GREEN STAR – DESIGN & AS BUILT

BUILDING ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS CALCULATION GUIDELINES V1

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This guide is to be used for both credits in the Energy category: Greenhouse Gas Emissions and Peak Electricity Demand Reduction

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1 INTRODUCTION

This document sets out the basis on which building energy performance modelling is to be completed for all Green Star Design and As Built rating assessments adopting the performance-based compliance approach. The methodology is based on the NCC Section J Verification Method JV3, with specific modifications to the methodology and the reference definitions to suit better the objectives of Green Star.

The main areas of focus in developing this guidance are as follows:

- Provide definite guidance on the requirements for modelling of building energy performance, in terms of end use inclusions and key considerations;
- Provide flexibility to the project team to adjust default operating profiles where appropriate to reflect better the anticipated operation of the building;
- Provide meaningful information from the energy analysis model to inform the ongoing monitoring management of building energy performance; and
- Consolidate existing guidance into a single comprehensive reference document applicable to all Design and As Built rating assessments.

2 DEFINITIONS

2.1 Benchmark Building

A hypothetical building that is responsible for 10% less energy consumption and greenhouse gas emissions than the Reference Building. Points are awarded where the energy consumption and greenhouse gas emissions of the Proposed Building are lower than equivalents for the Benchmark Building.

2.2 Carbon Dioxide Equivalent

Carbon dioxide equivalent (CO_2e) is a measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). The carbon dioxide equivalent for a gas is derived by multiplying the mass of the gas by the associated GWP (EPA, 2009). For the purposes of the Green Star rating tools, carbon dioxide equivalents are expressed as kilograms of carbon dioxide equivalent ($kgCO_2e$).

2.3 Greenhouse Gas Emissions Factor

Greenhouse gas emissions factors quantify the amount of greenhouse gas (in terms of carbon dioxide equivalent) which will be emitted into the atmosphere, as a result of using one unit of energy, i.e. the amount of greenhouse gas emitted due to using one kilowatt hour of electricity or one megajoule of gas, coal or bio-fuel ($kgCO_2e/kWh$, or $kgCO_2e/MJ$).

2.4 Global Warming Potential

Global warming potential (GWP) is defined as the cumulative radiative forcing effects of a gas over a specified time horizon resulting from the emission of a unit mass of gas relative to a reference gas (EPA, 2009). For the purpose of Green Star rating tools, the time horizon is 100 years and the reference gas is carbon dioxide. This is consistent with international greenhouse gas emissions reporting under the Kyoto protocol (IPCC, 1996). For example, methane has a GWP of 21; therefore one tonne of methane released into the atmosphere has the same warming effect, over 100 years, as 21 tonnes of carbon dioxide.

2.5 GreenPower®

GreenPower® is a voluntary government-accredited program that enables energy providers to purchase renewable energy on behalf of customers. It is a joint initiative of the ACT, NSW, SA, QLD, and VIC state governments. The GreenPower® accreditation guarantees that renewable electricity bought from energy retailers meets stringent environmental standards. The program independently audits the renewable energy sector to ensure that when customers buy accredited GreenPower®

products, the money paid is invested in the development of new infrastructure in the renewable energy sector. For more information refer to www.greenpower.com.au.

2.6 Intermediate Building

A hypothetical building of the same size, shape, floor area and glazing areas as the Proposed Building, and including all the same building envelope design and performance characteristics as the Proposed Building, but whose building services characteristics are based predominantly on the NCC Section J Deemed-to-Satisfy provisions as defined in this document.

2.7 Mechanical Ventilation

Describes the provision of controlled amounts of ventilation (outside) air by the use of mechanical equipment, typically comprising fans, filters, ductwork and terminal air devices. The temperature of the ventilation air may be controlled, but this is not required to be classified as mechanical ventilation.

2.8 Mixed-Mode Ventilation

Describes a mode of building control in which mechanical ventilation is used at low and high ambient temperature conditions, and natural ventilation is used at intermediate temperature conditions. The mechanical ventilation mode is typically coupled with temperature control by air conditioning, but this is not always the case.

2.9 National Construction Code

Section J of the National Construction Code (NCC) Volume One (referenced as NCC Section J in this document) addresses energy efficiency requirements for Class 2 to 9 buildings, and sets the minimum standard of performance required for the Reference Building. Since the NCC is updated annually, the applicable version is the version of the NCC referenced in the Building Surveyor's report for the project; or the version of the NCC current at the date of registration of the project with Green Star. All references to the NCC in this document are based on NCC, 2013, the current version at the time of the development of this document. If there is ever any discrepancy between the requirements of this document and those of the NCC, the NCC requirements will take precedence; any such issues must be noted in the credit submission.

2.10 Natural Ventilation

Describes the provision of uncontrolled amounts of ventilation (outside) air by the use of openings in the building envelope which are connected to the occupied space. The movement of air is controlled only by the prevailing environmental conditions, of which the main factors affecting ventilation are wind speed and direction and temperature difference between indoors and outdoors. Openings may be automatically or manually controlled.

2.11 Proposed Building

The building to be rated by the Green Star Design and As Built rating tool, as designed and modelled by the project team.

2.12 Reference Building

A hypothetical building of the same size, shape, floor area and glazing areas as the Proposed Building, but whose building fabric and building services characteristics are based predominantly on the NCC Section J Deemed-to-Satisfy provisions as defined in this document.

2.13 Scope 1, 2 & 3 Emissions

Scope 1 emissions are direct greenhouse gas emissions which occur due to activities within an organisation's boundary. Scope 2 and 3 emissions are indirect greenhouse gas emissions which occur due to activities outside of an organisation's boundary. The Scope 1 emissions that are calculated by the GHG Emission Calculator include the direct emissions due to the combustion of fuel on-site, such as the combustion of gas in a building's heating hot water or cogeneration system(s),

and the leakage of synthetic gases from the building's refrigeration plant. Scope 2 emissions are those which result from the generation of electricity used by the building. Scope 3 emissions include the indirect emissions that result from the processing and transportation of fuels used within the building. See Chapter 1 of the National Greenhouse Accounts (DIICCSRTE, 2013) for further information.

3 ENERGY CATEGORY

The Green Star Design and As Built Energy category incorporates two credits, Greenhouse Gas Emissions and Peak Electricity. When applying the modelled performance pathway the same building energy performance model is used as the basis of assessment of both credits. This document describes the required attributes of the building energy performance models used to assess the project's performance against these credits. The Green Star Energy Calculator automatically calculates the points achieved by the project based on building energy performance model output data modelled using approved software.

For the modelled performance pathway reference building method there are two criteria, Energy Consumption Reduction and Greenhouse gas emissions reduction.

Energy consumption reduction is calculated based on comparison of the Benchmark Building and the Intermediate Building. As per the definitions of these buildings, the only variables between the buildings are the building fabric, and this component of the credit therefore rewards passive design only.

Greenhouse gas emissions reduction is calculated based on comparison of the Benchmark Building and the Proposed Building. As per the definitions of these buildings, all design variables are reflected in this comparison, including services design strategy and choice of energy sources.

Based on the completed building energy performance analysis, the peak electricity demand reduction is calculated by entering the Reference and Proposed Buildings' peak electricity demand data into the Green Star calculator.

4 BUILDING ENERGY PERFORMANCE CALCULATION OVERVIEW

4.1 NCC Section J

NCC Section J provides three pathways for demonstrating compliance with Performance Requirement JP1 of Section J for Class 3 to Class 9 buildings, namely:

- Deemed-to-Satisfy based on adopting the prescriptive requirements outlined in Parts J1 to J7;
- Verification Method JV3 based on adopting the prescribed performance-based assessment methodology; and
- Alternative Solutions which may be adopted subject to the approval of the Building Surveyor.

Performance assessment methodology (JV3) provides a sensible basis from which to develop a Green Star-specific energy model. This methodology is adopted by the Green Star Design and As Built rating tool as the basis of the modelled performance pathway for the Energy category assessment.

4.2 Nationwide House Energy Rating Scheme

Class 2 buildings may demonstrate compliance with Section J by the use of the Nationwide House Energy Rating Scheme (NatHERS) assessment methodology. This calculation method is adopted as the basis of the Green Star modelled performance pathway for Class 2 buildings. Where projects are incorporating systems which may achieve energy and GHG performance improvement beyond that awarded by this pathway, they can adopt the reference building method as for Class 3 to 9 buildings. Where this is the case, all other requirements of this guide apply as if the Class 2 building were a Class 3 to 9 building.

4.3 National Australian Built Environment Rating Scheme (NABERS) Energy Rating

Class 5 buildings may demonstrated compliance with the Greenhouse Gas Emissions credit using NABERS energy rating calculations.

4.4 Australian Building Codes Board Simulation Protocol

Projects adopting the Verification Method JV3 shall utilise a dynamic thermal simulation software package which satisfies the requirement of the Australian Building Code Board's Protocol of Building Energy Analysis Software (v2006-1) (ABCB, 2006). The ABCB does not maintain a register of complying software, but software previously documented to have demonstrated compliance with the Protocol requirements includes (BC, 2006):

- Beaver (developed by ACADS-BSG);
- EnergyPlus (developed by LBNL and DOE);
- Tas (developed by EDSL);
- IES <VE> (developed by IES);
- IDA ICE (developed by Equa Solutions);
- TRACE 700 (developed by Trane CDS); and
- HAP E20-II (developed by Carrier).

The protocol requirements are adopted by the GBCA as the basis of demonstrating the suitability of software for completing the assessments detailed in this document. Projects using software other than those in the above list must demonstrate that the requirements of the Protocol are satisfied as part of the credit submission. In all cases, the project team must demonstrate how the requirement for training has been satisfied.

4.5 Use of Software and Other Calculation Methods

For the purposes of Green Star, the software must be used for the calculation of all air conditioning system loads (i.e. air side coil loads) and energy consumption. So far as practicable, the software must also be used for the calculation of all HVAC plant loads and associated energy consumption. However, it is recognised that all software packages have limitations and that some system components and/or arrangements may not be able to be assessed by the software directly. Where this is the case, the project team may use supplementary manual calculations (such as in a spreadsheet), but all components that have been calculated in this way must be disclosed, and a description of the methodology given, including commentary on any limitations of the methodology and their effect on the results of the calculation. Where the associated energy consumption and/or greenhouse gas emissions reduction for the associated end use represents a significant proportion (greater than 20%) of the total reduction, the Assessors may request further information to confirm that the methodology is appropriate and consistent with the rest of the model.

4.6 Approach to Greenhouse Gas Emissions Reduction Calculation for Green Star - Design & As Built

For the purposes of the assessment of building performance for the Green Star Energy category, projects must adopt a methodology consistent with the Verification Method JV3 approach. However, for the purposes of uniformity and appropriateness of assessment, this guidance document sets out alternative requirements for some parts of the assessment methodology that MUST be implemented for consistent equitable assessment of points awarded to all projects.

The specific calculation requirements are specified in Section 6 and the associated appendices.

5 INTERDEPENDENCE WITH OTHER GREEN STAR CREDITS

5.1 Commitment to Performance

Where the specific criteria within this credit is claimed, monthly benchmarks by submeter are to be included in As Built documentation and actual operational figures shared with GBCA.

5.2 Visual Comfort

Where credit is claimed for dimming control of artificial lighting in response to measured daylight in a space, other than by use of the deemed adjustment factors in Section 14.5.2, it must be demonstrated:

- If hourly internal daylight levels are calculated by the building energy performance simulation software from first principles, that all inputs to the simulation model are consistent with the inputs to the daylight model; or
- If daylight compensation is calculated by the building energy performance simulation software based on daylight factor and solar radiation data, that all daylight factors entered correlate to the calculated daylight factor distribution. This must include consideration of the depth of the daylit area relative to the HVAC zone and the position of the daylight sensor within the zone.

5.3 Quality of Indoor Air

Ventilation rates (that is the quantity of outdoor air introduced to the building) and the method of ventilation control as applied in the Quality of Indoor Air credit must be consistent with the quantities and controls claimed in this credit. Where demand-controlled ventilation is applied based on the use of carbon dioxide (CO_2) sensors, then this must be modelled using one of the following approaches, and with the CO_2 concentration set point in accordance with credit Quality of Indoor Air:

- In single-zone systems (including systems serving multiple instances of spatially uniform occupancy, e.g. open plan office spaces) the reduction in outdoor air flow rate may be assumed to be proportional to the reduction in space occupancy based on the following equation:

$$p_{OA} = 100\% - 0.8(100\% - p_{occ})$$

  Where $\mathrm{p_{OA}}$ is the percentage of design outdoor air supplied to the space, and $\mathrm{p_{occ}}$ is the percentage of design occupancy for any given hour of HVAC system operation. The factor of 0.8 is included to compensate for actual variability in occupancy between zones and imperfect control of dampers which will not maintain proportionality across the control range.

- In multi-zone systems, the calculation must be based on dynamic application of AS1668.2.2012 or ASHRAE, 2010 multiple enclosure rules.

The rate of bioeffluent CO_2 emission to the space shall be based on the following equation (NIST, 2001):

$$\dot{q}_{CO2} = \frac{0.00276 A_D M Q_R}{0.23 Q_R + 0.77}$$

Where $\dot{q}_{CO2}$ is the rate of CO_2 emission (L/s/person), A_D is the duBios body surface area (m²) (approx 1.8 m² for typical adults), M is the occupant metabolic activity rate (met), and Q_R is the respiratory quotient (the relative volumetric rates of carbon dioxide produced to oxygen consumed) (approximately 0.83 for sedentary-to-light activity, and increasing to 1.0 for heavy physical activity (5 met)). The occupant activity level used for each space type must be consistent with the inputs used for the Thermal Comfort credit; assume $A_D = 1.8$ m^2 and linear variation of Q_R from 0.83 at 1.2 met and below, to 1.0 at 5 met and above.

5.4 Thermal Comfort

Thermal comfort and building energy performance assessments should ideally be completed in the same software package using all of the same model inputs. However, where this cannot be done, the software used for both assessments must comply with the software requirements of this guide, and all of the same input parameters must be applied in both simulations.

5.5 Water

Domestic hot water usage for the reference and actual buildings must be based on the calculations completed in the Potable Water calculator. The calculator provides an annual total usage figure only; the project team must convert this to an hourly usage profile for use in conjunction with the simulation model. Guidance on water consumption profiles is provided in Section 6.9.

Heat rejection water consumption for the Reference Building is calculated by the Potable Water calculator based on monthly total heat rejection values; these values must be calculated from the simulation output, if not available directly. Project teams must differentiate between wet heat rejection (from water-cooled chillers) and dry-heat rejection (from air-cooled chillers and air-source heat pumps).

Heat rejection water consumption for the Proposed Building is calculated by the Potable Water calculator based on monthly total heat rejection values, where conventional evaporative cooling towers are used. If the Proposed Building uses alternative heat rejection technology (such as adiabatic coolers) then the water consumption must be calculated as part of the building energy performance simulation and the total usage value entered into the Potable Water calculator.

Where direct or indirect evaporative cooling systems are used in the Proposed Building, the associated water consumption must be calculated as part of the building energy performance simulation and the total entered into the Water category calculator.

6 CALCULATION REQUIREMENTS FOR GREEN STAR DESIGN AND AS BUILT

6.1 Scope of Building Energy End Use Inclusions

The following end uses must be included in assessment of the building energy consumption and greenhouse gas emissions, as a minimum:

- All HVAC systems for control of the building internal environment, including server, communications, equipment and electrical rooms;
- All HVAC systems for control of processes, where these are provided as part of the services engineer's scope of works (specialist systems by others are excluded);
- All internal and external artificial lighting, including task lighting, provided as part of the services engineer's scope of works (lighting provided as part of architectural or FFE scope of works are excluded);
- All water supply and treatment systems within the building, including cold water pressurisation, domestic hot water heating, rainwater distribution, grey- or blackwater treatment and distribution (including reverse osmosis, ultraviolet or other filtration systems);
- Vertical and horizontal transportation systems, including lifts, escalators and moving walkways;
- Specialist services systems provided as part of the services engineer's scope of works, for example medical gases, pneumatic tube system and steam generators in healthcare buildings.
- All swimming pool plant systems, including water heating, circulation pump(s), and underwater lighting. This includes general swimming pools and spas in leisure centres, gymnasia and residential buildings, and specialist pools, e.g. hydrotherapy pools.

Note that lift and domestic hot water energy consumption must be included in both the Proposed and Reference Building's energy consumption; NCC Section J clause JV3(e) does not apply.

Heat loads due to process loads must be accounted for, whether as airside or waterside system loads, but direct energy consumption due to operation of the process is not included, except for appliances in Class 2 buildings. The definition of process load includes, but is not limited to:

- Computers and similar IT equipment in office-type work environments;
- IT and communications equipment in server rooms, data centres and communications rooms;
- Specialist healthcare equipment such as MRI, CT, PET and X-ray imaging equipment;
- Commercial catering operations. Note that the associated kitchen ventilation systems are NOT process loads and must be included in the calculation;
- Operation of freezer rooms, cool rooms and hot rooms in laboratories, warehouses and similar (but the heat load in adjacent conditioned spaces must account for the temperature differential between them);
- Refrigerated display cabinets in food retail premises;
- Heating and cooling of, plunge pools, saunas and steam rooms in leisure facilities (but the heat load in adjacent conditioned spaces must account for the temperature differential between them). Note that the associated ventilation systems are NOT process loads and must be included in the calculation; and

- All industrial manufacturing processes.

Where present, on-site (i.e. contained within the title boundary of the premises being rated, and directly connected on the building side of the authority electricity meter) energy generation systems may be included, including both primary and ancillary energy inputs and energy outputs as applicable. 100% of the calculated energy contribution may be included in the assessment. Calculations must be completed in accordance with the methodology specified in this guidance document for the relevant technology.

6.2 General Modelling Criteria

The following table defines the main features of the Proposed and Reference Buildings to be used in the simulation model to assess the associated energy consumption and greenhouse gas emissions. The information in this section shall be read in conjunction with the supplementary definitions contained in Section 0.

Table 1: Modelling requirements for the design and reference buildings

Item	Description	Proposed Building	Reference Building
1	Thermal calculation method	As NCC Section J clause JV3(c), a thermal calculation method that complies with ABCB, 2006.	As Proposed Building model (as NCC Section J clause JV3(d)(ii)(A)).
2	Location (selection of climate file)	One of the following options, listed in order of preference: ▪ A Reference Meteorological Year (RMY) if the building location is within 50 km of a RMY location for the same climate zone; ▪ A Test Reference Year (TRY) if the building location is within 50 km of a TRY location for the same climate zone; or ▪ In the absence of local RMY or TRY weather data, an actual year of recorded weather data from a location within 50 km of the building location for the same climate zone; or ▪ In the absence of RMY, TRY or actual weather data within 50 km, interpolated data based upon 3 points within 250 km of the building location. Details of RMY and TRY data sets are available from the Australian Climatic Data Bank administered by ACADS-BSG. Please contact the Green Building Council of Australia for approval of alternative climate files if the project cannot comply with any of the above options.	As Proposed Building model (as NCC Section J clause JV3(d)(ii)(B)).
3	Adjacent structures and features	Overshadowing from the surrounding environment must be taken into account in the model. Existing adjacent buildings, including any already under construction, must be included in the model; proposed buildings on adjacent sites must be excluded if construction has not already commenced at the time of registration of the project.	As Proposed Building model (as NCC Section J clause JV3(d)(ii)(C)).
4	Environmental conditions	Factors such as ground reflectivity, sky and ground form factors, and temperatures of external bounding surfaces must be specified appropriately for the local conditions.	As Proposed Building model (as NCC Section J clause JV3(d)(ii)(D)).

Item	Description	Proposed Building	Reference Building
5	Orientation	The representation of the Proposed Building's orientation shall be consistent with the design documents.	As Proposed Building model (as NCC Section J clause JV3(d)(ii)(E)).
6	Geometric model	The representation of Proposed Building's geometry shall be consistent with the design documents.	As Proposed Building model (as NCC Section J clause JV3(d)(ii)(F, G, J)).
7	Building envelope	The simulation of the Proposed Building envelope shall be consistent with the design documents. Manual fenestration shading devices such as blinds or shades shall not be modelled.	The Reference Building thermal envelope shall be modelled based on the minimum performance requirements of Parts J1, J2 and J3 (NCC Section J clause JV3(d)(i)(A)). For Class 2 buildings, the requirements for Class 3 buildings shall be adopted to avoid the requirement for reverse engineering of NatHERS calculations to meet minimum star ratings. Glazing performance may not exceed U value 8.0 W/m² K and/or solar heat gain coefficient 1.0 on the basis that such performance is not physically realistic. External feature shading which has been included in the Proposed Building specifically for the control of solar radiation entering the building shall be excluded from the Reference building. Shading that occurs due to intrinsic features of the building form, such as reveals and returns in the building structure, and balconies or other amenities, shall be included in both the Proposed and Reference buildings. Where boundary conditions are defined for the Proposed Building which are not based directly on the hourly weather data, the same boundary conditions must be applied for the Reference Building (as NCC Section J clause JV3(d)(ii)(M)). Manual fenestration shading devices such as blinds or shades shall not be modelled.

