green star™

green building council australia

GREEN STAR EDUCATION V1 ENERGY CALCULATOR GUIDE

JANUARY 2010

REVISION B.1

EXECUTIVE SUMMARY

The Green Star – Education v1 rating tool has been developed to assess environmental attributes of new and refurbished education facilities in Australia. The Energy Calculator within this tool compares the predicted energy consumption of an education facility to a benchmark. This comparison is then used to award points to any facility with a predicted energy consumption that is less than the benchmark. Information on how these benchmarks were set can be found in Green Star – Education v1 Standard Practice Benchmark document.

To use the calculator the predicted energy consumption of the facility must be determined. Important components of this calculation are the heating and cooling energy consumption of the facility that 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 facility. The standard inputs include operational profiles and internal heat loads that facilitate comparison between different education facilities.

The predicted ancillary load energy consumption, such as that from lighting, mechanical ventilation and lifts, must also 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 – Education v1 Rating Tool Energy Calculator. The calculator compares the performance of the facility relative to set benchmarks.

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Tool Version	Revision	Date Issued	Changelog
Green Star – Education v1	A	January 2009	-
Green Star – Education v1	B	December 2009	1) In 'Appendix B: Primary/High School Operational Profiles', the peak occupancy figures have been amended for classrooms and common areas and off peak occupancy has been amended for workshops. 2) In 'Appendix C: University Operational Profiles' - the names of Tables 40 and 41 have been amended and overnight occupancy removed from dry and wetlabs 3) Colour coded map included in 'Appendix E: Daylight Dimming Calculation'.
Green Star – Education v1	B.1	January 2010	1) HVAC Plant operation in Wetlabs (shown in Table 38 'Appendix C: University Operational Profiles') has been updated. The HVAC hours of operation are now the same as other teaching areas in Universities; 7am to 5pm.

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 – Education v1 rating tool assesses the environmental performance of education facilities by measuring their environmental impact.

The assessment of environmental performance includes determining the predicted energy consumption of an education facility. The Green Star – Education v1 Energy Calculator has been developed to compare this 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 – Education v1 Calculator Benchmarking Methodology document.

2 GUIDELINES FOR SIMULATION INPUT PARAMETERS

The parameters used to simulate the HVAC energy consumption of an education facility 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.

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

2.2 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 none of the above options can be complied with.
Weather Data	• A Test Reference Year (TRY) if the building location is within 50km of a 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 none of the above options can be complied with.
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".

2.3 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, ceiling 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

2.4 INTERNAL LOADS FOR HVAC SIMULATION

Modelling Parameter	Requirements
Lighting	• Demonstrate that lighting is calculated based on floor area. • Demonstrate that the appropriate HVAC Model Operational Profile (see Appendices C and D) has been used in the HVAC Model
Equipment	• Demonstrate that all equipment loads is calculated based on floor area. • Demonstrate that the equipment loads are modelled using the operational profiles as prescribed in Appendices C and D.
Occupancy	• Demonstrate that all occupancies are calculated based on floor area. • Demonstrate that the occupancy profile used is that prescribed for each space type in Appendices C and D.

Table 3: Internal loads for HVAC Simulation

2.5 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.
Tenant condenser water	• If a tenant condenser water loop is provided, show that allowance has been made for the additional energy used for tenant supplementary condenser water pumping. • If relevant, demonstrate that the tenant condenser water loop pumping is calculated based on a tenant supplementary cooling load, the static pressure of the tenant condenser water pumps (typically 250kPa) and the flow rate in L/s.

Table 4: A/C pumping parameters

2.6 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 5: HVAC system simulation

2.7 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 economy cycles have 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 set-points 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 6: HVAC Controls Parameters

2.8 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;
- Lighting; and
- Mechanical exhaust.

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 water recycling 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 D. • Note that any other hot water supply (such as for laundries) is not to be included. • The methodology outlined in Appendix D 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 D.
Escalator and travelator loads	• Escalator and travelator loads are to be calculated using the method outlined in Appendix D.
Lighting	• Demonstrate that 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 E.
Mechanical exhaust systems	• Demonstrate that the energy requirements for mechanical exhaust systems that are provided as a base building service and provided in university wetlabs (such as those installed for toilets, kitchens and photocopy and computer server rooms and fume cupboards) are calculated using the following parameters: • Maximum power of the fan; • 50% fan efficiency; and • Follow the appropriate operational profile for that space type; that is, the fan should be operating anytime that the HVAC system is operating, unless mechanical/automated intervention (not systems which rely on manual intervention) are to be installed. • Computer server room exhausts can be modelled as described above, or be based on dynamic modelling. • Specialist educational equipment mechanical exhausts (such as dust extraction systems, darkroom exhausts and home economics classroom exhaust) are not assessed in this credit and therefore their energy consumption does not need to be included in the tool.
Ceiling Fans	• Where ceiling fans are used within modelling to claim points for IEQ-5 'Thermal Comfort', ceiling fan energy must be included within the energy modelling for Ene-Conditional Requirement and Ene-1 'Greenhouse Gas Emissions'. The same operating profiles must be used in both credits. • The Certified Assessors will check for consistency in the input to the models used in IEQ-5 'Thermal Comfort' and Ene-Conditional Requirement and Ene-1 'Greenhouse Gas Emissions'. • Where points for IEQ-5 'Thermal Comfort' are not sought, ceiling fans need not be included within the energy modelling for Ene-Conditional Requirement and Ene-1 'Greenhouse Gas Emissions'.

Table 7: Other services parameters

3 ENTERING SIMULATION OUTPUT DATA

The calculator is divided into six sections:

