green star™

green building council australia

GREEN STAR - RETAIL CENTRE V1

ENERGY CALCULATOR GUIDE

FEBRUARY 2009

EXECUTIVE SUMMARY

The Green Star – Retail Centre v1 rating tool has been developed to assess the environmental attributes of new and refurbished retail centre facilities in Australia. The Energy Calculator within this tool compares the predicted energy consumption of a retail centre design to a benchmark. This comparison is then used to award points to any retail centre that improves on the benchmark.

To use the calculator, the predicted energy consumption of the retail centre must be calculated. Important components of this calculation are the heating and cooling energy consumption of the retail centre, which must be determined using computer modelling. This guide specifies standard inputs to be used when modelling the heating, ventilation and cooling (HVAC) systems of the retail centre. The standard inputs include operational profiles and internal heat loads that facilitate comparison between different retail centre designs.

The predicted ancillary load energy consumption, such as that from lighting, mechanical ventilation and lifts, must also be calculated. This guide includes details on how to calculate these loads in such a way that they can be fairly compared to the benchmark.

Finally, this guide includes information on how to enter the simulation outputs and the ancillary load calculations into the Green Star – Retail Centre v1 Energy Calculator.

The calculator compares the performance of the retail centre relative to set benchmarks. Information on how these benchmarks were set can be found in the Green Star – Retail Centre v1 Standard Practice document, available from www.gbca.org.au.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Tool Version	Revision	Date Issued
Green Star – Retail Centre v1	A	February 2009

1 Introduction

The Green Building Council of Australia (GBCA) has developed a suite of rating tools to assess the environmental performance of buildings in Australia. As part of this package, the Green Star – Retail Centre v1 rating tool assesses the environmental performance of retail centres by measuring their environmental impact.

The assessment of environmental performance includes determining the predicted energy consumption of a retail centre. The Green Star – Retail Centre v1 Energy Calculator has been developed to compare the predicted energy consumption to a benchmark. This report has been written as a guide to the calculator and data to be entered for calculations. More information on how the benchmarks were set can be found in the Green Star – Retail Centre v1 Standard Practice document, available from www.gbca.org.au.

2 Guidelines for Simulation Input Parameters

The parameters used to simulate the HVAC energy consumption of retail centres are given in this section. These are standard criteria that must be adhered to in order to comply with the Green Star requirements for the Energy Calculator. The outputs from this simulation will then be entered in the calculator, as outlined in Section 4.

2.1 GENERAL GUIDANCE

If a common central plant is shared by the rated development and another building or space, the central plant must be treated as follows:

1) The size of the central plant used for the energy calculations in this rating tool must be assumed as equivalent to the peak demand of the development to be rated; and

2) The part load curves for the actual central plant shall be applied proportionally to the central plant used for the energy calculations.

<u>Note that any apportioning of the central plant should be confirmed with the GBCA through a Credit Interpretation Request (CIR).</u>

2.2 HVAC SCENARIOS FOR TENANCY SPACES

There are a number of different ways that the base building can provide HVAC. Further detail on how each of these should be modelled can be found in Section 2.7 and Appendix E, these are summarised below:

1) Tenancies are provided with full air-conditioning by the base building;

2) Tenancies are provided with condenser water (this includes cases where heat is injected into the condenser water or condenser water is provided with a heating hot water loop);

3) Tenancies are provided with chilled water and/or heating hot water;

4) Tenancies are not provided with access to any HVAC system (guidance varies for Minor, Mini-Major and Major tenancies); or

5) Tenancies are effectively naturally ventilated.

2.3 GENERAL PARAMETERS

Modelling Parameter	Requirements
Simulation Package	• Passed the BESTEST[1] validation test; or • The European Union draft standard EN13791 July 2000; or • Be certified in accordance with ANSI/ASHRAE Standard 140-2001. Please contact the Green Building Council of Australia if it is not possible to comply with any of the above options.
Weather Data	• A Test Reference Year (TRY) if the building location is within 50km of the TRY location; or •In the absence of local TRY weather data, an actual year of recorded weather data from a location within 50km of the building location; or • In the absence of TRY or actual weather data within 50km, interpolated data based upon 3 points within 250km of the building location. Please contact the Green Building Council of Australia if it is not possible to comply with any of the above options.
Over-shadowing	• Demonstrate that overshadowing from the surrounding environment has been taken into account in the model.
Space Type Breakdown	• Demonstrate that the correct space types have been allocated in the building, and that the correct areas have been used.

Table 1: General Parameters Table

[1] The International Energy Agency, working with the U.S. National Renewable Energy Lab, has created a benchmark for building energy simulation programs. This benchmark is entitled "BESTEST – International Energy Agency Building Energy Simulation Test and Diagnostic Method".

2.4 BUILDING ENVELOPE

Modelling Parameter	Requirements
Building Form	• Demonstrate that the simulation model is an accurate representation of the building's shape; • Demonstrate that all floors in the building are modelled; and • Show that there are limited simplifications to the building form.
Insulation	• Demonstrate that insulation in the walls, ceilings and floors has been accurately represented.
Glazing	• Demonstrate that glazing is modelled using the following parameters: - Visible light transmission; - Solar transmission; - Internal and external solar reflectance; and - Emissivity.
Windows and Spandrel	• Demonstrate that the sizes of windows and spandrel are accurately represented.
Shading	• Demonstrate that all shading of windows and external building fabric has been accurately represented.
Orientation	• Demonstrate that the building orientation has been included in the model.
Infiltration	• Demonstrate that infiltration has been modelled to reflect façade design specification. Typical default values are 0.5 air changes per hour for perimeter zones and zero air changes per hour for central zones.

Table 2: Building Envelope parameters

2.5 INTERNAL LOADS FOR HVAC SIMULATION

Modelling Parameter	Requirements
Tenancy Lighting	• Demonstrate that tenancy lighting is calculated based on floor area and 20W/m². • Demonstrate that the appropriate operational profile (see Appendix B) has been used in the HVAC Model.
Non-tenancy lighting	• Demonstrate that non-tenancy lighting is calculated based on floor area. • Demonstrate that the appropriate operational profile (see Appendix B) has been used in the HVAC Model.
Tenancy equipment	• Demonstrate that tenancy equipment is calculated based upon floor area and 40W/m². • Demonstrate that the equipment load is modelled using the operational profile given in Appendix B.
Non-tenancy equipment	• Demonstrate that all non-tenancy equipment is calculated based on floor area. • Demonstrate that the equipment loads are modelled using the operational profiles in Appendix B.
Tenancy occupancy	• Demonstrate that all tenancy occupancies are calculated based on floor area. • Demonstrate that the occupancy load and profile used is that prescribed in Appendix B.
Non-tenancy occupancy	• Demonstrate that all occupancies are calculated based on floor area. • Demonstrate that the occupancy profile used is that prescribed Appendix B.

Table 3: Internal loads parameters

2.6 A/C PUMPING

Modelling Parameter	Requirements
Chilled water	• Demonstrate that chilled water pumping is calculated using the building cooling load, the static pressure of the chilled water pumps (typically 250kPa) and the flow rate in L/s.
Heating hot water	• Demonstrate that the hot water pumping is calculated using the building heating load, the static pressure of the hot water pumps (typically 250kPa) and the flow rate in L/s.

Table 4: A/C pumping parameters

2.7 HVAC SYSTEM OPTIONS

Note:The energy consumption from Major Tenancies, which are not provided with air-conditioning by the base building, or which are provided with condenser water, does not need to be evaluated or included in the Green Star – Retail Centre v1 Energy Calculator. The area of these spaces should however be included in the 'Majors not provided with access to the base building air-conditioning system.' space type in the excel tool.