Item	Description	Proposed Building	Reference Building
8	External surfaces solar absorptance	As specified within design documents plus 0.05 (as NCC Section J clause JV3(d)(iii)); or, if not specified, 0.65 for walls and 0.75 for roofs.	Solar absorptance of 0.6 for walls and 0.7 for roofs (as NCC Section J clause JV3(d)(i)(B)).
9	Infiltration rate	The infiltration rate assumed for all spaces should be as specified in NCC Section J clause JV3(d)(i)(F). Where building air tightness pressure testing is undertaken in accordance with ATTMA, 2010, or an equivalent standard, then the infiltration rate may be applied based on the tested air leakage rate (or the targeted value for the Design rating). The infiltration rate shall be calculated as follows: $$I = \frac{\dot{q}_{50}}{20V}$$ Where I is the nominal infiltration rate (ACH), $\dot{q}_{50}$ is the building air leakage flow rate at 50 Pa test pressure (m³/h), and V is the building volume (m³) (CIBSE, 2000).	The infiltration rate assumed for all spaces should be as specified in NCC Section J clause JV3(d)(i)(F).

Item	Description	Proposed Building	Reference Building
10	Building operation	Building operation should be specified based on the default operating profiles included in Section 14.3 for the relevant space types. The simulation must incorporate variations for all day types as appropriate. Public holidays applicable to the building's location shall be included in the simulation, and, unless specifically stated otherwise, will use the weekend or Sunday profile. Where the anticipated operating hours of the Proposed building differ from the default operating hours, the project team may adjust them to better align with expectations. Where operation is varied by more than 10% of total default operating hours, this must be confirmed with the GBCA by a CIR prior to implementation in the model, and must be supported by design documentation or a statement from the client confirming the operational intent. Where the proposed building incorporates design features which are expected to vary the operating profiles from the default (such as automatic control features for equipment), the project team may submit a CIR requesting a change for the proposed building only. The CIR must include supporting evidence demonstrating why the change is justified.	As per the Design Building, except where profiles are specifically modified to reflect design features of the Design building. Operating hours must be the same in both models.
11	HVAC zones	The simulation of the Proposed HVAC zones shall be consistent with the design documents.	As Proposed Building model (NCC Section J clause JV3(d)(ii)(T)).

Item	Description	Proposed Building	Reference Building
12	Heating, Ventilation and Air Conditioning	The Proposed Building HVAC system type and configuration must be modelled based on the documented design. The simulated internal gains must be in accordance with Section 14.2. Where variable volume control is specified, part-load fan power shall be modelled using one of the methods in Section 14.4.3. All ventilation-only systems (e.g. in car parks, loading docks and warehouses) must be included in the energy model. Section 14.3 contains operational profiles which must be used for these system types. Where a system includes HEPA filters or other high-pressure drop components required for the process served, system fan power must include the effect of this component(s); unlike NCC Section J clause J5.2(a)(ix)(B), the associated energy consumption of these components must be included in the calculation. Credit may be taken for installing atmospheric contaminant monitoring systems and variable-speed fan control in car parks and loading docks by using the Adjustment Factor given in Section 14.5.1. In any areas of the building which are only fitted out to shell and core standard, a notional fit out must be modelled on the basis of the most energy intensive fit out allowable by NCC Section J. The design team must demonstrate the design provision (e.g. space allowance) that has been made for accommodating the system type modelled.	The Reference Building's HVAC system type, configuration and performance parameters must be as specified in Section 14.4.2. The design internal gains must be the same as for the Proposed Building; refer to Section 14.1 for further details. The simulated internal gains must be the same as for the Proposed Building (NCC Section J clauses JV3(d)(ii)(S, Z)), except where additional control features are included in the Proposed Building. Those spaces in the Proposed Building which are mechanically ventilated (such as car parks, loading docks and warehouse spaces), shall be fully mechanically ventilated (i.e. with no passive supply/passive exhaust) to the minimum requirements as per AS1668.2.2012. The Reference Building's ventilation systems shall meet the maximum fan shaft power requirements of Part J5.

Item	Description	Proposed Building	Reference Building
13	Artificial internal lighting	The annual energy consumption from internal artificial lighting, excluding emergency lighting, must be calculated on the basis of the proposed level of artificial lighting in the building with the daily profiles given in Section 14.3. This includes any internal car park lighting. Credit may be taken for lighting zoning and automatic controls which exceed the requirements of Part J6; refer to Section 14.5.2. In any areas of the building which are only fitted out to shell and core standard, the fit out must be modelled on the basis of the most energy intensive fit out allowable by NCC Section J.	The lighting power density used in the Reference Building must be in accordance with Part J6 and based on the design lighting levels as applied in the Proposed Building (as NCC Section J clause JV3(d)(ii)(R)). The Reference Building's lighting power density can be adjusted for Room Aspect Ratio (as per Table J6.2a note 3), but not for control devices (as per Table J6.2a note 4) (as NCC Section clause JV3(d)(i)(C)). The same operating profiles must be used as are used in the proposed building (given in Section 14.3).
14	Artificial external lighting	The annual energy consumption from external artificial lighting must be calculated on the basis of the proposed level of external artificial lighting provided with the daily profiles given in Section 14.3. All external lighting within the building title boundary, but excluding emergency lighting, must be included in the Proposed Building energy consumption calculation (this includes landscape and decorative lighting). Where the Proposed Building design lighting levels do not meet the horizontal illuminance requirements as per SA, 2005, the power density used in the energy consumption calculation must be the greater of: ▪ The proposed design lighting power density; or ▪ The reference lighting power density given in Section 14.4.4 for the applicable lighting type category. (This ensures that providing poor lighting amenity is not rewarded in this credit as an energy-saving measure.)	The annual energy consumption from the external lighting shall be calculated with the external lighting power density given in Section 14.4.4, and the same daily profiles as used in the Proposed Building. The same external areas shall be illuminated in the Reference Building as for the Proposed Building, excluding any landscape, decorative and emergency lighting. To establish which standard practice power density should be used for a particular area, the lighting designer must identify the appropriate category from SA, 2005.

Item	Description	Proposed Building	Reference Building
15	Domestic hot water systems It is necessary to complete the Potable Water Calculator before the energy consumption from the Proposed and Reference Building's domestic hot water system(s) can be calculated.	The domestic hot water usage of the Proposed Building is calculated by the Potable Water Calculator. The domestic hot water usage of the Proposed Building depends on the water efficiency of the building's taps and showers. Reduction in the volume of domestic hot water usage by installing water efficient fittings is one way to reduce greenhouse gas emissions associated with the building. Where make up water is provided from the mains water service, the water temperature shall be based on the monthly values in Table A6 of SA, 2008 for the climate zone applicable to the building location. The contribution due to solar thermal water heating shall be calculated based on the methodology described in Section 7.2.	As with the Proposed Building, the domestic hot water usage of the Reference Building is calculated by the Potable Water Calculator. Domestic hot water heating shall be by a dedicated water heating system comprising modular heaters (four off of equal capacity). System recovery time and cold water make up temperature shall be the same as the Proposed Building. The fuel shall be the same as the Reference Building space heating system (natural gas or diesel oil) (refer to Section 14.4.2 for definition), with full-load gross thermal efficiency as per NCC Section J Table J5.4b.
16	On-site energy generation	100% of the energy generated on-site from low or zero carbon sources, such as cogeneration, trigeneration, solar photovoltaic and wind, may be used to reduce the calculated annual energy consumption of the building. The modelling methodology for any such systems shall be as described in Sections 6.9 or 7, as applicable. Where a diesel generator is installed, it must be assumed that standard diesel, rather than any alternative liquid fuel, is used, unless the generator has been modified to accept the alternative fuel only.	None
17	Lifts	Modelled using the standard calculation methodology detailed in Section 14.4.5.	Modelled using the standard calculation methodology detailed in Section 14.4.5.

Item	Description	Proposed Building	Reference Building
18	Other energy consumption	All services required for the operation of the building must be included in the building energy consumption. Any other energy consumed on site for base building facilities such as a water-recycling treatment plant, must be included. All assumptions used in the calculation must be provided in the documentation and justified.	None
19	Small power and process loads	The direct energy consumption by small power or process equipment directly is not included in the assessment, except for Class 2 buildings (refer to item 20). This energy consumption is related to the function of the building rather than the physical attributes of the building fabric and services which is being assessed in this credit. However, the internal heat gains resulting from operation of the equipment must be included in the simulation of the HVAC energy consumption as detailed in Section 14.2.	As Proposed Building model.
20	Appliance and equipment loads – Class 2 buildings only	Energy consumption of appliances and equipment must be included in the building energy consumption, as follows: ▪ Refrigerators/freezers; ▪ Dish washers; ▪ Clothes washers; and ▪ Clothes dryers. The energy consumption shall be taken as the energy rating of the appliance (normalised energy consumption in kWh/annum). Refer to www.energyrating.gov.au. If only some of the above appliances are being provided as part of the apartment fitout, then for those appliances not being provided, the same energy performance as for the Reference Building shall be assumed.	Refer to Section 14.4.6 for energy consumption standards applicable to the Reference Building appliances.

Item	Description	Proposed Building	Reference Building
21	Swimming pools	The make up water requirement for a swimming pool, and the associated heat load for heating of make up water, is a function of water evaporation from the pool water surface and backflushing of filters. The project must estimate daily heating loads due to this water heating requirement. Where make up water is provided from the mains water service, the water temperature shall be based on the monthly values in Table A6 of SA, 2008 for the climate zone applicable to the building location. The contribution due to solar thermal water heating shall be calculated based on the methodology described in Section 7.2. Pump hours of operation and timing of backflushing cycles used in calculations must be justified by the design team. For internal pools, all other heat loss pathways may be ignored; for heated external pools, calculation of ground conduction, surface convection and body radiation heat transfer must be included.	The following attributes of the swimming pool shall be as per the Design Building: ▪ Swimming pool water volume and surface area; ▪ Water design temperature (except all outdoor pools are assumed to be unheated); ▪ Hours of operation of swimming pool; ▪ Pool make up water temperature The following apply to the Reference Building swimming pool: ▪ Room design conditions of water temperature +2 K and 40-60% relative humidity; ▪ 100% outside air supply with ventilation heat recovery, and supply air heating only; ▪ Pool blanket is in use for all hours outside of normal operating hours; ▪ Use the same heating fuel source and equipment efficiency as for Domestic Hot Water; ▪ Water recirculation time of 6 hours for the total pool water volume. Circulation pump specific power of 0.17 kW/(L/s). Circulation of the pool water shall be continuous throughout the hours of operation; ▪ No underwater pool lighting; and ▪ Operation of backflushing cycle for a period of 10 minutes per filter cell once a week. Number of filter cells shall be the same as for the Design Building

6.3 Operating Profiles

Default operating profiles for all building types shall be provided (as per existing guidance documents). Modifications to suit project specific conditions are acceptable as follows:

- Changes of no more than 10% of equivalent full-load operating hours: all changes made for the purpose of the assessment must be declared in the project submission; or
- Changes of more than 10% of equivalent full-load operating hours: all changes requested for the purpose of the assessment must be submitted for approval as a Credit Interpretation Request and must be accompanied by confirmation from the client that the changes made are in accordance with the anticipated building operation.

6.4 Modelling Daylight-Controlled Artificial Lighting Systems

Where credit is claimed for dimming control of artificial lighting in response to measured daylight in a space, other than by use of the deemed adjustment factors in Section 14.5.2, either of the following calculation methods may be applied:

- Calculation of hourly internal daylight levels by the building energy performance simulation software from first principles; or
- Calculation of daylight compensation by the building energy performance simulation software based on user-defined daylight factors and solar radiation from the weather data file.

Where points are claimed in credit Visual Comfort for the achievement of internal daylight levels, refer to Section 5.2 for details of required inputs to the building energy performance simulation model.

6.5 Modelling Control of Natural-Ventilation and Mixed-Mode Systems

6.5.1 Naturally-Ventilated Spaces with Heating Only

The project team shall assume the following control actuation:

- Heating system operates when $T_{space} < T_{lower} + 0.5$;
- Operable devices open only when $T_{OA} > 12$ °C;
- Operable devices are fully open when $T_{space} = 24$ °C;
- Operable devices are closed during any hour when the following conditions occur:
  - $T_{OA} > 35$ °C; or
  - $v_{wind} > 5$ m/s.

Where T_{space} is the space temperature (dry bulb, operative or other as applicable to the method of temperature control), T_{lower} is the lower limit of the space temperature control range, T_{OA} is the outdoor air dry bulb temperature (all °C), and v_{wind} is the external wind speed (m/s).

Note that this means that natural ventilation is the only means of ventilation. If operable devices are closed, no ventilation air enters the building.

6.5.2 Naturally-Ventilated Spaces with Heating and Cooling

Modelling shall be completed on the basis of agreed space temperature limits. Where the temperature control range is wider than the conventional range (21-24 °C), confirmation of client agreement of the temperature limits must be provided as part of the submission. The project team shall assume the following control actuation:

- Heating system operates when $T_{space} < T_{lower} + 0.5$;
- Operable devices open when $T_{OA} > 12$ °C;
- Operable devices are fully open when $T_{space} = T_{upper} - 1.0$;
- Operable devices close when $T_{OA} > 30$ °C; and
- Mechanical cooling system operates when $T_{space} > T_{upper} - 0.5$.
- Operable devices are closed during any hour when the following conditions occur:
  - $v_{wind} > 5$ m/s.

Where T_{space} is the space temperature (dry bulb, operative or other as applicable to the method of temperature control), T_{lower} and T_{upper} are the lower and upper limits of the space temperature control range respectively, T_{OA} is the outdoor air dry bulb temperature (all °C), and v_{wind} is the ambient wind speed (m/s).

Note that this means that natural ventilation is the only means of ventilation. If operable devices are closed, no ventilation air enters the building.

6.5.3 Mixed-Mode Spaces

Modelling shall be completed on the basis of agreed space temperature limits. Where the temperature control range is wider than the conventional range (21-24 °C), confirmation of client agreement of the temperature limits must be provided as part of the submission. The project team shall assume the following control actuation:

- Heating system operates when $T_{space} < T_{lower} + 0.5$;
- Heating system is deactivated and operable devices begin to open when $T_{space} = T_{lower} + 0.5$;
- Operable devices are fully open when $T_{space} = T_{upper} - 1.0$;
- Operable devices close when $T_{space} = T_{upper} - 0.5$; and
- Mechanical cooling system operates when $T_{space} > T_{upper} - 0.5$.

Where T_{space} is the space temperature (dry bulb, operative or other as applicable to the method of temperature control), and T_{lower} and T_{upper} are the lower and upper limits of the space temperature control range respectively (all °C).

If the project is implementing an alternative form of automatic control, an alternative simulation control methodology may be proposed by the project team. A CIR must be submitted prior to implementation in the model. Where system operation is dependent on occupant control of operable devices, the above criteria may not be modified under any circumstances.

Note that 'Mixed-Mode Spaces' means that natural ventilation only operates when space temperature is within the centre of the control range. When operable devices are closed, ventilation occurs via the mechanical/AC system.

6.6 Modelling Operation of Air Conditioning Systems

The air conditioning system component of the energy model must account for all of the following features of system operation, as relevant to the system and its control:

- Individual fans, fan duties (air flow and static pressure) and fan part-load performance characteristics (for variable-speed control systems);
- Economy cycle operation and control lockouts;
- Heat recovery system operation, control lockouts, ancillary components (i.e. pumps in runaround coil systems and fan motors in rotary thermal wheel systems), and heat transfer effectiveness (sensible and latent components);
- Supply air temperature reset controls;
- Ductwork distribution system heat gains and losses;
- Minimum flow rate settings for variable volume systems;
- Independent specification of supply air and outdoor air flow rates;
- Humidity control, including dehumidification and humidification, as applicable;
- Evaporative cooling stages;
- Cycling of fan operation with temperature control systems in packaged air conditioning units.

6.7 Modelling Operation of Chilled Water Refrigeration Plant

The chilled water plant component of the energy model must account for all of the following features of plant operation, as relevant to the system design and its control:

- Individual chillers, chiller capacities, and chiller part-load performance characteristics, including effect of compressor part-load, ambient relief and chilled water leaving temperature set point;

- Hydraulic configuration of chillers, including parallel, series, sidecar and combinations of these;
- Interlocked operation of chilled water and condenser water pumps, and variable speed control of pumps;
- Operation of secondary pumps, including variable speed control and staged control of ganged pumps as applicable;
- Staging and sequencing control of chillers in response to cooling load or other system variable;
- Chilled water set point temperature reset control;
- Distribution pipework thermal gains;
- Any additional cooling loads imposed on the chilled water system due to end uses other than space cooling, e.g. direct water cooling of process equipment;
- Heat rejection to individual or multiple heat rejection units, including staging control of heat rejection units; and
- Condenser water temperature reset in response to ambient temperature and fan speed control in response to leaving water temperature; and

Additionally, where the condenser water system is used to service heat rejection applications other than chilled water plant heat rejection, the following must be included, as relevant to the system design and control:

- Heat rejection from tenant supplementary heat rejection systems;
- Any additional cooling loads imposed on the condenser water system due to end uses other than space cooling, e.g. direct water cooling of process equipment; and
- Operation of condenser water pumps, and variable-speed control of pumps.

6.8 Modelling Operation of Space Heating Plant

Note that heating plant efficiencies are typically stated by manufacturers based on fuel lower heating value (LHV) or net calorific value (NCV); however, the cost and emission intensities of natural gas and diesel are typically based on fuel higher heating value (HHV) or gross calorific value (GCV). The project team must confirm that the system fuel consumption is based on the fuel HHV or GCV. For natural gas, the ratio of lower to higher heating value is approximately 0.9 (IEA, 2012), and correction may be made on the basis of this value using either of the following adjustments:

$$\eta_{HHV} = 0.9\eta_{LHV}$$

Or:

$$\dot{Q}_{HHV} = \frac{\dot{Q}_{LHV}}{0.9}$$

Where η is efficiency and $\dot{Q}$ is input power (kW).

The heating hot water plant component of the energy model must account for all of the following features of plant operation, as relevant to the system design and control:

- Individual boilers, boiler capacities, and boiler part-load performance characteristics;
- Hydraulic configuration of boilers, including parallel, series, sidecar and combinations of these;
- Interlocked operation boilers with heating hot water pumps, and variable speed control of pumps;
- Operation of secondary pumps, including variable speed control and staged control of ganged pumps as applicable;
- Staging and sequencing control of boilers in response to heating load or other system variable;
- Heating hot water set point temperature reset control;
- Distribution pipework thermal losses;

- Distribution system thermal inertia (lag in the heating system due to the requirement to heat all pipework and water in the system from a low temperature to operating temperature on start up); and
- Any additional heating loads imposed on the heating hot water system due to end uses other than space heating, e.g. indirect heating of domestic hot water, direct water heating of process equipment.

6.9 Modelling Domestic Hot Water Systems

The Proposed and Reference Building domestic hot water system energy consumption shall be based on the total domestic hot water usage calculated by the Potable Water calculator (refer to Section 5.5). This annual total shall be converted to an hourly usage profile by consideration of:

- The number of days of building operation and the extent of operation per day (i.e. whether all or only a part of the building is operational);
- The usage during each day of operation. This may be by consideration of the hours of operation of the building, the relative water usage for each end use in the building and the times at which these are likely to occur, by use of available reference data whether project specific or generic (e.g. the histograms in CIBSE, 2004), or any combination of these.

Estimation of daily usage profiles is of particular relevance where the DHW system is indirectly heated from a central heating hot water system, and/or the DHW system includes solar thermal heating. Where either of these situations applies, the project team must demonstrate how the domestic hot water usage profile has been determined.

6.10 Modelling Cogeneration Systems

Note that cogeneration unit efficiencies are typically stated by manufacturers based on fuel lower heating value (LHV) or net calorific value (NCV); however, the cost and emission intensities of natural gas and diesel are typically based on fuel higher heating value (HHV) or gross calorific value (GCV). The project team must confirm that the system fuel consumption is based on the fuel HHV or GCV. Adjustment may be made as stated in Section 6.8.

The cogeneration plant component of the energy model must account for all of the following features of plant operation, as relevant to the system design and control:

- Individual cogeneration units, unit capacities, and unit part-load performance characteristics. Part-load performance must be based on a minimum of three load points, with interpolation between points for other values;
- Connected electrical loads. The model must correctly differentiate between those loads which are connected to the cogeneration-supported supply, and those which are not. In particular, attention should be paid to the differentiation of base building and tenancy loads, and base building loads which are serviced by different transformers (supply authorities generally do not permit cogeneration units to be installed in parallel with more than one transformer);
- Hydraulic configuration of cogeneration interface with heating hot water system, including parallel, series, or sidecar location of heat exchange relative to boilers;
- Hydraulic configuration of cogeneration interface with condenser water system or other means of heat rejection, and additional heat rejection fan energy consumption;
- Interlocked operation of units with all associated water pumps for heating and heat rejection;
- Minimum continuous electrical output (minimum turndown) (typically 40-60%);
- Minimum import requirement for the operation of fault detection devices (rate-of-change-of-frequency relays, etc) (nominally 10% of generator rated output);
- De-rating effects due to altitude and/or ambient temperature (altitude de-rating typically occurs above 500 m, and ambient temperature de-rating typically occurs above 20 °C for microturbines and 40-50 °C for reciprocating engines). The temperature of air entering the engine shall be modelled as 2 K above the ambient temperature to allow for the effect of local heating from the unit;

- Heating-led or electrically-led demand control of cogeneration unit operation; and
- Staging and sequencing control of multiple cogeneration units;
- Allowance for preventative maintenance shutdowns and routine downtime (weekly, monthly and annual intervals; less frequent events do not need to be included). Where multiple cogeneration units are installed, the project team may assume that only one unit is out of operation at any one time.

