greenstar

Energy Use calculation guide

Guidance on calculation methods for the Energy Use credit

Version 1

10 October 2022

Green Building Council Australia

Building a sustainable future

Introduction

Version control

Version	Date	Description of changes
2	10/10/2022	Amendments for • Alternative method to demonstrate compliance with the Minimum Expectation under the Reference Building Pathway for the Energy Use Credit • Terminology changes from 'reference/proposed' project to 'reference/proposed' building to keep it consistent with the Green Star Buildings submission guidelines. • Updated modelling report section to capture information on the DTS requirements for Minimum Expectation and alternative pathway for building fabric • Removed repetitions.
1	07/09/2021	Initial release for Green Star Buildings. (Adapted from *Green Star – Design & As Built v1.3*)

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Green Star Buildings

Positive category

The *Green Star Buildings* Positive category incorporates the Energy Use credit.

This document describes the required attributes of the project's energy performance models used to assess performance. The *Green Star Buildings* Energy Use calculator automatically calculates the points achieved by the project based on project energy performance model output data modelled using approved software.

The energy consumption reduction is calculated based on comparison of the Reference building and the Proposed building. As per the definitions of these, all design variables are reflected in this comparison, including services design strategy and envelope design.

Energy Use credit

This document sets out the basis on which project energy performance modelling is to be completed for all *Green Star Buildings* rating assessments adopting the performance-based compliance approach (Reference building pathway and Reference fitout pathway). 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.

In the case of *Green Star Buildings* this guide is to be used for the Energy Use credit.

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

- Provide definite guidance on the requirements for modelling of project 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 project
- Provide meaningful information from the energy analysis model to inform the ongoing monitoring management of project energy performance; and

Note: At the time of publication, Green Star Fitouts is in development and as such guidance has not been included for this rating tool.

Interdependence with other Green Star credits

Verification and Handover

Air tightness targets set as part of the 'Environmental performance targets and information' section of the Commissioning and Tuning Verification and Handover Minimum Expectation requirement should be consistent with infiltration rates set in modelling.

Light Quality

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 (refer to Automatic lighting controls), it must be demonstrated:

- If hourly internal daylight levels are calculated by the 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 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.

Clean Air

Ventilation rates (that is the quantity of outdoor air introduced to the project) and the method of ventilation control as applied in the Clean 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 Clean 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 based on the values specified in either ASHRAE Standard 55 (2013) or ISO 7730 (2005) as appropriate to the space usage, and consistent with any thermal comfort assessment completed in accordance with Section J JV1, 2 or 3.

Water Use

Domestic hot water usage for the Reference and Proposed buildings must be based on the calculations completed in the Water Use 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 (refer to Modelling domestic hot water systems).

Heat rejection water consumption for the Reference building is calculated by the Water Use 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 Water Use 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 energy performance simulation, or supplementary manual calculations, and the total usage value entered into the Water Use 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 energy performance simulation and the total entered into the Water Use calculator.

Energy performance calculation

NCC Section J

NCC Section J provides multiple pathways for demonstrating compliance with Performance Requirement JP1 of Section J for Class 3 to Class 9 buildings, and common areas of Class 2 buildings, individually or in combination, namely:

- Deemed-to-Satisfy based on adopting the prescriptive requirements outlined in Parts J0 to J8;
- Verification Method JV1 based on a NABERS Energy Commitment Agreement (minimum 5.5-star) (for Class 5 buildings only), supplemented by mandatory DTS provisions as per Specification JVa. Projects using this pathway can use Green Star Design & As Built credit pathway 15B NABERS Commitment Agreement without any requirement for additional modelling;
- Verification Method JV2 based on Green Star - Design & As Built credit pathway 15E Reference building, i.e. the modelling approach described in this guide, supplemented by mandatory DTS provisions as per Specification JVa; (due for update to include Green Star Buildings in 2022)
- Verification Method JV3 based on adopting the prescribed performance-based assessment methodology, supplemented by mandatory DTS provisions as per Specification JVa; and
- Performance Solutions which may be adopted subject to the approval of the Building Certifier.

Verification Method JV3 provided the basis from which this Green Star-specific energy modelling protocol was originally developed. Now, with the inclusion of this Green Star-specific modelling protocol as Verification Method JV2 in NCC 2019, further development and refinement of the guidance has been undertaken to facilitate consistency (so far as possible) between the Verification Methods JV2 and JV3, and the revised Deemed-to-Satisfy requirements of NCC 2019.

This methodology is adopted by the Green Star Buildings rating tool as the basis of the Energy Use credit for the Positive Category, and by NCC 2019 as the basis of JV2. **With the introduction of Green Star Buildings, the rating tool no longer measures Greenhouse Gas Emissions directly.** The Energy Use credit assesses a building's energy consumption, regardless of its source, against a code compliant Reference building. The calculator will however provide the option for projects to convert to Greenhouse Gas emissions using state emissions factors. An amendment to JV2 to allow Green Star Buildings project to be included is currently in the draft version of NCC 2022.

For the purposes of **Green Star ratings**, in the event of any discrepancies between the requirements of this document and those of Specification JVb, this document takes precedence.

For the purposes of **Performance Solutions in accordance with Verification Method JV2**, the following specific variations between Specification JVb and this guide are noted, which will require projects to amend the reference building accordingly in each case:

- Specification JVb requires that Verification Method JV2 uses the same building services as the proposed building (clause Specification JVb 3(c)(i)), but this guide requires the use of a standard HVAC system (refer to Reference building HVAC Systems).
- Specification JVb requires that Verification Method JV2 uses the same domestic hot water usage rate as the proposed building (clause Specification JVb 3(c)(viii)), but this guide requires the reference building usage value calculated by the Water Use calculator.

In the event of any discrepancy between the requirements of this document and those of NCC Section J Parts J0 to J8, the NCC requirements will take precedence; any such issues must be noted in the credit submission.

Simulation software standards

Simulation software used for the purposes of this credit is required to have been tested in accordance with ASHRAE, 2007b (or a later version of the same standard), and have been demonstrated to be within the allowable range of results for all tests, as per the software requirements for Section J Verification Methods. The ABCB does not maintain a register of complying software, but software previously documented to have demonstrated compliance with the 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 800 (developed by Trane CDS)
- HAP E20-II (developed by Carrier).

These 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.

Additionally, all projects must demonstrate that software users or verifiers have received formal training from the software vendor in the use of the software.

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 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.

Definitions

Air conditioning

Describes the control of the temperature, and in some cases humidity, within a conditioned space (as defined herein) by application of either or both mechanical heating and mechanical cooling. These may include one or more of combustion, refrigeration (including reverse-cycle operation), direct electric heating, evaporative cooling or other processes specifically for the purpose of controlling the temperature in one or more spaces in a building. The heating or cooling effect in the space may be remote from the actual heating or cooling plant, with one or more transport media, such as air, water or refrigerant, used to transfer heat between the conditioned space and plant. An air conditioning system may also provide mechanical ventilation, but this is not necessary for the system to be classified as air conditioning.

Unlike the NCC definition, for the purposes of Green Star, air conditioning includes any services that directly maintain specialised conditions for any equipment or process, if that equipment or process is within the scope of the Green Star rating (refer to Scope of energy end use inclusions)

Conditioned space

A conditioned space is, as per the definition in the NCC, an internal space within a building, including a ceiling or under-floor supply air plenum or return air plenum, where the environment is likely, by the intended use of the space, to have its temperature controlled by air conditioning. For the purposes of defining the thermal envelope, exclusions as per the NCC definition apply (for non-habitable rooms of Class 2 and 4 buildings and parts of buildings; for spaces in Class 6, 7, 8 or 9b buildings with low energy input; and for lift shafts), but the energy (and water) use of these systems must be included if within the scope of the Green Star rating. Where a space is defined as conditioned, but the design does not include any specific air conditioning provision to service the space (i.e. a cold shell), the most energy-intensive fit out must be assumed based on the NCC DTS provisions and the most likely air conditioning fit out of the space.

A conditioned space may use natural, mechanical or mixed-mode ventilation, but is always air conditioned (whether by design or intent).

Mechanical ventilation

Describes the supply and/or exhaust 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 supply ventilation air may be controlled, but this is not necessary for the system to be classified as mechanical ventilation. May apply to conditioned or unconditioned spaces.

Mixed-mode ventilation

Describes a building control strategy in which natural ventilation occurs during favourable conditions, and mechanical ventilation occurs independently or supplementally when natural ventilation cannot satisfy requirements. The mechanical ventilation mode is typically coupled with temperature control by air conditioning and operates independently of natural ventilation, but this is not always the case, and is not necessary for the system to be classified as mixed-mode.

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. The version of the NCC applicable to a project is the version referenced in the Building Certifier's report (or equivalent certifying authority) for projects registered to *Green Star Buildings*. This revision of the guide is based on NCC 2019 and where the NCC is referenced in this document the applicable version is the 2019 code or any later version which is current at the time of the project's registration. Projects registered to earlier versions of Green Star and certifying against earlier versions of the code are instructed not to use this revision of the guide.

Natural ventilation

Describes the supply and/or exhaust of uncontrolled amounts of ventilation (outside) air by the use of openings in the building envelope (e.g. windows, non-powered ventilators and solar chimneys) which are connected to the conditioned space (as defined herein). 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. Active heating or cooling may be present in Naturally Ventilated spaces but may be subject to additional requirements. Ceiling fans are not considered active heating or cooling for the purposes of Green Star.

Energy

The type of resources that generate energy or electricity the building uses. This could be through renewable energy sources, such as solar PV, or grid electricity.