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

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

3.1 BUILDING LOCATION AND GREENHOUSE GAS EMISSIONS FACTORS

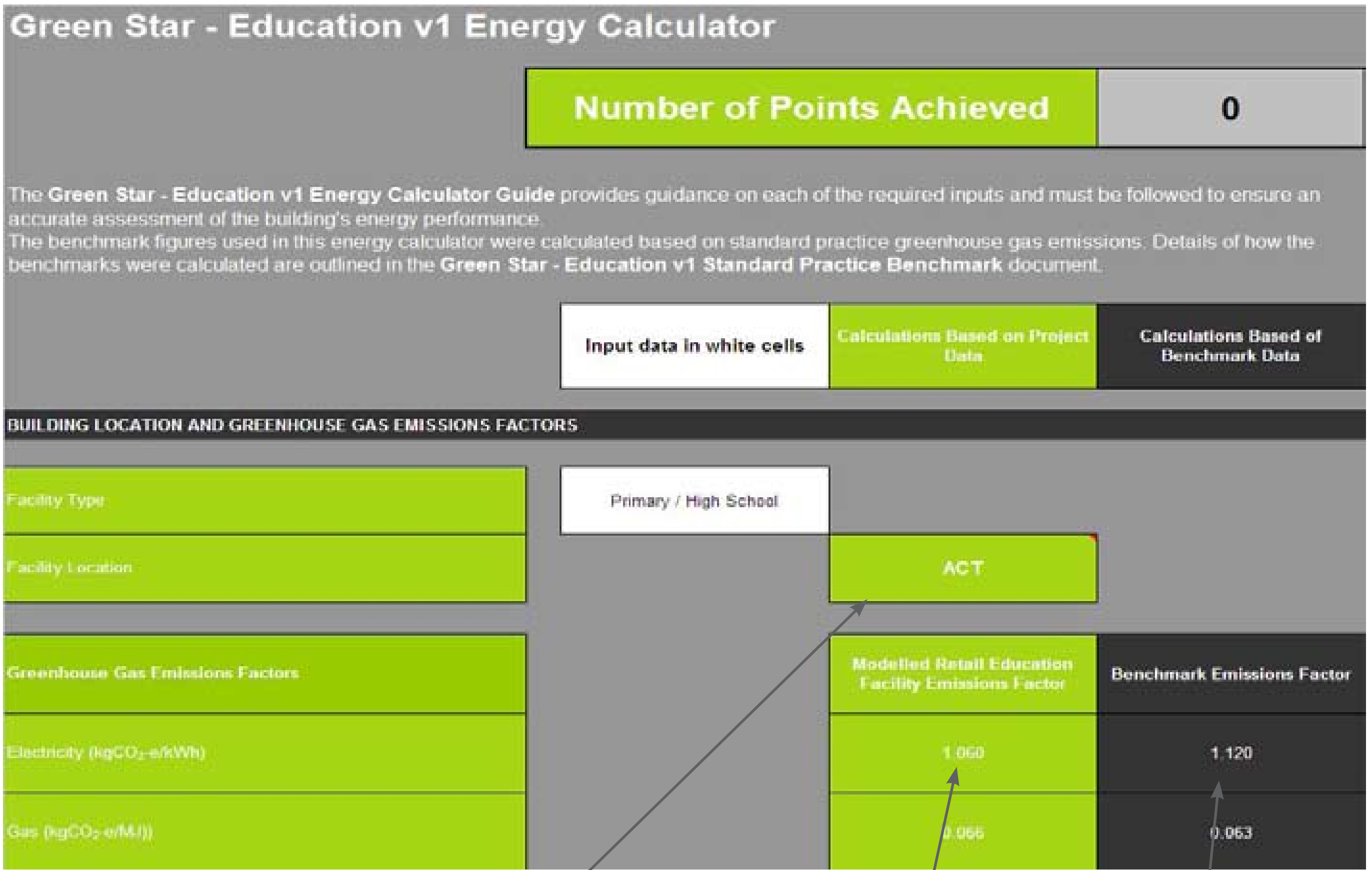


Figure 1: Building Location

State/Territory is displayed here. This is selected in the 'Building Input' tab. It is used to determine the gas and electricity GHG emissions factors shown in the cells below.

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 as defined in Appendix A. The column on the right hand side shows the benchmark GHG emissions associated with the HVAC system operation for that space type. Note that for University Buildings with Wet Labs the Total Peak Air Exhaust Rate must be entered in the relevant cell (See Figure 3).

Enter areas of each space type.

HVAC System Benchmark GHG Emissions for each space type are listed in this column.

BUILDING SPACE TYPES

Space Types within the building	Space Area (m^2)	HVAC Benchmark Greenhouse Gas Emissions ($kgCO_2$-e/yr)
Classroom / Multipurpose Spaces		0
Computer and Physics Labs		0
Office and Staff Rooms		0
Library		0
Common Spaces		0
Canteen		0
Workshops		0
Gymnasiums		0
Car Park		0
Subtotal	0	0

Number of car parking spaces	

Figure 2: Building Space Types (Primary/High School)

BUILDING SPACE TYPES

Space Types within the building	Space Area (m^2)	HVAC Benchmark Greenhouse Gas Emissions ($kgCO_2$-e/yr)
Teaching / Classroom Spaces		0
Dry Labs / Specialty Learning Spaces / Libraries		0
Office / Administrative Spaces		0
Common Spaces		0
Wet Labs	100	5,975
Gymnasiums		0
Car Park		0
Subtotal	100	**5,975**
Total peak air exhaust rate in wet lab areas (l/s)	500	
Number of car parking spaces		

When the building includes Wet Lab areas, enter the total peak air exhaust rate.

Figure 3: Building Space Types (University Building)

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.

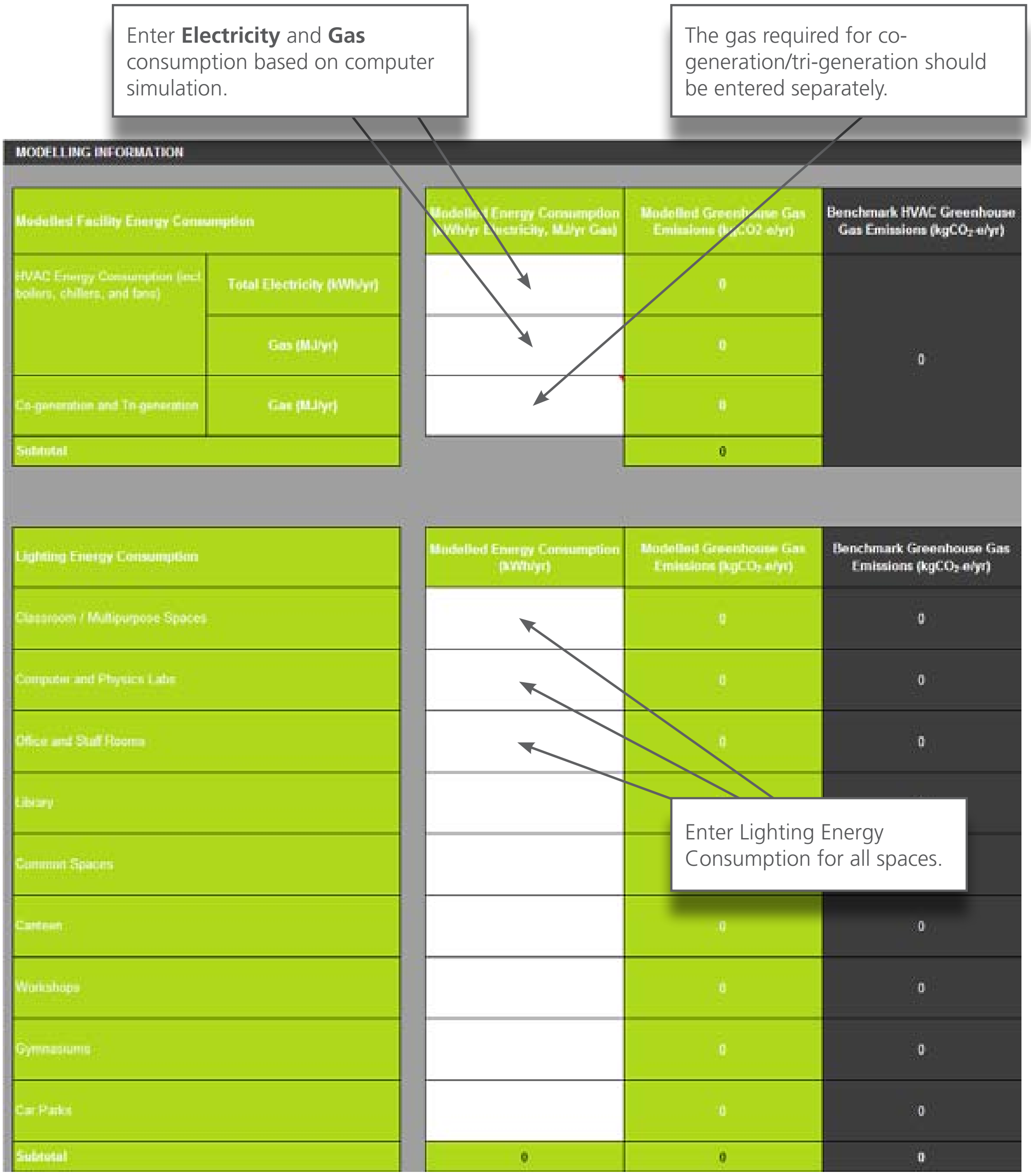


Figure 4: Modelling Information (1))