Where trigeneration is applied, the energy model must account for the following additional features of plant operation, as relevant to the system design and control:

- Prioritisation of thermal energy for heating or cooling duty;
- Absorption chiller capacity and part-load performance characteristics, including effect of reduced temperature of heating input, ambient relief and chilled water leaving temperature set point;
- Hydraulic configuration of absorption chiller in chilled water system;
- Interlocked operation of chilled water and condenser water pumps, and system primary flow control;
- Availability of thermal energy to operate the absorption chiller, and the effect of reduced heat hot water or steam temperature on cooling output;
- Absorption chiller minimum continuous cooling output (minimum turndown) (typically 80%);
- Staging and sequencing control of absorption chiller in response to cooling load or other system variable.

6.11 Modelling Local Shared Services Utilities

Where building energy is sourced from a local shared services utility, such as a district cogeneration or trigeneration system, as one or more of electricity, chilled water, heating hot water or domestic hot water, the modelling shall be completed so as to determine the demand to be met at the point of interface with the utility service. Specific considerations that must be addressed in the model include:

- Hydraulic configuration of chilled water interface in chilled water system;
- Staging and sequencing of chilled water interface where other conventional chilled water equipment is also provided in the building for duty operation;
- Hydraulic configuration of heating hot water interface in heating hot water system; and
- Staging and sequencing of heating hot water interface where other conventional heating hot water equipment is also provided in the building for duty operation.

Electrical demand loads shall be entered into the credit calculator as kWh values, and thermal demand loads (chilled, heating and domestic hot water) shall be entered into the credit calculator as MJ values.

6.12 Modelling Water Usage of Evaporative Cooling Systems

Evaporative cooling (direct or indirect) system water consumption models must account for all of the following features of plant operation, as relevant to the system design and control:

- Direct evaporation due to system cooling operation.

Direct evaporation shall be based on latent heat of vaporisation of water of 2,450 kJ/kg.

In systems utilising variable-speed fan control, the effect of air speed on saturation efficiency of the evaporative media shall be considered (generally, the lower the air speed the higher the efficiency) (e.g. DOE, 2013).

6.13 Modelling Water Usage of Heat Rejection Systems

Water consumption due to conventional cooling towers is calculated in the Potable Water calculator based on the monthly total heat rejection load (refer to Section 5.5). The simulation is only required to calculate water usage of heat rejection systems where technology other than conventional cooling towers (e.g. adiabatic coolers) are used. The calculation must account for water usage due to:

- Direct evaporation due to system cooling operation;
- Drift loss due to carry over of atomised water droplets in the air stream; and
- Blowdown loss due to the purging of high-mineral concentration water from either the condenser water (if an open condenser water system) or from the dedicated recirculation cooling water (if a closed condenser water system).

Direct evaporation shall be based on latent heat of vaporisation of water of 2,450 kJ/kg.

If water softening equipment is used to reduce the hardness of water prior to supply to the heat rejection equipment, the energy consumption of this equipment must be included in the building total energy consumption.

7 RENEWABLE ENERGY SYSTEMS MODELLING GUIDELINES

7.1 Photovoltaic Systems

Where on-site photovoltaic (PV) systems are provided, the associated power and energy generation must be assessed based on the following methodology.

7.1.1 General Modelling Criteria

The calculation of the power and energy generation of the PV system must include allowance for all of the parameters described in **Error! Reference source not found.**.

Table 2: Photovoltaic system performance modelling requirements

Item	Description	Requirement
1	Performance calculation method	Analysis software must satisfy the Green Star compliance framework. Refer to Section 7.1.2 for details.
2	Location (selection of climate file)	The analysis must use the same hourly weather dataset as used in the assessment of the HVAC system performance (refer to Section 6.2).
3	Adjacent structures and features	Existing adjacent buildings must be included in the model; refer to Section 6.2 (item 3) for details.
4	Environmental conditions	The analysis must use the same environmental conditions as used in the assessment of the HVAC system performance (refer to Section 6.2).
6	Geometric model	The representation of Proposed Building's PV system geometry shall be consistent with the design documents, including: ▪ Number and position of PV modules; ▪ PV module tilt angle; ▪ PV module azimuth angle; and ▪ PV array shading from building features.
7	PV system losses	Derating factors must be included to account for loss of power generated by the PV system, as follows: ▪ Mismatch: 0.98 ▪ Diodes and connections: 0.995 ▪ DC wiring: 0.98 ▪ Array soiling: 0.95 ▪ Tracking losses: 0.95 (note 1) ▪ Inverter and transformer: 0.92 (note 2) ▪ AC wiring: 0.99 If non-standard factors are used the project team must justify assumptions with appropriate evidence.
8	Cell temperature losses	Derating factor must be included for increase of PV cell temperature, typically expressed as a loss coefficient or efficiency reduction based on PV cell temperature compared with the reference temperature (e.g. %/K difference from reference temperature).

Notes:

1: Only required to be included if an automatic solar tracking system (single-axis or dual-axis) is included.

2: Where a specific inverter type is nominated in the design documents, the efficiency curve for the actual inverter may be used in place of this default value.

7.1.2 Software Compliance Framework

The requirements for PV performance analysis software used to estimate the power and energy generation of the PV system are defined in **Error! Reference source not found.**. The modelling tool used by the project team must incorporate ALL of the features listed under Mandatory Requirements; the additional features listed in the right hand column are not mandatory but will contribute to more robust estimation of energy generation.

The following is a list of software programs that are deemed by the GBCA to comply with the below requirements.

- System Advisory Model (SAM) (developed by the National Renewable Energy Laboratory, USA); and

- PVSyst (developed by PVSyst SA, Switzerland).

No supporting information needs to be provided to demonstrate compliance with the requirements where any of these programs are used by the project team. If a project team uses different software, they must demonstrate that the software is compliant with the framework in **Error! Reference source not found.**.

Table 3: Compliance framework for PV performance analysis software

Item	Mandatory Requirement	Additional Features
Climatic Data	Use hourly weather data for the applicable building location.	
User Defined Model	Allow the user to input the design PV module orientation; Allow the user to input the PV module efficiency for the design system; Allow the user to input the PV system losses as per the derating factors (either as individual values or one combined value); Allow the user to input the cell temperature losses as derating factors.	The modelling tool includes a database of tested product specific information which allows efficiency curves of PV modules and inverters to be applied and calculated hourly as part of the model simulation; System design details included within the model, e.g. number of strings.
Shading Analysis	The modelling tool used must satisfy one of the following conditions: ▪ The modelling tool incorporates an hourly shading analysis included as part of the model simulation. The tool may achieve this through creation of a 3D model of the array and shading elements, or, by assigning hourly shading derate factors for expected shading; or ▪ The modelling tool has a function to import results of a third-party hourly shading analysis.	The modelling tool includes a self-shading calculation based on the configuration of the PV array. The modelling tool accounts for the effect of shading caused by obstacles sufficiently far for considering the sun over or under the horizon line at a given time, i.e. the beam component of solar irradiation is considered off for the shaded time. This could be either as part of the model simulation itself or as separate derate factors per azimuth by altitude.

7.1.3 Shading Analysis Requirements

Where there are shading elements which cause shadowing of the PV system, the resultant shading may have a significant impact on the potential for energy generation from the PV system. Consideration of these effects through appropriate shading analysis must be included as part of the performance analysis. This includes the effect of adjacent buildings (existing and proposed), landscape features, and any other permanent shading source. Projects claiming that there are no significant shading sources must clearly demonstrate that this is the case.

The project team must describe how the derating factor due to the shading source has been applied in the calculation, in particular how the effect of partial shading of a module on the output of the whole string has been factored into the assessment. The GBCA has not yet finalised a standard methodology for calculating shading losses so it is up to the project team to propose a conservative methodology. As long as the proposed methodology provides a methodology for calculating the impact of the following issues, it will be accepted. Issues which must be considered when calculating shading losses:

- String length;
- Estimation of cell output loss in relation to amount of panel shaded; and

- The impact of the lowered output from one panel on the entire string.

Further, all projects shall consider the issue of self-shading which can occur at low sun-angles when PV modules may create a shadow on adjacent PV modules of the array. If self-shading is present, and unless it is demonstrated otherwise through a shading analysis, a default de-rating factor of 0.9 must be applied for the time during the year that self-shading occurs.

7.2 Solar Thermal Systems for Domestic Hot Water

7.2.1 Simple Calculation Method

The number of Renewable Energy Certificates (RECs) attributed to a particular solar thermal panel system can be used to estimate the energy savings attributable to solar heating. If this method is adopted there is no requirement for further modelling, unless the proportion of the building energy consumption due to domestic hot water heating is sufficiently large (>10%) to necessitate a more detailed calculation method. This will be indicated in the credit calculator when inputs are entered. The calculation methodology is as follows for each independent domestic hot water system:

- Calculate the annual domestic hot water heating demand for the project, based on the daily water usage (from the Potable Water calculator), make up water temperature as per **Error! Reference source not found.**, system storage and flow temperatures as per the design, and estimated system heat losses;
- For the selected solar thermal panel type, confirm the number of RECs attributable to the system with the manufacturer;
- Calculate the annual energy savings (kWh/annum) from the solar thermal panels based on the following equation:

$$E = \frac{1000 N_{REC} N_{panel}}{10} = 100 N_{REC} N_{panel}$$

  Where E is the annual energy saving (kWh/annum), N_{REC} is the number of RECs for the panel, and N_{panel} is the number of panels in the design. Note that the number of RECs allocated to a product is based on the savings achieved over 10 years; therefore dividing the number of RECs for the system by 10 gives the estimated annual energy savings;
- The annual energy saving is subtracted from the annual heating demand to give the net energy input required by the system. This value is adjusted by the system heating efficiency as required to give the total energy input required by the system.

Sum the total energy input for all systems to give the building total energy input required for domestic hot water heating.

7.2.2 Simulation Calculation Method

Where a more detailed assessment method is required, this shall be completed using an hourly simulation calculation method. The modelling algorithm for the solar thermal components must be based on the efficiency coefficients for the panel determined in accordance with the reference standard (SA, 2007 for glazed collectors and ISO, 1995 for unglazed collectors), and include hourly calculation of output based on solar radiation and ambient temperature values from the hourly weather dataset. Otherwise the calculation shall use all the same inputs as for the simple method, including the daily water usage (from the Potable Water calculator), system make up water temperature as per Section 6.2, system storage and flow temperatures, and estimated system heat losses.

7.3 Solar Thermal Systems for Space Heating or Solar Cooling

Where solar thermal systems are used for the generation of heating water to be used for space heating or space cooling applications (such as in conjunction with an absorption chiller), the analysis of the thermal output must be integrated with the main HVAC performance simulation, as per Section 6. The modelling algorithm for the solar thermal components must be based on the efficiency coefficients for the panel determined in accordance with the reference standard (SA, 2007 for glazed

collectors and ISO, 1995 for unglazed collectors), and include hourly calculation of thermal output based on ambient temperature values from the hourly weather dataset.

Note that owing to the seasonal variation of heating and cooling load and solar availability, it is not acceptable to apply the simple methodology for domestic hot water systems under any circumstances.

7.4 Wind Turbines

Calculation of the energy generation of wind turbines must account for all of the following features of operation, as relevant to the system design and control:

- Cut in and cut out wind speeds (i.e. maximum and minimum wind speeds at which the generator can operate);
- Aerodynamic efficiency or power output as a function of wind speed;
- Consideration of the effect of the turbine location on the output including:
    - Variation of the open field wind speed (as per the weather dataset) within the local urban environment, and variation of wind speed from the nominal value (as per the weather dataset) (typically measured at 10 m above ground level) to the actual installation height of the wind turbines. Correction shall be made in accordance with the methodology of BS, 1991 (Section 11.2, equation 5) or ASHRAE, 2013 (Chapter 24, equation 4);
    - Variation of wind speed and vortex effects where multiple wind turbines are located in close proximity. Project teams shall to demonstrate that due consideration of these effects has been made in determining the energy generation from wind turbines. This may include the application of computational fluid dynamics (CFD) modelling or design advice from a wind engineering consultant. A CIR must be submitted to confirm the approach prior to implementation in the model.

8 EVALUATING COMPLIANCE WITH THE CONDITIONAL REQUIREMENT

The conditional requirement for this credit is that the Proposed Building greenhouse gas emissions are less than those of the equivalent Benchmark Building. The Benchmark Building represents a 10% improvement on the Reference Building, i.e. a building which achieves minimal compliance with the NCC Section J DTS provisions. This criterion must be satisfied in order for the project to be eligible for a certified Green Star rating.

9 EVALUATING ENERGY AND GREENHOUSE GAS EMISSIONS REDUCTION

Based on the completed building energy performance analysis, the energy consumption and greenhouse gas emissions reduction are calculated by entering the Reference, Intermediate and Proposed Buildings' annual energy consumption data into the Green Star calculator. Values shall be entered for all end uses as applicable to the building. These values should represent the energy consumed by each end use, irrespective of the energy source; all offsets due to on-site generation and other such systems shall be treated as overall offsets on total site energy demand. The user shall also define the GHG emission factors applicable to the project by specifying the building location and entering the specific emission values for shared district energy services where these are used. The calculator automatically determines the energy demand and GHG emission reductions achieved, and calculates the number of points to be awarded.

Where greenhouse gas emission factors for shared district energy services are entered, these must be justified for every end use to which they are applied. In particular, it must be demonstrated that, if applied to both base building and tenant energy use, both parties have entered into the relevant supply contracts. More generally, it is expected that base building and tenant end uses will need to be differentiated and different emission factors applied to each. Common scenarios in which this may occur include, but are not limited to:

- Lighting in Class 5 office tenancies;
- Lighting and air conditioning in Class 6 retail tenancies; and

- Lighting, air conditioning and appliances in Class 2 dwellings

Energy consumption reduction is calculated based on comparison of the Reference Building and the Intermediate Building. As per the definitions of these buildings, the only variables between the buildings are the building fabric, and this component of the credit therefore rewards passive design only.

Greenhouse gas emissions reduction is calculated based on comparison of the Benchmark Building and the Proposed Building. As per the definitions of these buildings, all design variables are reflected in this comparison, including services design strategy and choice of energy sources.

Project teams shall also provide details of synthetic greenhouse gases used in the project, and the associated greenhouse gas emissions attributable to these sources. Note that this information is required for information only, and does not contribute to the credit points assessment.

10 EVALUATING PEAK ELECTRICITY DEMAND REDUCTION

Based on the completed building energy performance analysis, the peak electricity demand reduction is calculated by entering the Reference and Proposed Buildings' peak electricity demand data into the Green Star calculator. The peak electricity demand is determined as follows:

- For the Proposed Building, identify the peak hourly value of building electrical consumption;
- For the Reference Building, identify the peak hourly value of building electrical consumption which occurs on the same day as the peak for the Proposed Building. Confirm that no other value exceeds this value by more than 5%; if it does then the maximum value shall be used, otherwise the Proposed Building peak day value shall be used.

Note that the modelling requirements for cogeneration include provision of maintenance downtime. This can be ignored for the purposes of calculation of peak electricity demand reduction.

11 GREENHOUSE GAS EMISSIONS REPORT CONTENT

11.1 Analysis Software Description

Project teams must provide information on analysis software used.

Table 4: Building energy simulation analysis software reporting requirements

Software name and version	
Software developer	
Software validation standard (evidence of developer's compliance to be provided)	
Simulator's name (include description of training and experience with software)	

11.2 Building Description

Project teams must confirm all building parameters as listed in Table 5.

Table 5: Building general parameters reporting requirements

	Proposed Building	Reference Building
Climate zone		
Weather data (location and data format)		
Number of building storeys (below ground/above ground)		
Total modelled building gross floor area (GFA) (m²)		
Heating fuel(s)		
Cooling fuel(s)		

11.3 Building Space Summary

Project teams must confirm building space types and associated parameters as listed in Tables 6 and 7. Project teams may provide a set of drawing mark ups rather than a table summary if this is more convenient. Where operating profiles have been modified from the default values provided in Section 14.3, this should be noted and justification given in an accompanying document as per Section 6.3.

Table 6: Building area summary reporting requirements

Space Type	Building Level	Gross Floor Area (m²)		
		Conditioned	Unconditioned	Total

Table 7: Building simulation input summary reporting requirements

Space Type	Operating Profile(s) Applied	Temperature Control Range (°C)	Occupancy Density (m²/person)	Equipment Load (W/m²)

11.4 Building Fabric Description

11.4.1 Opaque Fabric Components

Project teams must report all R Values must for all wall and roof system types used in the building.

Table 8: Building opaque fabric parameters reporting requirements

Parameter	Proposed Building	Reference Building
External above-grade envelope wall construction and R value		
External below-grade envelope wall construction and R value		
Internal envelope wall construction and R value		
Roof construction, solar absorptance and R value		
Floor construction and R value		
Cool, cold or hot room construction and R value		

11.4.2 Transparent Fabric Components

Project teams must provide completed NCC Glazing Calculator for both Proposed and Reference Buildings incorporating glazing system performance values used in simulation analyses.

11.5 HVAC Services Description

11.5.1 Air Conditioning and Air Handling Systems

Project teams must provide details for each system present in the building.

Table 9: Air conditioning system parameters reporting requirements

Parameter	Proposed Building	Reference Building
Primary air conditioning system type		
Other air conditioning system type(s)		
Space served		
Design supply air temperature difference (K)		
Supply air temperature control		
Outdoor air design volume flow rate (L/s)		
Fan design supply air volume flow rate (L/s)		
Fan design absorbed power (kWe)		
Minimum flow rate turndown (%)		
Economy cycle control		
Demand-controlled ventilation		
Heat recovery type		
Heat recovery effectiveness		
Heat recovery parasitic power (kWe)		

Table 10: Ventilation system parameters reporting requirements

Parameter	Proposed Building	Reference Building
Ventilation system type		
Fan design supply air volume (L/s)		
Fan design absorbed power (kWe)		

11.5.2 Unitary Plant

Project teams must provide details for each system present in the building.

Table 11: Unitary plant parameters reporting requirements

Parameter	Proposed Building	Reference Building
Packaged equipment cooling performance (EER)		
Packaged equipment heating performance (COP)		

11.5.3 Cooling and Heat Rejection Plant

Project teams must provide details for each system present in the building. Note that chiller part-load performance should be stated in terms of net part-load value (NPLV, calculated at the design operating conditions), not integrated part-load value (IPLV, calculated at the reference operating conditions).

Table 12: Cooling and heat rejection plant parameters reporting requirements

Parameter	Proposed Building	Reference Building
Chiller type		
Chiller capacity (kWr)		
Design CHW flow temperature (°C)		
Design CHW temperature difference (K)		
Design CCW entering temperature (°C)		
Design CCW temperature difference (K)		
Chiller full-load performance (EER)		
Chiller part-load performance (NPLV)		
CHW flow temperature control		
Chiller sequencing and staging control		
System distribution losses (kW)		
Primary pump absorbed power (kWe)		
Primary pump control		
Primary pump minimum flow (if variable flow) (%)		
Secondary pump number and absorbed power (kWe)		
Secondary pump control		
CCW heat rejection type		
CCW heat rejection capacity (kW)		
Fan absorbed power (kWe)		
Leaving CCW temperature set point (°C)		
Fan speed control		
Heat rejection equipment drift loss (%)		
Heat rejection equipment cycles of concentration		

11.5.4 Heating Plant

Project teams must provide details for each system present in the building.

Table 13: Heating plant parameters reporting requirements

Parameter	Proposed Building	Reference Building
Heat source type		
Heat source capacity (kWr)		
Design HHW flow temperature (°C)		
Design HHW temperature difference (K)		
Heat source full-load performance (gross efficiency)		
HHW flow temperature control		
Heat source sequencing and staging control		
System distribution losses (kW)		
System thermal inertia (kW)		
Primary pump absorbed power (kWe)		
Secondary pump absorbed power (kWe)		
Primary pump control		
Secondary pump control		

11.6 Co- and Trigeneration Systems Description

Project teams must provide details for each system present in the building. Unit output should be stated for at least three (3) operating points (e.g. 100%, 75% and 50% of rated output). Heating plant interface details should be included in Section 11.5.4, and, where present, absorption chiller technical details should be included under Section 11.5.3. Where other types of electrical generators are used for on-site electricity generation, these reporting requirements should be used as applicable to the system type.

