



GREEN STAR - INDUSTRIAL PILOT ENERGY CALCULATOR GUIDE

FEBRUARY 2009

EXECUTIVE SUMMARY

The Green Star – Industrial PILOT rating tool has been developed to assess the environmental attributes of new and refurbished industrial facilities in Australia. The Energy Credit Calculator within this tool compares the predicted energy consumption of an industrial facility to a reference benchmark. This comparison is then used to award points to any facility with a predicted energy consumption that is less than the benchmark.

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 which must be determined using computer modelling. This guide specifies standard inputs to be used when modelling the heating, ventilation and air-conditioning (HVAC) systems of the facility. The standard inputs include operational profiles and internal heat loads that facilitate comparison between different industrial facilities.

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 – Industrial PILOT rating tool Energy Calculator. The calculator compares the performance of the facility relative to set benchmarks. Information on how these benchmarks were set can be found in the Green Star – Industrial PILOT Standard Practice Benchmark document.

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Tool Version	Revision	Date Issued
Green Star – Industrial PILOT Launch	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 – Industrial PILOT rating tool assesses the environmental performance of industrial facilities by measuring their environmental impact.

The assessment of environmental performance includes determining the predicted energy consumption of an industrial facility. The Green Star – Industrial PILOT Energy Calculator has been developed to compare this to a benchmark. This report has been written as a guide to the Calculator including data to be entered for calculations. More information on how the benchmarks were set can be found in the Green Star – Industrial PILOT Calculator Benchmarking Methodology document.

This report has been written as a guide to these calculations, and how they must be entered into the Green Star – Industrial PILOT Energy Calculator for comparison.

2 Guidelines for Simulation Input Parameters

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

2.2 GENERAL PARAMETERS

Modelling Parameter	Requirements
Simulation Package	<ul style="list-style-type: none"> • Passed the BESTEST¹ validation test; or • The European Union draft standard EN13791 July 2000; or • Be certified in accordance with ANSI/ASHRAE Standard 140-2001. <p>Please contact the Green Building Council of Australia if none of the above options can be complied with.</p>
Weather Data	<ul style="list-style-type: none"> • 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. <p>Please contact the Green Building Council of Australia if none of the above options can be complied with.</p>
Over-shadowing	<ul style="list-style-type: none"> • Demonstrate that overshadowing from the surrounding environment has been taken into account in the model.
Space Type Breakdown	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Demonstrate that insulation in the walls, ceiling and floors has been accurately represented.
Glazing	<ul style="list-style-type: none"> • Demonstrate that glazing is modelled using the following parameters: <ul style="list-style-type: none"> - Visible light transmission; - Solar transmission; - Internal and external solar reflectance; and - Emissivity.
Windows and Spandrel	<ul style="list-style-type: none"> • Demonstrate that the sizes of windows and spandrel are accurately represented.
Shading	<ul style="list-style-type: none"> • Demonstrate that all shading of windows and external building fabric has been accurately represented.
Orientation	<ul style="list-style-type: none"> • Demonstrate that the building orientation has been included in the model.
Infiltration	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Demonstrate that lighting is calculated based on floor area. • Demonstrate that the appropriate HVAC Model Operational Profile (see Appendix B) has been used in the HVAC Model
Equipment	<ul style="list-style-type: none"> • 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 Appendix B.
Occupancy	<ul style="list-style-type: none"> • Demonstrate that all occupancies are calculated based on floor area. • Demonstrate that the occupancy profile used is that prescribed for each space type in Appendix B.

Table 3: Internal loads parameters

2.5 A/C PUMPING

Modelling Parameter	Requirements
Chilled water	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Demonstrate that the HVAC system modelled represents the system design for each part of the building. • Select the appropriate drop down box for number of days that each space type is operational. • Select the appropriate internal conditions where applicable, e.g. manufacturing, cool room spaces.
Zoning	<ul style="list-style-type: none"> • Demonstrate that all air-conditioning zones represented in the thermal model accurately reflect system performance and zonal solar diversity.
Chiller plant	<ul style="list-style-type: none"> • 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. • <u>Water-cooled equipment</u>: Demonstrate that chiller data is specified under conditions that reflect the intended condenser water temperature controls. • <u>Air-cooled equipment</u>: Demonstrate that the air cooled chiller COP profiles have been accurately modelled with regard to loading and ambient conditions.
Boiler plant	<ul style="list-style-type: none"> • Demonstrate that the boiler plant size, thermal efficiency and distribution efficiency are accurately reflected in the model.
Supply Air and Exhaust Fans	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • If applicable, 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	<ul style="list-style-type: none"> • If applicable, 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Demonstrate that economy cycles have been modelled to reflect system specification noting any enthalpy/temperature cut-off and control point.
Primary duct temperature control	<ul style="list-style-type: none"> • <u>Constant Volume Systems</u>: Demonstrate that modelling has allowed supply air temperatures to vary to meet loads in the space. • <u>Variable Volume Systems</u>: 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Demonstrate, where relevant, that the minimum turndown airflow of each air supply is accurately reflected in the model.
Chiller/ compressor staging	<ul style="list-style-type: none"> • 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. • For refrigeration systems that use a cascading series of compressors, demonstrate that the COP incorporated is representative of the entire series.
Temperature control bands	<ul style="list-style-type: none"> • 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;