Modelling Parameter	Requirements
1. All tenancies provided with full air-conditioning by the base building	• Demonstrate that the area of these spaces has been entered into the "All Tenancy Space excluding Majors not provided with access to the base building air-conditioning system " space type. • Demonstrate that the cell in the excel tool labelled "Does the base building supply only centralized chilled water and/or heating hot water to minor tenancies" is marked as "NO". • Demonstrate that the HVAC system has been modelled in full, in accordance with this guide.
2. All tenancies provided with condenser water (this includes cases where heat is injected into the condenser water, and condenser water is provided with a heating hot water loop)	• Demonstrate that the area of these spaces has been entered into the "Majors not provided with access to the base building air-conditioning system" space type. • Demonstrate that the cell in the excel tool labelled "Does the base building supply centralized chilled water and/or heating hot water to minor tenancies" is marked as "NO". • Note that the HVAC systems in this space will not be considered.
3. All tenancies provided with chilled water and/or heating hot water	• Demonstrate that the area of these spaces has been entered into the "All Tenancy Space excluding Majors not provided with access to the base building air-conditioning system " space type. • Demonstrate that the cell labelled "Does the base building supply centralized chilled water and/or heating hot water to minor tenancies" is marked as "YES". • Demonstrate that the HVAC system has been modelled with fan coil units in tenancy spaces, as per the requirements in Appendix E. • Demonstrate that the pressure drop through the unit has been modelled, and that the air flow rates used include any outside air as required by AS1668.2.
4.a. All tenancies except for Majors, not provided with access to the base building air -conditioning system	• Demonstrate that the area of these spaces has been entered into the "All Tenancy Space excluding Majors not provided with access to the base building air-conditioning system " space type. • Demonstrate that the cell labelled "Does the base building supply centralized chilled water and/or heating hot water to minor tenancies" is marked as "NO" • Demonstrate that a package unit has been modelled, as per the requirements in Appendix E • Demonstrate that the tenancies have been provided with, and are modelled with, the appropriate outdoor air requirements as per AS 1668.2. This must include the appropriate static pressures for fans (if required). • Demonstrate that the units must be modelled as constant air volume units, with a minimum supply air temperature of 12°C and a maximum temperature of 30°C. Note: Major tenancies not provided with access to any system do not need to be modelled in this way. They can be excluded from the Green Star – Retail v1 energy calculator.
4.b. Majors not provided with access to the base building air-conditioning system	•Demonstrate that the area of these spaces has been entered into the "Majors not provided with access to the base building air-conditioning system" space type •No further modelling of these spaces is required,

Table 5: HVAC system options

Modelling Parameter	Requirements
5. All Naturally ventilated tenancies	• Demonstrate that the area of these spaces has been entered into the "All Tenancy Space excluding Majors not provided with access to the base building air-conditioning system" space type. • Demonstrate that the cell labelled "Does the base building supply centralized chilled water and/or heating hot water to minor tenancies" is marked as "NO". • Demonstrate that the spaces are effectively naturally ventilated, in accordance with AS 1668.2-2002. • Demonstrate that the spaces achieve at least one point in the thermal comfort credit. • HVAC system energy from this space will be compared against a fully air conditioned centre.

Table 5: HVAC system options

2.8 HVAC SYSTEM SIMULATIONS

Modelling Parameter	Requirements
HVAC System design	• Demonstrate that the HVAC system modelled represents the system design for each part of the building.
Zoning	• Demonstrate that all air-conditioning zones represented in the thermal model accurately reflect system performance and zonal solar diversity.
Chiller plant	• Demonstrate that the chiller plant size is accurately reflected in the model. •Demonstrate that the actual efficiency curves of the installed plant are used in the model. • Water cooled equipment: Demonstrate that chiller data is specified under conditions that reflect the intended condenser water temperature controls. • Air cooled equipment: Demonstrate that the air cooled chiller COP profiles have been accurately modelled with regard to loading and ambient conditions.
Boiler plant	• Demonstrate that the boiler plant size, thermal efficiency and distribution efficiency are accurately reflected in the model.
Supply Air and Exhaust Fans	• Demonstrate that fan performance curves are accurately represented in the model. • Demonstrate that index run pressure drops are accurately represented to include the total static inclusive of filters, coils and diffusers.
Cooling Tower Fans	• Demonstrate that allowance for energy consumption from cooling tower fans has been made, based upon the annual cooling load of the building and the supplementary cooling load for tenancy air-conditioning.
Cooling Tower and Condenser Water Pumping	• Demonstrate that allowance for energy consumption from cooling tower and condenser water pumping has been made, based upon the annual cooling load of the building.

Table 6: HVAC system simulation

2.9 HVAC CONTROLS

Modelling Parameter	Requirements
Outside Air	• Demonstrate that outdoor air flows have been modelled as documented in the mechanical design drawings and specifications, and in compliance with the appropriate standards.
Economy Cycle	• Demonstrate that the economy cycle has been modelled to reflect system specification noting any enthalpy/temperature cut-off and control point.
Primary duct temperature control	• Constant Volume Systems: Demonstrate that modelling has allowed supply air temperatures to vary to meet loads in the space • Variable Volume Systems: Demonstrate that modelling has allowed supply air volumes to vary to meet loads in the space • Demonstrate that setpoints have been scheduled as specified. Note that simplifications may be made to consider average zone temperature in lieu of high/low select.
Airflow Control	• Demonstrate that control logic describing the operation of the dampers to control outside and re-circulated airflow is inherent in the model and accurately reflects the airflow characteristics of the system.
Minimum turndown	• Demonstrate, where relevant, that the minimum turndown airflow of each air supply is accurately reflected in the model.
Chiller staging	• Demonstrate that for systems that employ multiple chillers with a chiller staging strategy, the correct controls are modelled to reflect the actual relationship between the chillers.
Temperature control bands	• Demonstrate that the temperature control bands of the system accurately reflect the thermal model.

Table 7: HVAC Controls parameters

2.10 OTHER SERVICES

In addition to the building's air-conditioning system, the following items must also be accounted for in the energy consumption assessment;

- Domestic hot water supply;
- Lifts, escalators and travelators; and
- Mall, amenity, food court and stage/promotional area lighting and equipment.

These items will be entered separately into the calculator. **Domestic water pumping can be excluded**. Any other normal or extraordinary energy item that would reasonably be considered significant in an energy model must also be included and the calculation or simulation methodology must be adequately justified. This shall include, but not be limited to, groundwater or black water treatment plants.

Modelling Parameter	Requirements
Domestic hot water loads	• Domestic hot water loads (to showers and wash hand basins) are to be calculated using the method outlined in Appendix C. • *The methodology outlined in Appendix C is for all domestic hot water systems except for solar water and heat pump booster systems. Such systems should be evaluated using the* ***'Green Star Solar Hot Water and Heat Pump Booster Energy Calculation Methodology'*** *which can be downloaded from the GBCA website, www.gbca.org.au.*
Lift loads	• Lift loads are to be calculated using the method outlined in Appendix C.
Escalator and travelator loads	• Escalator and travelator loads are to be calculated using the method outlined in Appendix C.
Mall, Amenities, Stages and Food Court, Back of House (permanently occupied) and Back of House (Not occupied) Lighting	• Demonstrate that all non-tenancy lighting is calculated based on floor area. • Demonstrate that the appropriate Lighting Energy Consumption Profile in Appendix B has been used. The lighting profile can be adjusted if the following are installed: • Occupancy sensors: Lighting must follow the appropriate lighting profile whenever the appropriate occupancy profile is larger than zero. • Time Clocks: If lighting operates on a time clock then common area lighting must follow the appropriate lighting profile when specified as "on" by the electrical specification. This must operate for no less time than described for the previous point. • Daylight dimming: Details on this system and the calculation method must be provided. The calculation must use the methodology outlined in Appendix D.
Mall, Amenities, Stages and Food Court, Back of House (permanently occupied) and Back of House (Not occupied) Equipment	• Demonstrate that the equipment loads are modelled using the operational profiles as prescribed by Appendix B.

Table 8: Ancillary services parameters

3 Entering the simulation output data

The calculator is divided into six sections:

- Building Location and Greenhouse Gas Emissions Factors;
- Building Space Types;
- Modelling Information;
- Results Summary;
- Point Score Calculator; and
- Costs Savings Calculator

In all sections, relevant data must be entered into the white cells.

3.1 BUILDING LOCATION AND GREENHOUSE GAS EMISSIONS FACTORS

This section is for information only. It displays the greenhouse gas (GHG) emissions factors that are being used for the modelled and benchmark facilities.

