

## C6 REFERENCE BUILDING

### C6.1 SCHEDULES

The default power densities for internal gains from occupants and plug loads are shown in table C1. The default schedules for occupancy, plug loads and lighting are shown in table C2.

**Table C1 – Default power densities for internal gains from occupants and plug loads**

| Building type | Occupancy ($W/m^2$) | Plug load ($W/m^2$) |
|---|---|---|
| Assembly | 14.5 | 2.7 |
| Health / institutional | 3.6 | 10.7 |
| Hotel / motel | 2.9 | 2.7 |
| Office | 2.7 | 8.1 |
| Car parking | NA | NA |
| Restaurant | 7.3 | 1.1 |
| Retail | 2.4 | 2.7 |
| School | 9.7 | 5.4 |
| Warehouse | 0.1 | 1.1 |

Table C2 – Default schedules for occupancy, plug loads and lighting (percentage of maximum load or percentage of power density)

**Assembly**

| | 12am – 8am | 8am – 11am | 11am – 6pm | 6pm – 10pm | 10pm – 12am |
|---|---|---|---|---|---|
| **Occupancy** | | | | | |
| Week | 0 | 20 | 80 | 20 | 0 |
| Saturday | 0 | 20 | 60 | 60 | 0 |
| Sunday | 0 | 20 | 70 | 70 | 0 |
| **Plug and lighting** | | | | | |
| Week | 5 | 40 | 75 | 75 | 5 |
| Saturday | 5 | 30 | 50 | 50 | 5 |
| Sunday | 5 | 30 | 65 | 65 | 5 |

**Health – Consultancy**

| | 12am – 8am | 8am – 11am | 11am – 6pm | 6pm – 10pm | 10pm – 12am |
|---|---|---|---|---|---|
| **Occupancy** | | | | | |
| Week | 0 | 80 | 80 | 30 | 0 |
| Saturday | 0 | 40 | 40 | 0 | 0 |
| Sunday | 0 | 5 | 5 | 0 | 0 |
| **Plug and lighting** | | | | | |
| Week | 10 | 90 | 90 | 30 | 10 |
| Saturday | 10 | 40 | 40 | 10 | 10 |
| Sunday | 5 | 10 | 10 | 5 | 5 |

**Health – Residential care**

| | 12am – 8am | 8am – 11am | 11am – 6pm | 6pm – 10pm | 10pm – 12am |
|---|---|---|---|---|---|
| **Occupancy** | | | | | |
| Week | 70 | 90 | 90 | 85 | 70 |
| Saturday | 70 | 90 | 90 | 85 | 70 |
| Sunday | 70 | 90 | 90 | 85 | 70 |
| **Plug and lighting** | | | | | |
| Week | 20 | 90 | 85 | 80 | 20 |
| Saturday | 20 | 90 | 85 | 80 | 20 |
| Sunday | 20 | 90 | 85 | 80 | 20 |

**Hotel – Motel**

| | 12am – 8am | 8am – 11am | 11am – 6pm | 6pm – 10pm | 10pm – 12am |
|---|---|---|---|---|---|
| **Occupancy** | | | | | |
| Week | 90 | 40 | 20 | 70 | 90 |
| Saturday | 90 | 50 | 30 | 60 | 70 |
| Sunday | 70 | 70 | 30 | 60 | 80 |
| **Plug and lighting** | | | | | |
| Week | 10 | 40 | 25 | 60 | 60 |
| Saturday | 10 | 40 | 25 | 60 | 60 |
| Sunday | 10 | 30 | 30 | 50 | 50 |

**Housing**

| | 12am – 8am | 8am – 11am | 11am – 6pm | 6pm – 10pm | 10pm – 12am |
|---|---|---|---|---|---|
| **Occupancy** | | | | | |
| Week | 100 | 60 | 60 | 100 | 100 |
| Saturday | 100 | 100 | 50 | 70 | 100 |
| Sunday | 100 | 100 | 50 | 70 | 100 |
| **Plug and lighting** | | | | | |
| Week | 3 | 23 | 23 | 27 | 20 |
| Saturday | 3 | 23 | 23 | 27 | 20 |
| Sunday | 3 | 23 | 23 | 27 | 20 |

**Table C2 – Default schedules for occupancy, plug loads and lighting (percentage of maximum load or percentage of power density)** (continued)

**Office**

| | 12am – 8am | 8am – 11am | 11am – 6pm | 6pm – 10pm | 10pm – 12am |
|---|---|---|---|---|---|
| **Occupancy** | | | | | |
| Week | 0 | 95 | 95 | 5 | 0 |
| Saturday | 0 | 10 | 5 | 0 | 0 |
| Sunday | 0 | 5 | 5 | 0 | 0 |
| **Plug and lighting** | | | | | |
| Week | 5 | 90 | 90 | 30 | 5 |
| Saturday | 5 | 30 | 15 | 5 | 5 |
| Sunday | 5 | 5 | 5 | 5 | 5 |

**Restaurant**

| | 12am – 8am | 8am – 11am | 11am – 6pm | 6pm – 10pm | 10pm – 12am |
|---|---|---|---|---|---|
| **Occupancy** | | | | | |
| Week | 0 | 5 | 50 | 80 | 35 |
| Saturday | 0 | 0 | 45 | 70 | 55 |
| Sunday | 0 | 0 | 20 | 55 | 20 |
| **Plug and lighting** | | | | | |
| Week | 15 | 40 | 90 | 90 | 50 |
| Saturday | 15 | 30 | 80 | 90 | 50 |
| Sunday | 15 | 30 | 70 | 60 | 50 |

**Retail**

| | 12am – 8am | 8am – 11am | 11am – 6pm | 6pm – 10pm | 10pm – 12am |
|---|---|---|---|---|---|
| **Occupancy** | | | | | |
| Week | 0 | 60 | 70 | 40 | 0 |
| Saturday | 0 | 60 | 80 | 20 | 0 |
| Sunday | 0 | 10 | 40 | 0 | 0 |
| **Plug and lighting** | | | | | |
| Week | 5 | 90 | 90 | 50 | 5 |
| Saturday | 5 | 90 | 90 | 30 | 5 |
| Sunday | 5 | 40 | 40 | 5 | 5 |

**School**

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

**Warehouse**

| | 12am – 8am | 8am – 11am | 11am – 6pm | 6pm – 10pm | 10pm – 12am |
|---|---|---|---|---|---|
| **Occupancy** | | | | | |
| Week | 0 | 90 | 85 | 0 | 0 |
| Saturday | 0 | 20 | 10 | 0 | 0 |
| Sunday | 0 | 0 | 0 | 0 | 0 |
| **Plug and lighting** | | | | | |
| Week | 5 | 90 | 90 | 5 | 5 |
| Saturday | 5 | 24 | 5 | 5 | 5 |
| Sunday | 5 | 5 | 5 | 5 | 5 |

# C7 INFORMATION AND DOCUMENTATION

## C7.1 SUPPORTING DOCUMENTATION

### C7.1.1

All analyses submitted shall be accompanied by an energy analysis comparison report. The report shall provide:

(a) The name of the modeller;

(b) Full reference details of the modelling program;

(c) Technical detail on the reference and proposed building designs and the differences between the designs.

### C7.1.2

The report for the reference building and the proposed building shall separately identify, if possible, the calculated annual energy consumption for space heating, space cooling, ventilation/fans and lighting. If cooling will not be provided in the building, cooling loads are not required to be modelled or reported. Where ventilation is proposed to be non-mechanical, modelling and reporting are not required. These energy consuming features shall be summed for each building and the results compared.

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