Energy use

Energy use refers to the total amount of energy a building consumes during operations

Process loads

A process load is defined as the load on a project resulting from the consumption of energy by a manufacturing, industrial or commercial process, and are unrelated to lighting, heating, ventilation, cooling and water heating or the comfort of occupants.

Project scope

All areas and activities in a project that have been registered for Green Star. This includes all buildings and any ancillary areas such as parking, landscaping and shared facilities.

Reference building

A hypothetical project of the same size, shape, floor area and same glazing shape and areas as the Proposed building, but whose building fabric and building services characteristics and air temperatures (as nominated in the NCC) are based predominantly on the NCC Section J Deemed-to-Satisfy provisions as defined in this document, and whose process energy consumption is based on appropriate benchmarks.

Proposed building fabric (formerly known as Intermediate Building under Design & As Built v1.3)

A hypothetical building of the same size, shape, floor area and same glazing shape and areas as the Proposed building, and including all the same building envelope design and performance characteristics as the proposed building, but building services characteristics and air temperatures (as nominated in the NCC)) are based predominantly on the NCC Section J Deemed-to-Satisfy provisions as defined in this document, and whose process energy consumption is based on appropriate benchmarks.

Proposed building

The building to be rated, with modelling undertaken in accordance with this guide where the below requirements are met:

- The performance of fan systems (J5.4), pump systems (J5.7), refrigerant chillers (J5.10) and heat rejection equipment (J5.12) must comply with the applicable efficiency requirements
- The performance of artificial lighting systems (J6.2) must comply with the overall lighting efficiency requirement
- Achieves thermal comfort requirements that complies with ASHRAE Standard 55 – 2020

Predicted mean vote (PMV) method

The PMV index predicts the mean response of a large group of people on a 7-point thermal sensation scale, from +3 (hot) to -3 (cold), where 0 is neutral. The metric is designed for fully mechanically ventilated buildings and is determined in accordance with *ANSI/ASHRAE Standard 55*. A PMV of -1 to +1 means that 80% of people are satisfied and comfortable.

Adaptive thermal comfort method

The Adaptive Thermal Comfort metric relates indoor design temperatures to outdoor temperatures. It is based on the understanding that occupants can adapt to, or even prefer a wider range of conditions.

Thermal comfort parameters

For the purposes of PMV calculation, thermal comfort parameters include:

- Air Temperature (°C)
- Air Speed (m/s)
- Relative Humidity (%)
- Mean Radiant Temperature (°C)
- Metabolic rates (met)
- Clothing Levels (clo)

Level of clothing (clo) and metabolic rates (met)

It is recommended that *ASHRAE 55:2020* is utilized for Clothing level (clo) and Metabolic rate (met), when determining PMV levels in the reference, proposed building fabric and proposed building. Alternatively, the below figures can be used and justified how they apply to spaces where adopted.

Building class space use	Clothing level (clo)	Metabolic rate (met)
Class 2 & 3 – All living areas (Summer)	0.36	1.0
Class 2 & 3 – All living areas (Winter)	0.74	1.0
Class 5 – Office (Summer)	0.61	1.1
Class 5 – Office (Winter)	0.96	1.1
Class 6 – Shopping Centre (Summer clothing)	0.5	1.7
Class 6 – Shopping Centre (Winter clothing)	1.0	1.7
Class 7 – Distribution areas	0.96	2.1
Class 7 – Storage areas	0.96	1.7

Calculation requirements

Green Star Buildings

Minimum Expectation

Green Star Buildings

The Minimum Expectation for this credit is that the Proposed building energy use is 10% less than that of the Reference Building.

In addition, it must be demonstrated that for the Proposed Building each of the following building system complies with the relevant DTS requirements of NCC Section J:

- The performance of wall-glazing constructions and display windows (J1.5) must comply with the total system R value, total system U value and system SHGC requirements, inclusive of thermal bridging effects. As an alternative to this requirements project teams may demonstrate compliance as per FAQ-271, included as appendix – *Alternative method to demonstrate compliance with Building Fabric*
- The performance of fan systems (J5.4), pump systems (J5.7), refrigerant chillers (J5.10) and heat rejection equipment (J5.12) must comply with the applicable efficiency requirements
- The performance of artificial lighting systems (J6.2) must comply with the overall lighting efficiency requirements.

Note:

On-site renewables cannot be used to contribute to the performance requirement for meeting the Minimum Expectation.

On-site renewable energy generation systems connected behind the meter **can be used** to calculate reductions in energy use of the building for the *Credit Achievement* and *Exceptional Performance*.

Evaluating energy reduction

Based on the completed project energy performance analysis, the energy consumption reduction is calculated by entering the Reference and Proposed Building annual energy consumption data into the Energy Use calculator. Values shall be entered for all end uses as applicable to the project. These values should represent the energy consumed by each end use, irrespective of the energy source. Offsets due to on-site generation:

- Will not contribute to meeting the Minimum Expectation in the Energy Use calculator
- Will contribute to meeting the Credit Achievement and Exceptional Performance in the Energy Use Calculator.

Sources generally are considered in the Energy Source credit.

The calculator automatically determines whether the Minimum Expectation has been satisfied, and the energy consumption reduction achieved, as well as calculating the number of points to be awarded.

Energy consumption reduction is calculated based on comparison of the Reference Building and the Proposed Building. As per the definitions of these, all design variables are reflected in this comparison, including services design strategy and choice of building fabric.

The energy consumption reduction is a direct comparison of the HVAC system loads and other services, such as lighting and vertical transportation, which affect the results of the energy consumption. The rationale of including other non-HVAC components in the calculation are to encourage the most cost-efficient solution without prejudice to any specific part of the building, as compared to a purely HVAC energy based calculation which will only emphasise a higher performing façade.

Scope of energy end use inclusions

The following end uses must be included in assessment of the building's energy use, as a minimum:

- All HVAC systems for control of the 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, 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.
- Where a space is defined as conditioned, but the design does not include any specific air conditioning provision to service the space (i.e. a cold shell), the most energy-intensive fit out must be assumed based on the NCC DTS provisions and the most likely air conditioning fit out of the space.

Note that lift and domestic hot water energy consumption must be included in both the Proposed and Reference Building energy consumption for Green Star ratings; NCC Section J clause Specification JVb 4(h) 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 residential projects (NCC Class 2). 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
- Commercial laundry operations. Note that the associated 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 (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 (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
- All industrial manufacturing processes.

For the *Minimum Expectation,* the Energy Use calculator will not allow on-site renewable energy generation systems connected behind the meter to contribute to reductions in energy use of the building.

Where present, on-site renewable energy generation systems connected behind the meter will be used to calculate reductions in energy use of the building for *Credit Achievement* and *Exceptional Performance* requirements in the calculator. Energy exported to the grid cannot be included in the calculator inputs.

Calculations must be completed in accordance with the methodology specified in this guidance document for the relevant technology.

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. For Design assessments, all references to as-built documents and material selections shall be read as references to equivalent design documents (Tender or Contract issue).

The information in this section shall be read in conjunction with the supplementary definitions (refer to Definitions).

Table 1: Modelling requirements for the Proposed and Reference building

Item	Description	Proposed building	Reference building
1	Thermal calculation method	A thermal calculation method that complies with ASHRAE 55 - 2020. Please refer to definition section on thermal comfort variables on different parameters that must be considered	As Proposed Building model (as NCC Section J Specification JVb clause 3(a)(i)). Please refer to definition section on thermal comfort variables on different parameters that must be considered
2	Location (selection of climate file)	One of the following options, listed in order of preference: A Reference Meteorological Year (RMY) if the project location is within 50 km of a RMY location for the same NCC climate zone A Test Reference Year (TRY) if the project location is within 50 km of a TRY location for the same NCC climate zone An International Weather Year for Energy Calculation (IWEC) if the project location is within 50 km of an IWEC location for the same NCC climate zone 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 project location for the same NCC climate zone In the absence of RMY, TRY or actual weather data within 50 km, interpolated data based upon 3 points within 250 km of the project location Details of RMY and TRY data sets are available from the Australian Climatic Data Bank administered by ACADS-BSG. IWEC data sets for Australia can be obtained from the EnergyPlus Weather Database.	As Proposed building model (as NCC Section J Specification JVb clause 3(a)(iii)).

Item	Description	Proposed building	Reference building
		In the event national or future climate files are released by the ABCB and required for use in meeting the NCC, these files must be used for Green Star. 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, or if an alternative source of weather data is considered to be more suitable for use given the nature of the project.	
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 Specification JVb clause 3(a)(iv)).
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 Specification JVb clause 3(c)(xiii)).
5	Orientation	The representation of the Proposed Building orientation shall be consistent with the as built documents.	As Proposed Building model (as NCC Section J Specification JVb clause 3(a)(v)).
6	Geometric model	The representation of Proposed building's geometry shall be consistent with the as built documents.	As Proposed building model (as NCC Section J Specification JVb clause 3(a)(vi)).
7	Building envelope	The simulation of the Proposed Building envelope shall be consistent with the as built documents and material selections. Actual construction R and U values shall be modelled inclusive of thermal bridging effects as required by Part J1.2(e). Where limitations exist to the definition of thermal bridges in the modelling software, it is acceptable to reduce the thickness of the insulation layer in a homogeneous construction until the actual R or U value is achieved.	The Reference Building thermal envelope shall be modelled based on the minimum performance requirements of Parts J1 and J3 (per NCC Section J Specification JVb clause 2(a)(i)). Glazing-wall construction parameters shall be determined using calculation method 2 per Specification J1.5. For residential parts of Class 2 buildings, the requirements for Class 3 buildings can be adopted to avoid the requirement for reverse engineering of NatHERS calculations to meet minimum star ratings.