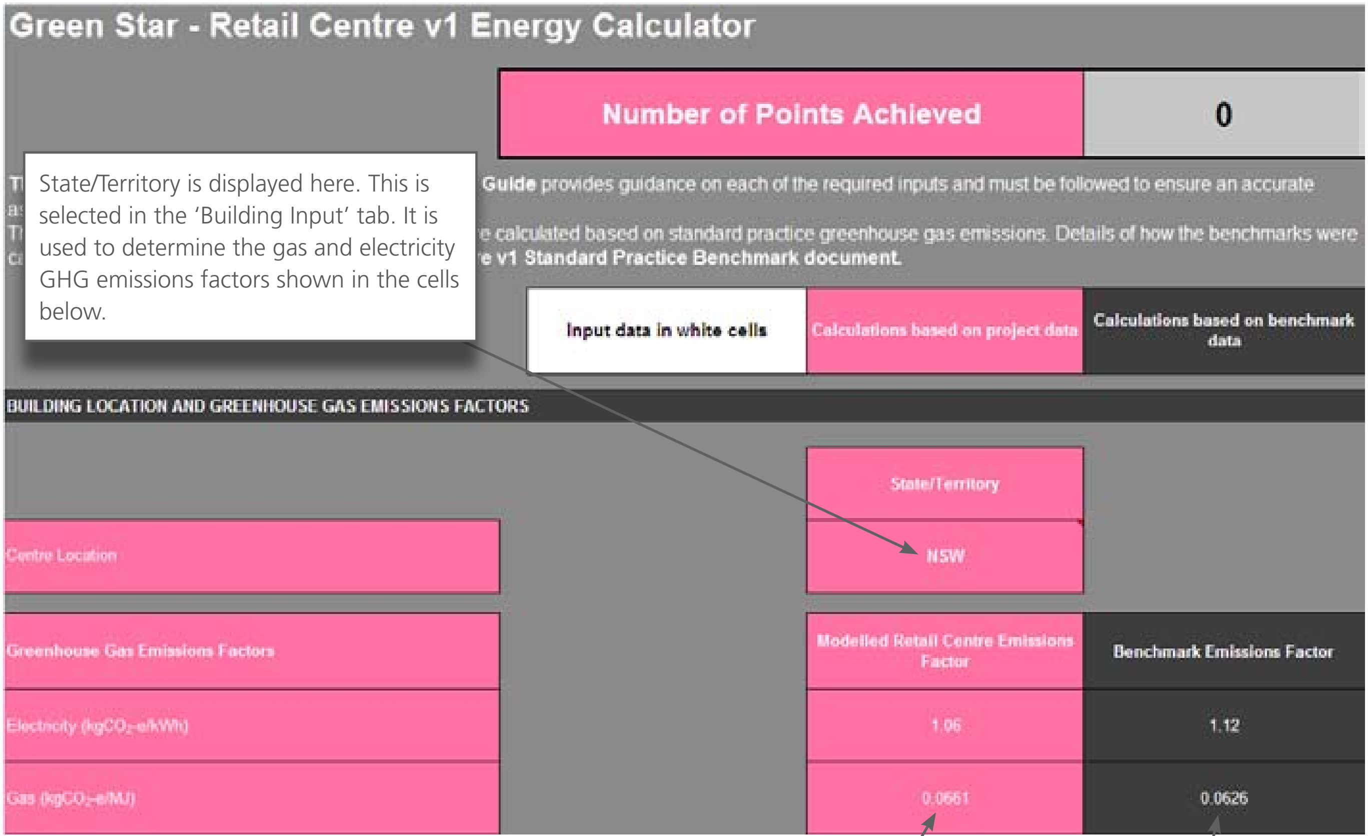


Figure 1: Building Location and Greenhouse Gas Emissions Factors

Greenhouse gas emissions factors used to determine the **modelled facility's** GHG emissions.

Greenhouse gas emissions factors used to determine the **benchmark** GHG emissions.

3.2 BUILDING SPACE TYPES

In this section, the user needs to enter the areas of each space type. The column on the right hand side shows the benchmark GHG emissions associated with the HVAC system operation for that space type

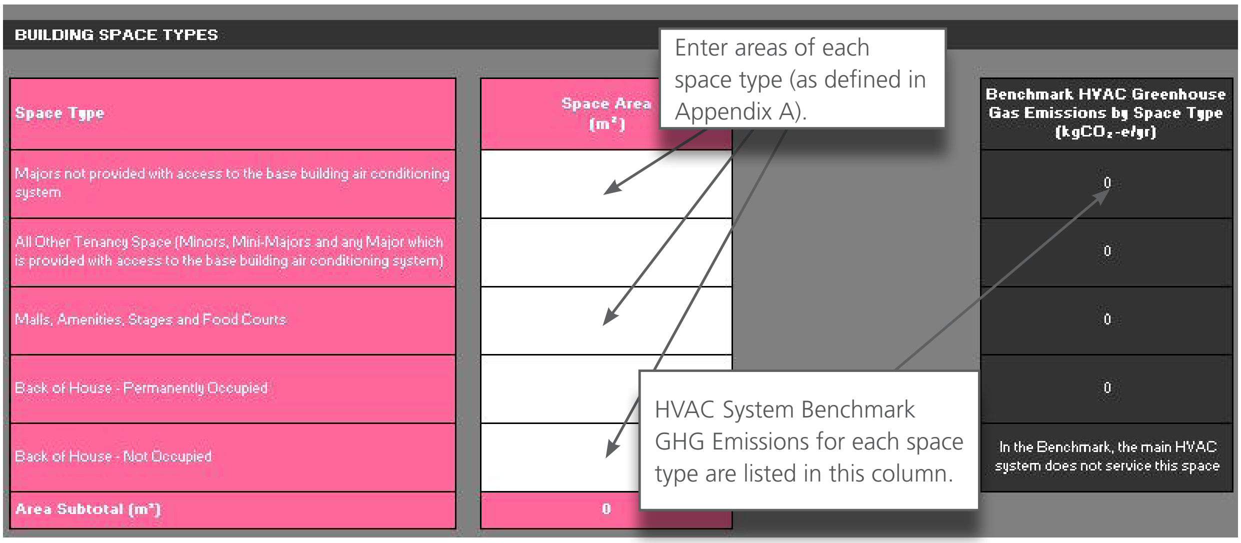


Figure 2: Building Space Types

3.3 MODELLING INFORMATION

This section requires the user to enter the energy consumption from the modelled HVAC, lighting and other energy consuming systems in the facility.

The columns on the right hand side present the GHG emissions associated with this energy use followed by the GHG emissions being assumed for the benchmark facility.

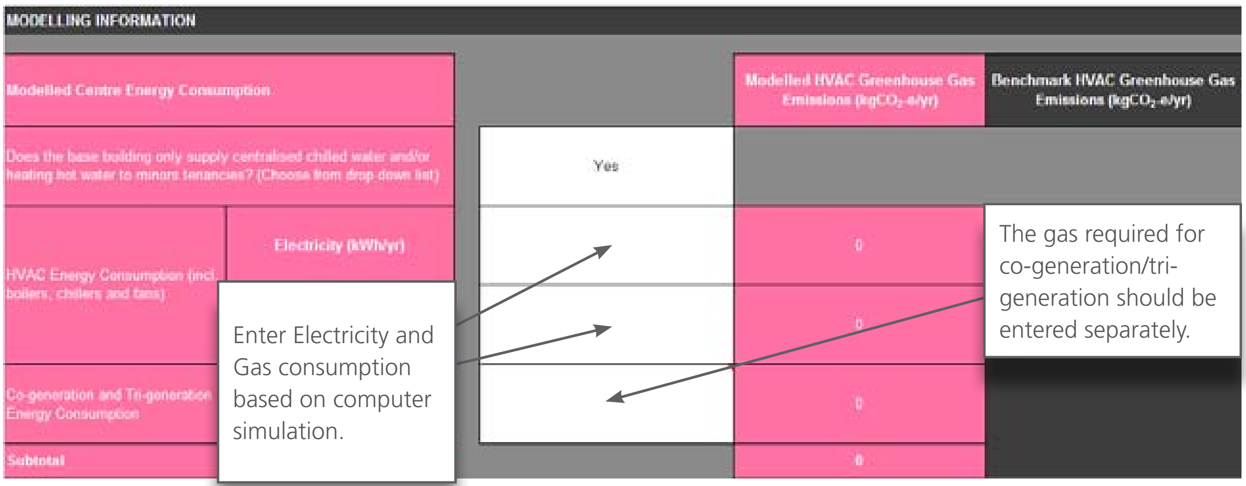


Figure 3: Modelling Information (1)