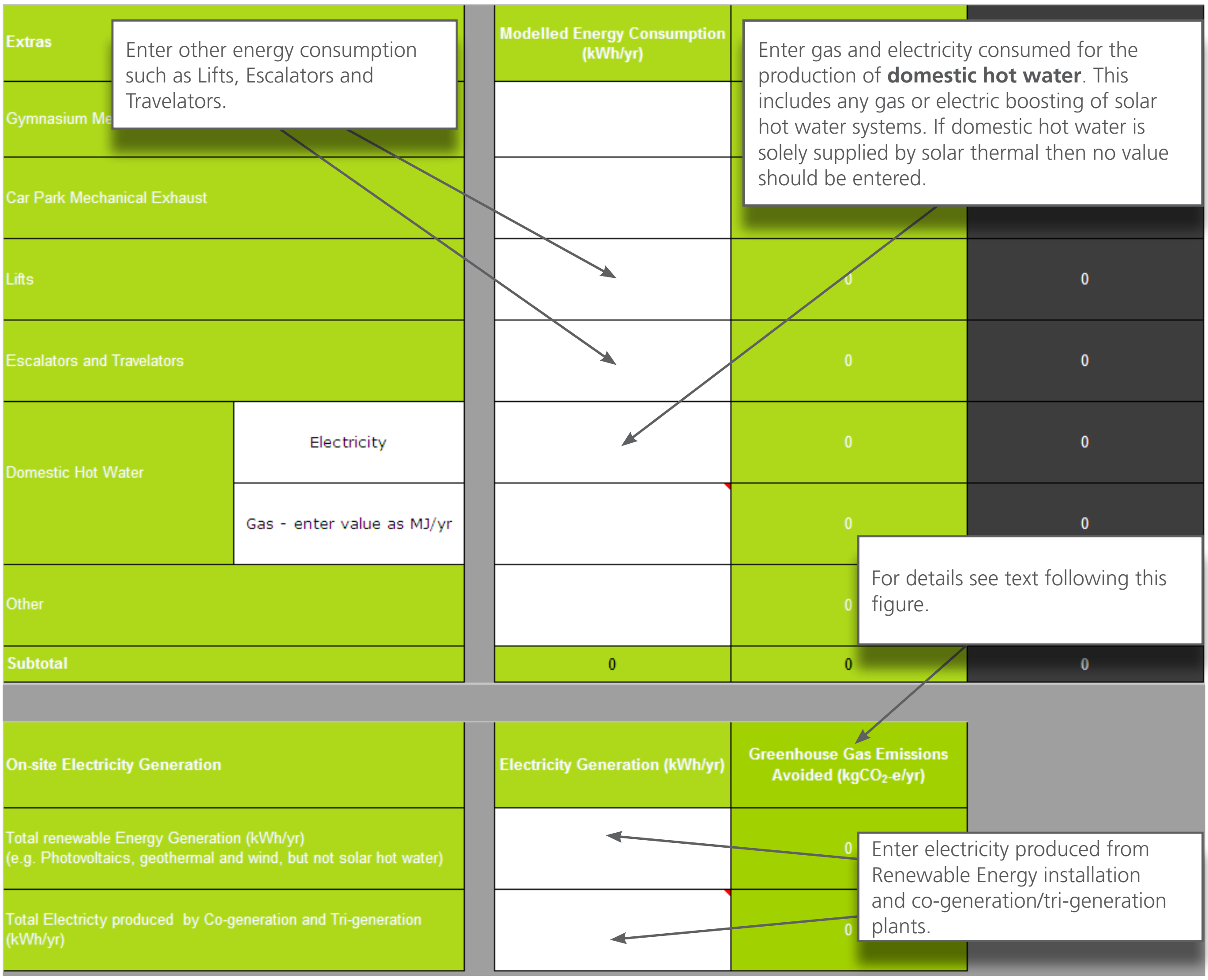


Figure 5: Modelling Information (2)

The 'Greenhouse Gas Emissions Avoided' column, to the right of the On-site Electricity 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 Energy Consumption (kWh/yr Electricity, MJ/yr Gas)	Total Project Greenhouse Gas Emissions ($kgCO_2$-e/yr)	Total Benchmark Greenhouse Gas Emissions ($kgCO_2$-e/yr)
Grid electricity	0	0	0
Gas	0	0	0
TOTAL		**0**	**0**
Greenhouse Gas Savings (Difference in greenhouse gas emissions between benchmark and facility (kgCO2/yr))		**0**	
Percentage reduction of Greenhouse Gas Emissions compared to the Standard Practice Benchmark		**0.0%**	

Figure 6: Results Summary

3.5 POINTS SCORE CALCULATION

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

POINT SCORE CALCULATION

Green Star Points	Percentage reduction of Greenhouse Gas Emissions compared to the Standard Practice Benchmark	Maximum greenhouse gas emissions to achieve points ($kgCO_2$-e/yr)
20	100%	0
19	95%	0
18	90%	0
17	85%	0
16	80%	0
15	75%	0
14	70%	0
13	65%	0
12	60%	0
11	55%	0
10	50%	0
9	45%	0
8	40%	0
7	35%	0
6	30%	0
5	25%	0
4	20%	0
3	15%	0
2	10%	0
1	5%	0
Conditional Requirement	0%	0

Is the Conditional Requirement met?	No
Number of Points Achieved	0

Shows the points awarded for the design.

Figure 7: Points Score Calculator

3.6 COST SAVINGS CALCULATOR

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

Figure 8: Cost Savings Calculator

Enter the cost of gas and electricity to find out the cost saving of the design compared to the benchmark energy consumption.

4 CASE STUDY – ON-SITE ENERGY GENERATION

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

The case study education facility has 25,000m² of teaching and classroom spaces 5,000m² of dry labs, specialty learning areas and libraries, 100m² of office space and 500m² of common space. It is located in NSW and generates electricity on site using cogeneration, solar hot water and renewable energy.

Firstly, the space type areas are calculated using the definitions in Appendix A.

Space Type	Area (m²)
Teaching / Classroom Spaces	25,000
Dry Labs / Specialty Learning Spaces / Libraries	5,000
Office / Administrative Spaces	100
Common Spaces	500

Table 8: 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 study gas consumption is only used to fire the cogeneration plant on site.

Energy Source	Energy Consumption (kWh/year)
Electricity (consumed by HVAC system)	1,000,000
Gas (consumed by cogeneration plant)	100,000

Table 9: HVAC Energy Consumption for case study

The lighting and equipment energy consumption is calculated using Section 2 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 D – Other Energy Consumption.

Item	Energy Consumption (kWh/year)
Teaching / Classroom Spaces Lighting	600,000
Dry Labs / Specialty Learning Spaces / Libraries Lighting	100,000
Office / Administrative Spaces Lighting	5,000
Common Spaces Lighting	10,000
Lifts	4,000
Domestic Hot Water	75,000 (MJ/year gas)

Table 10: 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 cogeneration 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 electricity generation	Electricity 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 11: On-site energy generation

This information is entered into the calculator as detailed below.

BUILDING LOCATION AND GREENHOUSE GAS EMISSIONS FACTORS

Facility Type	University Building	
Facility Location		NSW

Greenhouse Gas Emissions Factors	Modelled Retail Education Facility Emissions Factor	Benchmark Emissions Factor
Electricity ($kgCO_2$-e/kWh)	1.060	1.120
Gas ($kgCO_2$-e/MJ)	0.066	0.063

BUILDING SPACE TYPES

Space Types within the building	Space Area (m^2)	HVAC Benchmark Greenhouse Gas Emissions ($kgCO_2$-e/yr)
Teaching / Classroom Spaces	25,000	991,180
Dry Labs / Specialty Learning Spaces / Libraries	5,000	232,414
Office / Administrative Spaces	100	2,686
Common Spaces	500	9,825
Wet Labs		0
Gymnasiums		0
		0
		0
Car Park		0
Subtotal	30,600	1,236,104

Areas of the space types are entered here.