Table 14: Co- and trigeneration plant parameters reporting requirements

Parameter	Proposed Building
Cogeneration unit type	
Electrical output (kWe)	
Useful thermal output (kWth)	
Waste thermal output (kWth)	
Total fuel input (gross) (kW)	
Minimum turndown (%)	
Minimum import threshold (kWe)	
Installation altitude (m)	
Derating threshold temperature (°C)	
Demand control method	
Absorption chiller minimum operating load (kWr)	
Absorption chiller hydraulic configuration	
Heating or cooling priority control	
Preventative maintenance regime	

11.7 Lighting Description

Project teams must provide description of each space usage for both internal and external lighting. A completed NCC Lighting Calculator is acceptable in lieu of the information in this table for internal lighting. Project teams must provide details for each system present in the building.

Table 15: Internal lighting parameters reporting requirements

Parameter	Proposed Building	Reference Building
Lighting type		
Design illuminance (lux)		
Nominal lighting power density (W/m²)		
Occupant sensor controls		NA
Daylight controls		NA
Other lighting controls		NA
Adjustment factor applied		NA
Modelled lighting power density (W/m²)		

Table 16: External lighting parameters reporting requirements

Parameter	Proposed Building	Reference Building
Lighting type		
Lighting category		
Category minimum illuminance (lux)		
Design illuminance (lux)		
Design lighting power density (W/m²)		
Modelled lighting power density (W/m²)		
Controls		

11.8 Domestic Hot Water Services Description

Project teams must provide details for each system present in the building. Hot water usage profiles must be documented where the system uses either indirect heating hot water and/or solar thermal heating.

Table 17: Domestic hot water services parameters reporting requirements

Parameter	Proposed Building	Reference Building
System description		
System heat source		
Hot water usage (L/day)		
Hot water usage profile		
System storage capacity (L)		
System heating efficiency (gross) (%)		
System distribution losses (kW)		
System design supply temperature (°C)		
System minimum storage temperature (°C)		

11.9 Appliances Description

For Class 2 buildings only, project teams must provide details of the appliances provided as part of the fitout.

Table 18: Appliance parameters reporting requirements

Parameter	Proposed Building	Reference Building
Refrigerator/freezer manufacturer and model		NA
Refrigerator/freezer energy consumption (kWh/annum)		
Dish washer manufacturer and model		NA
Dish washer energy consumption (kWh/annum)		
Clothes washer manufacturer and model		NA
Clothes washer energy consumption (kWh/annum)		
Clothes dryer manufacturer and model		NA
Clothes dryer energy consumption (kWh/annum)		

11.10 Swimming Pools Description

Project teams must provide details for each swimming pool present in the building. Hot water usage profiles must be documented where the system uses either indirect heating hot water and/or solar thermal heating

Table 19: Swimming pool parameters reporting requirements

Parameter	Proposed Building	Reference Building
Pool water volume (m^3)		
Pool surface area (m^2)		
Heat source		
Heater efficiency		
Circulation pump power (kW)		
Use of pool blanket		
Backflushing cycle duration		
Number of filters		
Design water temperature (°C)		
Room air design dry bulb temperature and relative humidity (°C/%)		

11.11 Photovoltaic Analysis and System Description

Project teams must provide details for each system present in the building.

Table 20: Photovoltaic analysis software reporting requirements

Software name and version	
Software developer	

If software other than that recognised by the GBCA has been used, provide documentation demonstrating that it satisfies the compliance framework criteria.

Table 21: Photovoltaic array parameters reporting requirements

Parameter	Proposed Building
PV technology type	
PV module manufacturer and model	
PV rated output at STC (We)	
PV DC conversion efficiency at STC at full-load	
PV DC conversion efficiency at part-load	
Total PV array area (m²)	
Performance degradation	
PV array mounting system	
Inverter rating (kWe)	
Inverter efficiency at full-load and part-load	
System shading description	
PV array azimuth angle (°)	
PV array inclination angle (°)	
PV array losses	
PV cell temperature losses	

11.12 Solar Thermal System Description

Project teams must provide details for each system present in the building.

Table 22: Solar thermal array parameters reporting requirements

Parameter	Proposed Building
Solar collector type	
Collector absorber area (total) (m²)	
Collector efficiency coefficients (a_1 (-), a_2 (W/m² K) and a_3 (W/m² K²))	
Collector azimuth angle (°)	
Collector inclination angle (°)	
Circulation pump absorbed power (kWe)	
Preheat storage tank volume (L)	

11.13 Wind Turbine Description

Project teams must provide details for each system present in the building.

Table 23: Wind turbine parameters reporting requirements

Parameter	Proposed Building
Wind turbine type	
Wind turbine rated output (kWe)	
Wind turbine swept area (m²)	
Wind turbine cut in wind speed (m/s)	
Wind turbine cut out wind speed (m/s)	
Wind turbine part-load aerodynamic efficiency	
Wind speed adjustments applied	
Wind turbine spacing (if more than one)	
Method of adjustment of turbine generated output for proximity effects of other wind turbines	

11.14 Manual Calculations

The project team shall provide a summary of all manual calculations used in the assessment of the building total energy consumption. This shall include a description of the methodology applied, comments on the limitations of the method, the data sources used in the calculation (including software outputs as applicable) and a summary of the calculation results.

11.15 Output Data

Project teams shall provide software output reports documenting the energy end uses applicable to each of the building models (i.e. Reference, Intermediate and Proposed). This information shall be readily reconcilable against the inputs in the Green Star calculator. Where software output is supplemented with manual calculations, the manual calculation descriptions shall be cross referenced.

For shared utility services, the heating and cooling supplied to the building must be stated (as applicable). These, and the total electricity consumption, must be compared to the contractual agreements to demonstrate that they are within the specified limits. If no limits are specified, then it must be demonstrated that they are within the available output based on the details of the utility and any existing buildings' demands.

12 PEAK ELECTRICITY DEMAND REDUCTION REPORT CONTENT

Additional information shall be provided for this credit as follows:

- Annual building total electrical load profile for the Proposed Building, identifying the day of the peak electrical demand; and
- Building total electrical load profile for the Proposed and Reference Buildings for the day of the peak electrical demand, as identified above, and the value of the peak demand for each building.

13 REFERENCES

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14 APPENDICES

14.1 HVAC System Design Parameters

For the purpose of sizing the HVAC systems in the Reference Building, the thermal loads shall be consistent with the design parameters applied for the Proposed Building system design, as per **Error! Reference source not found.**.

Table 24: HVAC system design parameters

Design Load Parameter	Proposed Building	Reference Building
Design weather conditions (summer dry bulb and wet bulb, and winter dry bulb temperatures; solar radiation)	As per design	As Proposed Building
Room design temperature and humidity (where applicable)	As per design	As Proposed Building
Room occupant density	As per design	As Proposed Building
Occupant heat gain (sensible and latent)	As per design	As Proposed Building
Equipment heat gain (sensible and latent)	As per design	As Proposed Building
Lighting heat gain	As per design	As per Table J6.2a (note 1)
Outdoor air rate	As per design	As per NCC Section J clause JV3(d)(i)(A), i.e. “the amount of ventilation required by Part F4”, and consistent with the baseline calculation in credit Quality of Internal Air.
Building envelope	As per design	As per Section 6.2
Infiltration rate	As per design	As per Section 6.2

Notes:

1: Note that healthcare interventional suites are excluded from the requirements of NCC Part J6. For these space types, a Reference Building lighting power density of 25 W/m² shall be assumed.

14.2 HVAC System Simulation Parameters

The peak gain values that must be used for both the Proposed and Reference Buildings during the building simulation are as specified in this section, which, as specified in Section 6.2, must be used in place of those given in NCC Specification JV clause 2(a).

Table 25: HVAC simulation parameters

Item	Proposed Building	Reference Building
Temperature control band	For all air conditioned spaces, including process/manufacturing spaces and specialist labs such as clean rooms, the air conditioning must be modeled on the basis of the design temperature and humidity (where applicable) control ranges. Where spaces in the building have been designed to operate comfortably within a broader temperature band than for the Reference Building, this temperature band may be used in the modeling provided that: ▪ The design criteria for the project lists these space temperatures in the mechanical specifications for system sizing and selection; and ▪ The owner provides confirmation in a letter that the spaces will be operated under the design criteria provided; and that the thermostats will be programmed to these values; and ▪ Where an anchor tenant (at least 30% of NLA) has been confirmed for a speculative development, a letter from the tenant confirming their agreement for operating within this broader temperature band. When the credit Thermal Comfort is also claimed, the same temperature range must be used in evaluation of the PMV index.	As NCC Section J clause JV3(d)(i)(D), the Reference Building must operate within the temperature range 18 to 26 °C for at least 98% of plant operating hours. Where the design temperature range is within this range, the Reference Building shall use the same control band as the Proposed Building; where the design temperature range is outside of this range, the Reference Building shall use lower and upper temperature control limits of 18 and 26 °C respectively, as appropriate. (The intent of this requirement is that the Reference Building generally achieves the same level of service as the Proposed Building, but that energy efficiency is not gained at the expense of reduced occupant comfort, except where this is specifically acknowledged by the building owner.)
Maximum occupancy	The maximum occupancies that should be used in conjunction with the appropriate occupancy schedules, is the maximum design occupancy when known. Where it is not known, the occupancies given in Table D1.13 of the NCC or Appendix A of AS1668.2.2012 should be used.	As Proposed Building
Sensible and latent heat gain per person	The degree of activity within each space must be assessed by the design team and the appropriate sensible and latent gains used, and must be appropriate for the space design temperature. Acceptable sources of metabolic rates include AIRAH, 2013, ASHRAE, 2013 and CIBSE, 2006.	As Proposed Building

Item	Proposed Building	Reference Building
Maximum lighting	The maximum lighting power density that should be used in conjunction with the lighting profile should be the adjusted lighting power density based on the Proposed Building lighting design and control (i.e. after the adjustment factors given in Section 14.5.2 have been applied).	The maximum lighting power density that is permitted by NCC Part J6 Artificial lighting and power (note 1).
Maximum equipment	The equipment loads that must be used in conjunction with the equipment profiles are given in **Error! Reference source not found.**.	As Proposed Building.
Outdoor air rate	Outdoor air rates must be in accordance with the design. Outdoor air rates may be modulated if demand-controlled ventilation systems are specified; otherwise the design outdoor air rate must be simulated at all times during building operating hours.	Reference Building outdoor air rate must be as per NCC Section J clause JV3(d)(i)(A), i.e. "the amount of ventilation required by Part F4". No demand controlled ventilation shall be included.

Notes:

1: Note that healthcare interventional suites are excluded from the requirements of Part J6. For these space types, a Reference Building lighting power density of 25 W/m² shall be assumed.

Table 26: HVAC system simulation equipment loads

Space Type (note 1)		Equipment load (W/m²)
Office (including any Class 5-type space in a building of another classification)		11
Industrial space	Where temperature control is localised and is not designed to handle equipment loads (e.g. manufacturing space)	0
	General industrial spaces (e.g. laboratory, workshop, warehouse)	15
	Where the HVAC system has been specifically designed to handle the equipment loads from a defined industrial process (e.g. clean room, server room, cold room)	Realistic operational loads must be estimated by the design team. The design loadings must not be used as these are intended to be maximum loads and not realistic operational loads. The methodology must be clearly documented.
Retail	Showroom (including in a building of another classification)	5
	Stores	40
	Mall, food court, public amenities	Realistic operational loads must be estimated by the design team. The design loadings must not be used as these are intended to be maximum loads and not realistic operational loads. The methodology must be clearly documented.
Fire Station		8 (office areas) 1 (all other areas)
Kitchen		200
Gymnasium (including any gymnasium space in a building of another classification)		15
Secondary spaces (e.g. circulation, corridors, stairways, store rooms, car parks)		0
Healthcare		Realistic operational loads must be estimated by the design team. The design loadings must not be used as these are intended to be maximum loads and not realistic operational loads. The methodology must be clearly documented.
Residential	Living Space	1100 W (sensible), 750 W (latent) (with kitchen) 0 (excluding kitchen)
	Bedrooms	0
School	Classroom, multi-purpose space, library	5
	Computer/science laboratory	27
	Canteen, workshop	25
University	Dry laboratories, specialist learning	27

	spaces, libraries	
	Wet laboratories	40

Notes:

1: For any space types not referenced in this table, realistic operational loads must be estimated by the design team. The design loadings must not be used as these are intended to be maximum loads and not realistic operational loads. The methodology must be clearly documented.

14.3 Default Operating Schedules

This section contains the occupancy and operational profiles which must be applied to each zone within the building under assessment for calculation of the annual energy consumption.

In all cases, system operating hours are based on one hour of preconditioning occurring prior to the start of building (or zone) occupancy. The modeller should verify that design temperatures are met at the start of building (or zone) occupancy in the Proposed Building. Where this does not occur, the start time of system operation should be advanced until design temperatures are satisfied. This is not required in the Reference Building, except to the extent required to ensure that temperatures are within the limits set by NCC Section J clause JV3(d)(i)(D).

The equivalent full-load hours (per day type) are stated for all profiles, and should be used as the basis of evaluation of the variance noted in Section 6.3.

14.3.1 Office

To be used for all Class 5 areas, in both Class 5 and other types of buildings, and for minor spaces which accommodate clerical or administrative type activities, where occupants are primarily working seated at desks.

Table 27: Office operating schedules

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	15%	50%	OFF	0%	15%	50%	OFF
2	0%	15%	50%	OFF	0%	15%	50%	OFF
3	0%	15%	50%	OFF	0%	15%	50%	OFF
4	0%	15%	50%	OFF	0%	15%	50%	OFF
5	0%	15%	50%	OFF	0%	15%	50%	OFF
6	0%	15%	50%	OFF	0%	15%	50%	OFF
7	0%	15%	50%	OFF	0%	15%	50%	OFF
8	10%	40%	65%	ON	0%	15%	50%	OFF
9	20%	90%	80%	ON	5%	25%	55%	OFF
10	70%	100%	100%	ON	5%	25%	55%	OFF
11	70%	100%	100%	ON	5%	25%	55%	OFF
12	70%	100%	100%	ON	5%	25%	55%	OFF
13	70%	100%	100%	ON	5%	25%	55%	OFF
14	70%	100%	100%	ON	5%	25%	55%	OFF
15	70%	100%	100%	ON	5%	25%	55%	OFF
16	70%	100%	100%	ON	5%	25%	55%	OFF
17	70%	100%	100%	ON	5%	25%	55%	OFF
18	35%	80%	80%	ON	0%	15%	50%	OFF
19	10%	60%	65%	OFF	0%	15%	50%	OFF
20	5%	60%	55%	OFF	0%	15%	50%	OFF
21	5%	50%	55%	OFF	0%	15%	50%	OFF
22	0%	15%	50%	OFF	0%	15%	50%	OFF
23	0%	15%	50%	OFF	0%	15%	50%	OFF
24	0%	15%	50%	OFF	0%	15%	50%	OFF
TOTAL	6.45	13.3	17.0	11	0.45	4.5	12.45	0

14.3.2 Healthcare General Areas (12 hours/day)

This profile is typical of the operation of a large number of small healthcare facility spaces. It may also be appropriate for a number of hospital spaces. This profile can be applied to spaces that operate for five or seven days of the week. Examples of space types which would use this profile for five days of the week include outpatients, waiting areas, consulting areas, diagnostic areas, medical records, pathology, pharmacy, auditoriums and seminar rooms. Examples of space types which would use this profile for seven days of the week include cafes and the hospital main receptions.

Table 28: Healthcare general areas (12 hours/day) operating profiles

Hour of Day	Weekday				Weekend (exc 7 day/week areas)			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	10%	10%	OFF	0%	10%	10%	OFF
2	0%	10%	10%	OFF	0%	10%	10%	OFF
3	0%	10%	10%	OFF	0%	10%	10%	OFF
4	0%	10%	10%	OFF	0%	10%	10%	OFF
5	0%	10%	10%	OFF	0%	10%	10%	OFF
6	0%	10%	10%	OFF	0%	10%	10%	OFF
7	0%	10%	15%	OFF	0%	10%	10%	OFF
8	15%	40%	25%	ON	0%	10%	10%	OFF
9	50%	80%	70%	ON	0%	10%	10%	OFF
10	70%	100%	100%	ON	0%	10%	10%	OFF
11	70%	100%	100%	ON	0%	10%	10%	OFF
12	70%	100%	100%	ON	0%	10%	10%	OFF
13	70%	100%	100%	ON	0%	10%	10%	OFF
14	70%	100%	100%	ON	0%	10%	10%	OFF
15	70%	100%	100%	ON	0%	10%	10%	OFF
16	70%	100%	100%	ON	0%	10%	10%	OFF
17	70%	100%	100%	ON	0%	10%	10%	OFF
18	50%	80%	60%	ON	0%	10%	10%	OFF
19	15%	60%	25%	ON	0%	10%	10%	OFF
20	5%	40%	15%	OFF	0%	10%	10%	OFF
21	5%	20%	15%	OFF	0%	10%	10%	OFF
22	0%	10%	10%	OFF	0%	10%	10%	OFF
23	0%	10%	10%	OFF	0%	10%	10%	OFF
24	0%	10%	10%	OFF	0%	10%	10%	OFF
TOTAL	7.0	12.2	11.15	12.0	0	2.4	2.4	0

Healthcare General Areas (24 hours/day)

Areas that are conditioned for 24 hours a day, seven days a week and that have peak operation for five days of the week and reduced operation over night and at the weekends. These profiles are typical of the operation of a large number of hospitals space types. They may also be appropriate for some spaces in smaller healthcare facilities. Examples of spaces that would use these profiles include medical imaging, recovery, central sterilising services department, pathology and pharmacy areas, within a hospital.

Table 29: Healthcare general areas (24 hours/day) operating profiles

Hour of Day	Weekday				Weekend (exc 7 day/week areas)			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	10%	25%	30%	ON	10%	25%	30%	ON
2	10%	25%	30%	ON	10%	25%	30%	ON
3	10%	25%	30%	ON	10%	25%	30%	ON
4	10%	25%	30%	ON	10%	25%	30%	ON
5	10%	25%	30%	ON	10%	25%	30%	ON
6	10%	25%	30%	ON	10%	25%	30%	ON
7	10%	25%	30%	ON	10%	25%	30%	ON
8	15%	40%	50%	ON	10%	25%	30%	ON
9	60%	80%	70%	ON	10%	25%	30%	ON
10	70%	100%	100%	ON	10%	25%	30%	ON
11	70%	100%	100%	ON	10%	25%	30%	ON
12	70%	100%	100%	ON	10%	25%	30%	ON
13	70%	100%	100%	ON	10%	25%	30%	ON
14	70%	100%	100%	ON	10%	25%	30%	ON
15	70%	100%	100%	ON	10%	25%	30%	ON
16	70%	100%	100%	ON	10%	25%	30%	ON
17	70%	100%	100%	ON	10%	25%	30%	ON
18	50%	80%	60%	ON	10%	25%	30%	ON
19	15%	60%	30%	ON	10%	25%	30%	ON
20	10%	40%	30%	ON	10%	25%	30%	ON
21	10%	25%	30%	ON	10%	25%	30%	ON
22	10%	25%	30%	ON	10%	25%	30%	ON
23	10%	25%	30%	ON	10%	25%	30%	ON
24	10%	25%	30%	ON	10%	25%	30%	ON
TOTAL	8.2	12.75	13.7	24	2.4	6.0	7.2	24

14.3.3 Healthcare Interventional Suite (12 hours/day)

Operating suite areas that will predominantly operate five days per week (Mon-Fri) for 12 hours per day. While it might be expected that the operating suite may be used on weekends, this is not its expected primary use pattern. Examples of spaces that would use this profile include general and endoscopy operating suite areas.

Table 30: Healthcare interventional suite (12 hours/day) operating profiles

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	15%	15%	ON	0%	15%	30%	ON
2	0%	15%	15%	ON	0%	15%	30%	ON
3	0%	15%	15%	ON	0%	15%	30%	ON
4	0%	15%	15%	ON	0%	15%	30%	ON
5	0%	15%	15%	ON	0%	15%	30%	ON
6	0%	15%	15%	ON	0%	15%	30%	ON
7	30%	50%	50%	ON	0%	15%	30%	ON
8	30%	50%	50%	ON	0%	15%	30%	ON
9	50%	80%	80%	ON	0%	15%	30%	ON
10	60%	90%	90%	ON	30%	50%	50%	ON
11	70%	90%	90%	ON	30%	50%	50%	ON
12	70%	90%	90%	ON	30%	50%	50%	ON
13	70%	90%	90%	ON	30%	50%	50%	ON
14	70%	90%	90%	ON	30%	50%	50%	ON
15	70%	90%	90%	ON	30%	50%	50%	ON
16	60%	90%	90%	ON	0%	15%	30%	ON
17	50%	80%	80%	ON	0%	15%	30%	ON
18	30%	50%	50%	ON	0%	15%	30%	ON
19	0%	15%	15%	ON	0%	15%	30%	ON
20	0%	15%	15%	ON	0%	15%	30%	ON
21	0%	15%	15%	ON	0%	15%	30%	ON
22	0%	15%	15%	ON	0%	15%	30%	ON
23	0%	15%	15%	ON	0%	15%	30%	ON
24	0%	15%	15%	ON	0%	15%	30%	ON
TOTAL	6.6	11.2	11.2	24	1.8	5.7	8.4	24

14.3.4 Healthcare Interventional Suite – 24 hours/day

This profile should be used for interventional suites that are intended to be in operation for 24 hours per day, seven days per week. A typical area that would use this profile is an operating suite in the emergency department of a hospital.