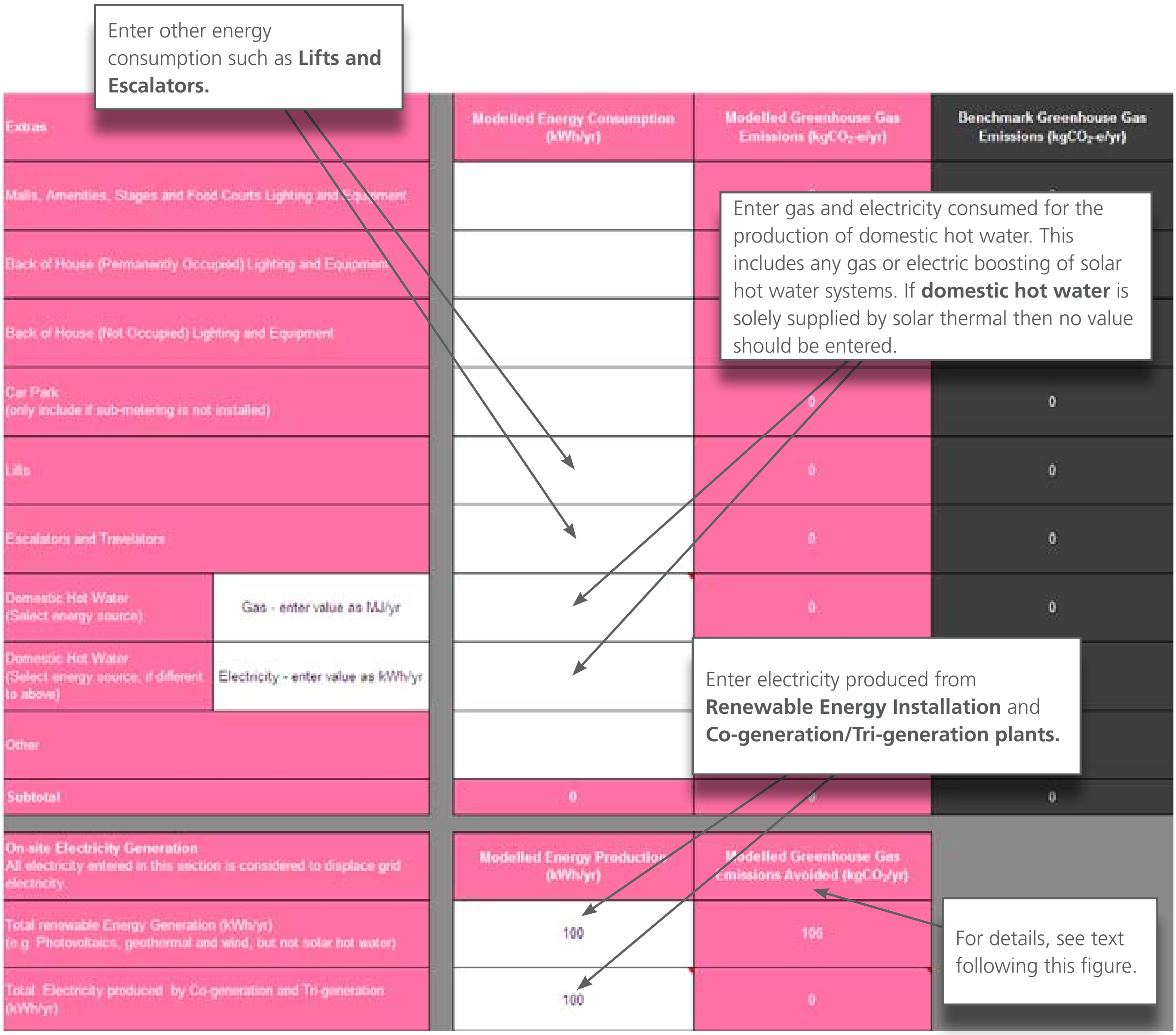


Figure 4: Modelling Information (2)

The 'Modelled Greenhouse Gas Emissions Avoided' column, to the right of the Energy Generation section, shows the quantity of GHG emissions from a grid power station that is no longer associated with this facility due to the production of electricity on site. However, where this electricity is being produced by the combustion of gas in a co-generation or tri-generation plant, there will be GHG emissions associated with it. The gas consumption should be entered into the appropriate cell at the beginning of this section.

If the co-generation/tri-generation plant is sized to produce more electricity than the facility needs, no carbon benefits will be associated with the exported electricity. A technical clarification detailing the calculations for this and all other Green Star energy calculators regarding the carbon emissions from co-generation and tri-generation plants has been prepared and is available in the GBCA website.

For a case study of onsite generation, please see Section 4: Case Study – On-site Energy Generation.

3.4 RESULTS SUMMARY

This section presents a summary of grid electricity and gas consumption from the modelled and benchmarked facilities along with the associated greenhouse gas (GHG) emissions.

The greenhouse gas savings are calculated as follows:
GHG savings = TOTAL Benchmark GHG emissions – TOTAL Facility GHG emissions

The percentage reduction of GHG emissions compared to the Standard Practice Benchmark is calculated as follows:

$$\% \text{ reduction} = \frac{(\text{TOTAL Benchmark GHG emissions} - \text{TOTAL Facility GHG emissions})}{\text{TOTAL Benchmark GHG emissions}} \times 100$$

RESULTS SUMMARY	Total Project Consumption (kWh Electricity, MJ Gas)	Total Project Greenhouse Gas Emissions ($kgCO_2$-e/yr)	Total Benchmark Greenhouse Gas Emissions ($kgCO_2$/yr)
Grid electricity	100	106	0
Gas	0	0	0
TOTAL		106	0
Greenhouse Gas Savings (Difference in greenhouse gas emissions between benchmark and facility (kgCO2/yr))		106	
Percentage reduction of Greenhouse Gas Emissions compared to the Standard Practice Benchmark		0.0%	

Figure 5: Results Summary

3.5 POINT SCORE CALCULATOR

This table displays the maximum GHG emissions that can be emitted by the facility to achieve the Green Star points. The percentage calculated in the previous section is used to determine the number of points achieved by the facility. The number of points is displayed below.

POINT SCORE CALCULATION

Green Star Points	Percentage Reduction of Greenhouse Gas Emissions Compared to Standard Practice Benchmark	Maximum Greenhouse Gas Emissions to achieve points ($kgCO_2$-e/yr)
20	100%	0
19	95%	37463
18	90%	74926
17	85%	112389
16	80%	149852
15	75%	187315
14	70%	224778
13	65%	262240
12	60%	299703
11	55%	337166
10	50%	374629
9	45%	412092
8	40%	449555
7	35%	487018
6	30%	524481
5	25%	561944
4	20%	599407
3	15%	636870
2	10%	674333
1	5%	711796
Standard Practice Benchmark	0%	749259

Number of Points Achieved	10

Figure 6: Point Score Calculation

3.6 COSTS SAVINGS CALCULATOR

The total grid electricity and gas consumed for the modelled and benchmark facility is multiplied by the costs per kWh and MJ entered by the user. This is used to calculate the annual savings that would be realised by the facility.

COST SAVINGS CALCULATOR	
Please note this this calculator does not take inflation or discounting into account. It is only intended as a rough guide to annual cost savings that could be made.	
Cost of Electricity ($/kWh)	
Cost of Gas ($/MWh)	
Possible Annual Cost Saving Compared to Benchmark ($/year)	$0.00

Figure 7: Cost Savings Calculator

4 Case Study – On-site Energy Generation

This case study illustrates how co-generation and solar hot water energy generation are captured within the calculator.

This centre has 25,000m² of tenancy area, 1,000m² of fully enclosed air conditioned mall, 100m² of back of house (permanently occupied) space, and 1,000m² of back of house (not occupied) space. It is located in NSW and generates electricity on site using co-generation, solar hot water and renewable energy. Firstly, the space type areas are calculated using the definitions in Appendix A.

Space Type	Area (m²)
Majors not provided with access to the base building air conditioning system	5,000
All Other Tenancy Space (Minors, Mini-Majors and any Major which is provided with access to the base building air conditioning system)	20,000
Malls, Amenities, Stages and Food Courts	1,000
Back of House - Permanently Occupied	100
Back of House - Not Occupied	1,000

Table 9: Space Type Areas for case study

Next, the HVAC consumption of electricity and gas is calculated using Section 2 of this Guide. Note that in this case gas consumption is only used to fire the co-generation plant on site. In other systems, gas used in the HVAC system should also be included here.

Energy Source	Energy Consumption (kWh/year)
Electricity	1,500,000
Gas	100,000 (MJ/year)

Table 10: HVAC Energy Consumption for case study

The lighting and equipment energy consumption is calculated using Section 3 of this Guide. Domestic hot water in this case is serviced by solar hot water with gas boost. Details of how to calculate energy consumption by domestic hot water systems are given in Appendix C – Other Energy Consumption.

Item	Energy Consumption (kWh/year)
Lighting and Equipment (Mall, Amenities, Stage/ Promotional Areas and Food Courts)	80,000
Back of House (Permanently Occupied) Lighting and Equipment	10,000
Back of House (Not Occupied) Lighting and Equipment	100,000
Car Park Energy Consumption (only enter energy consumption if sub-metering is not installed)	0
Lifts	120,000
Escalators and Travelators	170,000
Domestic Hot Water	175,000 (MJ/year gas)

Table 11: Lighting and Equipment Energy Consumption

Finally the onsite energy generation is calculated. Note that the solar hot water energy generation is not included here. The electricity produced from the co-generation plant however, is included here as it has not been accounted for as yet. In addition, 1000kWh of photovoltaic energy is included here.

On-site energy generation	Energy generation (kWh/year)
Renewable Energy (incl. Photovoltaics, Geothermal and Wind, but not solar hot water)	1,000
Onsite Generation (incl. Electricity from a co-generation/tri-generation system)	25,000

Table 12: On-site energy generation

This information is entered into the calculator as detailed below.