Figure 9: On-site Energy Generation Case Study (1)

Total peak air exhaust rate in wet lab areas (l/s)		
Number of car parking spaces		

MODELLING INFORMATION

Modelled Facility Energy Consumption		Modelled Energy Consumption (kWh/yr Electricity, MJ/yr Gas)	Modelled Greenhouse Gas Emissions (kgCO2-e/yr)	Benchmark HVAC Greenhouse Gas Emissions ($kgCO_2$-e/yr)
HVAC Energy Consumption (incl boilers, chillers, and fans)	Total Electricity (kWh/yr)	1000000	1,060,000	1,242,079
	Gas (MJ/yr)	100000	6,610	
Co-generation and Tri-generation	Gas (MJ/yr)		0	
Subtotal			1,066,610	

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

Lighting Energy Consumption	Modelled Energy Consumption (kWh/yr)	Modelled Greenhouse Gas Emissions ($kgCO_2$-e/yr)	Benchmark Greenhouse Gas Emissions ($kgCO_2$-e/yr)
Teaching / Classroom Spaces	600,000	636,000	728,000
Dry Labs / Specialty Learning Spaces / Libraries	100,000	106,000	145,600
Office / Administrative Spaces	5,000	5,300	3,985
Common Spaces	10,000	10,600	8,400
Wet Labs		0	0
Gymnasiums		0	0
Car Parks		0	0
Subtotal	715,000	757,900	885,985

Figure 10: On-site Energy Generation Case Study (2)

Extras		Modelled Energy Consumption (kWh/yr)	Modelled Greenhouse Gas Emissions ($kgCO_2$-e/yr)	Benchmark Greenhouse Gas Emissions ($kgCO_2$-e/yr)
Gymnasium Mechanical Exhaust			0	0
Car Park Mechanical Exhaust			0	0
Lifts		4,000	4,240	195,350
Escalators and Travelators			0	0
Domestic Hot Water	Electricity		0	79,957
	Gas - enter value as MJ/yr	75,000	4,958	0
Other			0	
Subtotal		79,000	9,198	

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

On-site Electricity Generation	Electricity Generation (kWh/yr)	Greenhouse Gas Emissi Avoided ($kgCO_2$-e/yr)
Total renewable Energy Generation (kWh/yr) (e.g. Photovoltaics, geothermal and wind, but not solar hot water)	1,000	1,060
Total Electricty produced by Co-generation and Tri-generation (kWh/yr)	25,000	26,500

RESULTS SUMMARY

	Total Project Energy Consumption (kWh/yr Electricity, MJ/yr Gas)	Total Project Greenhouse Gas Emissions ($kgCO_2$-e/yr)	Total Benchmark Greenhouse Gas Emissions ($kgCO_2$-e/yr)
Grid electricity	1,693,000	1,794,580	2,372,729
Gas	175,000	11,568	24,668
TOTAL		1,806,148	2,397,397
Greenhouse Gas Savings (Difference in greenhouse gas emissions between benchmark and facility (kgCO2/yr))		591,249	
Percentage reduction of Greenhouse Gas Emissions compared to the Standard Practice Benchmark		24.7%	

Figure 11: 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 – Education v1 Energy Calculator.

Primary and High Schools

Classroom / Multipurpose Spaces – These spaces include lecture theatres, classrooms, seminar rooms, tutorial rooms, studios and multipurpose general areas.

Computer and Physics Labs – These spaces include dry teaching labs (e.g. physics without high service requirements), light workshops (without heavy machinery) and computer labs.

Office and Staff Rooms –These spaces include offices and meeting rooms.

Libraries – These spaces include library areas, where reading and listening resources are kept for teaching and lending purposes. These areas may also include limited computer facilities.

Common Spaces – These spaces include foyers, amenities, passages, corridors, store rooms, stairs and circulation.

Canteen – These spaces include areas that are primarily used for the preparing and selling of food during morning tea and lunch breaks. These may also be known as a kiosk.

Workshops – These spaces are similar to computer and physics labs, except that they include heavy machinery.

Gymnasiums – These spaces primarily include indoor sports halls, such as basketball courts, but may also include small areas with weight lifting equipment.

Car Parks - These spaces include areas specifically designated for car parking.

University Buildings

Teaching and Learning Spaces – These spaces include lecture theatres, classrooms, seminar rooms, tutorial rooms, studios, eating areas and multipurpose general areas.

Dry Labs, Specialty Learning Spaces and Libraries –These spaces include: dry teaching labs (e.g. physics without high service requirements), light workshops (without heavy machinery) computer labs, and libraries.

Office Administrative Space – These spaces include offices, meeting rooms and conference facilities.

Common Spaces – These spaces include foyers, amenities, passages, corridors, store rooms, stairs and circulation.

Wet Labs – These spaces include wet laboratories (such as chemical and bioscience), heavy workshops (those that contain equipment that utilises significant services), food service areas, home economics labs and specialty medical and dental areas.

Gymnasiums – These spaces include professional indoor gymnasiums with weight lifting and cardiovascular equipment and indoor sport halls, such as basketball courts.

Car Parks - These spaces include areas specifically designated for car parking.

APPENDIX B: PRIMARY / HIGH SCHOOL OPERATIONAL PROFILES

Note: When calculating the HVAC energy consumption of these spaces, the model should use the lighting densities specified in the HVAC Model Operational Profile. When calculating the energy consumption of the lighting in the facility, the lighting profile should be used in conjunction with the lighting power densities as per the lighting specifications.

Classroom / Multipurpose Space

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/ person)	Lighting (W/m²)	Equipment (W/ m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0.5	0.25	Off
1am	0	0	0	0.5	0.25	Off
2am	0	0	0	0.5	0.25	Off
3am	0	0	0	0.5	0.25	Off
4am	0	0	0	0.5	0.25	Off
5am	0	0	0	0.5	0.25	Off
6am	0	0	0	0.5	0.25	Off
7am	2.63	2.25	27	3	4.25	On
8am	2.63	2.25	27	3	4.25	On
9am	17.50	15.00	4	10	5	On
10am	17.50	15.00	4	10	5	On
11am	17.50	15.00	4	10	5	On
12pm	8.75	7.50	8	8	3.5	On
1pm	17.50	15.00	4	10	5	On
2pm	17.50	15.00	4	10	5	On
3pm	17.50	15.00	4	10	5	On
4pm	17.50	15.00	4	10	5	On
5pm	2.63	2.25	27	3	1.5	Off
6pm	2.63	2.25	27	3	1.5	Off
7pm	0	0	0	0.5	0.25	Off
8pm	0	0	0	0.5	0.25	Off
9pm	0	0	0	0.5	0.25	Off
10pm	0	0	0	0.5	0.25	Off
11pm	0	0	0	0.5	0.25	Off

Table 12: Classroom / multipurpose space

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	5%
0700-0900	30%
0900-1200	100%
1200-1300	80%
1300-1700	100%
1700-1900	30%
1900-0000	5%

Table 13: Classroom / multipurpose lighting energy consumption profile

Computer / Physics Labs

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/ person)	Lighting (W/m²)	Equipment (W/ m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0.5	1.35	Off
1am	0	0	0	0.5	1.35	Off
2am	0	0	0	0.5	1.35	Off
3am	0	0	0	0.5	1.35	Off
4am	0	0	0	0.5	1.35	Off
5am	0	0	0	0.5	1.35	Off
6am	0	0	0	0.5	1.35	Off
7am	2.63	2.25	27	3	22.95	On
8am	2.63	2.25	27	3	22.95	On
9am	17.50	15.00	4	10	27	On
10am	17.50	15.00	4	10	27	On
11am	17.50	15.00	4	10	27	On
12pm	8.75	7.50	8	8	18.9	On
1pm	17.50	15.00	4	10	27	On
2pm	17.50	15.00	4	10	27	On
3pm	17.50	15.00	4	10	27	On
4pm	17.50	15.00	4	10	27	On
5pm	2.63	2.25	27	3	8.1	Off
6pm	2.63	2.25	27	3	8.1	Off
7pm	0	0	0	0.5	1.35	Off
8pm	0	0	0	0.5	1.35	Off
9pm	0	0	0	0.5	1.35	Off
10pm	0	0	0	0.5	1.35	Off
11pm	0	0	0	0.5	1.35	Off

Table 14: Computer / Physics Labs

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	5%
0700-0900	30%
0900-1200	100%
1200-1300	80%
1300-1700	100%
1700-1900	30%
1900-0000	5%