Table 31: Healthcare interventional suite (24 hours/day) operating profiles

Hour of Day	All Days			
	Occup	Lighting	Equip	HVAC
1	15%	25%	30%	ON
2	15%	25%	30%	ON
3	15%	25%	30%	ON
4	15%	25%	30%	ON
5	15%	25%	30%	ON
6	20%	30%	40%	ON
7	25%	40%	45%	ON
8	30%	50%	50%	ON
9	50%	80%	80%	ON
10	60%	90%	90%	ON
11	70%	90%	90%	ON
12	70%	90%	90%	ON
13	70%	90%	90%	ON
14	70%	90%	90%	ON
15	70%	90%	90%	ON
16	60%	90%	90%	ON
17	50%	80%	80%	ON
18	30%	50%	50%	ON
19	25%	40%	45%	ON
20	20%	30%	40%	ON
21	15%	25%	30%	ON
22	15%	25%	30%	ON
23	15%	25%	30%	ON
24	15%	25%	30%	ON
TOTAL	8.55	12.55	13.3	24

14.3.5 Healthcare Emergency Department

This profile should be used for all emergency department areas (except for the emergency interventional suites, which should use the Interventional Suite – 24 hour profile). All emergency areas are assumed to be conditioned for 24 hours per day, seven days per week. Two profiles are provided; one that should be used for the off-peak period between Sunday and Thursday and the other that should be used for the peak period of Friday and Saturday.

Table 32: Healthcare emergency department operating profiles

Hour of Day	Sunday-Thursday				Friday-Saturday			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	10%	100%	50%	ON	10%	100%	50%	ON
2	10%	100%	50%	ON	10%	100%	50%	ON
3	10%	100%	50%	ON	10%	100%	50%	ON
4	10%	100%	50%	ON	10%	100%	50%	ON
5	10%	100%	50%	ON	10%	100%	50%	ON
6	10%	100%	50%	ON	10%	100%	50%	ON
7	10%	100%	50%	ON	10%	100%	50%	ON
8	20%	100%	55%	ON	20%	100%	55%	ON
9	30%	100%	60%	ON	30%	100%	60%	ON
10	40%	100%	70%	ON	40%	100%	75%	ON
11	50%	100%	80%	ON	50%	100%	80%	ON
12	50%	100%	80%	ON	60%	100%	80%	ON
13	50%	100%	80%	ON	60%	100%	80%	ON
14	50%	100%	80%	ON	60%	100%	80%	ON
15	50%	100%	80%	ON	60%	100%	80%	ON
16	50%	100%	80%	ON	60%	100%	80%	ON
17	40%	100%	70%	ON	70%	100%	85%	ON
18	30%	100%	60%	ON	80%	100%	90%	ON
19	20%	100%	55%	ON	90%	100%	95%	ON
20	10%	100%	50%	ON	100%	100%	100%	ON
21	10%	100%	50%	ON	100%	100%	100%	ON
22	10%	100%	50%	ON	100%	100%	100%	ON
23	10%	100%	50%	ON	100%	100%	100%	ON
24	10%	100%	50%	ON	100%	100%	100%	ON
TOTAL	6.0	24	14.5	24	12.5	24	17.9	24

14.3.6 Healthcare Inpatient Units

All areas that are for the care and recovery of patients (in beds) which are occupied 24 hours per day, seven days per week. Areas that are expected to use this profile are all inpatient wards, maternity wards and critical care areas. It should also be used for the ward offices and nurse's stations.

Table 33: Healthcare inpatient unit operating profiles

Hour of Day	All Days			
	Occup	Lighting	Equip	HVAC
1	50%	10%	70%	ON
2	50%	10%	70%	ON
3	50%	10%	70%	ON
4	50%	10%	70%	ON
5	50%	10%	70%	ON
6	50%	25%	70%	ON
7	50%	25%	70%	ON
8	60%	80%	70%	ON
9	60%	100%	70%	ON
10	70%	100%	70%	ON
11	70%	100%	70%	ON
12	70%	100%	70%	ON
13	70%	100%	70%	ON
14	70%	100%	70%	ON
15	70%	100%	70%	ON
16	70%	100%	70%	ON
17	70%	100%	70%	ON
18	60%	80%	70%	ON
19	60%	25%	70%	ON
20	50%	25%	70%	ON
21	50%	25%	70%	ON
22	50%	10%	70%	ON
23	50%	10%	70%	ON
24	50%	10%	70%	ON
TOTAL	14.0	12.65	16.8	24

14.3.7 Kitchens

This profile should be used for large kitchens for full catering operations. The profile assumes 16 hour operation, seven days per week.

Table 34: Healthcare kitchen operating profiles

Hour of Day	All Days			
	Occup	Lighting	Equip	HVAC
1	0%	10%	10%	OFF
2	0%	10%	10%	OFF
3	0%	10%	10%	OFF
4	0%	10%	10%	OFF
5	0%	10%	10%	OFF
6	70%	100%	100%	ON
7	70%	100%	100%	ON
8	70%	100%	100%	ON
9	50%	100%	50%	ON
10	50%	100%	50%	ON
11	70%	100%	100%	ON
12	70%	100%	100%	ON
13	70%	100%	100%	ON
14	50%	100%	50%	ON
15	50%	100%	50%	ON
16	70%	100%	100%	ON
17	70%	100%	100%	ON
18	60%	100%	100%	ON
19	50%	100%	50%	ON
20	50%	100%	50%	ON
21	50%	100%	50%	ON
22	0%	10%	10%	OFF
23	0%	10%	10%	OFF
24	0%	10%	10%	OFF
TOTAL	9.7	16.8	13.3	16

14.3.8 Circulation (12 hours/day)

This profile should be used for all spaces that are lit and have low-level transient occupancy during the day only. This profile is expected to be used for corridors and stairways within facilities or departments with daytime operation only. Note that waiting areas are not considered transitory spaces.

Table 35: Circulation (12 hours/day) profiles

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	10%	0%	OFF	0%	10%	0%	OFF
2	0%	10%	0%	OFF	0%	10%	0%	OFF
3	0%	10%	0%	OFF	0%	10%	0%	OFF
4	0%	10%	0%	OFF	0%	10%	0%	OFF
5	0%	10%	0%	OFF	0%	10%	0%	OFF
6	0%	10%	0%	OFF	0%	10%	0%	OFF
7	0%	10%	0%	OFF	0%	10%	0%	OFF
8	0%	40%	0%	ON	0%	10%	0%	OFF
9	0%	80%	0%	ON	0%	10%	0%	OFF
10	0%	100%	0%	ON	0%	10%	0%	OFF
11	0%	100%	0%	ON	0%	10%	0%	OFF
12	0%	100%	0%	ON	0%	10%	0%	OFF
13	0%	100%	0%	ON	0%	10%	0%	OFF
14	0%	100%	0%	ON	0%	10%	0%	OFF
15	0%	100%	0%	ON	0%	10%	0%	OFF
16	0%	100%	0%	ON	0%	10%	0%	OFF
17	0%	100%	0%	ON	0%	10%	0%	OFF
18	0%	80%	0%	ON	0%	10%	0%	OFF
19	0%	60%	0%	ON	0%	10%	0%	OFF
20	0%	40%	0%	OFF	0%	10%	0%	OFF
21	0%	20%	0%	OFF	0%	10%	0%	OFF
22	0%	10%	0%	OFF	0%	10%	0%	OFF
23	0%	10%	0%	OFF	0%	10%	0%	OFF
24	0%	10%	0%	OFF	0%	10%	0%	OFF
TOTAL	0	12.2	0	12	0	2.4	0	0

14.3.9 Circulation (24 hours/day)

This profile should be used for all spaces that are lit and have low-level transient occupancy 24 hours per day, 7 days per week. This profile is expected to be used for corridors and stairways within facilities or departments with 24-hour operation. Note that waiting areas are not considered transitory spaces.

Table 36: circulation (24 hours/day) profiles

Hour of Day	All Days			
	Occup	Lighting	Equip	HVAC
1	0%	100%	0%	ON
2	0%	100%	0%	ON
3	0%	100%	0%	ON
4	0%	100%	0%	ON
5	0%	100%	0%	ON
6	0%	100%	0%	ON
7	0%	100%	0%	ON
8	0%	100%	0%	ON
9	0%	100%	0%	ON
10	0%	100%	0%	ON
11	0%	100%	0%	ON
12	0%	100%	0%	ON
13	0%	100%	0%	ON
14	0%	100%	0%	ON
15	0%	100%	0%	ON
16	0%	100%	0%	ON
17	0%	100%	0%	ON
18	0%	100%	0%	ON
19	0%	100%	0%	ON
20	0%	100%	0%	ON
21	0%	100%	0%	ON
22	0%	100%	0%	ON
23	0%	100%	0%	ON
24	0%	100%	0%	ON
TOTAL	0	24.0	0	24

14.3.10 Back of House

This profile should be used for back of house spaces which have very low transient occupancy and that are only lit during those periods of occupancy. Examples of areas that would use this profile are engineering or maintenance services, mechanical services and materials management areas. The HVAC section of this profile only applies to those back of house spaces which are conditioned; for all other areas, this should be taken as OFF. Regardless of the conditioning of the space, lighting is to be modelled as per this profile.

Table 37: Back of house operational profiles

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	10%	10%	OFF	0%	10%	10%	OFF
2	0%	10%	10%	OFF	0%	10%	10%	OFF
3	0%	10%	10%	OFF	0%	10%	10%	OFF
4	0%	10%	10%	OFF	0%	10%	10%	OFF
5	0%	10%	10%	OFF	0%	10%	10%	OFF
6	0%	10%	10%	OFF	0%	10%	10%	OFF
7	0%	10%	10%	OFF	0%	10%	10%	OFF
8	0%	50%	15%	ON	0%	10%	10%	OFF
9	0%	50%	70%	ON	0%	10%	10%	OFF
10	0%	50%	100%	ON	0%	10%	10%	OFF
11	0%	50%	100%	ON	0%	10%	10%	OFF
12	0%	50%	100%	ON	0%	10%	10%	OFF
13	0%	50%	100%	ON	0%	10%	10%	OFF
14	0%	50%	100%	ON	0%	10%	10%	OFF
15	0%	50%	100%	ON	0%	10%	10%	OFF
16	0%	50%	100%	ON	0%	10%	10%	OFF
17	0%	50%	100%	ON	0%	10%	10%	OFF
18	0%	50%	60%	ON	0%	10%	10%	OFF
19	0%	50%	25%	ON	0%	10%	10%	OFF
20	0%	10%	15%	OFF	0%	10%	10%	OFF
21	0%	10%	15%	OFF	0%	10%	10%	OFF
22	0%	10%	10%	OFF	0%	10%	10%	OFF
23	0%	10%	10%	OFF	0%	10%	10%	OFF
24	0%	10%	10%	OFF	0%	10%	10%	OFF
TOTAL	0	7.2	11.0	12	0	2.4	2.4	0

14.3.11 School Classroom and Multipurpose Spaces

This profile should be used for all teaching spaces, including computer and science laboratories, manual workshops, and libraries. This profile should also be used for common spaces and gymnasia, except that the equipment load will be 0% at all times.

Table 38: School classroom or multipurpose space operational profiles

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	5%	5%	OFF	0%	10%	10%	OFF
2	0%	5%	5%	OFF	0%	10%	10%	OFF
3	0%	5%	5%	OFF	0%	10%	10%	OFF
4	0%	5%	5%	OFF	0%	10%	10%	OFF
5	0%	5%	5%	OFF	0%	10%	10%	OFF
6	0%	5%	5%	OFF	0%	10%	10%	OFF
7	0%	30%	85%	OFF	0%	10%	10%	OFF
8	15%	30%	85%	ON	0%	10%	10%	OFF
9	15%	100%	100%	ON	0%	10%	10%	OFF
10	100%	100%	100%	ON	0%	10%	10%	OFF
11	100%	100%	100%	ON	0%	10%	10%	OFF
12	100%	50%	70%	ON	0%	10%	10%	OFF
13	50%	100%	100%	ON	0%	10%	10%	OFF
14	100%	100%	100%	ON	0%	10%	10%	OFF
15	100%	100%	100%	ON	0%	10%	10%	OFF
16	100%	100%	100%	ON	0%	10%	10%	OFF
17	100%	30%	30%	ON	0%	10%	10%	OFF
18	15%	30%	30%	OFF	0%	10%	10%	OFF
19	15%	5%	5%	OFF	0%	10%	10%	OFF
20	0%	5%	5%	OFF	0%	10%	10%	OFF
21	0%	5%	5%	OFF	0%	10%	10%	OFF
22	0%	5%	5%	OFF	0%	10%	10%	OFF
23	0%	5%	5%	OFF	0%	10%	10%	OFF
24	0%	5%	5%	OFF	0%	10%	10%	OFF
TOTAL	8.1	9.3	10.6	10	0	2.4	2.4	0

14.3.12 School Canteen

Table 39: School canteen operational profiles

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	0%	10%	OFF	0%	0%	10%	OFF
2	0%	0%	10%	OFF	0%	0%	10%	OFF
3	0%	0%	10%	OFF	0%	0%	10%	OFF
4	0%	0%	10%	OFF	0%	0%	10%	OFF
5	0%	0%	10%	OFF	0%	0%	10%	OFF
6	0%	0%	10%	OFF	0%	0%	10%	OFF
7	0%	0%	10%	OFF	0%	0%	10%	OFF
8	0%	0%	10%	OFF	0%	0%	10%	OFF
9	0%	0%	10%	OFF	0%	0%	10%	OFF
10	0%	0%	10%	ON	0%	0%	10%	OFF
11	50%	100%	50%	ON	0%	0%	10%	OFF
12	100%	100%	100%	ON	0%	0%	10%	OFF
13	100%	100%	100%	ON	0%	0%	10%	OFF
14	100%	100%	100%	ON	0%	0%	10%	OFF
15	100%	100%	100%	ON	0%	0%	10%	OFF
16	0%	0%	10%	ON	0%	0%	10%	OFF
17	0%	0%	10%	OFF	0%	0%	10%	OFF
18	0%	0%	10%	OFF	0%	0%	10%	OFF
19	0%	0%	10%	OFF	0%	0%	10%	OFF
20	0%	0%	10%	OFF	0%	0%	10%	OFF
21	0%	0%	10%	OFF	0%	0%	10%	OFF
22	0%	0%	10%	OFF	0%	0%	10%	OFF
23	0%	0%	10%	OFF	0%	0%	10%	OFF
24	0%	0%	10%	OFF	0%	0%	10%	OFF
TOTAL	4.5	5.0	6.5	7.0	0	0	2.4	0

14.3.13 University Teaching and Classroom Spaces

Table 40: University teaching and classroom space operational profiles

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	5%	0%	OFF	0%	5%	0%	OFF
2	0%	5%	0%	OFF	0%	5%	0%	OFF
3	0%	5%	0%	OFF	0%	5%	0%	OFF
4	0%	5%	0%	OFF	0%	5%	0%	OFF
5	0%	5%	0%	OFF	0%	5%	0%	OFF
6	0%	5%	0%	OFF	0%	5%	0%	OFF
7	0%	5%	0%	OFF	0%	5%	0%	OFF
8	50%	50%	0%	ON	0%	5%	0%	OFF
9	50%	100%	0%	ON	0%	5%	0%	OFF
10	100%	100%	0%	ON	0%	5%	0%	OFF
11	100%	100%	0%	ON	0%	5%	0%	OFF
12	100%	80%	0%	ON	0%	5%	0%	OFF
13	50%	100%	0%	ON	0%	5%	0%	OFF
14	100%	100%	0%	ON	0%	5%	0%	OFF
15	100%	100%	0%	ON	0%	5%	0%	OFF
16	100%	100%	0%	ON	0%	5%	0%	OFF
17	100%	100%	0%	ON	0%	5%	0%	OFF
18	20%	20%	0%	OFF	0%	5%	0%	OFF
19	20%	20%	0%	OFF	0%	5%	0%	OFF
20	20%	20%	0%	OFF	0%	5%	0%	OFF
21	5%	5%	0%	OFF	0%	5%	0%	OFF
22	5%	5%	0%	OFF	0%	5%	0%	OFF
23	5%	5%	0%	OFF	0%	5%	0%	OFF
24	5%	5%	0%	OFF	0%	5%	0%	OFF
TOTAL	9.3	10.45	0	10	0	1.2	0	0

14.3.14 University Dry Laboratories, Speciality Learning Spaces and Libraries

Table 41: University dry laboratory, speciality learning space and library operational profiles

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	5%	5%	OFF	0%	5%	5%	OFF
2	0%	5%	5%	OFF	0%	5%	5%	OFF
3	0%	5%	5%	OFF	0%	5%	5%	OFF
4	0%	5%	5%	OFF	0%	5%	5%	OFF
5	0%	5%	5%	OFF	0%	5%	5%	OFF
6	0%	5%	5%	OFF	0%	5%	5%	OFF
7	0%	5%	5%	OFF	0%	5%	5%	OFF
8	50%	50%	50%	ON	0%	5%	5%	OFF
9	50%	50%	50%	ON	0%	5%	5%	OFF
10	100%	100%	100%	ON	0%	5%	5%	OFF
11	100%	100%	100%	ON	0%	5%	5%	OFF
12	100%	100%	100%	ON	0%	5%	5%	OFF
13	50%	80%	70%	ON	0%	5%	5%	OFF
14	100%	100%	100%	ON	0%	5%	5%	OFF
15	100%	100%	100%	ON	0%	5%	5%	OFF
16	100%	100%	100%	ON	0%	5%	5%	OFF
17	100%	100%	100%	ON	0%	5%	5%	OFF
18	20%	20%	20%	OFF	0%	5%	5%	OFF
19	20%	20%	20%	OFF	0%	5%	5%	OFF
20	20%	20%	20%	OFF	0%	5%	5%	OFF
21	0%	5%	5%	OFF	0%	5%	5%	OFF
22	0%	5%	5%	OFF	0%	5%	5%	OFF
23	0%	5%	5%	OFF	0%	5%	5%	OFF
24	0%	5%	5%	OFF	0%	5%	5%	OFF
TOTAL	9.1	9.95	9.85	10	0	1.2	1.2	0

14.3.14.1 University Common Spaces

Table 42: University common space operational profiles

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	5%	0%	OFF	0%	5%	5%	OFF
2	0%	5%	0%	OFF	0%	5%	5%	OFF
3	0%	5%	0%	OFF	0%	5%	5%	OFF
4	0%	5%	0%	OFF	0%	5%	5%	OFF
5	0%	5%	0%	OFF	0%	5%	5%	OFF
6	0%	5%	0%	OFF	0%	5%	5%	OFF
7	0%	5%	0%	OFF	0%	5%	5%	OFF
8	5%	30%	0%	ON	0%	5%	5%	OFF
9	15%	30%	0%	ON	0%	5%	5%	OFF
10	100%	100%	0%	ON	0%	5%	5%	OFF
11	100%	100%	0%	ON	0%	5%	5%	OFF
12	100%	100%	0%	ON	0%	5%	5%	OFF
13	50%	80%	0%	ON	0%	5%	5%	OFF
14	100%	100%	0%	ON	0%	5%	5%	OFF
15	100%	100%	0%	ON	0%	5%	5%	OFF
16	100%	100%	0%	ON	0%	5%	5%	OFF
17	100%	100%	0%	ON	0%	5%	5%	OFF
18	20%	30%	0%	OFF	0%	5%	5%	OFF
19	5%	30%	0%	OFF	0%	5%	5%	OFF
20	0%	5%	0%	OFF	0%	5%	5%	OFF
21	0%	5%	0%	OFF	0%	5%	5%	OFF
22	0%	5%	0%	OFF	0%	5%	5%	OFF
23	0%	5%	0%	OFF	0%	5%	5%	OFF
24	0%	5%	0%	OFF	0%	5%	5%	OFF
TOTAL	7.95	9.6	0	10	0	1.2	1.2	0

14.3.15 University Wet Laboratories

Table 43: University wet laboratory operational profiles

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	15%	5%	OFF	0%	15%	5%	OFF
2	0%	15%	5%	OFF	0%	15%	5%	OFF
3	0%	15%	5%	OFF	0%	15%	5%	OFF
4	0%	15%	5%	OFF	0%	15%	5%	OFF
5	0%	15%	5%	OFF	0%	15%	5%	OFF
6	0%	15%	5%	OFF	0%	15%	5%	OFF
7	15%	15%	25%	OFF	0%	15%	5%	OFF
8	15%	15%	25%	ON	0%	15%	5%	OFF
9	100%	100%	100%	ON	0%	15%	5%	OFF
10	100%	100%	100%	ON	0%	15%	5%	OFF
11	100%	100%	100%	ON	0%	15%	5%	OFF
12	100%	100%	100%	ON	0%	15%	5%	OFF
13	50%	80%	70%	ON	0%	15%	5%	OFF
14	100%	100%	100%	ON	0%	15%	5%	OFF
15	100%	100%	100%	ON	0%	15%	5%	OFF
16	100%	100%	100%	ON	0%	15%	5%	OFF
17	100%	100%	100%	ON	0%	15%	5%	OFF
18	100%	100%	100%	OFF	0%	15%	5%	OFF
19	35%	50%	40%	OFF	0%	15%	5%	OFF
20	35%	50%	40%	OFF	0%	15%	5%	OFF
21	35%	50%	40%	OFF	0%	15%	5%	OFF
22	35%	50%	40%	OFF	0%	15%	5%	OFF
23	0%	15%	5%	OFF	0%	15%	5%	OFF
24	0%	15%	5%	OFF	0%	15%	5%	OFF
TOTAL	11.2	11.3	12.2	10	0	3.6	1.2	0

14.3.16 University Gymnasia

Table 44: University gymnasium operational profiles

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	5%	5%	OFF	0%	5%	5%	OFF
2	0%	5%	5%	OFF	0%	5%	5%	OFF
3	0%	5%	5%	OFF	0%	5%	5%	OFF
4	0%	5%	5%	OFF	0%	5%	5%	OFF
5	0%	5%	5%	OFF	0%	5%	5%	OFF
6	0%	5%	5%	OFF	0%	5%	5%	OFF
7	80%	100%	80%	ON	0%	5%	5%	OFF
8	80%	100%	80%	ON	0%	5%	5%	OFF
9	80%	100%	80%	ON	0%	5%	5%	OFF
10	25%	100%	25%	ON	0%	5%	5%	OFF
11	25%	100%	25%	ON	0%	5%	5%	OFF
12	25%	100%	25%	ON	0%	5%	5%	OFF
13	100%	100%	100%	ON	0%	5%	5%	OFF
14	100%	100%	100%	ON	0%	5%	5%	OFF
15	25%	100%	25%	ON	0%	5%	5%	OFF
16	25%	100%	25%	ON	0%	5%	5%	OFF
17	25%	100%	25%	ON	0%	5%	5%	OFF
18	80%	100%	80%	ON	0%	5%	5%	OFF
19	80%	100%	80%	ON	0%	5%	5%	OFF
20	80%	100%	80%	ON	0%	5%	5%	OFF
21	35%	100%	35%	ON	0%	5%	5%	OFF
22	35%	100%	35%	ON	0%	5%	5%	OFF
23	0%	5%	5%	OFF	0%	5%	5%	OFF
24	0%	5%	5%	OFF	0%	5%	5%	OFF
TOTAL	9.0	16.4	9.4	16	0	1.2	1.2	0

14.3.17 Working Spaces (1 shift/day)

This profile should be used for workshops, galleries, function spaces, libraries, classrooms, laboratories, clean rooms and any other space that will be occupied during normal business hours only. This profile is based on 5 day per week operation; if the space is in use for longer, the profile should be adjusted accordingly.