Areas of space types entered here.

BUILDING SPACE TYPES

Space Type	Space Area (m^2)	Benchmark HVAC Greenhouse Gas Emissions by Space Type ($kgCO_2$-e/yr)
Majors not provided with access to the base building air conditioning system	5,000	0
All Other Tenancy Space (Minors, Mini-Majors and any Major which is provided with access to the base building air conditioning system)	20,000	3,852,800
Malls, Amenities, Stages and Food Courts	1,000	76,417
Back of House - Permanently Occupied	100	11,309
Back of House - Not Occupied	1,000	In the Benchmark, the main HVAC system does not service this space
Area Subtotal (m^2)	**27,100**	

Figure 8: On-site Energy Generation Case Study (1)

MODELLING INFORMATION

Modelled Centre Energy Consumption			Modelled HVAC Greenhouse Gas Emissions ($kgCO_2$-e/yr)	Benchmark HVAC Greenhouse Gas Emissions ($kgCO_2$-e/yr)
Does the base building only supply centralised chilled water and/or heating hot water to minors tenancies? (Choose from drop down list)		Yes		
HVAC Energy Consumption (incl. boilers, chillers and fans)	Electricity (kWh/yr)	1,500,000	1,590,000	3,940,526
	Gas (MJ/yr)		0	
Co-generation and Tri-generation Energy Consumption	Gas (MJ/yr)	100,000		
Subtotal				

HVAC and lighting electricity consumption and gas used by co-generation plant is entered here.

Extras		Modelled Energy Consumption (kWh/yr)	Modelled Greenhouse Gas Emissions ($kgCO_2$-e/yr)	Benchmark Greenhouse Gas Emissions ($kgCO_2$-e/yr)
Malls, Amenities, Stages and Food Courts Lighting and Equipment		80,000	84,800	102,200
Back of House (Permanently Occupied) Lighting and Equipment		10,000	10600	14,594
Back of House (Not Occupied) Lighting and Equipment		100,000	106,000	83,804
Car Park (only include if sub-metering is not installed)			0	0
Lifts		120,000	127,200	221,200
Escalators and Travelators		170,000	180,200	168,000
Domestic Hot Water (Select energy source)	Gas - enter value as MJ/yr	175,000	11,568	0
Domestic Hot Water (Select energy source, if different to above)	Electricity - enter value as kWh/yr		0	50,400
Other				
Subtotal		655,000		

On-site Electricity Generation All electricity entered in this section is considered to displace grid electricity.	Modelled Energy Production (kWh/yr)	Mode... E...
Total renewable Energy Generation (kWh/yr) (e.g. Photovoltaics, geothermal and wind, but not solar hot water)	1,000	1,060
Total Electricity produced by Co-generation and Tri-generation (kWh/yr)	25,000	26,500

On-site generation is entered here. This includes electricity generated from co-generation and from renewables. This does not however include energy generated from solar hot water.

Figure 9: On-site Energy Generation Case Study (2)

RESULTS SUMMARY

	Total Project Consumption (kWh Electricity, MJ Gas)	Total Project Greenhouse Gas Emissions ($kgCO_2$-e/yr)	Total Benchmark Greenhouse Gas Emissions ($kgCO_2$/yr)
Grid electricity	1,954,000	2,071,240	4,579,619
Gas	275,000	18,178	1,105
TOTAL		2,089,418	4,580,724

Greenhouse Gas Savings (Difference in greenhouse gas emissions between benchmark and facility (kgCO2/yr))	2,491,306
Percentage reduction of Greenhouse Gas Emissions compared to the Standard Practice Benchmark	54.4%

POINT SCORE CALCULATION

Green Star Points	Percentage Reduction of Greenhouse Gas Emissions Compared to Standard Practice Benchmark	Maximum Greenhouse Gas Emissions to achieve points ($kgCO_2$-e/yr)
20	100%	0
19	95%	229036
18	90%	458072
17	85%	687109
16	80%	916145
15	75%	1145181
14	70%	1374217
13	65%	1603253
12	60%	1832289
11	55%	2061326
10	50%	2290362
9	45%	2519398
8	40%	2748434
7	35%	2977470
6	30%	3206507
5	25%	3435543
4	20%	3664579
3	15%	3893615
2	10%	4122651
1	5%	4351687
Standard Practice Benchmark	0%	4580724

This retail centre gains 10 points under Ene-1.

Number of Points Achieved	10

Figure 10: On-site Energy Generation Case Study (3)

APPENDIX A: SPACE TYPE DEFINITIONS

The following provides definitions of the space types used within the Green Star - Retail Centre v1 Energy Calculator.

Tenancy Space

Those spaces designated to future retail tenancy cores. These spaces are generally not provided with any base building lighting. These spaces include majors, minors, banks, gyms, specialty stores, fast food restaurants and mini majors. The areas of these spaces must be entered into one of two cells in the excel tool:

1. All Tenancy Space excluding Majors not provided with access to the base building air conditioning system; or
2. Majors not provided with access to the base building air conditioning system

Please refer to Section 2.7: HVAC System Options, for further guidance on where to enter the tenancy space areas into the excel tool (where to enter the figures depends on the HVAC servicing strategy of each tenancy space). It is important to enter the areas correctly as this defines the benchmark figure which the proposed retail centre is compared against,

Malls

Malls are circulation spaces onto which shopfronts open. These spaces are usually air-conditioned, mechanically ventilated and provided with lighting from the base building. Some equipment may also be provided to these spaces.

Where shopfronts open onto non-enclosed space (the outdoors), the area up to 5 metres from the shopfront or bounded by a road or other obstruction, can be counted as external mall space. This may include portions of recreation space, courtyards or other spaces which are directly in front of shop fronts.

Also note that the external mall space area boundary should be perpendicular to the boundary of the shopfront and that overlapping areas should not be counted more than once. These points are illustrated in the diagram below.

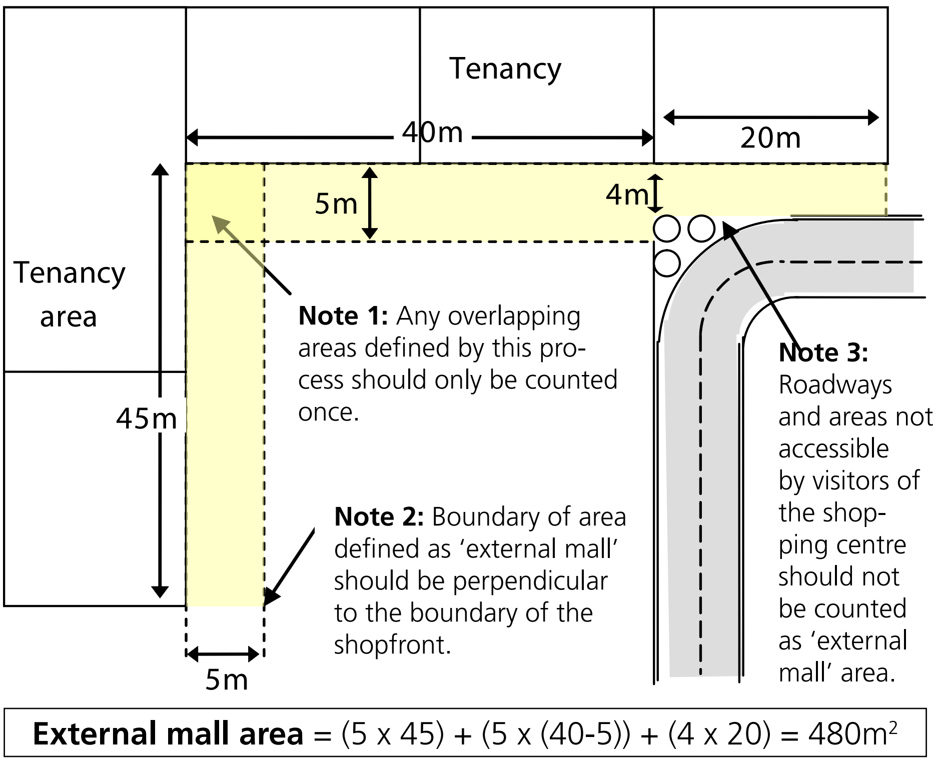


Figure 11: Example Calculation of External Mall Area

Amenities

Amenities consist of toilets, change rooms, showers, lockers and parents' rooms. These spaces are usually provided with mechanical ventilation and artificial lighting.

Food Courts

Food courts are classed as open areas where people eat and congregate. These spaces usually have a higher occupant density than mall areas and will be air conditioned and mechanically ventilated by the base building. Lighting may also be provided by the base building.