Table 15: Computer / Physics Labs lighting energy consumption profile

Office and Staff Rooms

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/ person)	Lighting (W/m²)	Equipment (W/ m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	1	1.1	Off
1am	0	0	0	1	1.1	Off
2am	0	0	0	1	1.1	Off
3am	0	0	0	1	1.1	Off
4am	0	0	0	1	1.1	Off
5am	0	0	0	1	1.1	Off
6am	0	0	0	1	1.1	Off
7am	0.27	0.23	260	4	2.75	On
8am	1.08	0.92	65	8	7.7	On
9am	1.79	1.54	39	10	11	On
10am	1.79	1.54	39	10	11	On
11am	1.79	1.54	39	10	11	On
12pm	1.79	1.54	39	10	11	On
1pm	1.79	1.54	39	10	11	On
2pm	1.79	1.54	39	10	11	On
3pm	1.79	1.54	39	10	11	On
4pm	1.79	1.54	39	10	11	On
5pm	0.90	0.77	78	8	6.6	On
6pm	0.27	0.23	260	6	2.75	Off
7pm	0.27	0.23	260	6	2.75	Off
8pm	0.27	0.23	260	6	2.75	Off
9pm	0	0	0	1	1.1	Off
10pm	0	0	0	1	1.1	Off
11pm	0	0	0	1	1.1	Off

Table 16: Office / Staff Rooms

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	10%
0700-0800	40%
0800-0900	80%
0900-1700	100%
1700-1800	80%
1800-2100	60%
2100-0000	10%

TTable 17: Office / Staff Rooms lighting energy consumption profile

Libraries

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/ person)	Lighting (W/m²)	Equipment (W/ m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0.6	0.25	Off
1am	0	0	0	0.6	0.25	Off
2am	0	0	0	0.6	0.25	Off
3am	0	0	0	0.6	0.25	Off
4am	0	0	0	0.6	0.25	Off
5am	0	0	0	0.6	0.25	Off
6am	0	0	0	0.6	0.25	Off
7am	1.50	1.29	47	3.6	4.25	On
8am	1.50	1.29	47	3.6	4.25	On
9am	10.00	8.57	7	12	5	On
10am	10.00	8.57	7	12	5	On
11am	10.00	8.57	7	12	5	On
12pm	5.00	4.29	14	9.6	3.5	On
1pm	10.00	8.57	7	12	5	On
2pm	10.00	8.57	7	12	5	On
3pm	10.00	8.57	7	12	5	On
4pm	10.00	8.57	7	12	5	On
5pm	1.50	1.29	47	3.6	1.5	Off
6pm	1.50	1.29	47	3.6	1.5	Off
7pm	0	0	0	0.6	0.25	Off
8pm	0	0	0	0.6	0.25	Off
9pm	0	0	0	0.6	0.25	Off
10pm	0	0	0	0.6	0.25	Off
11pm	0	0	0	0.6	0.25	Off

Table 18: Office / Staff Rooms

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	5%
0700-0900	30%
0900-1200	100%
1200-1300	80%
1300-1700	100%
1700-1900	30%
1900-0000	5%

Table 19: Libraries lighting energy consumption profile

Common Spaces

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/person)	Lighting (W/m²)	Equipment (W/m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0.3	0	Off
1am	0	0	0	0.3	0	Off
2am	0	0	0	0.3	0	Off
3am	0	0	0	0.3	0	Off
4am	0	0	0	0.3	0	Off
5am	0	0	0	0.3	0	Off
6am	0	0	0	0.3	0	Off
7am	0.88	0.75	80	1.8	0	On
8am	0.88	0.75	80	1.8	0	On
9am	5.83	5	12	6	0	On
10am	5.83	5	12	6	0	On
11am	5.83	5	12	6	0	On
12pm	2.92	2.5	24	4.8	0	On
1pm	5.83	5	12	6	0	On
2pm	5.83	5	12	6	0	On
3pm	5.83	5	12	6	0	On
4pm	5.83	5	12	6	0	On
5pm	0.88	0.75	80	1.8	0	Off
6pm	0.88	0.75	80	1.8	0	Off
7pm	0	0	0	0.3	0	Off
8pm	0	0	0	0.3	0	Off
9pm	0	0	0	0.3	0	Off
10pm	0	0	0	0.3	0	Off
11pm	0	0	0	0.3	0	Off

Table 20: Common Spaces

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	5%
0700-0900	30%
0900-1200	100%
1200-1300	80%
1300-1700	100%
1700-1900	30%
1900-0000	5%

Table 21: Common spaces lighting energy consumption profile

Canteen

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/ person)	Lighting (W/m²)	Equipment (W/ m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0	2.5	Off
1am	0	0	0	0	2.5	Off
2am	0	0	0	0	2.5	Off
3am	0	0	0	0	2.5	Off
4am	0	0	0	0	2.5	Off
5am	0	0	0	0	2.5	Off
6am	0	0	0	0	2.5	Off
7am	0	0	0	0	2.5	Off
8am	0	0	0	0	2.5	Off
9am	0	0	0	0	2.5	On
10am	1.06	0.91	66	20	17.5	On
11am	2.12	1.82	33	20	25	On
12pm	2.12	1.82	33	20	25	On
1pm	2.12	1.82	33	20	25	On
2pm	2.12	1.82	33	20	25	On
3pm	0	0	0	0	0	On
4pm	0	0	0	0	0	Off
5pm	0	0	0	0	0	Off
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 22: Canteens

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-1000	0%
1000-1500	100%
1500-0000	0%

Table 23: Canteen lighting energy consumption profile

Workshops

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/ person)	Lighting (W/m²)	Equipment (W/ m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0.5	1.25	Off
1am	0	0	0	0.5	1.25	Off
2am	0	0	0	0.5	1.25	Off
3am	0	0	0	0.5	1.25	Off
4am	0	0	0	0.5	1.25	Off
5am	0	0	0	0.5	1.25	Off
6am	0	0	0	0.5	1.25	Off
7am	0.88	0.75	80	3	21.25	On
8am	0.88	0.75	80	3	21.25	On
9am	5.83	5.00	12	10	25	On
10am	5.83	5.00	12	10	25	On
11am	5.83	5.00	12	10	25	On
12pm	2.92	2.50	24	8	17.5	On
1pm	5.83	5.00	12	10	25	On
2pm	5.83	5.00	12	10	25	On
3pm	5.83	5.00	12	10	25	On
4pm	5.83	5.00	12	10	25	On
5pm	0.88	0.75	80	3	7.5	Off
6pm	0.88	0.75	80	3	7.5	Off
7pm	0	0	0	0.5	1.25	Off
8pm	0	0	0	0.5	1.25	Off
9pm	0	0	0	0.5	1.25	Off
10pm	0	0	0	0.5	1.25	Off
11pm	0	0	0	0.5	1.25	Off

Table 24: Workshops

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	5%
0700-0900	30%
0900-1200	100%
1200-1300	80%
1300-1700	100%
1700-1900	30%
1900-0000	5%

Table 25: Workshops lighting energy consumption profile

Gymnasiums

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/ person)	Lighting (W/m²)	Equipment (W/ m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0.8	0	Off
1am	0	0	0	0.8	0	Off
2am	0	0	0	0.8	0	Off
3am	0	0	0	0.8	0	Off
4am	0	0	0	0.8	0	Off
5am	0	0	0	0.8	0	Off
6am	0	0	0	0.8	0	Off
7am	1.36	2.44	114	4.8	0	On
8am	1.36	2.44	114	4.8	0	On
9am	9.06	16.24	17	16	0	On
10am	9.06	16.24	17	16	0	On
11am	9.06	16.24	17	16	0	On
12pm	4.53	8.12	34	12.8	0	On
1pm	9.06	16.24	17	16	0	On
2pm	9.06	16.24	17	16	0	On
3pm	9.06	16.24	17	16	0	On
4pm	9.06	16.24	17	16	0	On
5pm	1.36	2.44	114	4.8	0	Off
6pm	1.36	2.44	114	4.8	0	Off
7pm	0	0	0	0.8	0	Off
8pm	0	0	0	0.8	0	Off
9pm	0	0	0	0.8	0	Off
10pm	0	0	0	0.8	0	Off
11pm	0	0	0	0.8	0	Off

Table 26: Gymnasiums

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	5%
0700-0900	30%
0900-1200	100%
1200-1300	80%
1300-1700	100%
1700-1900	30%
1900-0000	5%

Table 27: Gymnasium lighting energy consumption profile

Car Parks

Note: Only small car parks (those with less than 1 car parking space per 200m² UFA) are assessed by the energy tool. For this reason, the car park benchmark is calculated as being 30% "entry area" and lighting benchmark for car parks is assuming that 30% of car park area is located within 20m of an entry.