Table 45: Working space (1 shift/day) operational profiles

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	15%	15%	OFF	0%	15%	15%	OFF
2	0%	15%	15%	OFF	0%	15%	15%	OFF
3	0%	15%	15%	OFF	0%	15%	15%	OFF
4	0%	15%	15%	OFF	0%	15%	15%	OFF
5	0%	15%	15%	OFF	0%	15%	15%	OFF
6	0%	15%	15%	OFF	0%	15%	15%	OFF
7	0%	15%	15%	OFF	0%	15%	15%	OFF
8	15%	40%	65%	ON	0%	15%	15%	OFF
9	50%	90%	80%	ON	0%	15%	15%	OFF
10	70%	100%	100%	ON	0%	15%	15%	OFF
11	70%	100%	100%	ON	0%	15%	15%	OFF
12	70%	100%	100%	ON	0%	15%	15%	OFF
13	70%	100%	100%	ON	0%	15%	15%	OFF
14	70%	100%	100%	ON	0%	15%	15%	OFF
15	70%	100%	100%	ON	0%	15%	15%	OFF
16	70%	100%	100%	ON	0%	15%	15%	OFF
17	70%	100%	100%	ON	0%	15%	15%	OFF
18	40%	80%	80%	ON	0%	15%	15%	OFF
19	15%	60%	65%	OFF	0%	15%	15%	OFF
20	5%	60%	55%	OFF	0%	15%	15%	OFF
21	5%	50%	55%	OFF	0%	15%	15%	OFF
22	0%	15%	15%	OFF	0%	15%	15%	OFF
23	0%	15%	15%	OFF	0%	15%	15%	OFF
24	0%	15%	15%	OFF	0%	15%	15%	OFF
TOTAL	6.9	13.3	13.5	11	0	3.6	3.6	0

14.3.18 Industrial Working Spaces (>1 shift/day)

This profile should be used for warehouse spaces and production/manufacturing spaces, and any other spaces which operate with multiple shifts per day. This profile is based on 5 day per week operation; if the space is in use for longer, the profile should be adjusted accordingly.

Table 46: Industrial working space (>1 shift/day) operational profiles

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	15%	15%	OFF	0%	15%	15%	OFF
2	0%	15%	15%	OFF	0%	15%	15%	OFF
3	0%	15%	15%	OFF	0%	15%	15%	OFF
4	0%	15%	15%	OFF	0%	15%	15%	OFF
5	15%	40%	65%	ON	0%	15%	15%	OFF
6	50%	90%	80%	ON	0%	15%	15%	OFF
7	70%	100%	100%	ON	0%	15%	15%	OFF
8	70%	100%	100%	ON	0%	15%	15%	OFF
9	70%	100%	100%	ON	0%	15%	15%	OFF
10	70%	100%	100%	ON	0%	15%	15%	OFF
11	70%	100%	100%	ON	0%	15%	15%	OFF
12	70%	100%	100%	ON	0%	15%	15%	OFF
13	70%	100%	100%	ON	0%	15%	15%	OFF
14	70%	100%	100%	ON	0%	15%	15%	OFF
15	70%	100%	100%	ON	0%	15%	15%	OFF
16	70%	100%	100%	ON	0%	15%	15%	OFF
17	70%	100%	100%	ON	0%	15%	15%	OFF
18	70%	100%	100%	ON	0%	15%	15%	OFF
19	70%	100%	100%	ON	0%	15%	15%	OFF
20	70%	100%	100%	ON	0%	15%	15%	OFF
21	70%	100%	100%	ON	0%	15%	15%	OFF
22	40%	80%	80%	ON	0%	15%	15%	OFF
23	15%	60%	65%	OFF	0%	15%	15%	OFF
24	0%	15%	15%	OFF	0%	15%	15%	OFF
TOTAL	11.7	18.45	18.65	18	0	3.6	3.6	0

14.3.19 Industrial Working Spaces (24 hours/day)

This profile should be used for production/manufacturing spaces, and any other spaces which operate 24 hours per day. This profile is based on 5 day per week operation; if the space is in use for longer, the profile should be adjusted accordingly.

Table 47: Industrial working space (24 hour/day) operational profiles

Hour of Day	Weekday				Weekend			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	70%	100%	100%	ON	0%	15%	15%	OFF
2	70%	100%	100%	ON	0%	15%	15%	OFF
3	70%	100%	100%	ON	0%	15%	15%	OFF
4	70%	100%	100%	ON	0%	15%	15%	OFF
5	70%	100%	100%	ON	0%	15%	15%	OFF
6	70%	100%	100%	ON	0%	15%	15%	OFF
7	70%	100%	100%	ON	0%	15%	15%	OFF
8	70%	100%	100%	ON	0%	15%	15%	OFF
9	70%	100%	100%	ON	0%	15%	15%	OFF
10	70%	100%	100%	ON	0%	15%	15%	OFF
11	70%	100%	100%	ON	0%	15%	15%	OFF
12	70%	100%	100%	ON	0%	15%	15%	OFF
13	70%	100%	100%	ON	0%	15%	15%	OFF
14	70%	100%	100%	ON	0%	15%	15%	OFF
15	70%	100%	100%	ON	0%	15%	15%	OFF
16	70%	100%	100%	ON	0%	15%	15%	OFF
17	70%	100%	100%	ON	0%	15%	15%	OFF
18	70%	100%	100%	ON	0%	15%	15%	OFF
19	70%	100%	100%	ON	0%	15%	15%	OFF
20	70%	100%	100%	ON	0%	15%	15%	OFF
21	70%	100%	100%	ON	0%	15%	15%	OFF
22	70%	100%	100%	ON	0%	15%	15%	OFF
23	70%	100%	100%	ON	0%	15%	15%	OFF
24	70%	100%	100%	ON	0%	15%	15%	OFF
TOTAL	16.8	24.0	24.0	24	0	3.6	3.6	0

14.3.20 Industrial Retail, Factory Shop and Showroom

These profiles should be used for areas involved in the sale of goods, such as direct factory outlets. This profile is based on 6 day per week operation; if the space is in use for longer, the profile should be adjusted accordingly.

Table 48: Industrial retail, factory shop and showroom operational profiles

Hour of Day	Monday-Saturday				Sunday			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	15%	15%	OFF	0%	15%	15%	OFF
2	0%	15%	15%	OFF	0%	15%	15%	OFF
3	0%	15%	15%	OFF	0%	15%	15%	OFF
4	0%	15%	15%	OFF	0%	15%	15%	OFF
5	0%	15%	15%	OFF	0%	15%	15%	OFF
6	0%	15%	15%	OFF	0%	15%	15%	OFF
7	0%	15%	15%	OFF	0%	15%	15%	OFF
8	10%	100%	70%	ON	0%	15%	15%	OFF
9	20%	100%	70%	ON	0%	15%	15%	OFF
10	20%	100%	70%	ON	0%	15%	15%	OFF
11	15%	100%	70%	ON	0%	15%	15%	OFF
12	25%	100%	70%	ON	0%	15%	15%	OFF
13	25%	100%	70%	ON	0%	15%	15%	OFF
14	15%	100%	70%	ON	0%	15%	15%	OFF
15	15%	100%	70%	ON	0%	15%	15%	OFF
16	15%	100%	70%	ON	0%	15%	15%	OFF
17	15%	100%	70%	ON	0%	15%	15%	OFF
18	5%	100%	70%	ON	0%	15%	15%	OFF
19	5%	100%	70%	OFF	0%	15%	15%	OFF
20	0%	15%	15%	OFF	0%	15%	15%	OFF
21	0%	15%	15%	OFF	0%	15%	15%	OFF
22	0%	15%	15%	OFF	0%	15%	15%	OFF
23	0%	15%	15%	OFF	0%	15%	15%	OFF
24	0%	15%	15%	OFF	0%	15%	15%	OFF
TOTAL	1.85	13.8	10.2	11	0	3.6	3.6	0

14.3.21 Common Area

These profiles should be used for foyers, lobbies, reception areas, break-out spaces, lunch rooms, and small gymnasia or fitness rooms. This profile is based on 5 day per week operation; if the space is in use for longer, the profile should be adjusted accordingly.

Table 49: Common areas operational profiles

Hour of Day	Monday-Saturday				Sunday			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	15%	15%	OFF	0%	15%	15%	OFF
2	0%	15%	15%	OFF	0%	15%	15%	OFF
3	0%	15%	15%	OFF	0%	15%	15%	OFF
4	0%	15%	15%	OFF	0%	15%	15%	OFF
5	0%	15%	15%	OFF	0%	15%	15%	OFF
6	0%	15%	15%	OFF	0%	15%	15%	OFF
7	20%	100%	100%	ON	0%	15%	15%	OFF
8	50%	100%	100%	ON	0%	15%	15%	OFF
9	5%	100%	100%	ON	0%	15%	15%	OFF
10	0%	100%	100%	ON	0%	15%	15%	OFF
11	5%	100%	100%	ON	0%	15%	15%	OFF
12	85%	100%	100%	ON	0%	15%	15%	OFF
13	100%	100%	100%	ON	0%	15%	15%	OFF
14	5%	100%	100%	ON	0%	15%	15%	OFF
15	0%	100%	100%	ON	0%	15%	15%	OFF
16	50%	100%	100%	ON	0%	15%	15%	OFF
17	0%	100%	100%	ON	0%	15%	15%	OFF
18	20%	100%	100%	ON	0%	15%	15%	OFF
19	20%	100%	100%	ON	0%	15%	15%	OFF
20	0%	15%	15%	OFF	0%	15%	15%	OFF
21	0%	15%	15%	OFF	0%	15%	15%	OFF
22	0%	15%	15%	OFF	0%	15%	15%	OFF
23	0%	15%	15%	OFF	0%	15%	15%	OFF
24	0%	15%	15%	OFF	0%	15%	15%	OFF
TOTAL	3.6	14.65	14.65	13	0	3.6	3.6	0

14.3.22 Fire Stations

These profiles should be used for the sleeping and living areas of fire stations; administrative and equipment areas should use the relevant profiles from other sections. Profiles are given separately for sleeping and other areas; both of these apply 7 days per week.

Table 50: Fire station sleeping and living area operational profiles

Hour of Day	Sleeping Areas				Living Areas			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	100%	0%	100%	ON	100%	100%	100%	ON
2	100%	0%	100%	ON	100%	100%	100%	ON
3	100%	0%	100%	ON	100%	100%	100%	ON
4	100%	0%	100%	ON	100%	100%	100%	ON
5	100%	0%	100%	ON	100%	100%	100%	ON
6	100%	0%	100%	ON	100%	100%	100%	ON
7	0%	100%	100%	ON	100%	50%	100%	ON
8	0%	100%	100%	ON	100%	50%	100%	ON
9	0%	0%	100%	ON	100%	50%	100%	ON
10	0%	0%	100%	ON	100%	50%	100%	ON
11	0%	0%	100%	ON	100%	50%	100%	ON
12	0%	0%	100%	ON	100%	50%	100%	ON
13	0%	0%	100%	ON	100%	50%	100%	ON
14	0%	0%	100%	ON	100%	50%	100%	ON
15	0%	0%	100%	ON	100%	50%	100%	ON
16	0%	0%	100%	ON	100%	50%	100%	ON
17	0%	0%	100%	ON	100%	50%	100%	ON
18	0%	0%	100%	ON	100%	50%	100%	ON
19	0%	100%	100%	ON	100%	100%	100%	ON
20	0%	100%	100%	ON	100%	100%	100%	ON
21	0%	100%	100%	ON	100%	100%	100%	ON
22	0%	100%	100%	ON	100%	100%	100%	ON
23	100%	100%	100%	ON	100%	100%	100%	ON
24	100%	0%	100%	ON	100%	100%	100%	ON
TOTAL	8.0	7.0	24.0	24	24.0	18.0	24.0	24

14.3.23 Retail Stores

This profile should be used for all speciality retail, mini majors, majors, department stores and food and beverage outlets. It can be used for standalone retail outlets, and those in retail shopping centres and strip malls. This profile is based on 6 day per week operation; if the space is in use for longer, the profile should be adjusted accordingly.

Table 51: Retail centre stores operational profiles

Hour of Day	Monday-Saturday				Sunday			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	5%	0%	OFF	0%	5%	0%	OFF
2	0%	5%	0%	OFF	0%	5%	0%	OFF
3	0%	5%	0%	OFF	0%	5%	0%	OFF
4	0%	5%	0%	OFF	0%	5%	0%	OFF
5	0%	5%	0%	OFF	0%	5%	0%	OFF
6	0%	5%	0%	OFF	0%	5%	0%	OFF
7	0%	5%	0%	OFF	0%	5%	0%	OFF
8	10%	100%	100%	ON	0%	5%	0%	OFF
9	85%	100%	100%	ON	0%	5%	0%	OFF
10	100%	100%	100%	ON	0%	5%	0%	OFF
11	95%	100%	100%	ON	0%	5%	0%	OFF
12	95%	100%	100%	ON	0%	5%	0%	OFF
13	75%	100%	100%	ON	0%	5%	0%	OFF
14	75%	100%	100%	ON	0%	5%	0%	OFF
15	50%	100%	100%	ON	0%	5%	0%	OFF
16	50%	100%	100%	ON	0%	5%	0%	OFF
17	50%	100%	100%	ON	0%	5%	0%	OFF
18	0%	5%	0%	OFF	0%	5%	0%	OFF
19	0%	5%	0%	OFF	0%	5%	0%	OFF
20	0%	5%	0%	OFF	0%	5%	0%	OFF
21	0%	5%	0%	OFF	0%	5%	0%	OFF
22	0%	5%	0%	OFF	0%	5%	0%	OFF
23	0%	5%	0%	OFF	0%	5%	0%	OFF
24	0%	5%	0%	OFF	0%	5%	0%	OFF
TOTAL	6.85	10.7	10.0	10	0	1.2	0	0

14.3.24 Retail Centre Public Spaces Areas

This profile should be used for all malls, food court, amenities and promotional areas. This profile is based on 6 day per week operation; if the space is in use for longer, the profile should be adjusted accordingly.

Table 52: Retail centre public spaces operational profiles

Hour of Day	Monday-Saturday				Sunday			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	5%	0%	OFF	0%	5%	0%	OFF
2	0%	5%	0%	OFF	0%	5%	0%	OFF
3	0%	5%	0%	OFF	0%	5%	0%	OFF
4	0%	5%	0%	OFF	0%	5%	0%	OFF
5	0%	5%	0%	OFF	0%	5%	0%	OFF
6	0%	5%	0%	OFF	0%	5%	0%	OFF
7	0%	5%	0%	OFF	0%	5%	0%	OFF
8	0%	100%	100%	ON	0%	5%	0%	OFF
9	85%	100%	100%	ON	0%	5%	0%	OFF
10	85%	100%	100%	ON	0%	5%	0%	OFF
11	100%	100%	100%	ON	0%	5%	0%	OFF
12	100%	100%	100%	ON	0%	5%	0%	OFF
13	95%	100%	100%	ON	0%	5%	0%	OFF
14	95%	100%	100%	ON	0%	5%	0%	OFF
15	95%	100%	100%	ON	0%	5%	0%	OFF
16	75%	100%	100%	ON	0%	5%	0%	OFF
17	50%	100%	100%	ON	0%	5%	0%	OFF
18	0%	5%	0%	OFF	0%	5%	0%	OFF
19	0%	5%	0%	OFF	0%	5%	0%	OFF
20	0%	5%	0%	OFF	0%	5%	0%	OFF
21	0%	5%	0%	OFF	0%	5%	0%	OFF
22	0%	5%	0%	OFF	0%	5%	0%	OFF
23	0%	5%	0%	OFF	0%	5%	0%	OFF
24	0%	5%	0%	OFF	0%	5%	0%	OFF
TOTAL	7.8	10.7	10.0	10	0	1.2	0	0

14.3.25 Retail Centre Back of House

This profile should be used for back of house areas which are continuously occupied during retail centre operating hours.

Table 53: Retail centre back of house operational profiles

Hour of Day	Monday-Saturday				Sunday			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	15%	15%	OFF	0%	15%	15%	OFF
2	0%	15%	15%	OFF	0%	15%	15%	OFF
3	0%	15%	15%	OFF	0%	15%	15%	OFF
4	0%	15%	15%	OFF	0%	15%	15%	OFF
5	0%	15%	15%	OFF	0%	15%	15%	OFF
6	0%	15%	15%	OFF	0%	15%	15%	OFF
7	25%	40%	40%	OFF	0%	15%	15%	OFF
8	50%	90%	90%	ON	0%	15%	15%	OFF
9	100%	100%	100%	ON	0%	15%	15%	OFF
10	100%	100%	100%	ON	0%	15%	15%	OFF
11	100%	100%	100%	ON	0%	15%	15%	OFF
12	100%	100%	100%	ON	0%	15%	15%	OFF
13	100%	100%	100%	ON	0%	15%	15%	OFF
14	100%	100%	100%	ON	0%	15%	15%	OFF
15	100%	100%	100%	ON	0%	15%	15%	OFF
16	100%	100%	100%	ON	0%	15%	15%	OFF
17	50%	80%	80%	ON	0%	15%	15%	OFF
18	0%	60%	60%	OFF	0%	15%	15%	OFF
19	0%	60%	60%	OFF	0%	15%	15%	OFF
20	0%	15%	15%	OFF	0%	15%	15%	OFF
21	0%	15%	15%	OFF	0%	15%	15%	OFF
22	0%	15%	15%	OFF	0%	15%	15%	OFF
23	0%	15%	15%	OFF	0%	15%	15%	OFF
24	0%	15%	15%	OFF	0%	15%	15%	OFF
TOTAL	9.25	12.95	12.95	10	0	3.6	3.6	0

14.3.26 Car Parks and Loading Docks

This profile should be used for all internal car parks and loading docks for any building type. It is based on operation 6 days per week. In buildings which operate for longer or shorter periods, the profile should be adjusted accordingly.