Stage/ Promotional areas

Spaces where people congregate to watch events. These spaces will have a higher occupant density than food courts when in use, but may not be used every day. These spaces are usually air conditioned and mechanically ventilated by the base building. They may also be provided with some lighting and equipment.

The area of mall, amenity, food court and stage/promotional areas are added as a single area into the Green Star – Retail Centre v1 Energy Calculator.

Back of House - Permanently Occupied

Back of house areas that are permanently occupied include control rooms and offices. The base building will usually provide these spaces with mechanical ventilation, air-conditioning and artificial lighting. These spaces include centre management offices.

Back of House - Not Occupied

Back of house areas that are not occupied include non-publicly accessible areas such as plant rooms, storage areas, fire-stairs and passageways. The base building will usually provide these spaces with mechanical ventilation and artificial lighting but not air-conditioning.

Car Parks and Loading Docks

Interior and Exterior car parks and loading docks are spaces where cars and delivery vehicles are parked or can circulate. These spaces will have higher circulation rates than commercial building car parks of a similar size. These spaces are considered to be external impermeable spaces and will be provided with mechanical ventilation and artificial lighting by the base building.

APPENDIX B: OPERATIONAL PROFILES

Tenancy Areas

HVAC Model Operational Profile

Operational Profile applicable for 7 days / week						
Time	Occupancy Gains (W/m²)		Occupancy (m²/person)	Lighting (W/m²)	Equipment (W/m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0	0	Off
1am	0	0	0	0	0	Off
2am	0	0	0	0	0	Off
3am	0	0	0	0	0	Off
4am	0	0	0	0	0	Off
5am	0	0	0	0	0	Off
6am	0	0	0	0	0	Off
7am	0	0	0	0	0	On
8am	0	0	0	20	40	On
9am	15	10.6	4.67	20	40	On
10am	17.8	12	3.93	20	40	On
11am	17	11	4.12	20	40	On
12pm	17	11	4.12	20	40	On
1pm	13	9	5.30	20	40	On
2pm	13	9	5.30	20	40	On
3pm	8.9	6	7.86	20	40	On
4pm	8.9	6	7.86	20	40	On
5pm	8.9	6	7.86	20	40	On
6pm	0	0	0	0	0	Off
7pm	0	0	0	0	0	Off
8pm	0	0	0	0	0	Off
9pm	0	0	0	0	0	Off
10pm	0	0	0	0	0	Off
11pm	0	0	0	0	0	Off

Table 13: Tenant operational profile

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0800	0%
08000-1600	100%
1500-0000	0%

Table 14: Tenant operational Lighting Energy Consumption Profile

Malls, Food Courts, Amenities and Stage/Promotional Areas

The table below outlines the operational profile for malls, food courts, stage/promotional areas and amenities on weekdays, Saturdays and Sundays. Note that when modelling these spaces, the model should use the lighting and equipment densities as designed for these spaces.

HVAC Model Operational Profile

Operational Profile applicable for 7 days / week						
Time	Occupancy Gains (W/m²)		Occupancy (m²/person)	Lighting (W/m²)	Equipment (W/m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0	0	Off
1am	0	0	0	0	0	Off
2am	0	0	0	0	0	Off
3am	0	0	0	0	0	Off
4am	0	0	0	0	0	Off
5am	0	0	0	0	0	Off
6am	0	0	0	0	0	Off
7am	0	0	0	0	0	Off
8am	0	0	0	25	0	On
9am	15	10.6	4.67	25	0	On
10am	15	10.6	4.67	25	0	On
11am	17.8	12	3.93	25	0	On
12pm	17.8	12	3.93	25	0	On
1pm	17	11	4.12	25	0	On
2pm	17	11	4.12	25	0	On
3pm	17	11	4.12	25	0	On
4pm	13	9	5.3	25	0	On
5pm	8.9	6	7.86	25	0	On
6pm	0	0	0	0	0	Off
7pm	0	0	0	0	0	Off
8pm	0	0	0	0	0	Off
9pm	0	0	0	0	0	Off
10pm	0	0	0	0	0	Off
11pm	0	0	0	0	0	Off

Table 15: Operational profile for malls, food courts, amenities and stage and promotional areas

Back of House Permanently Occupied

The table below outlines the operational profile for back of house permanently occupied areas on weekdays, Saturdays and Sundays.

If these spaces are not fitted out as part of the base building works, a peak value of 11W/m² may be used.

HVAC Model Operational Profile

Operational Profile applicable for 7 days / week						
Time	Occupancy Gains (W/m²)		Occupancy (m²/person)	Lighting (W/m²)	Equipment (W/m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	2	6	Off
1am	0	0	0	2	6	Off
2am	0	0	0	2	6	Off
3am	0	0	0	2	6	Off
4am	0	0	0	2	6	Off
5am	0	0	0	2	6	Off
6am	0	0	0	2	6	Off
7am	1	0.5	70	5	7	Off
8am	2	1.7	35	11	9	On
9am	3.9	3	17.5	12	11	On
10am	3.9	3	17.5	12	11	On
11am	3.9	3	17.5	12	11	On
12pm	3.9	3	17.5	12	11	On
1pm	3.9	3	17.5	12	11	On
2pm	3.9	3	17.5	12	11	On
3pm	3.9	3	17.5	12	11	On
4pm	3.9	3	17.5	12	11	On
5pm	2	1.7	35	10	9	On
6pm	0	0	0	7	7	Off
7pm	0	0	0	7	7	Off
8pm	0	0	0	7	7	Off
9pm	0	0	0	2	6	Off
10pm	0	0	0	2	6	Off
11pm	0	0	0	2	6	Off

Table 16: Operational profile for back of house permanently occupied

Back of House not occupied

The table below outlines the operational profile for the back of house areas that are not occupied. Note that when modelling these spaces, the model should use the lighting and equipment densities as designed for these spaces.

Temperature and humidity limits: Uncontrolled
Air change rate: In accordance with AS1660.2 (10 air changes per hour) or engineered design

Weekdays, Saturdays and Sundays		
Time	Lighting profile (% of maximum)	Equipment profile (% of maximum)
12am – 8am	0	0
8am – 6pm	100%	100%
5pm – 12am	0	0

Table 16: Operational profile for back of house not occupied

Car Parks and Loading Docks

The table below outlines the operational profile for car parks and loading docks on weekdays, Saturdays and Sundays. Note that when modelling these spaces, the model should use the lighting and equipment densities as designed for these spaces.

Note that energy consumption from the car parks and loading docks should only be included if sub-metering of these spaces is not included.

Temperature and humidity limits: Uncontrolled
Air change rate: In accordance with AS1668.2 or engineered design

Weekdays, Saturdays and Sundays		
Time	Lighting profile (% of maximum)	Equipment profile (% of maximum)
12am – 8am	0	0
8am – 6pm	100%	100%
6pm – 12am	0	0

Table 17: Operational profile for car parks and loading docks

APPENDIX C: OTHER ENERGY CONSUMPTION

This section is included to show the energy consumptions that are to be assumed for each space when calculating the energy consumption for the following:

- Domestic Hot Water
- Lifts
- Escalators and Travelators

Domestic hot water energy consumption

*The following methodology is for all domestic hot water systems except for solar water and heat pump booster systems. Such systems should be evaluated using the **'Green Star Solar Hot Water and Heat Pump Booster Energy Calculation Methodology'** which can be downloaded from the GBCA website, www.gbca.org.au*

WATER SUPPLIED TO:	DOMESTIC HOT WATER REQUIREMENTS (L/m² of total tenancy/day)*
Hot water basins	0.09
	0.05 (if using six star WELS rated taps)
	0 (if no hot water is supplied to the bathrooms)

Table 18: Benchmarks for hot water energy consumption

*The hot water supply is a fixed component. It may only be reduced if documentation is provided proving that hot water consumption is less than average.

Protocol for calculating domestic hot water energy use

1. Calculate the Total **Domestic Hot Water Requirements** multiplying the hot water supply (L/m²/day) by the total tenancy area (m²).

2. Calculate the Daily **Domestic Hot Water Energy Requirements** by determining how much primary energy input is required to heat this amount of water to 60°C per day **using the domestic hot water systems as designed for the retail centre.** Ensure distribution and generation efficiencies are included. Where distribution efficiencies are unknown, an efficiency of 40% should be applied to any pump in the system, and piping losses of 20W per metre length of pipe should be applied.

3. Multiply the Daily Domestic Hot Water Energy Requirement by 365 days to calculate the **Total yearly energy usage.** This is the figure to be entered into the **Green Star - Retail Centre v1 Energy Calculator**.