- o Domestic hot water supply;
- o Lifts, escalators and travelators;
- o Lighting; and
- o 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	<ul style="list-style-type: none"> • Domestic hot water loads (to showers and wash hand basins) are to be calculated using the method outlined in Appendix C. • Note that any other hot water supply (such as for laundries) is not to be included.
Lighting	<ul style="list-style-type: none"> • Demonstrate that lighting is calculated based on floor area. • Demonstrate that the appropriate Lighting Energy Consumption Profile in Appendix B has been used. <p>The lighting profile can be adjusted if the following are installed:</p> <ul style="list-style-type: none"> • <u>Occupancy sensors</u>: Lighting must follow the appropriate lighting profile whenever the appropriate occupancy profile is larger than zero. • <u>Time Clocks</u>: 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. • <u>Daylight dimming</u>: Details of this system and the calculation method must be provided. The calculation must use the methodology outlined in Appendix D.
Mechanical exhaust systems	<ul style="list-style-type: none"> • Demonstrate that the energy requirements for mechanical exhaust systems (such as those installed for toilets, kitchens and any other purpose specific systems such as photocopy or computer server room exhausts) are calculated using the following parameters: <ul style="list-style-type: none"> • Maximum power of the fan; • 50% fan efficiency; and • An operational profile based on the operational profiles; that is, the fan should be operating anytime that the HVAC system is on.
Lift loads	<ul style="list-style-type: none"> • Lift loads are to be calculated using the method outlined in Appendix C.
Escalator and travelator loads	<ul style="list-style-type: none"> • Escalator and travelator loads are to be calculated using the method outlined in Appendix C.

Table 7: Other services parameters

3 Entering the simulation output data

The calculator is divided into 6 sections:

- Building location;
- Building space types;
- Building Energy Consumption and Generation;
- Results Summary;
- Points Score Calculator; and
- Costs savings calculator.

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

3.1 BUILDING LOCATION

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

Green Star - Industrial PILOT
Credit Summary for

Energy Credit Calculator
Input information in white cells:

The Green Star - Industrial PILOT Energy Calculator Guide provides guidance on each of the required inputs and must be followed to ensure an accurate assessment of the building's energy performance. The benchmark figures used in this energy calculator were calculated based on standard practice greenhouse gas emissions. Details of how the benchmarks were calculated are outlined in the Green Star - Industrial PILOT Standard Practice / benchmark document.

Number of Points Achieved: 0 [Back to Energy Credits](#)

Input Data Information	Input data into white cells	Calculations based on input data	Calculations based on benchmark data
Building Location			
Greenhouse Gas Coefficients		State/Territory	
Facility Location		ACT	
		Modelled facility emissions factor	Benchmark facility emissions factor
Electricity greenhouse gas coefficient (kgCO ₂ -e/kWh)		1.06	1.12
Gas Emissions Factor (kgCO ₂ -e/MJ)		0.0661	0.0626

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.

Figure 1: Building location

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. Depending on the space type, additional information needs to be specified:

- Space types in the first table require the days of operation to be specified;
- Laboratories require the equipment gains and peak exhaust rate for fume cupboards to be specified;
- Clean rooms require the equipment gains to be specified;
- Cold rooms need the volume and required temperature to be specified.

The column on the right hand side shows the benchmark GHG emissions associated with the HVAC system operation for that space type.

Enter **areas of each space type** (as defined in Appendix A).

Choose the **operational profiles** for each space type.

Building Space Types			HVAC Benchmark Greenhouse Gas Emissions (kgCO ₂ -e/yr)
Space Type:	Area (m ²)	Days of Operation	
Warehouse	10,000	High Bay - Mon-Fri	41,440
Office	2,000	Office - Mon-Fri	89,600
Kitchen	10	Kitchen - Mon-Fri	571
Common Area	25		Please select days of operation
Workshop		<div style="border: 1px solid black; padding: 2px; font-size: x-small;"> Common Area - Mon-Fri Common Area - Mon-Sat Common Area - Mon-Sun </div>	0
Showroom			0
Laboratory	50	Laboratory - Mon-Fri	Please enter exhaust rate below
Clean Room			0
Enclosed Car Park	100	Car Park - Mon-Fri	2,016
Loading Docks			0
Subtotal	12,185		133,627

If **Laboratory** or **Clean Room** spaces are included, specify equipment loads and air-exhaust rate if applicable.

Additional information for above space types			Enter & submit data
Laboratory Equipment Gains W/m ²	30		
Peak Exhaust Air rate for Fume Cupboards L/s			
Clean Room Equipment Gains W/m ²			

Note: If different space types on site have different days of operation, the **Car Park** will operate in correlation with the space type with the longest operational profile.