Table 54: Car park and loading dock operational profiles

Hour of Day	Monday-Saturday				Sunday			
	Occup	Lighting	Equip	HVAC	Occup	Lighting	Equip	HVAC
1	0%	0%	0%	OFF	0%	0%	0%	OFF
2	0%	0%	0%	OFF	0%	0%	0%	OFF
3	0%	0%	0%	OFF	0%	0%	0%	OFF
4	0%	0%	0%	OFF	0%	0%	0%	OFF
5	0%	0%	0%	OFF	0%	0%	0%	OFF
6	0%	0%	0%	OFF	0%	0%	0%	OFF
7	0%	0%	0%	OFF	0%	0%	0%	OFF
8	0%	0%	0%	OFF	0%	0%	0%	OFF
9	0%	100%	100%	ON	0%	0%	0%	OFF
10	0%	100%	100%	ON	0%	0%	0%	OFF
11	0%	100%	100%	ON	0%	0%	0%	OFF
12	0%	100%	100%	ON	0%	0%	0%	OFF
13	0%	100%	100%	ON	0%	0%	0%	OFF
14	0%	100%	100%	ON	0%	0%	0%	OFF
15	0%	100%	100%	ON	0%	0%	0%	OFF
16	0%	100%	100%	ON	0%	0%	0%	OFF
17	0%	100%	100%	ON	0%	0%	0%	OFF
18	0%	100%	100%	ON	0%	0%	0%	OFF
19	0%	0%	0%	OFF	0%	0%	0%	OFF
20	0%	0%	0%	OFF	0%	0%	0%	OFF
21	0%	0%	0%	OFF	0%	0%	0%	OFF
22	0%	0%	0%	OFF	0%	0%	0%	OFF
23	0%	0%	0%	OFF	0%	0%	0%	OFF
24	0%	0%	0%	OFF	0%	0%	0%	OFF
TOTAL	0	10.0	10.0	10	0	0	0	0

14.3.27 External Lighting

This profile should be used for external lighting applications including pathway lighting, decorative lighting, landscape lighting and external car park lighting. It does not include external lighting for sports events. Three profile types are given, as follows:

- Normal: to be used when all parts of a building function for no more than 12 hours per day during normal business hours;
- Long: to be used when any part of a building operates for more than 12 hours but less than 20 hours per day; and
- 24 hour: to be used when any part of a building operates for more than 20 hours per day.

Where a building operates less than 7 days per week, the applicable profile shall be used for all operating days, and the Normal profile for all other days.

Table 55: External lighting operational profiles

Hour of Day	Normal	Long	24-hour
1	15%	15%	100%
2	15%	15%	100%
3	15%	15%	100%
4	15%	100%	100%
5	15%	100%	100%
6	15%	100%	100%
7	0%	0%	0%
8	0%	0%	0%
9	0%	0%	0%
10	0%	0%	0%
11	0%	0%	0%
12	0%	0%	0%
13	0%	0%	0%
14	0%	0%	0%
15	0%	0%	0%
16	0%	0%	0%
17	0%	0%	0%
18	0%	0%	0%
19	100%	0%	100%
20	15%	0%	100%
21	15%	100%	100%
22	15%	100%	100%
23	15%	100%	100%
24	15%	15%	100%
TOTAL	2.65	6.6	12.0

14.3.28 Multi-Unit Residential Living Space (including Kitchen)

These profiles should be used for the primary living space within an apartment and for the kitchen space if separate.

Table 56: Apartment living space (including kitchen) operational profiles

Hour of Day	All Days				
	Occup	Lightin g	Equip-Sens	Equip-Latent	HVAC
1	0%	0%	9.1%	0%	OFF
2	0%	0%	9.1%	0%	OFF
3	0%	0%	9.1%	0%	OFF
4	0%	0%	9.1%	0%	OFF
5	0%	0%	9.1%	0%	OFF
6	0%	0%	9.1%	0%	OFF
7	0%	0%	9.1%	0%	OFF
8	100%	60%	36.4%	40.3%	ON
9	100%	60%	9.1%	9.3%	ON
10	50%	0%	9.1%	4.7%	ON
11	50%	0%	9.1%	4.7%	ON
12	50%	0%	9.1%	4.7%	ON
13	50%	0%	9.1%	4.7%	ON
14	50%	0%	9.1%	4.7%	ON
15	50%	0%	9.1%	4.7%	ON
16	50%	0%	9.1%	4.7%	ON
17	50%	0%	9.1%	4.7%	ON
18	75%	100%	9.1%	7.0%	ON
19	75%	100%	100%	100%	ON
20	75%	100%	22.7%	7.0%	ON
21	75%	100%	22.7%	7.0%	ON
22	75%	100%	22.7%	7.0%	ON
23	0%	0%	9.1%	0%	ON
24	0%	0%	9.1%	0%	ON
TOTAL	9.75	6.2	3.77	2.15	17

14.3.29 Multi-Unit Residential Living Space (excluding Kitchen)

These profiles should be used for any secondary living spaces, and for all corridors and amenity spaces within an apartment.

Table 57: Apartment living space (excluding kitchen) operational profiles

Hour of Day	All Days				
	Occup	Lightin g	Equip-Sens	Equip-Latent	HVAC
1	0%	0%	0%	0%	OFF
2	0%	0%	0%	0%	OFF
3	0%	0%	0%	0%	OFF
4	0%	0%	0%	0%	OFF
5	0%	0%	0%	0%	OFF
6	0%	0%	0%	0%	OFF
7	0%	0%	0%	0%	OFF
8	100%	60%	0%	0%	ON
9	100%	60%	0%	0%	ON
10	50%	0%	0%	0%	ON
11	50%	0%	0%	0%	ON
12	50%	0%	0%	0%	ON
13	50%	0%	0%	0%	ON
14	50%	0%	0%	0%	ON
15	50%	0%	0%	0%	ON
16	50%	0%	0%	0%	ON
17	50%	0%	0%	0%	ON
18	75%	100%	0%	0%	ON
19	75%	100%	0%	0%	ON
20	75%	100%	0%	0%	ON
21	75%	100%	0%	0%	ON
22	75%	100%	0%	0%	ON
23	0%	0%	0%	0%	ON
24	0%	0%	0%	0%	ON
TOTAL	9.75	6.2	0	0	17

14.3.30 Multi-Unit Residential Bedroom

These profiles should be used for all bedrooms within an apartment.

Table 58: Apartment bedroom operational profiles

Hour of Day	All Days				
	Occup	Lighting	Equip-Sens	Equip-Latent	HVAC
1	100%	0%	0%	0%	ON
2	100%	0%	0%	0%	ON
3	100%	0%	0%	0%	ON
4	100%	0%	0%	0%	ON
5	100%	0%	0%	0%	ON
6	100%	0%	0%	0%	ON
7	100%	0%	0%	0%	ON
8	0%	0%	0%	0%	ON
9	0%	0%	0%	0%	ON
10	0%	0%	0%	0%	OFF
11	0%	0%	0%	0%	OFF
12	0%	0%	0%	0%	OFF
13	0%	0%	0%	0%	OFF
14	0%	0%	0%	0%	OFF
15	0%	0%	0%	0%	OFF
16	0%	0%	0%	0%	OFF
17	0%	0%	0%	0%	ON
18	0%	0%	0%	0%	ON
19	0%	0%	0%	0%	ON
20	0%	100%	0%	0%	ON
21	0%	100%	0%	0%	ON
22	0%	100%	0%	0%	ON
23	100%	100%	0%	0%	ON
24	100%	0%	0%	0%	ON
TOTAL	9.0	4.0	0	0	17

14.3.31 Multi-Unit Residential Common Areas

These profiles should be used for common areas such as foyers, lobbies, hallways and corridors areas (i.e. areas which are not part of a private dwelling).

Table 59: Multi-unit residential common area operational profiles

Hour of Day	All Days				
	Occup	Lightin g	Equip-Sens	Equip-Latent	HVAC
1	0%	0%	0%	0%	OFF
2	0%	0%	0%	0%	OFF
3	0%	0%	0%	0%	OFF
4	0%	0%	0%	0%	OFF
5	0%	0%	0%	0%	OFF
6	0%	50%	0%	0%	OFF
7	0%	50%	0%	0%	ON
8	0%	100%	0%	0%	ON
9	0%	100%	0%	0%	ON
10	0%	100%	0%	0%	ON
11	0%	100%	0%	0%	ON
12	0%	50%	0%	0%	ON
13	0%	50%	0%	0%	ON
14	0%	50%	0%	0%	ON
15	0%	50%	0%	0%	ON
16	0%	50%	0%	0%	ON
17	0%	50%	0%	0%	ON
18	0%	100%	0%	0%	ON
19	0%	100%	0%	0%	ON
20	0%	100%	0%	0%	ON
21	0%	100%	0%	0%	ON
22	0%	100%	0%	0%	ON
23	0%	100%	0%	0%	ON
24	0%	50%	0%	0%	ON
TOTAL	0	14.5	0	0	18

14.4 Supplementary Building and Systems - Definitions and Calculation Methods

14.4.1 Refrigerated Cool Room and Cold Room Wall Construction

Where refrigerated cool rooms and/or cold rooms are present, the assumed construction for the reference building shall be taken as follows:

Table 60: Reference building construction for refrigerated cool rooms and cold rooms

Construction (outside to inside of refrigerated room)	R value (m² K/W)
Concrete (100mm) Insulation (90mm) Cavity (50mm) Composite Panel (25mm)	4.17

14.4.2 Reference Building HVAC Systems

The following guidance has been based on Appendix G of ASHRAE Standard Energy Standard for Buildings, 2007, and where appropriate the requirements have been modified to better suit the Australian market.

The Reference Building HVAC system(s) must be of the type and description given in this section. The system(s) shall meet the general HVAC system requirements specified in Section B2, and shall meet any system-specific requirements given in Section B3 that are applicable to the Standard Practice HVAC system type(s). All requirements given in Part J5 of the NCC must be met by the Reference Building HVAC systems.

Table 61: Reference building HVAC system types by building type

Building Type	System Type	System Description
Residential	1	Air-cooled split DX heat pump systems (one per apartment)
Residential common areas	-	Not conditioned
Non-residential and < 2,300 m²	1	Air-cooled packaged reverse cycle heat pump systems
Non-residential > 2,300 m² and less than 1,000 kWr total cooling capacity	2	Variable air volume with reheat air conditioning Air-cooled chillers
Non-residential and more than 1,000 kWr total cooling capacity	3	Variable air volume with reheat air conditioning Water-cooled chillers
Fire Stations	1	Package/Split DX reverse cycle (heat pump) systems

Table 62: Reference building HVAC system

System Type	System type	Fan control	Cooling type	Heating type
1	Package/Split DX reverse cycle (heat pump) systems	Constant volume	Direct expansion	Electric heat pump + direct electric auxiliary heating
2	Air-cooled chillers	Variable volume	Chilled water	Heating hot water fossil fuel boiler
3	Water-cooled chillers	Variable volume	Chilled water	Heating hot water fossil fuel boiler

Table 63: Reference Building HVAC system design and operating parameters

Item	Description	Requirement
1	Standard Practice HVAC System Type and Description	The HVAC systems in the Reference Building shall be based on the usage, conditioned floor area and heating sources as specified in Table 62: Reference building HVAC system , and shall conform to the system descriptions in Table 63: Reference Building HVAC system design and operating parameters . For system type 1, each thermal block shall be modeled with its own HVAC system. For system types 2 and 3, floors with identical thermal blocks can be grouped for modeling purposes. For Class 5 and 9b (education) buildings or parts of buildings, one system per perimeter orientation (where differing by 45° or more) shall be assumed; for all other building types, one system per building level shall be assumed. Spaces that have occupancy or process loads or schedules that differ significantly (note 1) from the rest of the building, or with specific pressurization requirements, require separate single-zone systems conforming to the requirements of system type 1 (if less than 500 m²), or an independent VAV system (if greater than 500 m²). (Modified from G3.1.1 (ASHRAE, 2007).)
2	Equipment Efficiencies	All equipment efficiencies in the Reference Building shall be modeled in accordance with NCC Section J or Minimum Energy Performance Standards (MEPS) (E3, 2014) requirements as applicable to the type and capacity of equipment.
3	Equipment Capacities	The Reference Building's HVAC plant shall be sized to meet the design criteria of the Reference Building as given in Section 14.1. The number of unmet load hours from the system simulation must be reported. It must be justified that the accuracy of the simulation is not significantly compromised by the unmet cooling or heating loads.
4	Preheat coils	The Reference HVAC system shall not be modeled with a preheat or precool coil, regardless of whether there is preheat or precool coil in the proposed design.
5	Fan system operation	Supply and return fan operation in the Reference Building shall be as required by NCC Section J.
6	Economizers	The Reference Building HVAC systems shall include economy cycles where required by NCC Part J5.
7	Design outside airflow rates	In accordance with the minimum requirements of NCC Part F4 and consistent with the baseline calculation in credit Quality of Internal Air.
8	Ventilation heat recovery	The Reference Building shall have only the minimum required amount of ventilation air (as per NCC Part F4) and therefore does not need to include ventilation heat recovery (as per NCC Section J clause J5.2(b)(ii)(A)(cc)).

Item	Description	Requirement
9	Design Supply Airflow Rates	System design supply airflow rates for the Reference Building shall be based on a supply-air-to-room-air temperature difference of 11 K or the required ventilation air or makeup air, whichever is greater. If return or relief fans are specified in the Proposed Building, then the Reference Building shall also be modeled with fans serving the same functions and sized for the Reference Building (modified from clause G3.1.2.8 (ASHRAE, 2007)).
10	System fan power	The system fan power of the Reference Building system design shall be as specified below: ▪ For centralized all air systems (including single-zone and multi-zone constant and variable air volume systems), the system total fan power shall be as the maximum allowable in NCC Part J5.2. Fan power shall be assumed to be split in the ratio 2:1 between supply and return fans where both fans are present. ▪ For fan coil units, packaged air conditioning units and indoor units of split systems, the specific fan power for all terminal units shall be 0.8 W/(L/s) (based on UK Part L2 2006 limiting requirement). ▪ For centralized outdoor air systems serving chilled beam, chilled ceiling, and terminal unit systems, the system total specific fan power shall be 2.0 W/(L/s) (based on UK Part L2 2006 limiting requirement). ▪ Fan power shall be assumed to be split in the ratio 2:1 between supply and exhaust fans respectively, where both fans are present. Where a system includes HEPA filters or other high-pressure drop components required for the process served, the above fan power allowances may be increased by 1.0 W/(L/s) (DCLG, 2008); unlike Part J5.2(a)(ix)(B), the associated energy consumption of these components must be included in the calculation.
11	Heat pumps (system type 1 as per Table 60)	Electric air-source heat pumps shall be modeled with electric auxiliary heating. The systems shall be controlled with multistage space thermostats and an outdoor air thermostat wired to energize auxiliary heat only on the last thermostat stage and when out-door air temperature is less than 4 °C (clause G3.1.3.1 (ASHRAE, 2007)). Heat pumps shall be modeled with the required EER (cooling mode) and COP (heating mode) as per the minimum requirements of NCC Section J or MEPS. Where only EER is specified, the COP shall be assumed to be equal to the EER. Where AEER and ACOP values are specified, the EER and COP shall be assumed to be 10% less than the stated values.
12	Direct electric heating	Where applicable, direct electric heating will be applied with an associated efficiency of 100%.

Item	Description	Requirement
13	Type and number of heating hot water boilers	Where the nominated fuel source is fossil fuel, then, regardless of the actual heating energy source, where natural gas is available at the site boundary, natural gas will be used as the heating fuel in the Reference Building; otherwise diesel oil will be used. Boilers shall be modeled in parallel configuration. The number of boilers shall be modeled as two, each sized at 60% of design heating capacity. The Reference Building boiler(s) will have the minimum required full-load gross thermal efficiency as given in NCC Section J Table J5.4b. Part load efficiency variation shall be modeled as a straight line between full-load value at 100% of output, and 70% of full-load efficiency at 15% of output.
14	Heating hot water supply temperature (system types 2 and 3 as per Table 60)	Heating hot water system design flow and return temperatures shall be modeled as 80 and 65 °C respectively (modified from G3.1.3.3 (ASHRAE, 2007)).
15	Heating hot water pumps (system types 2 and 3 as per Table 60)	The Reference Building hot-water pump system shall meet all the requirements of the NCC. Systems shall be modeled with constant primary flow rate through each boiler.
16	Piping losses and thermal inertia (system types 2 and 3 as per Table 60)	Piping losses for heating hot water and chilled water shall be the same for the Reference Building as modeled in the Proposed Design. Thermal inertia for heating hot water systems in the Reference Building shall be varied in proportion to the ratio of the peak heating load between the Reference and Proposed buildings.
17	Type and number of chillers (system types 2 and 3 as per Table 60)	Electric chillers shall be used in the Reference Building, regardless of the actual cooling energy source. Where the Reference Building's design cooling load is less than 1,000 kWr, air-cooled chillers shall be modeled. Where the design cooling load is greater than 1,000 kWr, water-cooled chillers shall be modeled (modified from clause G3.1.3.7 (ASHRAE, 2007)). Chillers shall be modeled in parallel configuration. For air-cooled chillers, the number of chillers shall be modeled as two, each sized at 55% of design cooling capacity. Staging of chillers will occur when the first operating chiller reaches 100% of capacity. For water-cooled chillers, the number of chillers shall be modeled as three, sized at 45%, 45% and 15% of design cooling capacity, and the sequence of operation shall be 15% only; 45% only; 45% and 15%; two off 45%; and all chillers on. Staging will occur when all operating chillers have reached 100% of capacity. The chillers will have the minimum required EER and IPLV values as given in the NCC Section J or MEPS as applicable to the unit capacity (note 2), adjusted as required to reflect non-standard CHW and CCW operating temperatures (refer to Appendix E of SA, 2008b).
18	Chilled water design supply temperature (system types 2 and 3 as per Table 60)	Chilled-water design supply temperature shall be modeled at 6.5 °C and return water temperature at 12.5 °C (modified from clause G3.1.3.8 (ASHRAE, 2007)).

Item	Description	Requirement
19	Chilled water pumps (system types 2 and 3 as per Table 60)	The Reference Building chilled water pump system shall meet the requirements of the NCC. Pumping systems shall be modeled with variable primary flow, with a minimum flow rate of 70% of design through each chiller. Pump powers shall be apportioned in the same ratio as the chiller cooling capacities as per item 17.
20	Heat rejection (system type 3 as per Table 60)	For water-cooled chiller systems, the heat rejection device shall be two off axial fan cooling towers of equal capacity (50% of design heat rejection) with variable-speed fan control. Condenser water design leaving temperature shall be 29.5 °C or 5.5 K approach on design wet-bulb temperature, whichever is lower, with a range ΔT of 4.5 K (modified from clause G3.1.3.11 (ASHRAE, 2007)). Cooling tower control shall be based on maintaining a condenser water temperature of 20 °C with minimum wet bulb approach of 3 K. The Reference Building fan power shall meet the requirements of the NCC Section J for the applicable fan type.
21	Condenser water pumps (system type 3 as per Table 60)	The Reference Building condenser water pump system shall meet all the requirements of the NCC. Systems shall be modeled with constant primary flow rate through each chiller. Pump powers shall be apportioned according to the heat rejection duty, including allowance for the tenant supplement heat rejection system, where applicable.
22	Tenant supplementary heat rejection	Tenant supplementary heat rejection shall be provided by a dedicated axial fan cooling tower sized for 100% of duty. Staged primary/secondary variable speed pumping (two pumps each at 50% of design flow rate) shall be used. System design temperatures shall be as per item 20. Where actual heat rejection duty is unknown, assume 50% of design load Monday to Friday, 8am to 6pm, and 20% of design load at all other times. Pump powers shall be apportioned according to the heat rejection duty, including allowance for the cooling plant condenser water system, where applicable.
23	VAV minimum flow setpoints (system types 2 and 3 as per Table 60)	Minimum turndown ratio for VAV systems shall be modeled at 40% of design supply air flow rate or equal to the outdoor air supply rate, whichever is greater.
24	VAV fan part-load performance (system types 2 and 3 as per Table 60)	VAV system supply fans shall have variable speed drives, and their part-load performance characteristics shall be modeled using Method 1 as per Section 14.4.3 (clause G3.1.3.15 (ASHRAE, 2007)).

Notes:

1: Peak thermal loads that differ by 30% or more from the average of other spaces served by the system, or schedules that differ by more than 40 equivalent full-load hours per week from other spaces served by the system are considered to differ significantly.

2: In order to model chiller part-load operation to achieve the required IPLV, apply the multipliers as per **Error! Reference source not found.** to calculate the EER at 75%, 50% and 25% of full-load output at nominated reference conditions (SA, 2008b).

Table 64: Reference Building chiller part-load EER multipliers

Chiller Capacity (kWr)	Air-Cooled Chiller			Water-Cooled Chiller		
	75%	50%	25%	75%	50%	25%
<350	1.143	1.556	1.521	1.192	1.368	1.089
350-499	1.143	1.556	1.521	1.053	1.142	1.142
500-699	1.143	1.556	1.521	1.112	1.232	1.232
700-999	1.235	1.736	1.725	1.1065	1.174	1.181
1000-1499	1.235	1.736	1.725	1.1065	1.174	1.181
≥1500	1.235	1.736	1.725	1.053	1.142	1.142

14.4.3 Variable Air Volume Fan Speed Control

Where the Proposed and/or Reference Buildings contain variable air volume (VAV) systems their part-load performance characteristics shall be modelled using Method 1 given below (based on clause G3.1.3.15 (ASHRAE, 2007)). Where the Proposed Building adopts system pressure optimisation reset control, Method 2 may be applied:

14.4.3.1 Method 1 – Part-Load Fan Power Equation for Standard Control

$$P_{fan} = 0.0013 + 0.1470PLR_{fan} + 0.9506PLR_{fan}^2 - 0.0998PLR_{fan}^3$$

Where P_{fan} is the proportion of full-load fan power used at any given fan part-load ratio, and PLR_{fan} is the fan part-load ratio (ratio of actual system air flow rate (m³/s) in any given hour to the design system air flow rate (m³/s)).