Example (yellow section to be filled in)

(In this example the energy required to heat 1L of water to 60°C from 18°C is 0.054kWh/L)

WATER SUPPLIED TO:	HOT WATER REQUIREMENTS (L/m²/day)	TOTAL	HOT WATER REQUIREMENTS (L/day)	DAILY ENERGY REQUIRED TO HEAT HOT WATER (kWh/day)	YEARLY ENERGY REQUIRED TO HEAT HOT WATER (kWh/year)
Hot water basins	0.09	2,500	225	12.15	4,434.75

Table 19: Example to how to calculate hot water energy consumption

The figure to be entered into the Green Star – Retail Centre v1 Energy Calculator is **4,434.75**

Protocol for calculating lift energy use

To calculate lift energy use:

1. Determine the lift power ratings **R** in kW from supplier specifications;

2. Determine the **St**andby power from car lights and lift control system in kW from supplier specifications; and then

3. Calculate the annual **E**nergy usage using the following formula

$$E = \left(\frac{R \times S \times T\,(100\% + P)}{3{,}600} + (St \times Hrs \times 365)\right) \times \text{No. Lifts}$$

Where:

E = annual **E**nergy usage (kWh/year)

R = Power **R**ating of the motor (kW)

S = number of **S**tarts per year (S=420,000 for the purposes of the Green Star – Retail Centre v1 lift energy calculations)

T = typical **T**rip time (seconds) (T=5s for the purposes of the Green Star – Retail Centre v1 lift energy calculations)

P = **P**enalty factor

Where lifts with speeds over 2.5 m/s have regenerative brakes, P=0%

Where lifts with speeds over 2.5 m/s do not have regenerative brakes, P=15%

St = **St**andby power – car lights and lift control systems (kW)

Hrs = number of **hours** per day lifts are operating

Where lift has a power off feature, hrs = 18

Where lift does not have a power off features, hrs = 24

No.Lifts = Number of lifts of this type in the project under assessment.

Note that:

- o The figure of 3,600 converts the first half of the equation, which is in kWs, into kWh.
- o The hours x 365 takes the standby power and multiplies it by operational hours and days in a year to get annual energy consumption.
- o If a lift only services three floors, is to solely be used as a disabled lift and is labelled as such, the energy consumption of this lift can be discounted by 90%.

This calculates the **annual energy usage**. This is the figure to be entered into the **Green Star – Retail Centre v1 Energy Calculator**

Equation Symbol	Description	Lift type 1	Lift type 2
R	Lift Power Rating (kW)	30	45
S	Number of starts per year	420,000	420,000
T	Typical Trip Time (s)	5	5
St	Standby Power Rating (kW)	0.1	0.1
Hrs	Lift operating hours (hrs/day)	18 (lift has power off feature)	24 (lift does not have power off feature)
P	Penalty factor (for having no regenerative brakes)	0% (speed of lift >2.5m/s, lift has regenerative brakes)	15% (speed of lift >2.5m/s, lift does not have regenerative brakes)
No. Lifts	Number of lifts of this type	2	1

Table 20: Example parameters for lift energy consumption

$$\textbf{E (type1)= (}\frac{\textbf{30 x 420,000 x 5 (100\% + 0\%)}}{\textbf{3,600}}\textbf{+ (0.1 x 18 x 365)) x 2}$$

E (type1)= 36,314kWh/yr

$$\textbf{E (type2)= (}\frac{\textbf{45 x 420,000 x 5 (100\% + 15\%)}}{\textbf{3,600}}\textbf{+ (0.1 x 24 x 365)) x 1}$$

E (type2)= 31,063.5kWh/yr

E (Total)= 67,377.5kWh/yr

The figure to be entered into the Green Star – Retail Centre v1 Energy Calculator for this example is **67,377.5kWh/yr.**

Protocol for calculating escalator and travelator energy use

1. Determine the escalator or travelator power **R**ating from supplier specifications

2. Determine the **U**sage factor based on the presence of an escalator or travelator sensor. These sensors detect movement and start the escalator or travelator moving if someone is walking towards it. The usage factor is:
   a. 0.75 if there is sensor; and
   b. 1 with a no sensor.

3. Calculate the annual **E**nergy usage using the following formula

E = R x U x Hrs/Year x No. Escalators or Travelators

Where:

E = annual **E**nergy usage (kWh/year)

R = Power **R**ating of the motor (kW)

U = Usage factor (sensor dependent)

Hrs/Year = 3,285 for the purposes of Green Star – Retail Centre v1 energy calculations (9 hrs a day (average of operational profiles) multiplied by 365 days a year equals 3,285 hrs/year)

No. Escalators/Travelators = Number of escalators OR travelators of this type in the project

Example (yellow sections are those that are to be filled in):

ESCALATOR TRAVELATOR POWER RATING	USAGE FACTOR (sensor dependent)	NUMBER OF ESCALATORS	HOURS IN A YEAR	YEARLY ENERGY USAGE
8kW (without sensor)	4	1	3,285	105,120
8kW (with sensor)	2	0.75	3,285	39,420
TOTAL YEARLY ENERGY CONSUMPTION (kWh/year)				144,540

Table 21: Example of how to calculate escalator or travelator energy consumption

The figure to be entered into the Green Star – Retail Centre Energy Calculator is **144,540kWh/year**

APPENDIX D: DAYLIGHT DIMMING CALCULATION

Protocol for calculating HVAC energy reduction due to daylight dimming

Due to the complexity of modelling, a reduction in HVAC loads due to daylight dimming or switching should only be included if there will be a substantial reduction compared to the base case (i.e. greater than 2% of total energy consumption).

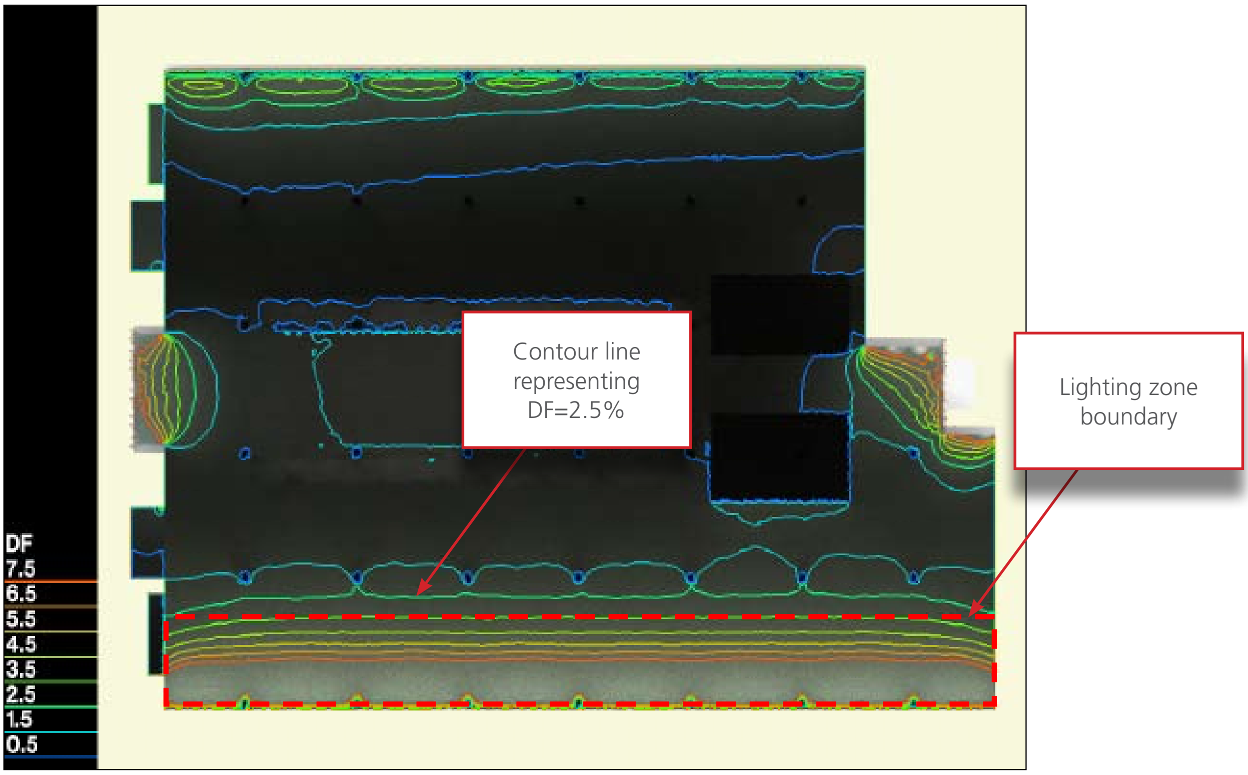
The calculation methodology for use of daylight dimming or switching should be submitted to the GBCA via a CIR prior to submission.