Figure 2: Building Space Types (1)

If there are **cool rooms/cold store** spaces within the facility, enter **area, volume** of the space and the maintained **temperature** for each type of storage (long term/short term/distribution centre).

Space Type:	Area (m ²)	Volume (m ³)	Cooling Temperature (°C)	HVAC Benchmark Greenhouse Gas Emissions (kgCO ₂ -e/yr)
Cool Rooms / Cold Stores Long Term Storage	6	18	5	697
Cool Rooms / Cold Stores Short Term Storage				0
Cool Rooms / Cold Stores Distribution Centre				0
Subtotal	6	18		697

Space Type:	Area (m ²)	HVAC Benchmark Greenhouse Gas Emissions (kgCO ₂ -e/yr)
Manufacturing / Process Area - No Temperature Control		0
Manufacturing / Process Area - Low Temperature Control		0
Manufacturing / Process Area - Medium Temperature Control	150	14,280
Manufacturing / Process Area - High Temperature Control		0
Manufacturing / Process Area - Temperature and Rh Control		0
Subtotal	150	14,280

	Area (m ²)	TOTAL HVAC Benchmark Greenhouse Gas Emissions (kgCO ₂ -e/yr)
TOTAL	12,341	148,604

Figure 3: Building Space Type (2)

If there are **manufacturing/process** areas within the facility, enter the **area** in the cell for the appropriate degree of control over the internal environment.

Details of the classification of internal conditions can be found in the operational profiles for manufacturing spaces in Appendix B.

3.3 BUILDING ENERGY CONSUMPTION AND GENERATION

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 the energy use for each space type followed by the GHG emissions being assumed for the benchmark facility.

Building Energy Consumption and Generation					
Modelled Facility Energy Consumption		Total Modelled Energy Consumption			
HVAC Energy Consumption (incl. boilers, chillers, fans)	Electricity (kWh/yr)	125,000		Modelled HVAC Greenhouse Gas Emissions (kgCO₂-e/yr)	TOTAL HVAC Benchmark Greenhouse Gas Emissions (kgCO₂-e/yr)
	Gas (MJ/yr)	250,000		132,500	152,681
Co-generation and Tri-generation	Gas (MJ/yr)			16,525	
				0	
Lighting Energy Consumption		Total Calculated Energy Consumption (kWh/yr)		Modelled Greenhouse Gas Emissions (kgCO₂-e/yr)	Benchmark Greenhouse Gas Emissions (kgCO₂-e/yr)
Warehouse		400,000		424,000	515,200
Office		100,000		106,000	87,360
Kitchen		500		530	426
Common Area		500		530	644
Workshop				0	0
Showroom				0	0
Laboratory		2,000		2,120	2,688
Clean Room				0	0
Cool Rooms				0	67
Manufacturing				0	25,032

Enter **Electricity** and **Gas** consumption based on computer simulation. The gas required for co-generation or tri-generation should be entered separately.

Enter **Lighting Energy Consumption** for all spaces.

Figure 4: Building Energy Consumption and Generation (1)