Item	Description	Proposed building	Reference building
		Manual fenestration shading devices such as blinds or shades may be modelled using realistic operating criteria.	In order to maintain uniform building areas in the geometry models (per NCC Section J clause Specification JVb 3(b)(iii)), the modeller may manipulate either the insulation layer thickness, the insulation material thermal conductivity value, or both to achieve the required reference R or U value without affecting the building area where the modelling software uses defined construction thicknesses to determine net internal floor area. Glazing performance may not exceed U value 8.0 W/m².K and/or solar heat gain coefficient 0.87 on the basis that such performance is not physically realistic. The total R value of a wall construction shall not be less than the specified minimum value in clause J1.5(d), or more than 4.0 m².K/W. 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 Building. 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 Specification JVb 3(c)(ii)). Manual fenestration shading devices such as blinds or shades may be modelled using the same colour and operating criteria as for the Proposed building (as NCC Section J Specification JVb clause 3(b)(iv)).
8	External surfaces solar absorptance	The simulation of the Proposed Building envelope shall be consistent with the as built documents and material selections, except that solar absorptance shall be increased by 0.05 for walls and roofs to account for fouling and weathering of the materials.	Solar absorptance of 0.6 for walls *(as NCC Section J* Specification JVb *clause* 2(b)*), and as per J1.3(b) for roofs*. For climate zone 8, 0.7 for roofs.
9	Infiltration rate	Where no additional air leakage mitigation measures are taken beyond Part J3, the whole-building infiltration rate assumed for all spaces should be as specified in NCC Section J clause Specification JVb 2(d).	The whole-building infiltration rate applied for all spaces shall be as specified in NCC Section J Specification JVb clause 2(d).

Item	Description	Proposed building	Reference building
		Target infiltration rates converted from targets set as part of the Verification and Handover Minimum Expectation for air tightness pressure testing, per NCC Section J clause Specification JVb 3(c)(ix)(C), in accordance with ATTMA, 2010, or an equivalent standard, must be applied. The whole-building infiltration rate shall be determined from the specified or calculated building leakage rated using Tables 4.16 to 4.24 of CIBSE, 2010. Where an alternative approach to building air tightness testing has been approved by a Building Certifier, the building team may submit a Technical Question requesting a change for the Proposed Building only. The Technical Question must include supporting evidence demonstrating why the change is justified.	
10	Building operation	Operation should be specified based on the default operating profiles (refer to Default operating schedules) for the relevant space types. The simulation must incorporate variations for all day types as appropriate. Public holidays applicable to the project 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 Technical Question 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 technical question requesting a change for the Proposed Building only. The technical question must include supporting evidence demonstrating why the change is justified.	As per the Proposed Building, except where profiles are specifically modified to reflect design features of the Proposed building. Operating hours must be the same in both models.

Item	Description	Proposed building	Reference building
11	HVAC zones	The simulation of the Proposed building HVAC zones shall be consistent with the as built documents.	As Proposed building model (NCC Section J Specification JVb clause 3(c)(vi)), unless required to be modified to meet the system zoning requirements of Table 64 Item 1. However, if the external wall orientations of a perimeter zone differ by more than 45 deg, but the out-of-range segment accounts for less than 20% of the total wall length, then this does not need to be modified.
12	Heating, Ventilation and Air Conditioning	The Proposed Building HVAC system type and configuration must be modelled based on the as-built design. The simulated internal gains must be in accordance with HVAC system simulation parameters. Where variable volume control is specified, part-load fan power shall be modelled using one of the methods (refer to Variable air volume fan speed control). All ventilation-only systems (e.g. in car parks, loading docks and warehouses) must be included in the energy model. Refer to Default operating schedules 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). 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 (refer to Car park and loading dock atmospheric contaminant control systems). 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.	For Green Star ratings: The Reference Building HVAC system type, configuration and performance parameters must be as specified (refer to Reference building HVAC Systems) (NCC Section J Specification JVb clause 3(c)(i) does not apply). For Verification Method JV2: The Reference Building HVAC system type, configuration and performance parameters must be the same as the Proposed Building (NCC Section J Specification JVb clause 3(c)(i) applies). The design internal occupancy and equipment gains must be the same as for the Proposed Building (refer to HVAC system design parameters). The simulated internal occupancy and equipment gains must be the same as for the Proposed Building (NCC Section J Specification JVb clause 3(c)(vii)), 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 ventilation systems shall meet the maximum fan shaft power requirements of Part J5.
13	Artificial internal lighting	The Proposed Building artificial internal lighting system types and configuration must be modelled based on the as-built design. The annual energy consumption from internal artificial lighting, excluding emergency lighting, must be calculated on the basis of the proposed level	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 Specification JVb clause 3(c)(iv)). The Reference Building lighting power density can be adjusted for

Item	Description	Proposed building	Reference building
		of artificial lighting in the project with the daily profiles (refer to Default operating schedules). 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 Automatic lighting controls). 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.	Room Aspect Ratio (as per Table J6.2a note 2), but not for control devices (as per Table J6.2a note 3) (as NCC Section Specification JVb clause 2(e)). The same operating profiles must be used as are used in the Proposed Building (refer to Default operating schedules).
14	Artificial external lighting	The Proposed Building artificial external lighting system types and configuration must be modelled based on the as-built design. 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 (refer to Default operating schedules). All external lighting within the project 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 • The reference lighting power density (refer to Reference building pump power) 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 (refer to Reference building pump power), 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 AS/NZS 1158.3.1:2020.
15	Domestic hot water systems.	The Proposed Building domestic hot water system types and configuration, including fuel source, must be modelled based on the as-built design.	For Green Star ratings: The Reference Building hot water consumption shall be as calculated by the Green Star Potable Water calculator (NCC Section J Specification JVb clause 3(c)(viii) does not apply).

Item	Description	Proposed building	Reference building
	It is necessary to complete the Water Use calculator before the energy consumption from the Proposed and Reference Building domestic hot water system(s) can be calculated.	The Proposed Building hot water consumption shall be as calculated by the Green Star Potable Water calculator. The domestic hot water usage of the Proposed Building depends on the water efficiency of the taps and showers. Reduction in the volume of domestic hot water usage by installing water efficient fittings is one way to reduce energy use 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. Where from another source, the building team shall make appropriate assumptions which must be stated in the submission. The contribution due to solar thermal water heating shall be calculated based on the methodology (refer to Solar thermal systems for domestic hot water).	For Verification Method JV2: The Reference Building hot water consumption shall be the same as the proposed building (NCC Section J Specification JVb clause 3(c)(viii) applies). The domestic hot water heating system shall generally be of the same type or types (where multiple systems exist) as for the Proposed Building. Refer to Reference building domestic hot water systems for details of the Reference Building system properties. Make up water temperature shall be the same as for the Proposed Building. The fuel shall be the same as the Reference Building space heating system (refer to Reference building HVAC Systems), with full-load gross thermal efficiency as per NCC Section J clause J5.9(d).
16	On-site energy generation	The Proposed Building on-site (i.e. behind-the-meter) energy generation system types and configuration, including fuel source, must be modelled based on the as-built design. 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. Refer to Modelling domestic hot water systems and Renewable energy systems modelling guidelines for the modelling methodology for any such systems, as applicable. Where on-site energy generation systems cannot be controlled by time of use (e.g. renewable energy systems) any on-site generation that exceeds the prevailing building demand and is exported to the grid must be excluded from the contribution to the building. Where battery systems are used to store the excess energy for later use, they must be located on-site in order for the building to benefit from the stored energy.	None

Item	Description	Proposed building	Reference building
		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.	
17	Lifts	Modelled using the standard calculation methodology (refer to Lift energy consumption methodology).	Modelled using the standard calculation methodology (refer to Lift energy consumption methodology).
18	Other energy consumption	All services required for the operation of the building must be included in the 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 is not included in the assessment, except for residential parts of buildings (BCA Class 2), 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 (refer to HVAC system simulation parameters).	As Proposed Building model.
20	Appliances Applicable to Green Star- Design & As Built Residential parts of buildings (NCC Class 2)	Energy consumption of appliances and equipment must be included in the building energy consumption, as follows: • Refrigerators/freezer • Dish washers • Clothes washers • Clothes dryers	Refer to Reference building appliances for energy consumption standards applicable to the Reference Building appliances.

Item	Description	Proposed building	Reference building
		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. All other appliances are considered small power.	
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 project location. The contribution due to solar thermal water heating shall be calculated based on the methodology (refer to Solar thermal systems for domestic hot water). 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 Proposed 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 and associated plant • 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 (sensible heat transfer effectiveness of 50%), 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 2 hours, or as otherwise regulated. • Circulation of the pool water shall be continuous throughout the hours of operation • Circulation pumps shall have minimum pump power (refer to Reference building pump power) based on the flow rate defined by the

Item	Description	Proposed building	Reference building
			recirculation rate and using the same system pressure head as for the Proposed Building • No underwater pool lighting • 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 Proposed Building.

Operating profiles

Default operating profiles for all project types are provided (refer to Default operating schedules). 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 technical question and must be accompanied by confirmation from the client that the changes made are in accordance with the anticipated project operation.

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 (refer to Automatic lighting controls), either of the following calculation methods may be applied:

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

Where points are claimed in credit Light Quality for the achievement of internal daylight levels, (refer to Automatic lighting controls) for details of required inputs to the project energy performance simulation model.

Modelling control of natural-ventilation and mixed-mode systems

The purpose of the inclusion of simulation control parameters for natural ventilation and mixed-mode systems is to provide consistency in simulations which could otherwise potentially produce widely varying results depending on the parameters applied, particularly where a system relies on occupant control. While there is no absolute correct specification of the control parameters, the following guidelines have been developed to be consistent with the holistic objectives of Green Star. Variation from these parameters, other than where specifically stated, is therefore not allowed.