14.4.3.2 Method 2 – Part-Load Fan Power Equation for System Pressure Optimisation Reset Control

$$P_{fan} = 0.0012 - 0.0579PLR_{fan} + 0.5864PLR_{fan}^2 + 0.4712PLR_{fan}^3$$

Where definitions of variables P_{fan} and PLR_{fan} are as per Method 1.

The difference in proportion of full-load fan power calculated using these methods is illustrated in Figure 1:

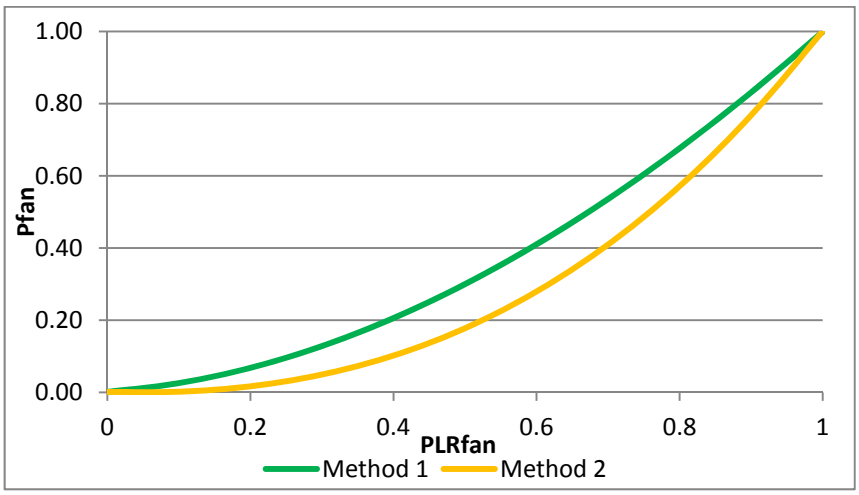


Figure 1: Proportion of full-load fan power for Method 1 and Method 2

14.4.4 External Artificial Lighting

Lighting power densities to be applied for the Reference Building (and Proposed Building where minimum illuminance values as per AS 1680 are not achieved by the design) shall be applied according to the usage category as follows:

Table 65: Standard practice external lighting power densities

Category	Power Density	Category	Power Density
P1 (note 1)	7.1 W/m	P8	0.8 W/m²
P2 (note 1)	4.3 W/m	P9	Match adjacent category
P3 (note 1)	3.5 W/m	P10	1.7 W/m²
P4 (note 1)	2.6 W/m	P11a	1.5 W/m²
P5 (note 1)	2.2 W/m	P11b	0.6 W/m²
P6	2.1 W/m²	P11c	0.2 W/m²
P7	1.4 W/m²	P12	9.0 W/m²

Notes
1: Based on path widths up to 6 metres. For path widths greater than 6 metres, multiply power density by number of 6 metre widths or part thereof, e.g. if path is 8 metres wide, this is 1.33 widths, therefore multiply by 2.

14.4.5 Lift Energy Consumption Methodology

Estimation of the Proposed and Reference building annual lift energy consumption shall be based on the following methodology (adapted from Barney, 2007):

$$E = N\frac{\bar{T}_{trip}}{3600}\dot{Q}_{avg} + \dot{Q}_{standby}T_{standby}D_{standby}$$

Where E is the annual energy consumption of the lift (kWh/annum), N is the number of lift trips, $\bar{T}_{trip}$ is the average trip time (s), $\dot{Q}_{avg}$ is the average motor load (kW), $\dot{Q}_{standby}$ is the lift standby power (kW), $T_{standby}$ is the hours of lift standby operation (hours/day), and $D_{standby}$ is the number of days of lift standby operation (days/annum). Average trip time is calculated as follows:

$$\bar{T}_{trip} = \frac{H}{2v_{rated}}$$

Where H is the total travel distance of the lift between terminal floors (m), and v_{rated} is the rated travel speed of the lift (m/s) (the factor of 2 is introduced based on the assumption that the average travel distance is half of the total travel distance).

This formula should be used for both the Proposed and Reference Building. The design team needs to establish the trip time, lift power rating and standby power for the Proposed Building (definitions below). All other parameters for the Proposed and all parameters for the Reference Building are given in **Error! Reference source not found.** below.

Table 66: Lift energy consumption calculation input parameters

Parameter	Definition	Proposed Building	Reference Building
Number of trips	The standard number of trips per year for the relevant building type.	The number of trips for the Proposed Building should be taken from Table 68: Reference building nominal lift travel time between terminal floors .	As Proposed Building
Average trip time	The time, in seconds, for the lift to travel half the possible travel distance measured from doors closed to doors opening.	This parameter needs to be calculated by the design team. It will depend on the distance the lift will travel and the rated speed of the lift.	The travel distance is the same as the Proposed Building. The rated speed of the Reference Building lifts shall be taken as the smaller value of 8 m/s and H/T, where T is the nominal travel time between terminal floors (refer to **Error! Reference source not found.**) (CIBSE, 2005).
Average power load	The average power load is assumed to be the lift motor rated power (kW).	From design calculations or supplier specifications for the lift being assessed. This figure can be reduced by 20% if the lift has regenerative breaks.	The rated motor power shall be calculated based on the specified lift rated speed and rated carrying capacity (kg) assuming overhead electric traction with gearless variable voltage variable frequency (VVVF) drives, roping factor of 2:1, counterbalance of 0.5, and 100% compensation for rated speeds greater than 2.5 m/s (refer to equation below).
Standby power	Standby power from car lights and lift control system.	From supplier specifications for lift being assessed.	0.15 kW
Standby hours per day	Number of hours per day that the car lights and lift control systems are operating.	24 hours unless the lift has a power off feature, in which case the figure used should be 18 hours.	24 hours
Standby days per year	Number of days the standby power is applicable.	365 days, except for offices and education facilities where the lift has a power off feature in which case the number of weekdays less the number of public holidays should be used.	365 days

Reference Building rated motor power shall be calculated using the following equation:

$$\dot{Q} = \frac{1.05 g f_{roping} v_{rated}}{1000}\left(\frac{M}{f_{roping}}(1-B) - \frac{H}{2}\left(\frac{M_t N_t}{2} + 2M_c N_c - 2M_s N_s\right)\right) + 0.5$$

Where $\dot{Q}$ is the lift motor rated power (kW), g is acceleration due to gravity (9.81 m/s²), f_{roping} is the roping factor (2 for the Reference Building lifts), v_{rated} is the lift rated travel speed (m/s), M is the lift rated carrying capacity (kg), B is the counterbalance proportion of total lift car mass (0.5 for the Reference Building lifts), H is the total travel distance of the lift between terminal floors (m) (as per the Proposed Building), M_t, M_c and M_s are the mass per unit length of the travelling cables, compensator cables and main cables, respectively (kg/m) (0.43, 1.0 and 1.0 kg/m, respectively, for the Reference Building lifts), and N_t, N_c and N_s are the number of travelling cables, compensator cables and main cables, respectively (4, 6 and 6, respectively, for the Reference Building lifts). Note that for lifts without compensation (rated speed less than 2.5 m/s), $M_c = N_c = 0$.

Table 67: Lift trips by building usage

Lift Duty	Trips per day	Building types (lift operating days/week)	Trips per year		
			5 days/week (260 days/year)	6 days/week (312 days/year)	7 days/week (365 days/year)
Low	200	Residential care (7) Goods lifts (5) Library (6) Entertainment centres (7)	52,000	62,400	73,000
Medium	600	Office car parks (5) General car parks (7) Residential (7) University (5) Hotels (7) Low-rise hospitals (7) Shopping centres (7)	156,000	NA	219,000
High	1500	Office (5) Airports (7) High-rise hospitals (7)	390,000	NA	547,500
Intensive	2000	HQ office (5)	520,000	NA	NA

Table 68: Reference building nominal lift travel time between terminal floors

Building Type	Travel time between terminal floors (s)
Large offices, hotels, etc	20
Small offices, hotels, etc	20
Hospitals, nursing and residential homes, etc	24
Residential buildings	25
Factories, warehouses, retail, etc	30

Note that DDA access lifts having travel distances of one storey or less are not required to be included as their energy consumption is negligible.

As an alternative to the above, for Class 5 buildings the project team may use the empirical model of lift energy consumption developed by (Bannister, 2011). The Reference Building shall use the following inputs, consistent with **Error! Reference source not found.**:

- Lift car mass: heavy;
- Lift drive type: variable voltage variable frequency AC (VVVFAC);
- Regenerative braking: none; and
- All other inputs: as per the Proposed Building.

Note that this method is based on correlation against an empirical dataset which includes office buildings only. It cannot be used for other building types, or where any lift within a building serves independent Class 5 and other usages, under any circumstances.

Where the project team considers the methodologies presented do not adequately calculate the improvement due to the Proposed Building lift design, they may submit a CIR proposing an alternative methodology. This may include lift simulation travel analysis. Where this is the case, the CIR must demonstrate the suitability of the lift call profiles to be used in the simulation with respect to the actual building usage, and the Reference Building simulation must be based on the lift system specified in **Error! Reference source not found.**.

14.4.6 Reference Building Appliances

For Class 2 buildings, appliances shall be included in the building total energy consumption. The performance standard to be used in the Reference Building is as follows:

Table 69: Reference Building appliance energy ratings

Item	Reference Specification	Reference Performance	Maximum Available Rating (note 1)	Normalised Energy Consumption (note 3)
Refrigerator/freezer	Group: 5T Fresh food: 250 L Freezer: 100 L	1.5-star below maximum available star rating	4-star	436 kWh/annum (2.5-star)
Dish washer	Place settings: 12	1.5-star below maximum available star rating	4.5-star	282 kWh/annum (3.0-star)
Clothes washer (note 2)	Load: 7 kg	1.5-star below maximum available star rating	5-star	367 kWh/annum (3.5-star)
Clothes dryer	Load: 6 kg	1.5-star below maximum available star rating	6-star	200 kWh/annum (4.5-star)

Notes:

1: Based on energy performance reported at www.energyrating.gov.au; project teams shall amend the reference building parameters as required according to the maximum available rating at the time of documentation.

2: Based on warm-wash cycle energy consumption.

3: Refer to E3, 2010 or relevant Australian Standards for equations used to calculate normalised energy consumption.

14.5 Energy Consumption Adjustment Factors

14.5.1 Car Park and Loading Dock Atmospheric Contaminant Control Systems

The following energy consumption adjustment factors apply to the installation of atmospheric contaminant monitoring systems and associated variable-speed fan control in car parks and loading docks. The adjustment factors provided in **Error! Reference source not found.** are used to establish the adjusted full-load absorbed fan power as follows:

$$P_{fan,adj} = P_{fan} \times F_{adj}$$

Where $P_{fan,adj}$ is the adjusted full-load absorbed fan power (kW), P_{fan} is the absorbed fan power at the specified operating duty point (kW), and F_{adj} is the adjustment factor for atmospheric contaminant monitoring and variable speed fan control from **Error! Reference source not found.**.

The adjusted absorbed fan power is then used with the appropriate car park/loading dock HVAC profile to establish the annual energy use of the Proposed Building.

Table 70: Adjustment factor for atmospheric contaminant monitoring and variable-speed fan control

Requirement for Adjustment Factor	Adjustment Factor
Car park and/or loading dock mechanical ventilation fans that include variable-speed drives on supply and exhaust fans (as applicable) controlled by an atmospheric contaminant monitoring system in accordance with AS1668.2:2013	0.7

Where a building contains multiple physically separate car parks and/or loading docks, the adjustment factor must be applied individually to each area with a qualifying atmospheric contaminant monitoring and variable-speed fan control system.

14.5.2 Automatic Lighting Controls

The adjustment factors are used to establish an adjusted illumination power density for the Proposed Building as follows:

$$LPD_{prop,adj} = LPD_{prop} \times F_{adj}$$

Where $LPD_{prop,adj}$ is the adjusted proposed lighting power density (W/m²), LPD_{prop} is the nominal proposed lighting power density (W/m²), and F_{adj} is the adjustment factor for the proposed automatic lighting control system, as detailed in **Error! Reference source not found.**.

The adjustment factors can only be applied to luminaires controlled by the control system, not to the entire space.

Where more than one illumination power density adjustment factor applies to an area, they are to be combined using the following formula:

$$F_{adj} = F_{adj,A} \times \left(F_{adj,B} + \frac{1 - F_{adj,B}}{2}\right)$$

Where $F_{adj,A}$ is the lowest of the applicable lighting power density adjustment factors, and$F_{adj,B}$ is the second lowest of the applicable lighting power density adjustment factors. Note that if addressable lighting control is included, the fixed increment should be subtracted *after* the above calculation.

The adjusted proposed lighting power density is then used with the standard lighting profile for the space type (from Section 14.3) to establish the annual lighting energy use of the Proposed Building.

If your project includes automatic lighting controls that are not included here, approval to use specific alternative adjustment factors is required from the GBCA. The project team may submit a CIR describing how they propose to apply adjustments for the specific control features and how the improvements have been assessed.

Table 71: Automatic lighting control adjustment factors

Item	Requirement for the use of the Adjustment Factor		Adjustment Factor
	Space type	Limitations	
Motion detector in accordance with Specification J6	All spaces within a building except for 'industrial spaces' and car parks	Where an area of 200 m² or less is switched or dimmed as a block by one or more detectors.	0.9 (note 1)
	For 'industrial spaces'	Where the maximum area switched or dimmed as a block by one or more detectors is the area of the space divided by 10, or 2000 m², whichever is smaller. The minimum required block size is 200 m².	0.9 (note 1)
	All spaces within a building except for car parks	Where up to and including 6 lights are switched or dimmed as a block by one or more detectors.	0.7 (note 1)
		Where up to and including 2 lights are switched or dimmed as a block by one or more detectors.	0.55 (note 1)
	Car parks	Where an area of a car park of less than 500 m^2 is switched or dimmed as a block by one or more detectors.	0.7 (note 1)
Fixed dimming (note 4)	All	Lighting is controlled by fixed dimmers that reduce the overall lighting level and the power consumption of the lighting.	% of full power to which the dimmer is set
Daylight sensor and dynamic lighting control in accordance with Specification J6 – dimming or stepped switching of lights adjacent to windows and/or roof lights	All	(a) Lights within the space adjacent to windows other than roof lights for a distance from the window equal to the floor-to-window-head height.	0.75 (notes 2 and 3)
		(b) Where the total area of roof lights is less than 10% of the floor area, but greater than 5%.	0.8 (notes 2 and 3)
		(c) Where the total area of roof lights is 10% or more of the floor area	0.75 (notes 2 and 3)
		For spaces other than those described under (a), (b) and (c), where lighting is controlled by dynamic dimming (note 5)	0.95 (notes 2 and 3)
Addressable lighting control system	All	Where an individually addressable system is installed, the adjustment factor can be further reduced by subtraction of an additional fixed increment.	additional fixed increment of 0.05

Notes:
1: Where luminaires are not switched off, but are only dimmed, the following equation must be used to determine the modified adjustment factor applicable to these luminaires:

$$F_{adj,dimmed} = F_{adj,switched} + \left(P_{dimmed} \times F_{adj,switched}\right)$$

Where $F_{adj,dimmed}$ is the adjustment factor to be applied to dimmed luminaires, $F_{adj,switched}$ is the adjustment factor applicable to switched luminaires (as per this table), and P_{dimmed} is the proportion of full-load power to which the luminaire input reduces when it is dimmed.

2: These adjustment factors do not apply to tungsten halogen or other incandescent sources.

3: These adjustment factors are conservative. If the design team believes that increased benefit will be realised, then the control operation should be modelled in accordance with Section 6.4.

The benefits of automatic controls can also be demonstrated by proposing modifications to the lighting schedules to be used. Such modified lighting schedules need to be approved by the GBCA through the standard CIR process before being used in the modelling process.

4: Fixed dimming is the control through control gear adjustment or lighting control software of the maximum luminaire light output that cannot be adjusted by the space user.

5: Dynamic dimming is the automatic and continuous control of the luminaire light output in response to the signal from a photoelectric cell to compensate for the availability of natural light.

14.6 Greenhouse Gas Emission Factors

Greenhouse gas emissions factors adopted in the Green Star calculation of greenhouse gas emissions are specified as follows, based on the documented values of Scope 1, 2 and 3 emissions in DIICCSRTE, 2013:

Table 72: Greenhouse gas emission factors by fuel type

Fuel and Location	Fuel GHG Emission Factor			
	Scope 1	Scope 2	Scope 3	Total
Electricity ($kgCO_2e/kWh$)				
▪ ACT	0	0.87 (note 1)	0.19 (note 2)	1.05
▪ NSW	0	0.87 (note 1)	0.19 (note 2)	1.05
▪ NT	0	0.69 (note 1)	0.08 (note 2)	0.77
▪ QLD	0	0.82 (note 1)	0.14 (note 2)	0.95
▪ SA	0	0.62 (note 1)	0.11 (note 2)	0.73
▪ TAS	0	0.20 (note 1)	0.02 (note 2)	0.22
▪ VIC	0	1.17 (note 1)	0.15 (note 2)	1.32
▪ WA	0	0.78 (note 1)	0.06 (note 2)	0.84
Natural Gas ($kgCO_2e/GJ$)				
▪ ACT	51.33 (note 3)	0	12.8 (note 4)	64.13
▪ NSW	51.33 (note 3)	0	12.8 (note 4)	64.13
▪ NT	51.33 (note 3)	0	0 (note 4)	51.33
▪ QLD	51.33 (note 3)	0	8.7 (note 4)	60.03
▪ SA	51.33 (note 3)	0	10.4 (note 4)	61.73
▪ TAS	51.33 (note 3)	0	0 (note 4)	51.33
▪ VIC	51.33 (note 3)	0	3.9 (note 4)	55.23
▪ WA	51.33 (note 3)	0	4.0 (note 4)	55.33

Fuel and Location	Fuel GHG Emission Factor			
	Scope 1	Scope 2	Scope 3	Total
Coal ($kgCO_2e/GJ$)	88.43 (note 10)	0	4.6 (note 11)	93.03
Diesel Oil ($kgCO_2e/GJ$)	69.5 (note 7)	0	5.3 (note 5)	74.8
LPG ($kgCO_2e/GJ$)	59.9 (note 7)	0	5.0 (note 5)	64.9
Biomass ($kgCO_2e/GJ$)	1.8 (note 8)	0	0 (note 9)	1.8
Liquid Biofuel ($kgCO_2e/GJ$)	0.26 (note 7)	0	0 (note 6)	0.26

Notes:

1: Value from Table 5; WA covers South-West Interconnected System (SWIS) area only.

2: Value from Table 41; based on "Latest Estimate" value. WA covers South-West Interconnected System (SWIS) area only.

3: Value from Table 2; based on "Natural gas distributed in a pipeline"; value stated is the sum of the CO_2, CH_4 and N_2O components.

4: Value from Table 37. Values for TAS and NT are listed as "Not Applicable".

5: Value from Table 40.

6: In table 40 this value is listed as "Not Estimated" because the associated factors are "highly dependent on individual plant and project characteristics". Projects should confirm the value proposed to be used based on consultation with suppliers and submit a CIR.

7: Value from Table 3.

8: Value from Table 1; based on "Primary solid biomass fuels".

9: No values for solid fuels other than fossil fuels are provided in the document. Projects should confirm the value proposed to be used based on consultation with suppliers and submit a CIR.

10: Value from Table 1; based on bituminous coal.

11: Value from Table 36.

14.7 Leakage of Synthetic Greenhouse Gases

The methodology used to assess the contribution to the greenhouse gas emission from a building through leakage of synthetic gases is that given in DIICCSRTE, 2013. This information shall be reported with each Green Star rating submission, but is not yet used as part of the assessment. The requirement for reporting is in accordance with the framework for the Common Carbon Metric (UNEP, 2010).

The calculation method is as follows (DIICCSRTE, 2013):

$$E = \sum_j m_j \times L_j$$

Where E is the total emissions of synthetic GHG calculated by summation over all applicable equipment types ($kgCO_2e$), m_j is the mass of hydrofluorocarbon (HFC) or sulphur hexafluoride (SF_6) contained in equipment item j (kg) (based on the name plate capacity), and L_j is the default specific GHG leakage rate from equipment item j ($kgCO_2e/kg/annum$), as per **Error! Reference source not found.**.

Table 73: Synthetic greenhouse gas leakage rates from typical building equipment types

Equipment type	Default annual leakage rates of gas ($kgCO_2e/kg/annum$)	
	HFC	SF_6
Commercial air conditioning – chillers	0.09	
Commercial refrigeration – supermarket systems	0.23	
Industrial refrigeration including food processing and cold storage	0.16	
Gas insulated switchgear and circuit breaker applications		0.0089