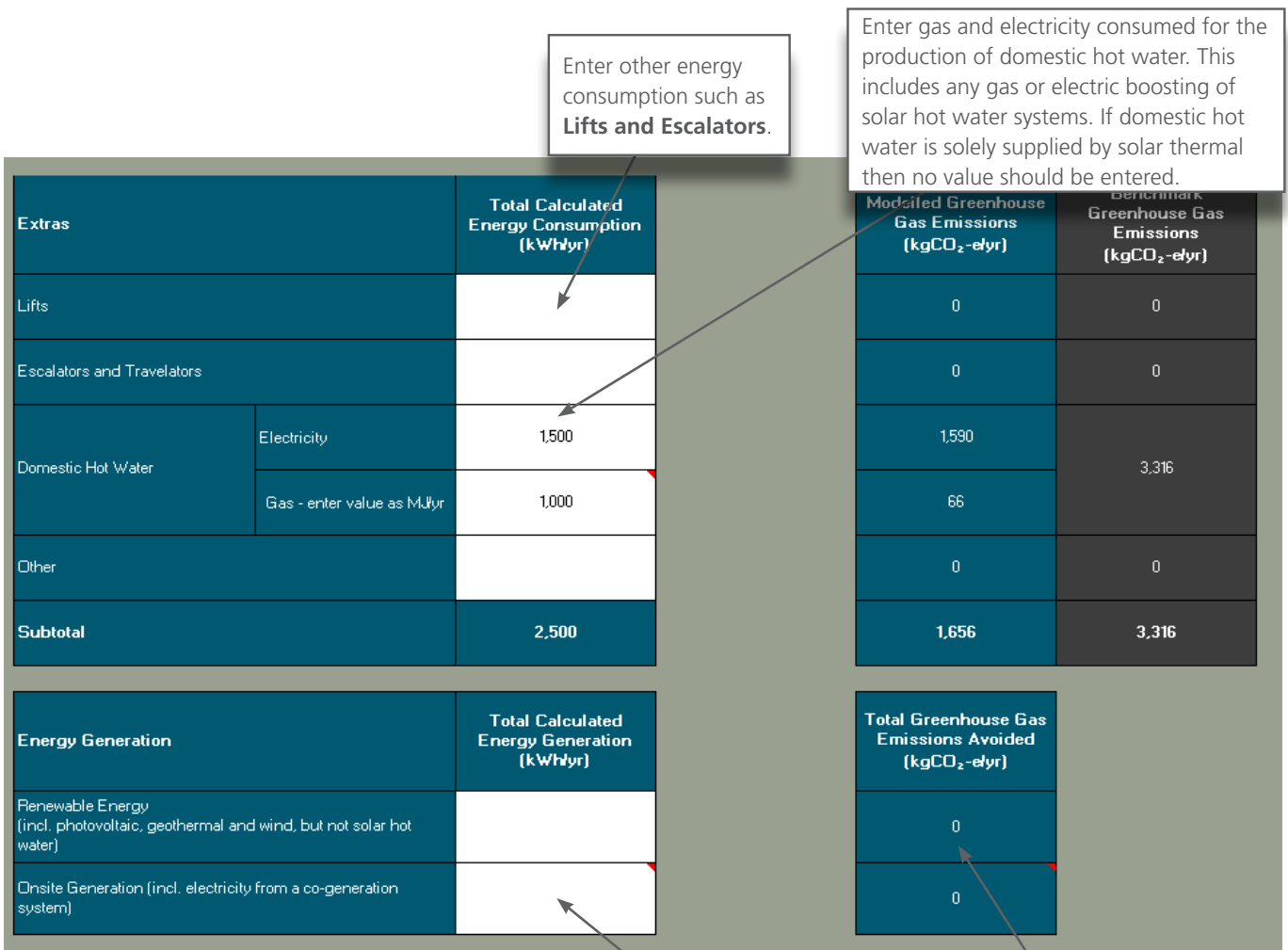


Figure 5: Building Energy Consumption and Generation (2)

Enter electricity produced from Renewable Energy installation and co-generation/ tri-generation plants.

For details, see text following this figure.

The 'Total 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 benchmark facilities along with the associated greenhouse gas (GHG) emissions.

The greenhouse gas savings are calculated as follows:

$$\text{GHG savings} = \text{TOTAL Benchmark GHG emissions} - \text{TOTAL Facility GHG emissions}$$

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 Facility Consumption (kWh Electricity, MJ Gas)	Benchmark Consumption (kWh Electricity, MJ Gas)	Facility Greenhouse Gas Emissions (kgCO ₂ /yr)	Benchmark Greenhouse Gas Emissions (kgCO ₂ /yr)
Total grid electricity	632,500	704,704	670,450	789,269
Total gas	251,500	11,516	16,624	721
TOTAL			687,074	789,989
Greenhouse Gas Savings (Difference in greenhouse gas emissions between benchmark and facility (kgCO₂/yr))			102,915	
Percentage reduction of Greenhouse Gas Emissions compared to the Standard Practice Benchmark			13.0%	

Figure 6: Results Summary

3.5 POINTS SCORE CALCULATOR

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. The number of points is displayed below.

Point Score Calculator		
Green Star Points	Maximum greenhouse gas emissions to achieve points (kg CO ₂ /yr)	Percentage Reduction of Greenhouse Gas Emissions compared to the Standard Practice Benchmark
20	0	100%
19	39,499	95%
18	78,999	90%
17	118,498	85%
16	157,998	80%
15	197,497	75%
14	236,997	70%
13	276,496	65%
12	315,996	60%
11	355,495	55%
10	394,995	50%
9	434,494	45%
8	473,994	40%
7	513,493	35%
6	552,993	30%
5	592,492	25%
4	631,992	20%
3	671,491	15%
2	710,991	10%
1	750,490	5%
Conditional Requirement	789,989	0%

Is the Conditional Benchmark Requirement met?	Yes
Number of Points Achieved	2

Shows the points awarded for the design.

Figure 7: Points Score Calculator

3.7 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	
Enter data into white cells	
Cost of Electricity (\$/kWh)	\$0.30
Cost of Gas (\$/MJ)	\$0.08
Possible Annual Cost Saving Compared to Benchmark (\$/year)	\$2,462.53

Enter the **cost of gas and electricity** to find out the cost saving of the design compared to the benchmark energy consumption. "Average" costs should be used because most tariffs are very complex.

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.

Figure 8: Cost Saving Calculator

4 Case Study – On-site Energy Generation

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

The case study industrial facility has 25,000m² of warehouse space and 5,000m² of office space. It is located in NSW, operates from Monday to Friday, and generates electricity on-site using co-generation, solar hot water and renewable energy. The Solar water heater is gas boosted with 75,000m² of gas per annum.

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

Space Type	Area (m ²)
Warehouse	25,000
Offices	5,000

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 gas consumption is used to fire the co-generation plant on site.