For the following three systems, these controls are only required to be applied during the hours of project or plant operation, as specified in the operating schedules, not continuously. Natural ventilation openings would be expected to be fully closed outside of these times.

Naturally-ventilated spaces with heating only

Modelling shall be completed on the basis of agreed minimum space temperature. Where the control temperature is less than the conventional value (21 °C for generally occupied spaces, or 18 °C for transitory occupied spaces), confirmation of client agreement of the minimum space temperature must be provided as part of the submission. The project team shall assume the following control actuation:

- Minimum operable device opening factor: 10%
- Heating system operates when $T_{space} < T_{lower} + 0.5$
- Operable devices open from minimum position when $T_{OA} > 12$ ℃ and $T_{space} \geq T_{lower} + 0.5$ (i.e. heating is off in the space)
- Operable devices are fully open when $T_{space} = 24$ ℃
- Operable devices close to minimum position during any hour when the following conditions occur:
  - $T_{OA} > 35$ ℃
  - $v_{wind} > 5$ 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. Operable devices will be open at all time during occupancy, including when heating systems are operational, and outside air load will contribute directly to the room heating load. If operable devices are closed, no ventilation air enters the building.

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 for generally occupied spaces, or 18-25 °C for transitory occupied spaces), 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:

- Minimum operable device opening factor: 10%
- Heating system operates when $T_{space} < T_{lower} + 0.5$
- Operable devices open from minimum position when $T_{OA} > 12$ ℃ and $T_{space} \geq T_{lower} + 0.5$ (i.e. heating is off in the space)
- Operable devices are fully open when $T_{space} = T_{upper} - 1.0$
- Mechanical cooling system operates when $T_{space} > T_{upper} - 0.5$
- Operable devices close to minimum position during any hour when the following conditions occurs:
  - $T_{OA} > 30$ ℃
  - $v_{wind} > 5$ 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. Operable devices will be open at all time during occupancy, including when cooling and heating systems are operational, and outside air load will contribute directly to the room heating or cooling load. If operable devices are closed, no ventilation air enters the building.

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 for generally occupied spaces, or 18-25 °C for transitory occupied spaces), 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, based on a mixed-mode strategy incorporating air conditioning:

- 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 $T_{space} = T_{upper} - 0.5$
- 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 Technical Question 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 active heating and cooling systems are off. When operable devices are closed, ventilation occurs via the mechanical/AC system.

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) (as NCC Section J clauses Specification JVb 4(b) and 4(e))
- 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.

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
- Operation of oil sump heaters to maintain the oil temperature above a minimum threshold (where applicable)
- 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
- Condenser water temperature reset in response to ambient temperature and fan speed control in response to leaving water temperature
- Cooling tower fan power and variable speed control of fans
- Staging and sequencing control of cooling towers in response to heat rejection load or other system variable
- Any other requirements as per NCC Section J clauses Specification JVb 4(b) and 4(c), and, for pumping energy, per NCC Section J clause Specification JVb 4(f)

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
- Operation of condenser water pumps, and variable-speed control of pumps

Modelling operation of space heating plant

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)
- 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
- Any other requirements as per NCC Section J clauses Specification JVb 4(b) and 4(c), and, for pumping energy, per NCC Section J clause Specification JVb 4(f)

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 Water Use calculator (refer to Water Use).

Where the Proposed building features multiple independent systems, the Reference Building must include the same number of systems serving the same areas of the project. The total domestic hot water usage for the project, as determined by the Water Use calculator, must be apportioned to each of these systems. The project team must demonstrate how this has been calculated. This may be by consideration of the building area served by each system, the relative water usage for each end use in the project, by use of available reference or empirical data whether project specific or generic (e.g. the histograms in CIBSE, 2004), or any combination of these or other methods. Where the same system type with the same primary energy source serves more than one part of the project, they may be aggregated for calculation purposes.

Where the project team is of the opinion that hot water usage included in the Water Use calculator is outside of the scope of the applicable rating type, and should be excluded from the calculations, this should be addressed in a technical question.

Where a system is indirectly fired from another thermal energy source, e.g. heating hot water system, a solar thermal collector requiring application of the detailed calculation method (refer to Solar thermal systems for domestic hot water) or recovered energy from another process, the annual total water usage for the system shall be converted to an hourly usage profile by consideration of:

- The number of days of project operation and the extent of operation per day (i.e. whether all or only a proportion of the end uses served by the system are operational)
- The usage during each day of operation. This may be by consideration of the hours of operation of the project the relative water usage for each end use in the project 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 hourly usage profiles is necessary in these cases to ensure that consideration is given to the simultaneity of energy availability and energy demand, and the consequential impacts on overall energy utilisation and system efficiency and performance.

Calculations of energy consumption may generally be based on total annual delivery volume of domestic hot water, with due account made for system losses from tanks, pipework and other components as applicable. Refer to Reference building domestic hot water systems for default values, which are to be used for the Reference building in all cases, and for the Proposed Building where the project team chooses. Where the project team chooses to apply loss factors for the Proposed Building that is less than the Reference Building values, these must be justified by the project team. Make up water temperature is the time-weighted average of the defined reference values. However, for indirect-fired systems as described above, calculations must be based on an hourly calculation of demand, losses and input. Such calculations must be completed as part of the overall energy simulation (refer to Energy performance calculation) and it is expected that the software would facilitate the calculation of losses based on system physical characteristics (including storage tank geometry and insulation thickness, and distribution pipework system length, representative diameter, and insulation thickness) and environmental temperatures (which may be based on unconditioned space temperatures calculated in the thermal simulation model, for example); where this is the case, Proposed Building losses must be calculated in this way.

The general form of the annual energy calculation is:

$$Q_{input} = \frac{q_{DHW} c_p \Delta T}{1000 \eta_{heater}} \left(1 + f_{standing} + f_{distribution}\right)$$

Where Q_{input} is the system total annual energy consumption (MJ/annum), q_{DHW} is the system annual domestic hot water usage (L/annum), c_p is the specific heat capacity of water (approximately 4.19 kJ/kg.K), ΔT is the temperature difference between supply and make up water temperatures (K), η_{heater} is the gross thermal efficiency of the water heater (%), $f_{standing}$ is a factor accounting for standing losses in the system, and $f_{distribution}$ is a factor accounting for distribution losses in the system. The factor 1000 adjusts from kilojoules to megajoules. Note that for the purpose of this calculation it is assumed that 1 L of water has a mass of exactly 1 kg, regardless of temperature.

As for space heating plant, the project team must confirm that the system fuel consumption is based on the fuel HHV or GCV (refer to Modelling operation of space heating plant).

Energy consumption of circulation pumps and other ancillary system components must be included in the building total energy consumption for both the Proposed and Reference Buildings. For the Reference Building, these values may be determined by prorating the Proposed Building values as follows:

$$X_{ref} = \frac{q_{ref}}{q_{prop}} X_{prop}$$

Where X is the quantity to be prorated, q is the annual domestic hot water usage (L/annum) for the system, and subscripts ref and prop refer to the Reference Building and Proposed Building values respectively.

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 (refer to Modelling operation of space heating plant).

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
- Staging and sequencing control of multiple cogeneration units
- Operation of oil sump heaters to maintain the oil temperature above a minimum threshold (where applicable)
- 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

Allowance must be made for all auxiliary equipment required for the operation of the system, per NCC Section J clause Specification JVb 4(g).

Modelling local shared services utilities

Where the project 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

- 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.

Refer to the *Green Star Buildings Shared Services and Low-Carbon Energy Supply Assessment Guidelines* for further details.

Modelling water usage of evaporative cooling systems

Evaporative cooling (direct or indirect) system water consumption models must account for 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).

Modelling water usage of heat rejection systems

Water consumption due to conventional cooling towers is calculated in the Water Use calculator based on the monthly total heat rejection load (refer to Water Use). The simulation is only required to calculate water usage of heat rejection systems where technology other than conventional cooling towers (e.g. adiabatic coolers) is 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
- 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 project total energy consumption.

Renewable energy systems modelling guidelines

Photovoltaic systems

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

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 Table 2: Photovoltaic system performance modelling requirements.

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 Software compliance framework).
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 General modelling criteria – Item 2)
3	Adjacent structures and features	Existing adjacent buildings must be included in the model (refer to General modelling criteria – Item 3).
4	Environmental conditions	The analysis must use the same environmental conditions as used in the assessment of the HVAC system performance (refer to General modelling criteria).
6	Geometric model	The representation of Proposed Building 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 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

Item	Description	Requirement
		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:

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

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 Table 3. 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)
- PVSyst (developed by PVSyst SA, Switzerland)
- Helioscope

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 Table 3.

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	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

Item	Mandatory Requirement	Additional Features
	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.	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.

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
- 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.

Solar thermal systems for domestic hot water

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 Water Use calculator), make up water temperature, 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.

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 Water Use calculator), system make up water temperature (refer to Scope of energy end use inclusions), system storage and flow temperatures, and estimated system heat losses.

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 (refer to Water Use). The modelling algorithm for the solar thermal components must e 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.

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 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 Technical Question must be submitted to confirm the approach prior to implementation in the model.

Modelling report content

Analysis software description

Project teams must provide information on analysis software used.

Table 4: Energy simulation analysis software reporting requirements

Software name and version	
Software name and version	
Software developer	
Software validation standard (evidence of developer's compliance to be provided)	
Simulator's name	
Summary of simulator's software training history*	
Verifier's name	
Summary of verifier's software training history*	

* One or other of the software user or verifier must have received specific training in the use of the software from the software vendor

Description

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

Table 5: General parameters reporting requirements

Paramater	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)		

Space summary

Project teams must confirm project space types and associated parameters as listed in

Table 6 and Table 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 (refer to Default operating schedules), this should be noted and justification given in an accompanying document (refer to Operating profiles).