Protocol for calculating lighting plug load energy reduction due to daylight dimming

For lighting plug loads the following methodology must be used. A worked example from Adelaide is included for reference. The lighting zone adjacent to the southern perimeter (floor area of 500m²) features daylight dimming, such that the light output from dimming ballasts is adjusted to maintain an illuminance of 320 lux. The lighting power density of the system (no dimming) is 8W/m².

1. Determine the minimum daylight factor achieved within the zone between 9am and 5pm, as measured at the working plane

- For the modelled example, the minimum daylight factor (DF) achieved in the zone at the working plane is calculated to be 2.5%, as illustrated below



2. Determine the external horizontal illuminance, Eh, that must occur in order for an internal illuminance of 320 lux to be achieved at the working plane. The following formula applies:

$$Eh = \frac{Ei}{\text{Daylight Factor}} \times 100\%$$

where:

Ei = interior illuminance at a point from a sky of assumed luminance distribution (lux)

Eh = the simultaneous external horizontal illuminance on an unobstructed horizontal plane from a sky of the same assumed luminance distribution (lux)

For the modelled example, the minimum horizontal illumance, Eh, that must occur to achieve an internal illuminance, Ei, of 320 lux at the working plane is calculated to be 12.8 kilo lux as below

$$Eh = \frac{Ei}{\text{Daylight Factor}} \times 100\%$$

$$= \frac{320}{2.5} \times 100\%$$

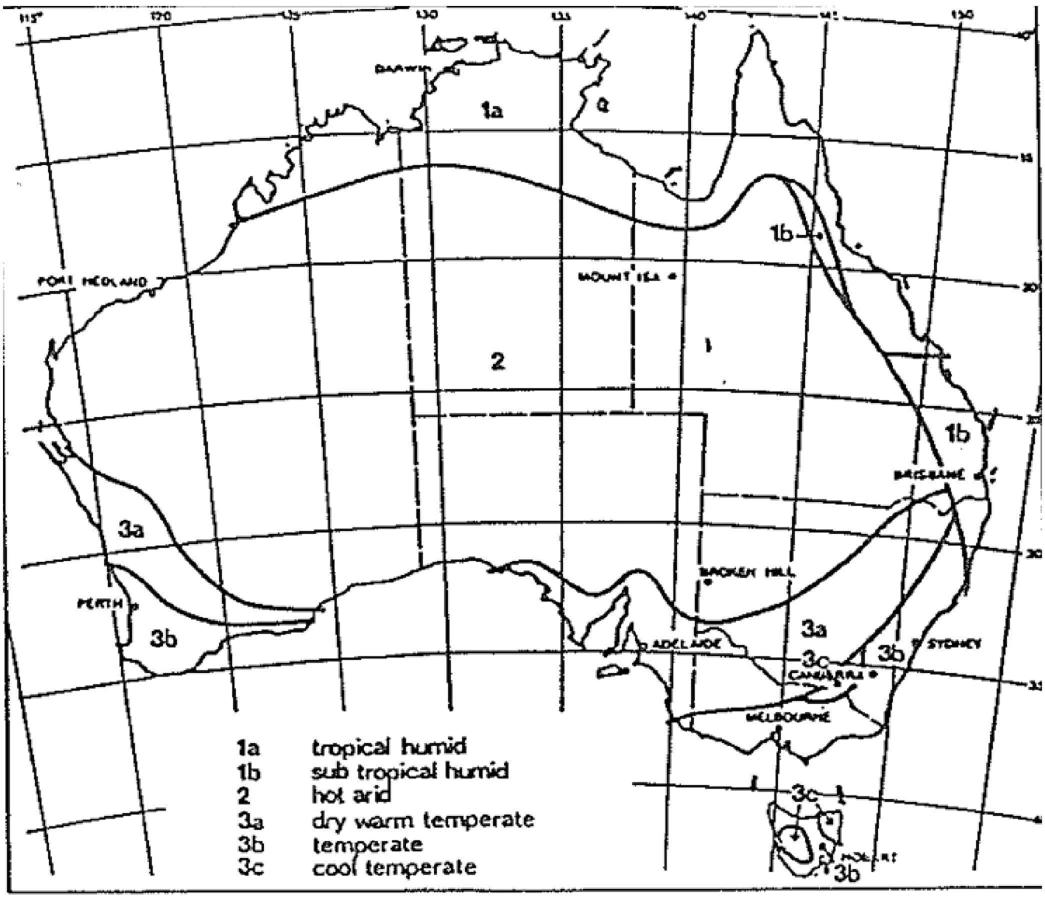
$$= 12.8 \text{ klx}$$

3. Determine the percentage of operational hours between 9am and 5pm for which this horizontal illuminance is exceeded, based on the table below

Percentage Working Year Illuminance is Exceeded	Diffuse Horizontal Illuminance (kilo lux)						
	Sydney	Perth / Adelaide	Broken Hill	Brisbane	Mount Isa	Port Hedland	Darwin
Climatic Zone	Temperate	Temperate	Hot arid	Sub-tropical	Hot arid	Hot arid	Hot humid
Location on map (below)	3b	3b	2	1b	2	2	1a
100	0.0	1.3	0.0	0.0	8.0	4.2	7.6
95	6.3	7.0	4.6	4.7	9.3	6.7	10.8
90	8.8	8.8	5.9	7.9	10.2	7.5	12.7
85	10.6	9.7	6.6	8.8	11.1	7.9	13.3
80	11.3	10.5	7.2	9.4	11.4	8.4	14.8
75	13.3	11.1	7.6	10.1	11.9	8.6	16.1
70	14.5	11.9	8.0	11.0	12.3	8.8	17.8
65	16.1	12.6	8.4	12.8	12.7	9.1	19.0
60	18.4	14.2	8.7	15.8	13.2	9.4	19.8
55	19.9	15.8	9.1	19.0	13.8	9.7	21.3
50	22.0	17.2	9.6	21.0	14.7	10.1	23.1
45	23.3	18.1	10.2	22.4	16.0	13.2	24.4
40	24.1	18.9	12.9	23.8	17.9	15.2	25.5
35	26.7	20.2	14.7	25.9	19.2	16.8	26.4
30	28.2	21.2	16.5	27.3	20.4	17.7	27.9
25	30.2	22.3	17.4	29.7	21.7	19.3	29.6
20	32.4	23.7	21.0	31.8	23.0	20.2	31.5
15	34.3	25.1	23.2	34.0	24.9	22.3	32.4
10	36.9	26.8	27.4	37.1	26.0	24.1	34.4
5	39.4	29.5	32.5	40.7	28.3	28.8	37.8
0	44.9	53.7	39.6	51.0	44.0	49.0	43.0

This table is sourced from "Skylight Availability in Australia – Data and their Application to Design" by N.C. Ruck PhD. Published by Illuminating Engineering Society of Australia, 2001.

Note that at this stage, this information is only available in a limited number of locations, and only between 9 and 5pm. The locations were chosen as being "representative of the major climatic zones on the Australian continent, together with their latitudes and climatic classification". It is recommended that the closest location with the closest climatic zone of the project be chosen for this calculation (see figure below).



- For the modelled example, from the lookup table provided, an external horizontal illuminance of 12.6 kilo lux is exceeded for 65% of hours between 9am and 5pm in Adelaide.

4. To obtain the lighting power density that should be modelled, multiply the lighting power density (no dimming) by the proportion of hours for which artificial lighting is required (i.e. for which 320lux daylight is not exceeded).

- For the modelled example, the lighting power density would be: $8W/m^2 \times 35\% = 2.8W/m^2$

APPENDIX E: HVAC OPTIONS REQUIREMENTS

The following table of values should be used to model a package unit in tenancies that are not supplied with access to any form of HVAC or effective natural ventilation.

Equipment	Minimum energy efficiency ratio (EER) (W_r/W_{input} power)			
	0 – 39kWr capacity	39kWr – 65kWr capacity	65kWr to 95kWr capacity	More than 95kWr capacity
Air conditioner – cooling only	3.5	3.2	2.7	2.8
Heat pump – cooling	3.5	3.2	2.6	2.7
Heat pump – heating	3.4	3.4	3.4	3.7

If tenancies are provided with chilled water and/or heating hot water, or condenser water WITH a heating hot water loop, then these spaces must be modelled with a fan coil unit, using the information in the table below.

System Static Pressure	Maximum fan motor input power to air flow rate ratio (W/(L/s))[3]
Up to 200	0.73
300	1.0
400	1.27
500	1.5
600	1.9
700	2.1
800	2.4
900	2.7
1000	2.9
Greater than 1000	3.3