Energy Source	Energy Consumption (kWh/year)
Electricity	200,000
Gas	100,000

Table 9: HVAC Energy Consumption for Case Study

The lighting energy consumption is calculated using Section 2 of this Guide. 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)
Warehouse Lighting	600,000
Office/Administrative Spaces Lighting	100,000
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 as this section is for onsite electricity generation. 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 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 Space Types			
(There are 3 space type sections to be completed)			
Space Type:	Area (m ²)	Days of Operation	HVAC Benchmark Greenhouse Gas Emissions (kgCO ₂ -e/yr)
Warehouse	25,000	Low Bay - Mon-Fri	103,600
Office	5,000	Office - Mon-Fri	224,000
Kitchen			0
Common Area			0
Workshop			0
Showroom			0
Laboratory			0
Clean Room			0
Enclosed Car Park			0
Loading Docks			0
Subtotal	30,000		327,600

Areas and days of operation of the two space types are entered here.

Additional information for above space types	Laboratory Equipment Gains W/m ²	Peak Exhaust Air rate for Fume Cupboards L/s	Clean Room Equipment Gains W/m ²

Space Type:	Area (m ²)	Volume (m ³)	Cooling Temperature (°C)	HVAC Benchmark Greenhouse Gas Emissions (kgCO ₂ -e/yr)
Cool Rooms / Cold Stores Long Term Storage				0
Cool Rooms / Cold Stores Short Term Storage				0
Cool Rooms / Cold Stores Distribution Centre				0
Subtotal	0	0		0

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

Building Energy Consumption and Generation				
Modelled Facility Energy Consumption		Total Modelled Energy Consumption	Modelled HVAC Greenhouse Gas Emissions (kgCO ₂ -e/yr)	TOTAL HVAC Benchmark Greenhouse Gas Emissions (kgCO ₂ -e/yr)
HVAC Energy Consumption (incl. boilers, chillers, fans)	Electricity (kWh/yr)	200,000	212,000	327,600
	Gas (MJ/yr)		0	
Co-generation and Tri-generation	Gas (MJ/yr)	100,000		
Lighting Energy Consumption		Total Calculated Energy Consumption (kWh/yr)	Modelled Greenhouse Gas Emissions (kgCO ₂ -e/yr)	Benchmark Greenhouse Gas Emissions (kgCO ₂ -e/yr)
Warehouse		600,000		1,036,000
Office		100,000	106,000	218,400
Kitchen			0	0
Common Area			0	0
Workshop			0	0
Showroom			0	0
Laboratory			0	0
Clean Room			0	0
Cool Rooms			0	0
Manufacturing			0	0
Enclosed Car Park			0	0
Loading Dock			0	0
Subtotal		700,000	742,000	1,254,400
Extras		Total Calculated Energy Consumption (kWh/yr)	Modelled Greenhouse Gas Emissions (kgCO ₂ -e/yr)	Benchmark Greenhouse Gas Emissions (kgCO ₂ -e/yr)
Lifts				0
Escalators and Travelators				0
Domestic Hot Water	Electricity		0	6,328
	Gas - enter value as MJ/yr	75,000		
Other				
Subtotal		0		
On-Site Electricity Generation		Total Calculated Electricity Generation (kWh/yr)	Total Greenhouse Gas Emissions Avoided (kgCO ₂ -e/yr)	
Renewable Energy (incl. photovoltaic, geothermal and wind, but not solar hot water)		1,000	1,060	
Other On-Site Electricity Generation (incl. electricity from a co-generation system)		25,000	26,500	

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

Gas used to boost the solar water heater is entered here.

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

Results Summary				
	Total Facility Consumption (kWh Electricity, MJ Gas)	Benchmark Consumption (kWh Electricity, MJ Gas)	Facility Greenhouse Gas Emissions (kgCO2/yr)	Benchmark Greenhouse Gas Emissions (kgCO2/yr)
Total grid electricity	949,000	1,418,150	1,005,940	1,588,328
Total gas	100,000	0	6,610	0
TOTAL			1,012,550	1,588,328
Greenhouse Gas Savings (Difference in greenhouse gas emissions between benchmark and facility (kgCO2/yr))			575,778	
Percentage reduction of Greenhouse Gas Emissions compared to the Standard Practice Benchmark			36.3%	
Point Score Calculator				
Green Star Points	Maximum greenhouse gas emissions to achieve points (kg CO2/yr)	Percentage Reduction of Greenhouse Gas Emissions compared to the Standard Practice Benchmark		
20	0	100%		
19	79,416	95%		
18	158,833	90%		
17	238,249	85%		
16	317,666	80%		
15	397,082	75%		
14	476,498	70%		
13	555,915	65%		
12	635,331	60%		
11	714,748	55%		
10	794,164	50%		
9	873,580	45%		
8	952,997	40%		
7	1,032,413	35%		
6	1,111,830	30%		
5	1,191,246	25%		
4	1,270,662	20%		
3	1,350,079	15%		
2	1,429,495	10%		
1	1,508,912	5%		
Conditional Requirement	1,588,328	0%		
Is the Conditional Benchmark Requirement met?	Yes			
Number of Points Achieved	7			

This facility gains 7 points under Ene-1

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 – Industrial PILOT rating tool Energy Calculator.