Table 6: Area summary reporting requirements

Space Type	Building level	Gross floor area (m²)		
		Conditioned	Unconditioned	Total

Table 7: Simulation input summary reporting requirements

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

Building fabric description

Opaque fabric components

Project teams must report all R Values 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		

Transparent fabric components

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

Manual shading devices

Project teams must provide details of each manual shading device present in the project and included in the simulation.

Parameter	Proposed building	Reference building
Device type		
Location (internal or external)		
Colour		
Operating criteria		

Compliance with relevant DTS requirements of NCC Section J

This section must be completed where the method to demonstrate compliance with building fabric has been undertaken in accordance with the approach in the Submission Guidelines. For an alternative approach that allows modelling rather than DTS improvements, refer Appendix – *Alternative method to demonstrate compliance with Building Fabric.*

Wall-glazing constructions - Total system R Value

Wall reference	Allowable maximum area weighted system R value	Project achieved area weighted system R value	Percentage Improvement	Compliant? (Y/N)
	[R Value]	[R Value]	*[%]*	*[Y/N]*

Wall-glazing constructions - Total system U Value

Wall reference	Allowable maximum area weighted system U value	Project achieved area weighted system U value	Percentage Improvement	Compliant? (Y/N)
	[U Value]	[U Value]	*[%]*	*[Y/N]*

Wall-glazing constructions – SHGC Value

Wall-glazing reference	NCC Maximum allowable SHGC	Project Achieved system SHGC	Percentage Improvement	Compliant? (Y/N)
			[%]	*[Y/N]*

Display-glazing – Total System R Value

Display reference	Allowable maximum area weighted system R value	Project achieved area weighted system R value	Percentage Improvement	Compliant? (Y/N)
	[R Value]	*[R Value]*	*[%]*	*[Y/N]*

Display-glazing – Total System U Value

Display reference	Allowable maximum area weighted system U value	Project achieved area weighted system U value	Percentage Improvement	Compliant? (Y/N)
	[U Value]	*[U Value]*	*[%]*	*[Y/N]*

Display-glazing – SHGC Value

Display reference	NCC Maximum allowable SHGC	Project Achieved system SHGC	Percentage Improvement	Compliant? (Y/N)
			[%]	*[Y/N]*

Fan Systems (J5.4)

Fan type	Installation type	NCC Minimum Value	Proposed	Percentage Improvement	Compliant
[e.g. 101 -150]	*A/B/C/D*			*[%]*	*[Y/N]*

Pump Systems (J5.7)

Pump type	Reference pump motor input power	Proposed pump motor input power	Percentage Improvement	Compliant
[e.g. 101 -150]	*[W/m^2]*	*[W/m^2]*	*[%]*	*Y/N*

Refrigerant Chillers (J5.10)

Equipment type	NCC minimum energy efficiency ratio for full load operation (W_r//$W_{input\ power}$)	Achieved energy efficiency ratio for full load operation (W_r//$W_{input\ power}$)	Percentage improvement	NCC minimum energy efficiency ratio for integrated part load operation (W_r//$W_{input\ power}$)	Achieved energy efficiency ratio for integrated part load operation (W_r//$W_{input\ power}$)	Percentage improvement	Compliant
[e.g. Water Cooled Chiller]	*[Wr//Winput power]*	*[Wr//Winput power]*	*[%]*	*[Wr//Winput power]*	*[Wr//Winput power]*	*[%]*	*Y/N*

Heat Rejection equipment (J5.12)

Please complete the section, as relevant to the project.

Equipment type	NCC Cooling tower maximum fan motor input power (W/kW rej)	Proposed Cooling tower maximum fan motor input power (W/kW rej)	Percentage improvement	Compliant
				Y/N

Equipment type	NCC Closed circuit cooler maximum fan motor input power (W/kW rej)	Proposed Closed circuit cooler maximum fan motor input power (W/kW rej)	Percentage improvement	Compliant
				Y/N

Equipment type	NCC Evaporative condenser maximum fan motor input power (W/kW rej)	Proposed Evaporative condenser maximum fan motor input power (W/kW rej)	Percentage improvement	Compliant
				Y/N

Artificial lighting systems (J6.2)

Space type	NCC Maximum Aggregate Illumination Power	Project Achieved Aggregate Illumination Power	Percentage Improvement	Compliant
Whole Building	*[W]*	*[W]*	*[%]*	*Y/N*

Thermal comfort check

This section must be completed where the alternative method to demonstrate compliance with building fabric has been undertaken in accordance with Appendix – *Alternative method to demonstrate compliance with Building Fabric.*

Mechanically ventilated regularly occupied areas

95% of the mechanically ventilated regularly occupied areas must achieve a PMV (thermal comfort) value of +1 and -1 for 98% of the annual operating hours of the building in line with ASHRAE Standard 55 – 2020.

Space Type	Area (m2)	Reference building	Proposed building fabric	Proposed building
e.g. Office area		PMV value	PMV value	PMV value

Naturally ventilated regularly occupied areas

All naturally ventilated regularly occupied areas maintain the comfort level within 80% of acceptability limits in line with ASHRAE Standard 55 – 2020

Space Type	Area (m2)	Comfort level (%) within 80% of acceptability limits in line with ASHRAE Standard 55 – 2020		
		Reference building	Proposed building fabric	Proposed building
e.g. Warehouse area		%	%	%

Proposed Building Fabric check

The energy use (MJ/m2), of the proposed building fabric must be less or equal to the reference building modelled in accordance with the Table 1.

Reference Building (MJ/m2)	Proposed Building Fabric (MJ/m2)	Percentage improvement (%)	Compliant
			Y/N

HVAC services description

Air conditioning and air handling systems

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

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)		

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)		

Cooling and heat rejection plant

Project teams must provide details for each system and each individual item of equipment present. 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 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		

Parameter	Proposed building	Reference building
CCW heat rejection type		
CCW heat rejection capacity (kW)		
Fan absorbed power (kWe)		
Leaving CCW temperature set point (°C)		
Fan speed control		
Heat rejection sequencing and staging control		
Heat rejection equipment drift loss (%)		
Heat rejection equipment cycles of concentration		

Heating plant

Project teams must provide details for each system and each individual item of equipment present.

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		

Parameter	Proposed building	Reference building
Secondary pump control		

Co- and trigeneration systems description

Project teams must provide details for each system and each individual item of equipment present. 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 (refer to HVAC services description) and where present, absorption chiller technical details should be included (refer to Cooling and heat rejection plant). 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	

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 project.

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		

Domestic hot water services description

Project teams must provide details for each system present in the project. Hot water usage profiles must be documented where required to be used (refer to Modelling domestic hot water systems).

Table 17: Domestic hot water services parameters reporting requirements

Parameter	Proposed building	Reference building
System type		
System heat source		
Solar thermal collector (Y/N)		

Parameter	Proposed building	Reference building
Hot water usage (L/annum)		
System storage capacity (L)		
Storage tank volume, each (L)		
Heater thermal efficiency (%)		
System supply water temperature (°C)		
System make up water temperature (°C)		
Recirculation pump (Y/N)		
Operating days (days/annum)		
No of connected outlets		
System standing loss factor		

Appliances description

For residential (BCA Class 2) components of a *Green Star – Design & As Built* and *Green Star* – Interiors projects 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)		

Swimming pools description

Project teams must provide details for each swimming pool present in the project. 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 (m3)		
Pool surface area (m2)		
Heat source		
Heater efficiency		
Pool operation Hours		
Plant operations hours		
Recirculation time (hours)		
Circulation pump power (kW)		
Use of pool blanket		
Backflushing cycle duration		
Number of filters		
Design Water Temperature (oC)		
Room air design dry bulb temperature and relative humidity (oC/%)		

Process loads description

Project teams must provide details for each process present in the project. Project teams must provide evidence to justify the ratings and operation of both Proposed and Reference building process loads, particularly where improvements are claimed.

Where a project team is able to demonstrate an improvement on a benchmark for a particular process load, the GBCA will assess the proposed benchmarks on a case by case basis, through a Technical Question.

Table 20: Process load parameters reporting requirements

Parameter	Proposed building	Reference building
Process description		
Energy source		
Full-load power (kW)		
Equivalent full-load hours run		

Photovoltaic analysis and system description

Project teams must provide details for each system present in the project. Where an installation comprises of arrays having different inclinations and/or orientations, each array must be separately defined

Table 21: 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 22: 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	

Solar thermal system description

Project teams must provide details for each system present in the project. Where an installation comprises of arrays having different inclinations and/or orientations, each array must be separately defined.

Table 23: 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)	

Wind turbine description

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

Table 24: 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	

Manual calculations

The project team shall provide a summary of all manual calculations used in the assessment of the project 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.

Output data

Project teams shall provide software output reports documenting the energy end uses applicable to the Reference and Proposed building models. This information shall be readily reconcilable against the inputs in the Energy Use 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 project 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.

References

ASHRAE, 2007. American Society of Heating, Refrigerating and Air-Conditioning Engineers. “Standard 90.1-2007. Energy Standard for Buildings Except Low-Rise Residential Buildings (SI Edition),” American Society of Heating, Refrigerating and Air-Conditioning Engineers, USA. 2007.

ASHRAE, 2007b. American Society of Heating, Refrigerating and Air-Conditioning Engineers. “Standard 140-2007. Standard method of test for the evaluation of building energy analysis computer programs,” American Society of Heating, Refrigerating and Air-Conditioning Engineers, USA. 2007.