HVAC Model Operational Profile

Weekdays Only			
Time	Lighting (W/m^2)	Equipment (W/m^2)	Plant Operation
12am	0	0	Off
1am	0	0	Off
2am	0	0	Off
3am	0	0	Off
4am	0	0	Off
5am	0	0	Off
6am	0	0	Off
7am	10	0	On
8am	10	0	On
9am	10	0	On
10am	10	0	On
11am	10	0	On
12pm	10	0	On
1pm	10	0	On
2pm	10	0	On
3pm	10	0	On
4pm	10	0	On
5pm	10	0	On
6pm	10	0	On
7pm	0	0	Off
8pm	0	0	Off
9pm	0	0	Off
10pm	0	0	Off
11pm	0	0	Off

Table 28: Car Parks

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	0%
0700-1800	100%
1800-0000	0%

Table 29: Car park lighting energy consumption profile

APPENDIX C: UNIVERSITY BUILDINGS OPERATIONAL PROFILES

Teaching / Classroom Spaces

Note: When calculating the HVAC energy consumption of these spaces, the model should use the specified lighting densities in the HVAC Model Operational Profile. When calculating the energy consumption of the lighting in the facility, the lighting profile should be used in conjunction with the lighting densities as per the lighting specifications.

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/ person)	Lighting (W/m²)	Equipment (W/ m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0.5	0	Off
1am	0	0	0	0.5	0	Off
2am	0	0	0	0.5	0	Off
3am	0	0	0	0.5	0	Off
4am	0	0	0	0.5	0	Off
5am	0	0	0	0.5	0	Off
6am	0	0	0	0.5	0	Off
7am	2.92	2.50	24	5	0	On
8am	2.92	2.50	24	5	0	On
9am	5.83	5.00	12	10	0	On
10am	5.83	5.00	12	10	0	On
11am	5.83	5.00	12	10	0	On
12pm	2.92	2.50	24	8	0	On
1pm	5.83	5.00	12	10	0	On
2pm	5.83	5.00	12	10	0	On
3pm	5.83	5.00	12	10	0	On
4pm	5.83	5.00	12	10	0	On
5pm	1.17	1.00	60	2	0	Off
6pm	1.17	1.00	60	2	0	Off
7pm	1.17	1.00	60	2	0	Off
8pm	0.29	0.25	240	0.5	0	Off
9pm	0.29	0.25	240	0.5	0	Off
10pm	0.29	0.25	240	0.5	0	Off
11pm	0.29	0.25	240	0.5	0	Off

Table 30: Teaching / Classroom Spaces

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	5%
0700-0900	50%
0900-1200	100%
1200-1300	80%
1300-1700	100%
1700-2000	20%
2000-0000	5%

Table 31: Teaching / Classroom Spaces lighting energy consumption profile

Dry Labs / Specialty Learning Spaces / Libraries

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/ person)	Lighting (W/m²)	Equipment (W/ m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0.5	1.35	Off
1am	0	0	0	0.5	1.35	Off
2am	0	0	0	0.5	1.35	Off
3am	0	0	0	0.5	1.35	Off
4am	0	0	0	0.5	1.35	Off
5am	0	0	0	0.5	1.35	Off
6am	0	0	0	0.5	1.35	Off
7am	2.92	2.50	24	5	13.5	On
8am	2.92	2.50	24	5	13.5	On
9am	5.83	5.00	12	10	27	On
10am	5.83	5.00	12	10	27	On
11am	5.83	5.00	12	10	27	On
12pm	2.92	2.50	24	8	18.9	On
1pm	5.83	5.00	12	10	27	On
2pm	5.83	5.00	12	10	27	On
3pm	5.83	5.00	12	10	27	On
4pm	5.83	5.00	12	10	27	On
5pm	1.17	1.00	60	2	5.4	Off
6pm	1.17	1.00	60	2	5.4	Off
7pm	1.17	1.00	60	2	5.4	Off
8pm	0	0	0	0.5	1.35	Off
9pm	0	0	0	0.5	1.35	Off
10pm	0	0	0	0.5	1.35	Off
11pm	0	0	0	0.5	1.35	Off

Table 32: Dry Lab / Specialty Learning Spaces / Libraries

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	5%
0700-0900	50%
0900-1200	100%
1200-1300	80%
1300-1700	100%
1700-2000	20%
2000-0000	5%

Table 33: Dry Lab / Specialty Learning Spaces / Libraries lighting energy consumption profile

Office Administrative Spaces

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/person)	Lighting (W/m²)	Equipment (W/m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	1	1.1	Off
1am	0	0	0	1	1.1	Off
2am	0	0	0	1	1.1	Off
3am	0	0	0	1	1.1	Off
4am	0	0	0	1	1.1	Off
5am	0	0	0	1	1.1	Off
6am	0	0	0	1	1.1	Off
7am	0.39	0.34	178	4	2.75	On
8am	1.58	1.35	45	8	7.7	On
9am	2.63	2.25	27	10	11	On
10am	2.63	2.25	27	10	11	On
11am	2.63	2.25	27	10	11	On
12pm	2.63	2.25	27	10	11	On
1pm	2.63	2.25	27	10	11	On
2pm	2.63	2.25	27	10	11	On
3pm	2.63	2.25	27	10	11	On
4pm	2.63	2.25	27	10	11	On
5pm	1.31	1.13	54	8	6.6	On
6pm	0.39	0.34	178	6	2.75	Off
7pm	0.39	0.34	178	6	2.75	Off
8pm	0.39	0.34	178	6	2.75	Off
9pm	0	0	0	1	1.1	Off
10pm	0	0	0	1	1.1	Off
11pm	0	0	0	1	1.1	Off

Table 34: Office / Administrative Spaces

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	5%
0700-0900	50%
0900-1200	100%
1200-1300	80%
1300-1700	100%
1700-2000	20%
2000-0000	5%

Table 35: Office / Administrative Spaces lighting energy consumption profile

Common Spaces

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/ person)	Lighting (W/m²)	Equipment (W/ m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0.3	0	Off
1am	0	0	0	0.3	0	Off
2am	0	0	0	0.3	0	Off
3am	0	0	0	0.3	0	Off
4am	0	0	0	0.3	0	Off
5am	0	0	0	0.3	0	Off
6am	0	0	0	0.3	0	Off
7am	0.13	0.11	533	1.8	0	On
8am	0.39	0.34	178	1.8	0	On
9am	2.63	2.25	27	6	0	On
10am	2.63	2.25	27	6	0	On
11am	2.63	2.25	27	6	0	On
12pm	1.31	1.13	53	4.8	0	On
1pm	2.63	2.25	27	6	0	On
2pm	2.63	2.25	27	6	0	On
3pm	2.63	2.25	27	6	0	On
4pm	2.63	2.25	27	6	0	On
5pm	0.53	0.45	133	1.8	0	Off
6pm	0.13	0.11	533	1.8	0	Off
7pm	0	0	0	0.3	0	Off
8pm	0	0	0	0.3	0	Off
9pm	0	0	0	0.3	0	Off
10pm	0	0	0	0.3	0	Off
11pm	0	0	0	0.3	0	Off