Warehouse (High Bay) – These spaces include storage spaces for goods and commodities that are more than 7.6m in height. Note that this refers to the average height of the space and not the ridge height.

Warehouse (Low Bay) – These spaces include storage spaces for goods and commodities that are less than 7.6m in height. Note that this refers to the average height of the space and not the ridge height.

Warehouse (Automated) – These spaces include storage spaces for goods and commodities that are completely automated with conveyor belts loading stock in programmed locations, with all handling and distribution being mechanised.

Offices – These spaces include operational and administrative offices that are associated with storage and manufacturing facilities.

Manufacturing/Process Area – These spaces would include areas used for the production and manufacture of goods, involving mechanised and manual handling and including product assembly lines.

Retail/Factory Shop/Showroom – These spaces would include areas involved in the sale of goods produced on-site or functions as a centralised wholesale distribution. Areas such as direct factory outlets are included within this space type.

Workshop – These spaces would be associated with the retail component described above. This category does not include spaces with intensive equipment use; they would be included in the manufacturing/production category.

Cool Room/Freezer – These spaces include walk-in rooms used for storage below 15°C. These would include cool rooms, and walk-in freezers. This category addresses low temperature storage spaces only; display cabinets, small scale freezers would be classified as equipment and excluded from this category.

Laboratory – This category includes spaces involved in testing, research and development. They may include a variety of space types from test spaces for small scale physical mock-ups, to spaces that involve chemical processing, radiation equipment and electronics testing.

Clean rooms – These spaces would be primarily related to precision manufacturing that would require a highly controlled environment to maintain the integrity of the products. Industries likely to be associated with this category include semiconductor processing and other sensitive applications within the IT industry.

Kitchens – These spaces refer to the on-site kitchens designed to cater to employees only. The space type has been benchmarked for medium level of equipment use, commercial kitchens would be penalised in comparison to this benchmark.

Enclosed Car park – This space type includes large and small scale enclosed parking areas, catering to employees or used as a commercial parking lot.

Common Area – This space type includes all break-out spaces, lunch rooms, and reception areas. First aid rooms may also be included within this category.

Loading Dock – This space type includes any covered/uncovered external spaces for loading and unloading of goods that would have significant lighting use.

APPENDIX B: INDUSTRIAL BUILDINGS OPERATIONAL PROFILES

Warehouse – High Bay

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.

Default Inputs:

(Can be altered to suit the building and system design):

Upper Temperature Limit: None

Lower Temperature Limit: None

Air change rate: In accordance with AS1668.2 or engineered design

HVAC Model Operational Profile

Operational Profile applicable to 5, 6 or all 7 days depending on the Actual Design						
Time	Occupancy Gains (W/m ²)		Occupancy (m ² /person)	Lighting (W/m ²)	Equipment (W/m ²)	Plant Operation
	Sensible	Latent				
12am	0.0	0.0	0	1.0	1.2	Off
1am	0.0	0.0	0	1.0	1.2	Off
2am	0.0	0.0	0	1.0	1.2	Off
3am	0.0	0.0	0	1.0	1.2	Off
4am	0.0	0.0	0	1.0	1.2	Off
5am	0.2	0.3	667	4.0	3.0	Off
6am	1.1	1.9	100	10.0	12.0	On
7am	1.1	1.9	100	10.0	12.0	On
8am	1.1	1.9	100	10.0	12.0	On
9am	1.1	1.9	100	10.0	12.0	On
10am	1.1	1.9	100	10.0	12.0	On
11am	1.1	1.9	100	10.0	12.0	On
12pm	1.1	1.9	100	10.0	12.0	On
1pm	1.1	1.9	100	10.0	12.0	On
2pm	1.1	1.9	100	10.0	12.0	On
3pm	1.1	1.9	100	10.0	12.0	On
4pm	1.1	1.9	100	10.0	12.0	On
5pm	1.1	1.9	100	10.0	12.0	On
6pm	1.1	1.9	100	10.0	12.0	On
7pm	1.1	1.9	100	10.0	12.0	On
8pm	0.6	0.9	200	8.0	12.0	On
9pm	0.2	0.3	667	6.0	7.2	Off
10pm	0.1	0.1	2000	4.0	3.0	Off
11pm	0.0	0.0	0	2.0	1.8	Off

Table 12: Warehouse – High Bay

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0400	10%
0400-0500	40%
0500-1900	100%
1900-2000	80%
2000-2100	60%
2100-2200	40%
2200-2300	20%
2300-0000	10%

Table 13: Warehouse – High Bay Lighting Energy Consumption Profile

Warehouse – Low Bay

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.