ASHRAE, 2010. American Society of Heating, Refrigerating and Air-Conditioning Engineers. “Standard 62.1-2010. Ventilation for Acceptable Indoor Air Quality,” American Society of Heating, Refrigerating and Air-Conditioning Engineers, USA. 2010.

ASHRAE, 2011. American Society of Heating, Refrigeration and Air Conditioning. “HVAC Applications Handbook,” American Society of Heating, Refrigeration and Air Conditioning, USA. 2011.

ASHRAE, 2013. American Society of Heating, Refrigeration and Air Conditioning. “Fundamentals Handbook,” American Society of Heating, Refrigeration and Air Conditioning, USA. 2013.

ATTMA, 2010. Air Tightness Testing and Measurement Association. “Technical Standard L2 Measuring Air Permeability of Building Envelopes (Non-Dwellings),” Air Tightness Testing and Measurement Association, UK. October 2010. http://www.attma.org/wp-content/uploads/2013/10/ATTMA-TSL2-Issue-1.pdf (accessed 12th March 2014).

ABCB, 2019. Australian Building Codes Board. “Building Code of Australia Volume One: Class 2 to Class 9 Buildings,” Australian Building Codes Board, Australia. May 2019.

Bannister, 2011. Bannister, Paul, Chris Bloomfield, and Haibo Chen. “Empirical Prediction of Office Building Lift Energy Consumption,” Proceedings of Building Simulation 2011: 12th Conference of International Building Performance Simulation Association, Australia. November 2011. http://www.ibpsa.org/proceedings/BS2011/P_1815.pdf (accessed 12th March 2014).

Barney, 2007. Barney, Gina. “Energy Efficiency of Lifts – Measurement, Conformance, Modelling, Prediction and Simulation,” Gina Barney Associates, UK. 2007. http://www.cibseliftsgroup.org/docs/Barney-on-energy%20efficiency%20of%20lifts.pdf (accessed 13th March 2013).

BC, 2006. Building Commission Victoria. “Practice Note 2006-09. Building energy analysis for commercial buildings,” Building Commission Victoria, Australia. June 2006. Superseded.

BSI, 1991. British Standards Institute. “BS 5925:1991 Code of Practice for Ventilation principles and designing for natural ventilation,” British Standards Institute, UK. 1991.

CIBSE, 2004. Chartered Institute of Building Services Engineers. “CIBSE Guide G: Public health engineering,” Chartered Institute of Building Services Engineers, UK. 2004.

CIBSE, 2005. Chartered Institute of Building Services Engineers. “CIBSE Guide D: Transportation systems in buildings,” Chartered Institute of Building Services Engineers, UK. 2005.

CIBSE, 2015. Chartered Institute of Building Services Engineers. “CIBSE Guide A: Environmental Design,” Chartered Institute of Building Services Engineers, UK. 2015.

DEE, 2018. Department of Environment and Energy. “Australian National Greenhouse Accounts: National Greenhouse Accounts Factors” Department of Environment and Energy, Australia. July 2018. https://www.environment.gov.au/system/files/resources/80f603e7-175b-4f97-8a9b-2d207f46594a/files/national-greenhouse-accounts-factors-july-2018.pdf (accessed 6th May 2019).

DOE, 2013. United States Department of Energy. “Energy Plus Engineering Reference Manual,” United States Department of Energy, USA. October 2013. http://apps1.eere.energy.gov/buildings/energyplus/pdfs/engineeringreference.pdf (accessed 19th March 2014).

E3, 2010. Energy Efficient Strategies. “Appliance Energy Consumption in Australia: Equations for Appliance Star Ratings,” Equipment Energy Efficiency (E3) Committee, Australia. September 2010. http://www.energyrating.gov.au/wp-content/uploads/2011/02/appliance-star-ratings1.pdf (accessed 26th March 2014).

EPA, 2013. United States Environment Protection Agency. “Glossary of Climate Change Terms,” United States Environment Protection Agency, USA. 2013. http://www.epa.gov/climatechange/glossary.html (accessed 13th March 2014).

IEA, 2012. International Energy Agency. “IEA Statistics: Natural Gas Information,” International Energy Agency, France. 2012. http://www.iea.org/media/training/presentations/statisticsmarch/NaturalGasInformation.pdf (accessed 13th March 2014).

IPCC, 1996. Intergovernmental Panel on Climate Change. “Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories,” UN. http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.html (accessed 13th March 2014).

ISO, 1995. International Organization for Standardization. “ISO 9806-3:1995 Test methods for solar collectors - Part 3: Thermal performance of unglazed liquid heating collectors (sensible heat transfer only) including pressure drop,” International Organization for Standardization, Switzerland. 1995. Superseded.

NIST, 2001. Emmerich, Steven J and Andrew K Persily. “State-of-the-Art Review of CO_2 Demand Controlled Ventilation Technology and Application,” Building and Fire Research Laboratory, National Institute of Standards and Testing, USA. March 2001. http://fire.nist.gov/bfrlpubs/build01/PDF/b01117.pdf (accessed 9th March 2014).

SA,2002. Standards Australia. “AS/NZS3666.1:2002 Air Handling and water systems of buildings – Microbial control. Part 1: Design, installation and commissioning,” Standards Australia. 2002.

SA, 2005. Standards Australia. “AS/NZS 1158.3.1:2005 Lighting for roads and public spaces - Pedestrian area (Category P) lighting - Performance and design requirements,” Standards Australia. 2005.

SA, 2007. Standards Australia. “AS/NZS 2535.1:2007 Test methods for solar collectors - Thermal performance of glazed liquid heating collectors including pressure drop,” Standards Australia. 2007.

SA,2008. Standards Australia. “AS/NZS4234:2008 Heated water systems—Calculation of energy consumption,” Standards Australia. 2008.

SA, 2008b. Standards Australia. “AS/NZS4776.2:2008 Liquid-chilling packages using the vapour compression cycle. Part 2: Minimum energy performance standard (MEPS) and compliance requirements,” Standards Australia. 2008.

SA, 2012. Standards Australia. “AS/NZS 1668.2:2012 Standards Australia. The use of ventilation and airconditioning in buildings – Mechanical ventilation in buildings,” Standards Australia. 2012.

UNEP, 2010: United Nations Energy Program. “Common Carbon Metric: Protocol for Measuring Energy Use and Reporting Greenhouse Gas Emissions from Building Operations (Draft for Pilot Testing),” Sustainable Buildings Climate Initiative, United Nations Energy Program, USA. 2010. http://www.unep.org/sbci/pdfs/Common-Carbon-Metric-for_Pilot_Testing_220410.pdf (accessed 13th March 2014).

Appendix

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 Table 25.

Table 25: 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	Refer to General modelling criteria
Infiltration rate	As per design	Refer to General modelling criteria

Notes:

- 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.

HVAC system simulation parameters

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

Table 26: 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 project have been designed to operate comfortably within a broader temperature band than for the Reference building, this widened 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 Specification JVb 2(c), the Reference building must operate within the temperature range 18 to 25 °C for at least 98% of plant operating hours in all conditioned spaces, and within the temperature range 21 to 24 °C for at least 98% of plant operating hours in all permanently occupied conditioned spaces. Where the design temperature range is within the relevant range for the space occupancy type, 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 25 °C respectively, or 21 and 24 °C respectively, as appropriate to the space occupancy. (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 should be used.	As Proposed building, per NCC Section J clause Specification JVb 3(c)(v).
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, per NCC Section J clause Specification JVb 3(c)(v).
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 (refer to Automatic lighting controls) have been applied.	The maximum lighting power density that is permitted by NCC Part J6 Artificial lighting and power (note 1).

Item	Proposed building	Reference building
Maximum equipment	The equipment loads that must be used in conjunction with the equipment profiles are given in Table 27.	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 the projects 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”.

Notes:

- 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 27: HVAC system simulation equipment loads

Space type (note 1)		Equipment load (W/m²)
Office (including any BCA 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

Space type (note 1)		Equipment load (W/m²)
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 spaces, libraries	27
	Wet laboratories	40

Notes:

- 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.

Default operating schedules

This section contains the occupancy and operational profiles which must be applied to each zone within the project 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 project occupancy. The modeller should verify that design temperatures are met at the start of project 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 (refer to Operating profiles).

Office

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

Table 28: 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

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 29: Healthcare general areas (12 hours/day) operating 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%	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 overnight 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 30: Healthcare general areas (24 hours/day) operating profiles

Hour of day	Weekday				(excl 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

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 31: 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

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 32: 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

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 33: 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

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 34: 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

Kitchens

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

Table 35: Kitchen operating profiles

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

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 36: 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

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 37: 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

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 38: 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

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 39: 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

School canteen

Table 40: 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

University teaching and classroom spaces

Table 41: 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

University dry laboratories, speciality learning spaces and libraries

Table 42: 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

University common spaces

Table 43: 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

University wet laboratories

Table 44: 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

University gymnasia

Table 45: 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

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 46: 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

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 47: 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

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 48: 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

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 49: 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

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 50: 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

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 51: 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

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 52: 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

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 53: 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

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 54: 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

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 55: 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

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

Where a project 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 56: 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

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 57: Apartment living space (including kitchen) operational profiles

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

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 58: Apartment living space (excluding kitchen) operational profiles

Hour of day	All days				
	Occup	Lighting	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

Multi-unit residential bedroom

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

Table 59: 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

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 60: Multi-unit residential common area operational profiles

Hour of day	All days				
	Occup	Lighting	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

Supplementary building and systems - definitions and calculation methods

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 61: 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

Reference building HVAC Systems

The following guidance has been based on Appendix G of ASHRAE Standard 90.1 (ASHRAE, 2007), and where appropriate the requirements have been modified to better suit the Australian market.