Table 36: Common Spaces

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	5%
0700-0900	50%
0900-1200	100%
1200-1300	80%
1300-1700	100%
1700-2000	20%
2000-0000	5%

Table 37: Common Spaces lighting energy consumption profile

Wet Labs

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/person)	Lighting (W/m²)	Equipment (W/m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	2.25	6	Off
1am	0	0	0	2.25	6	Off
2am	0	0	0	2.25	6	Off
3am	0	0	0	2.25	6	Off
4am	0	0	0	2.25	6	Off
5am	0	0	0	2.25	6	Off
6am	0.39	0.34	178	2.25	6	Off
7am	0.39	0.34	178	2.25	6	On
8am	2.63	2.25	27	15	40	On
9am	2.63	2.25	27	15	40	On
10am	2.63	2.25	27	15	40	On
11am	2.63	2.25	27	15	40	On
12pm	1.31	1.13	54	12	28	On
1pm	2.63	2.25	27	15	40	On
2pm	2.63	2.25	27	15	40	On
3pm	2.63	2.25	27	15	40	On
4pm	2.63	2.25	27	15	40	On
5pm	2.63	2.25	27	15	40	Off
6pm	0.92	0.79	77	3	8	Off
7pm	0.92	0.79	77	3	8	Off
8pm	0.92	0.79	77	3	8	Off
9pm	0.92	0.79	77	3	8	Off
10pm	0	0	0	2.25	2	Off
11pm	0	0	0	2.25	2	Off

Table 38: Wet Labs

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0800	15%
0800-1200	100%
1200-1300	80%
1300-1700	100%
1700-2200	20%
2200-0000	5%

Table 39: Wet Labs lighting energy consumption profile

Gymnasium

HVAC Model Operational Profile

Weekdays Only						
Time	Occupancy Gains (W/m²)		Occupancy (m²/ person)	Lighting (W/m²)	Equipment (W/ m²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0.8	0.75	Off
1am	0	0	0	0.8	0.75	Off
2am	0	0	0	0.8	0.75	Off
3am	0	0	0	0.8	0.75	Off
4am	0	0	0	0.8	0.75	Off
5am	0	0	0	0.8	0.75	Off
6am	12.32	22.08	13	16	12	On
7am	12.32	22.08	13	16	12	On
8am	12.32	22.08	13	16	12	On
9am	3.85	6.90	40	16	3.75	On
10am	3.85	6.90	40	16	3.75	On
11am	3.85	6.90	40	16	3.75	On
12pm	15.40	27.60	10	16	15	On
1pm	15.40	27.60	10	16	15	On
2pm	3.85	6.90	40	16	3.75	On
3pm	3.85	6.90	40	16	3.75	On
4pm	3.85	6.90	40	16	3.75	On
5pm	12.32	22.08	13	16	12	On
6pm	12.32	22.08	13	16	12	On
7pm	12.32	22.08	13	16	12	On
8pm	5.39	9.66	29	16	5.25	On
9pm	5.39	9.66	29	16	5.25	On
10pm	0	0	0	0.8	0.75	Off
11pm	0	0	0	0.8	0.75	Off

Table 40: Gymnasium

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0600	5%
0600-2200	100%
2200-0000	5%

Table 41: Gymnasium lighting energy consumption profile

Car Parks

Note: Only small car parks (those with less than 1 car parking space per 200m² UFA) are assessed by the energy tool. For this reason, the car park benchmark is calculated as being 30% "entry area" and lighting benchmark for car parks is assuming that 30% of car park area is located within 20m of an entry.

HVAC Model Operational Profile

Weekdays Only			
Time	Lighting (W/m²)	Equipment (W/m²)	Plant Operation
12am	0	0	Off
1am	0	0	Off
2am	0	0	Off
3am	0	0	Off
4am	0	0	Off
5am	0	0	Off
6am	0	0	Off
7am	10	0	On
8am	10	0	On
9am	10	0	On
10am	10	0	On
11am	10	0	On
12pm	10	0	On
1pm	10	0	On
2pm	10	0	On
3pm	10	0	On
4pm	10	0	On
5pm	10	0	On
6pm	10	0	On
7pm	0	0	Off
8pm	0	0	Off
9pm	0	0	Off
10pm	0	0	Off
11pm	0	0	Off

Table 42: Car Parks

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	0%
0700-1800	100%
1800-0000	0%

Table 43: Car park lighting energy consumption profile

APPENDIX D: OTHER ENERGY CONSUMPTION

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

- Domestic Hot Water;
- Lifts; and
- Escalators and Travelators.

DOMESTIC HOT WATER

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.*

DOMESTIC HOT WATER REQUIREMENTS

The following table shows the hot water consumption that is to be assumed for each space type when calculating the energy consumption of a hot water system. Note that it is assumed that there is no hot water energy consumption associated with car parks.

A building that achieves the maximum points in Tra-3 Cyclist Facilities with WELS 3 star rated showers has been used as the benchmark case. As the calculator is assessing the efficiency of the hot water system not how much hot water is being used, the achievement of the Tra-3 Cyclist Facilities credit is not relevant.

Primary / High Schools			
	Occupancy (m²/person/day)	Domestic Hot Water Requirement per person (L/person/day)	Domestic hot water requirement per square meter (L/m²/day) Rounded to 2d.pl.
Classroom / Multipurpose Spaces	12	1.5	0.14
Computer and Physics Labs	4	1.5	0.38
Office and Staff Rooms	39	5.5	0.15
Library	7	1.5	0.21
Common Spaces	4	1.5	0.38
Canteen	33	1.5	0.05
Workshops	12	1.5	0.13
Gymnasiums	17	12	0.71
Car Parks	0	0	0

Table 44: Continued on the next page...

University Buildings			
	Occupancy (m²/person/day)	Domestic Hot Water Requirement per person (L/person/day)	Domestic hot water requirement per square meter (L/m²/day) Rounded to 2d.pl.
Teaching / Classroom Spaces	9	1.5	0.17
Dry Labs / Specialty / Libraries Learning Spaces	9	1.5	0.17
Office / Administrative Spaces	20	5.5	0.28
Common Spaces	20	1.5	0.08
Wet Labs	20	1.5	0.08
Gymnasiums	19	12	0.63
Car Parks	0	0	0

Table 44: 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 **Daily Domestic Hot Water Requirements** by multiplying the hot water supply (L/m²/day) found in the table above by each of the space type areas (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 education facility**. 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/m of pipe should be applied.

3. Multiply the Daily Domestic Hot Water Energy Requirement by 260 days to calculate the Yearly Hot Water Energy Requirement. This is the figure to be entered into the **Green Star - Education 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 AREA (m²)	HOT WATER REQUIREMENTS (L/day)	DAILY ENERGY REQUIRED TO HEAT HOT WATER (kWh/ day)	YEARLY ENERGY REQUIRED TO HEAT HOT WATER (kWh/year)
Classroom / Multipurpose Spaces	0.13	2500	325	17.55	4,563

Table 45: Example of how to calculate hot water energy consumption

The figure to be entered into the Green Star – Education v1 Energy Calculator is 4,563kWh/year.