Default Inputs:

(Can be altered to suit the building and system design):

Upper Temperature Limit: None

Lower Temperature Limit: None

Air change rate: In accordance with AS1668.2 or engineered design

HVAC Model Operational Profile

Operational Profile applicable to 5, 6 or all 7 days depending on the Actual Design						
Time	Occupancy Gains (W/m ²)		Occupancy (m ² /person)	Lighting (W/m ²)	Equipment (W/m ²)	Plant Operation
	Sensible	Latent				
12am	0.0	0.0	0	0.80	1.0	Off
1am	0.0	0.0	0	0.80	1.0	Off
2am	0.0	0.0	0	0.80	1.0	Off
3am	0.0	0.0	0	0.80	1.0	Off
4am	0.0	0.0	0	0.80	1.0	Off
5am	0.2	0.3	667	3.20	2.5	Off
6am	1.1	1.9	100	8.00	10.0	On
7am	1.1	1.9	100	8.00	10.0	On
8am	1.1	1.9	100	8.00	10.0	On
9am	1.1	1.9	100	8.00	10.0	On
10am	1.1	1.9	100	8.00	10.0	On
11am	1.1	1.9	100	8.00	10.0	On
12pm	1.1	1.9	100	8.00	10.0	On
1pm	1.1	1.9	100	8.00	10.0	On
2pm	1.1	1.9	100	8.00	10.0	On
3pm	1.1	1.9	100	8.00	10.0	On
4pm	1.1	1.9	100	8.00	10.0	On
5pm	1.1	1.9	100	8.00	10.0	On
6pm	1.1	1.9	100	8.00	10.0	On
7pm	1.1	1.9	100	8.00	10.0	On
8pm	0.6	0.9	200	6.40	10.0	On
9pm	0.2	0.3	667	4.80	6.0	Off
10pm	0.1	0.1	2000	3.20	2.5	Off
11pm	0.0	0.0	0	1.60	1.5	Off

Table 14: Warehouse – Low Bay Profile

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0400	10%
0400-0500	40%
0500-1900	100%
1900-2000	80%
2000-2100	60%
2100-2200	40%
2200-2300	20%
2300-0000	10%

Table 15: Warehouse – Low Bay Lighting Energy Consumption Profile

Warehouse – Automated

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

Default Inputs:

(Can be altered to suit the building and system design):

Upper Temperature Limit: None

Lower Temperature Limit: None

Air change rate: In accordance with AS1668.2 or engineered design

HVAC Model Operational Profile

Operational Profile applicable for 7 days/week						
Time	Occupancy Gains (W/m ²)		Occupancy (m ² /person)	Lighting (W/m ²)	Equipment (W/m ²)	Plant Operation
	Sensible	Latent				
12am	0	0	0	0	18	On
1am	0	0	0	0	18	On
2am	0	0	0	0	18	On
3am	0	0	0	0	18	On
4am	0	0	0	0	18	On
5am	0	0	0	0	36	On
6am	0	0	0	0	36	On
7am	0	0	0	0	36	On
8am	0	0	0	0	36	On
9am	0	0	0	0	36	On
10am	0	0	0	0	36	On
11am	0	0	0	0	36	On
12pm	0	0	0	0	36	On
1pm	0	0	0	0	36	On
2pm	0	0	0	0	36	On
3pm	0	0	0	0	36	On
4pm	0	0	0	0	36	On
5pm	0	0	0	0	36	On
6pm	0	0	0	0	36	On
7pm	0	0	0	0	36	On
8pm	0	0	0	0	36	On
9pm	0	0	0	0	36	On
10pm	0	0	0	0	36	On
11pm	0	0	0	0	18	On

Table 16: Warehouse – Automated HVAC Operational Profile

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0400	50%
0400-2200	100%
2200-0000	50%

Table 17: Warehouse – Automated Lighting Energy Consumption Profile

Office

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.

Default Inputs:

(Can be altered to suit the building and system design):

Upper Temperature Limit: 24°C

Lower Temperature Limit: 21°C

Air change rate: In accordance with AS1668.2 or engineered design

HVAC Model Operational Profile

Operational Profile applicable to 5, 6 or all 7 days depending on the Actual Design						
Time	Occupancy Gains (W/m ²)		Occupancy (m ² /person)	Lighting (W/m ²)	Equipment (W/m ²)	Plant Operation
	Sensible	Latent				
12am	0.00	0.0	0	1.0	1.5	Off
1am	0.00	0.0	0	1.0	1.5	Off
2am	0.00	0.0	0	1.0	1.5	Off
3am	0.00	0.0	0	1.0	1.5	Off
4am	0.00	0.0	0	1.0	1.5	Off
5am	0.00	0.0	0	1.0	1.5	Off
6am	0.00	0.0	0	1.0	1.5	Off
7am	0.70	0.6	100	4.0	3.8	On
8am	4.67	4.0	15	10.0	15.0	On
9am	4.67	4.0	15	10.0	15.0	On
10am	4.67	4.0	15	10.0	15.0	On
11am	4.67	4.0	15	10.0	15.0	On
12pm	4.67	4.0	15	10.0	15.0	On
1pm	4.67	4.0	15	10.0	15.0	On
2pm	4.67	4.0	15	10.0	15.0	On
3pm	4.67	4.0	15	10.0	15.0	On
4pm	4.67	4.0	15	10.0	15.0	On
5pm	4.67	4.0	15	10.0	15.0	On
6pm	4.67	4.0	15	10.0	15.0	On
7pm	2.34	2.0	30	8.0	9.0	On
8pm	0.70	0.6	100	6.0	3.8	Off
9pm	0.23	0.2	300	4.0	2.3	Off
10pm	0.00	0.0	0	2.0	1.5	Off
11pm	0.00	0.0	0	1.0	1.5	Off