The Reference building HVAC systems must be of the type and description given in Table 61 and Table 62. The systems shall meet the general HVAC system requirements and any system-specific requirements as nominated in Table 63 (items 1-10 and 11-24 respectively) that are applicable to the Reference building HVAC system type(s).

All requirements given in Part J5 of the NCC must be met by the Reference building HVAC systems.

Building areas refer to the total conditioned area within the project scope only. For *Green Star Buildings* projects, 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.

Table 62: Reference building HVAC system types by project type

Project 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		
Base building systems (*Green Star Buildings* projects)	1	Air-cooled packaged reverse cycle heat pump systems No provision for tenant supplementary plant
Non-residential > 2,300 m² and less than 1,000 kWr total cooling capacity		
Base building systems (*Green Star Buildings* projects)	2	Variable air volume with reheat air conditioning Air-cooled chillers

Project type	System type	System description
		Where provided for the Proposed building, tenant supplementary condenser water system with open-circuit cooling towers
Non-residential and more than 1,000 kWr total cooling capacity		
Base building systems (Design & As Built projects)	3	Variable air volume with reheat air conditioning Water-cooled chillers Where provided for the Proposed building, tenant supplementary condenser water system with open-circuit cooling towers
Fire Stations	1	Package/Split DX reverse cycle (heat pump) systems

Table 63: 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
4	Package reverse cycle (heat pump) systems	Constant volume	Direct expansion	Electric heat pump

GBCA notes reference systems may change as fossil fuel systems are phased out of general use.

Table 64: 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, and shall conform to the system descriptions in Table 63. For system type 1 and 4, 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, parts of buildings or fitout works, 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).)

Item	Description	Requirement
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 HVAC plant shall be sized to meet the design criteria of the Reference building (refer to HVAC system design parameters). 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 or demand controlled ventilation	Where required by NCC Section J clause J5.3(a)(ii)(A) either ventilation heat recovery or demand controlled ventilation must be included in accordance with the requirements of this clause.
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: The method for determining reference fan power is as follows. The same method is applied for all fans applicable to the reference building: • System pressure loss is based on the design value without adjustment. Where a project considers there to be reasonable further benefit to be demonstrated by a more detailed calculation of the equivalent reference building pressure loss, as per Parts J5.4(c) and (d), this is allowed, but detailed calculation is not mandatory. • System flow rate is calculated for air conditioning systems from the total building cooling/heating load (as calculated by the software) and the defined system supply air temperature difference herein; and for ventilation-only systems based on the design supply or exhaust value, or the minimum quantity required by AS1668.2. • The above pressure and flow parameters define the reference duty point for the fan. • The fan system efficiency is minimum required value, as per clause J5.4(b), assuming the same fan type and installation arrangement as for the actual

Item	Description	Requirement
		system. This requires an iterative approach since the motor power is both dependent on the efficiency and an input to the efficiency calculation, but is relatively insensitive. With an initial efficiency value of 0.45, calculate the motor power and hence efficiency, then adjust the efficiency value in the motor power calculation to the new efficiency value. Continue until successive values of P_{ref}differ by no more than 0.1, which generally requires only two or three iterations. • The fan power is calculated as: $P_{ref} = \frac{q\Delta p}{1{,}000{,}000 \cdot \eta_{system}}$ Where P_{ref} is the reference pump power (kW), q is the duty flow rate (L/s), Δp is the system duty pressure loss (Pa) and η_{system} is the system efficiency (and pressure and efficiency are either static or total values, as applicable for the fan installation type).
11	Heat pumps (system type 1 and 4 as per Table 61)	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 clause J5.11 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 taken as equal to the stated values. Partial loads for heat pumps should be modelled as per the specified unit. Where energy modelling is performed prior to the specification of actual units, it is acceptable to use standard part load curves provided by the simulation software. The same part loads must be used for both the proposed and reference models. For reverse cycle heat pumps, where no 'typical' part loads curves are available, it is acceptable for these systems to be modelled to operate uniformly at the full load EER/COP.
12	Direct electric heating	Where applicable, direct electric heating will be applied with an associated efficiency of 100%.
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, natural gas will be used as the heating fuel in the Reference building, per NCC Section J clause J5.9(a). 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 clause J5.9(d). 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 and operating temperature (system types 2 and 3 as per Table 61)	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)). Operational temperatures shall be reset as follows (in accordance with NCC Section J clause Specification JVb 3(c)(xii)(A)): • Outside air temperature <8 °C: 80 °C supply temperature

Item	Description	Requirement
		• Outside air temperature 8-16 °C: linear variation from 80 to 60 °C Outside air temperature >16 °C: 60 °C supply temperature
15	Heating hot water pumps (system types 2 and 3 as per Table 61)	The Reference building hot-water pump system shall meet all the requirements of the NCC (refer to Reference building pump power). 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 61)	Piping losses for heating hot water and chilled water shall be the same for the Reference building as modeled in the Proposed building. 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 building.
17	Type and number of chillers (system types 2 and 3 as per Table 61)	Electric chillers shall be used in the Reference building, regardless of the actual cooling energy source. Where the Reference building 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 (Option 2) 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 and operating supply temperature (system types 2 and 3 as per Table 61)	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)). Operational temperatures shall be reset as follows (in accordance with NCC Section J clause Specification JVb 3(c)(xii)(A)): • Outside air temperature <16 °C: 10 °C supply temperature • Outside air temperature 16-24 °C: linear variation from 10 to 6.5 °C Outside air temperature >24 °C: 6.5 °C supply temperature
19	Chilled water pumps (system types 2 and 3 as per Table 61)	The Reference building chilled water pump system shall meet the requirements of the NCC (refer to Reference building pump power). 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 61)	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 greater, 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.

Item	Description	Requirement
		The Reference building fan power shall meet the requirements of the NCC Section J clause J5.12(a) for the applicable fan type.
21	Condenser water pumps (system type 3 as per Table 61)	The Reference building condenser water pump system shall meet all the requirements of the NCC (refer to Reference building pump power). 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 condenser water supplementary heat rejection (system types 2, 3 and 4 as per Table 61)	Tenant supplementary heat rejection shall be provided by a dedicated single-cell axial fan cooling tower sized for 100% of duty. Staged primary/secondary variable speed pumping (both two pumps each at 50% of design flow rate) shall be used, with a heat exchanger to separate primary (open) and secondary (closed) systems. System total pump power shall be assumed to be split in the ratio 1:2 between primary and secondary pumps. 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. Condenser water design leaving temperature shall be 29.5 °C or 5.5 K approach on design wet-bulb temperature, whichever is greater, 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 tower leaving condenser water temperature of 25 °C with minimum wet bulb approach of 3 K; and a heat exchange temperature difference of 1 K (i.e. nominal secondary system flow temperature of 26ºC). The tower fan shall be variable-speed controlled to maintain leaving water temperature at set point. The minimum variable speed pump operating point shall be assumed to be 30% of design flow rate (for an individual pump). The minimum flow rate through the cooling tower shall be assumed to be 40% of design flow rate. The Reference building fan power shall meet the requirements of the NCC Section J clause J5.12(a) for the applicable fan type.
23	VAV minimum flow setpoints (system types 2 and 3 as per Table 61)	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 61)	VAV system supply fans shall have variable speed drives, and their part-load performance characteristics shall be modeled using Method 1 (refer to Method 1 – part-load fan power equation for standard control) (clause G3.1.3.15 (ASHRAE, 2007)).

Notes:

- 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.
- In order to model chiller part-load operation to achieve the required IPLV, apply the multipliers as per Table 65 to the full-load EER to calculate the EER at 75%, 50% and 25% of full-load output at nominated reference conditions (SA, 2008b).

Table 65: 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

Chiller Capacity (kWr)	Air-cooled chiller			Water-cooled chiller		
	75%	50%	25%	75%	50%	25%
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

Chiller Type		Capacity		EER Multiplier at Part Load Factor		
Heat Rejection	Compressor	Min	Max	75%	50%	25%
Air-cooled	Any	0	528	1.59	1.79	1.2
Air-cooled	Any	>528		1.62	1.83	1.22
Water-cooled	Screw	0	264	1.51	1.71	1.16
Water-cooled	Screw	264	528	1.49	1.69	1.11
Water-cooled	Screw	528	1055	1.52	1.68	1.17
Water-cooled	Screw	1055	2110	1.48	1.68	1.14
Water-cooled	Screw	>2110		1.49	1.7	1.15
Water-cooled	Centrifugal	0	528	1.54	1.75	1.13
Water-cooled	Centrifugal	528	1055	1.39	1.59	1.12
Water-cooled	Centrifugal	1055	1407	1.49	1.68	1.11
Water-cooled	Centrifugal	>1407		1.49	1.7	1.15

Variable air volume fan speed control

Where the Proposed and/or Reference building 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:

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)).