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

$$E = \left(\frac{R \times S \times T\ (100\% + P)}{3600} + (St \times Hrs \times 260) \right) \times \text{No. Lifts}$$

Where:

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

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

S = number of **S**tarts per year (S=300,000 for the purposes of the Green Star – Education v1 lift energy calculations)

T = typical **T**rip time (seconds) (T=5s for the purposes of the Green Star – Education 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 3600 converts the first half of the equation, which is in kWs, into kWh.

o The hours x 260 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 – Education v1 Energy Calculator**

Equation Symbol	Description	Lift
R	Lift Power Rating (kW)	40
S	Number of starts per year	300,000
T	Typical Trip Time (s)	5
St	Standby Power Rating (kW)	0.1
Hrs	Lift operating hours (hrs/day)	18 (as lift has power off feature)
P	Penalty factor (for having no regenerative brakes)	15% (speed of lift >2.5m/s, lift does not have regenerative brakes)
No. Lifts	Number of lifts of this type	3

Table 46: Example parameters for lift energy consumption

$$\mathbf{E = \left(\frac{40 \times 300{,}000 \times 5\ (100\% + P)}{3600} + (\ 0.1 \times 18 \times 260\ ) \right) \times 3}$$

E = 58,904kWh/yr

The figure to be entered into the Green Star – Education v1 Energy Calculator for this example is **58,904kWh/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 = 2080 for the purposes of Green Star – Education v1 energy calculations (8 hrs a day (average of operational profiles) multiplied by 260 days a year equals 2080 hrs/year)

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

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

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

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)	1	4	2080	66,560
8kW (with sensor)	0.75	2	2080	24,960
TOTAL YEARLY ENERGY CONSUMPTION (kWh/year)				91,520

Table 47: Example of how to calculate escalator or travelator energy consumption

The figure to be entered into the Green Star – Education v1 Energy Calculator is 91,520kWh/year

APPENDIX E: 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).

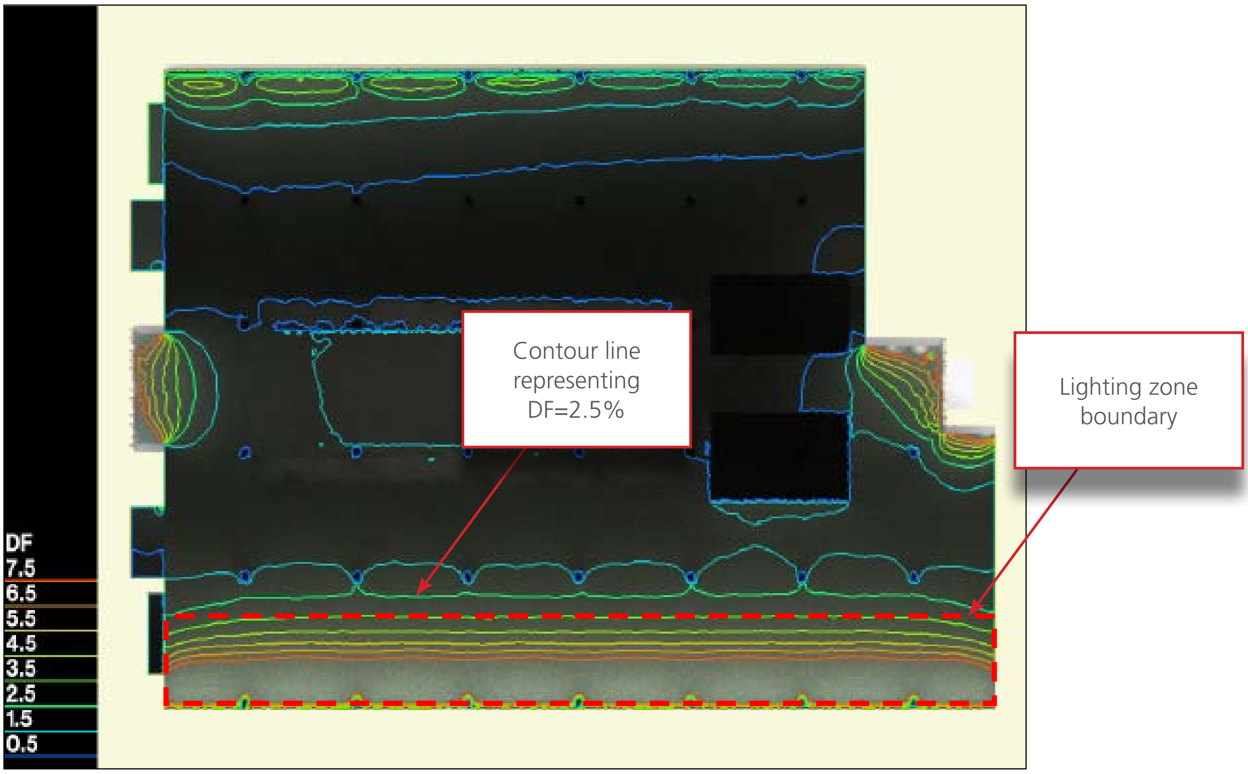
The calculation methodology for use of daylight dimming or switching should be submitted to the GBCA via a CIR prior to submission.

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:

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

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

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

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

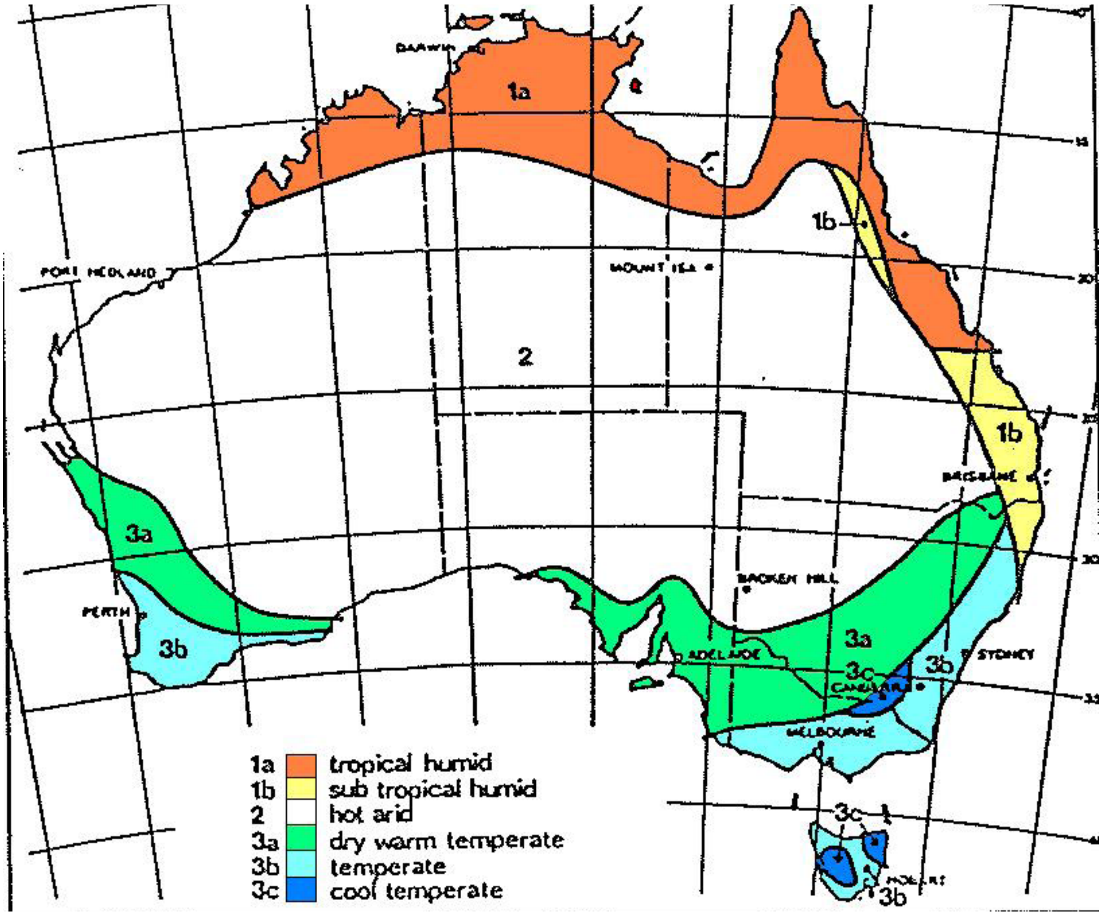
$$= 12.8 \text{ kilo lux}$$

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: $8W/m^2 \times 35\% = 2.8W/m^2$