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:

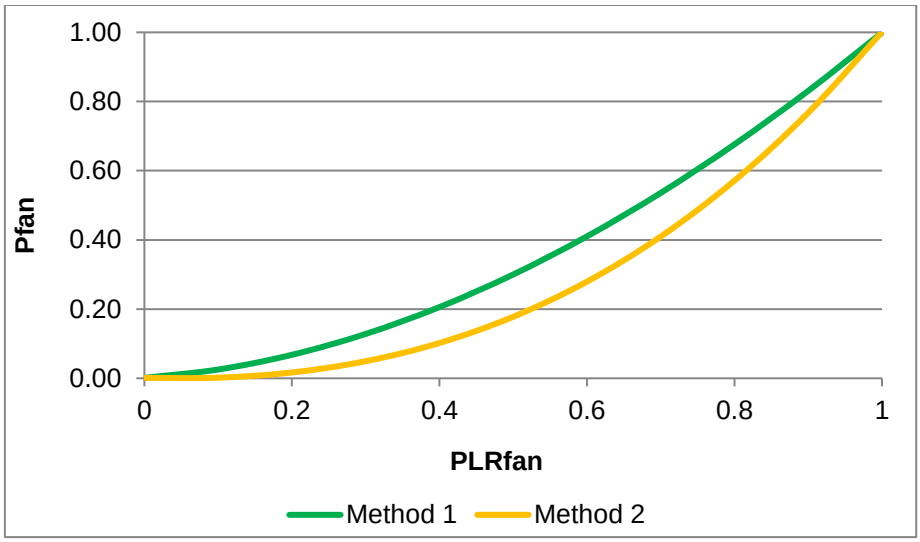

Figure 1: Proportion of full-load fan power for Method 1 and Method 2

Reference building pump power

The method for determining reference pump power is as follows. The same method is applied for all pumps applicable to the reference building:

- System pressure loss is based on the design value without adjustment. Where a project considers there to be reasonable further benefit to be demonstrated by a more detailed calculation of the equivalent reference building pressure loss, as per Part J5.7(c), this is allowed, but detailed calculation is not mandatory.
- System flow rate is calculated from the total building cooling/heating load (as calculated by the software) and the defined system temperature flow and return temperatures herein.
- The above pressure and flow parameters define the reference duty point for the pump.
- To determine the pump motor power, assuming the same pump type and rated motor speed as for the actual system:
  - For glandless impeller pumps, pump motor input power is based on the reference power as follows, assuming that the maximum flow and head values occur are at the reference duty point:

$$P_{ref} = 0.623 \cdot q\Delta p + 17\left(1 - e^{-0.11 \cdot q\Delta p}\right)$$

– Where P_{ref} is the reference pump power (W), q is the duty flow rate (L/s) and Δp is the system pressure loss (kPa); and

– For other pump types, pump efficiency is based on the minimum required efficiency as per EU 547/2012 Annex III, assuming that the reference duty point is the best efficiency point (BEP), as follows:

$$\eta_{pump} = 88.59 \cdot \ln n_s + 13.46 \cdot \ln q - 11.48(\ln n_s)^2 - 0.85(\ln q)^2 - 0.38 \cdot \ln n_s \cdot \ln q - C$$

Where η_{pump} is the pump combined mechanical and hydraulic efficiency (%), n_s is pump specific speed, q is the duty flow rate (m³/hour) and C is an efficiency parameter. Pump specific speed is defined as follows:

$$n_s = n \frac{\sqrt{q}}{\left({}^{1}/_{i}\,\Delta p\right)^{\frac{3}{4}}}$$

Where n is the pump speed (rev/minute), i is the number of pump stages (in the case of a multistage pump), and Δp is the system pressure head (m). C values are defined as follows, based on the specified minimum efficiency index (MEI) of 0.4:

Table 66: Pump efficiency parameter (C) by pump type and speed [MEI = 0.4]

Pump type	Pump speed (rev/minute)	C
End suction – own bearing	1450	128.07
	2900	130.27
End suction – close coupled	1450	128.46
	2900	130.77
End suction – close coupled inline	1450	132.30
	2900	133.69
Multistage – vertical	2900	133.95
Multistage – submersible	2900	128.79

The pump power is then evaluated as:

$$P_{ref} = \frac{2.725 \cdot q\Delta p}{\eta_{pump} \cdot \eta_{elec}}$$

Where P_{ref} is the reference pump power (W), q is the duty flow rate (m³/hour), Δp is the system pressure head (m) and η_{elec} is the overall electrical efficiency of the pump drive system (motor and variable speed drive). This value is taken to be the product of the MEPS minimum motor efficiency as applicable to the motor type (assuming high efficiency motor) (note: 2900 rev/minute is a 2-pole and 1450 rev/minute is a 4-pole motor) and a default value of 97% for a variable speed drive. MEPS values must be based on the 2018 GEMS Determination, not the 2012 version. Since the motor efficiency is a function of motor rated output, it is necessary to apply an iterative approach. With an initial efficiency value of 0.85, calculate the motor power and hence efficiency, then adjust the efficiency value in the motor power calculation to the new efficiency value. Continue until the successive values of P_{ref} differ by no more than 0.1, which generally requires only three or four iterations.

Reference building domestic hot water systems

The Reference building domestic hot water system(s) must generally be of the same type as installed in the Proposed building. However, if the Proposed building contains any indirect-fired domestic hot water systems using an energy source from an external system, such as heating hot water system or recovered energy from another process, then the Reference building shall be assessed

as if this energy source was not present and instead supplied solely by a dedicated water heater with the fuel source as per Table 1. Any solar thermal collectors shall also be ignored in assessment of the Reference building.

Where the Proposed building has storage systems, the Reference building may assume that the total storage volume is varied in proportion to the annual domestic hot water usage by use of the prorating method (refer to Modelling domestic hot water systems), and that the number of storage tanks is equal to the Proposed building.

For direct gas-fired storage water systems, the standing loss factor is as follows. The storage tank volume is the volume of each individual storage tank in the system. Interpolation between values is allowed, but not outside of the range. These values shall be used for the Reference building regardless of the fuel type:

Storage tank volume (L)	Storage tank turnover ratio			
	0.5	1	2	5
25	1.58	1.23	0.93	0.59
50	1.20	0.90	0.64	0.35
100	0.91	0.65	0.43	0.18
250	0.64	0.41	0.22	0.01
500	0.47	0.27	0.10	0.01
1000	0.34	0.16	0.03	0

For direct electric storage water systems, the standing loss factor is as follows. The storage tank volume is the volume of each individual storage tank in the system. Interpolation between values is allowed, but not outside of the range:

Storage tank volume (L)	Storage tank turnover ratio			
	0.5	1	2	5
25	0.46	0.38	0.30	0.21
50	0.38	0.30	0.23	0.15
100	0.31	0.24	0.17	0.09
250	0.23	0.16	0.10	0.02
500	0.17	0.11	0.05	0.01
1000	0.12	0.06	0.02	0

The storage tank turnover ratio is a measure of the number of times the water within the tank is replaced per day. This is calculated as follows:

$$R_{tank} = \frac{q_{DHW}}{NV_{total}}$$

Where R_{tank} is the storage tank turnover ratio (cycles per day), q_{DHW} is the system annual domestic hot water usage (L/annum), N is the annual number of days of operation of the system (days/annum), and V_{total} is the total storage volume of all tanks in the system.

For gas-fired instantaneous and continuous flow water heaters, the standing loss factor is 0.03. This value shall be used for the Reference building regardless of the fuel type.

For all system types the distribution loss factor is as follows. For the Reference building, use the values noted with an asterisk (*):

No of outlets per system	Without recirculation pump	With recirculation pump
1-10	0.01*	0.01
11-50	0.04*	0.03
51-100	0.07	0.05*
100-250	0.10	0.08*
251-500	0.13	0.10*
500+	0.20	0.15*

For the Reference building, these values may be determined by prorating the Proposed building values as follows:

$$X_{ref} = \frac{q_{ref}}{q_{prop}} X_{prop}$$

Where X is the quantity to be prorated, q is the annual domestic hot water usage (L/annum) for the system, and subscripts *ref* and *prop* refer to the Reference building and Proposed building values respectively.

External artificial lighting

Lighting power densities to be applied for the Reference building (and Proposed building where minimum illuminance values as per AS 1158.3.1 are not achieved by the design) shall be applied according to the usage category as follows:

Table 67: 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:

- 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.

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 building and all parameters for the Reference building are given in Table 68 below.

Table 68: 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 project type.	The number of trips for the Proposed building should be taken from Table 68.	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 Table 70) (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), $M_c = N_c = 0$.s

Table 69: Lift trips by project 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 70: 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 Table 69:

- 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 Technical Question proposing an alternative methodology. This may include lift simulation travel analysis. Where this is the case, the Technical Question 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 Table 69.

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 71: 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:

- 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.
- Based on warm-wash cycle energy consumption.
- Refer to E3, 2010 or relevant Australian Standards for equations used to calculate normalised energy consumption.

Energy consumption adjustment factors

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 Table 73 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 Table 72.

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 72: 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 project 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.

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 Table 73.

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 (refer to Default operating schedules) 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 Technical Question describing how they propose to apply adjustments for the specific control features and how the improvements have been assessed.

Table 73: Automatic lighting control adjustment factors

Item	Requirement for the use of the adjustment factor		Adjustment Factor
	Reference specification	**Reference performance**	
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 m2 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:
  - $F_{adj,dimmed} = F_{adj,switched} + (P_{dimmed} \times F_{adj,switched})$
  - 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 (refer to Modelling daylight-controlled artificial lighting systems). 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 Technical Question 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.

Alternative method to demonstrate compliance with Building Fabric

When targeting the Energy Use credit in Green Star Buildings using the Reference Building Pathway, as an alternative to meeting the DTS requirements of NCC section J1.5a listed on page 146 of the Green Star Buildings Rev B submission guidelines, project teams may demonstrate compliance using the below.

- The project team demonstrates that energy use is equal or less (MJ/m2), than a reference building modelled in accordance with the Table 1 of the Green Star Buildings Energy Use guide for both the
  - Proposed building fabric
  - Proposed building
- All three buildings (reference, proposed building fabric and proposed building) meet the thermal comfort requirements where:
  - 95% of the mechanically ventilated regularly occupied areas achieve a PMV (thermal comfort) value of +1 and -1 for 98% of the annual operating hours of the building in line with ASHRAE Standard 55 – 2020
  - All naturally ventilated regularly occupied areas maintain the comfort level within 80% of acceptability limits in line with ASHRAE Standard 55 – 2020