Table 18: Office Profile

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0600	10%
0600-0700	40%
0700-1800	100%
1800-1900	80%
1900-2000	60%
2000-2100	40%
2100-2200	20%
2200-0000	10%

Table 19: Office Lighting Energy Consumption Profile

Manufacturing/Process Area

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.

The space types have been benchmarked for varying HVAC consumption; divided into five broad categories:

- With **No** temperature Control: this category includes space types that do not require any temperature control for the production process. Fan energy consumption can be calculated manually and no computer modelling is required. The benchmark building is mechanically ventilated, but the modelled building may be naturally ventilated as long as the sufficient evidence is provided of meeting air change rates in accordance to AS1668.2.
 - o Temperature range for Model: none.
- With **Low** temperature Control: this category includes spaces where there is minimal temperature control and modelled buildings would have internal temperatures not exceeding 30°C.
 - o Temperature range for Model: 0°C – 30°C.
- With **Median** temperature Control: this category includes spaces where there is some control over air quality and internal temperature, relevant to processes that require regulated internal conditions but not precision manufacture.
 - o Temperature range for Model: 21°C – 27°C.
- With **High** temperature Control: this category includes spaces that involve precision manufacture. This profile would include high efficiency filtration and incorporate a total pressure drop of 400pa.
 - o Temperature range for Model: 20°C – 24°C.
- With **High** temperature and Humidity Control: this category includes spaces that involve manufacture or production of goods that require temperature and humidity control. This profile would include high efficiency filtration and incorporate a total pressure drop of 400pa.
 - o Temperature range for Model: 20°C – 24°C.
 - o Relative Humidity range for Model: 55% ±5% Rh

The HVAC modelling for different space types should be conducted using the operational profile described below and with the internal conditions described above as appropriate.

Default Inputs:

(Must be altered to suit the building and system design):

Upper Temperature Limit: as applicable based on the classification above

Lower Temperature Limit: as applicable based on the classification above

Air change rate: In accordance with AS1668.2 or engineered design

HVAC Model Operational Profile

Operational Profile applicable for 7 days/week						
Time	Occupancy Gains (W/m ²)		Occupancy (m ² /person)	Lighting (W/m ²)	Equipment (W/m ²)	Plant Operation
	Sensible	Latent				
12am	1.70	2.55	100	17.00	0	On
1am	1.70	2.55	100	17.00	0	On
2am	1.70	2.55	100	17.00	0	On
3am	1.70	2.55	100	17.00	0	On
4am	1.70	2.55	100	17.00	0	On
5am	1.70	2.55	100	17.00	0	On
6am	6.80	10.20	25	17.00	0	On
7am	34.00	51.00	5	17.00	0	On
8am	34.00	51.00	5	17.00	0	On
9am	34.00	51.00	5	17.00	0	On
10am	34.00	51.00	5	17.00	0	On
11am	34.00	51.00	5	17.00	0	On
12pm	34.00	51.00	5	17.00	0	On
1pm	6.80	10.20	25	17.00	0	On
2pm	34.00	51.00	5	17.00	0	On
3pm	34.00	51.00	5	17.00	0	On
4pm	34.00	51.00	5	17.00	0	On
5pm	34.00	51.00	5	17.00	0	On
6pm	34.00	51.00	5	17.00	0	On
7pm	6.80	10.20	25	17.00	0	On
8pm	1.70	2.55	100	17.00	0	On
9pm	1.70	2.55	100	17.00	0	On
10pm	1.70	2.55	100	17.00	0	On
11pm	1.70	2.55	100	17.00	0	On

Table 20: Manufacturing Profile

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-2400	100%

Table 21: Manufacturing Lighting Energy Consumption Profile

Showroom

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.

Default Inputs:

(Can be altered to suit the building and system design):

Upper Temperature Limit: 24°C

Lower Temperature Limit: 21°C

Air change rate: In accordance with AS1668.2 or engineered design

HVAC Model Operational Profile

Operational Profile applicable for 7 days/week						
Time	Occupancy Gains (W/m ²)		Occupancy (m ² /person)	Lighting (W/m ²)	Equipment (W/m ²)	Plant Operation
	Sensible	Latent				
12am	0.00	0.00	0	2.50	0.50	Off
1am	0.00	0.00	0	2.50	0.50	Off
2am	0.00	0.00	0	2.50	0.50	Off
3am	0.00	0.00	0	2.50	0.50	Off
4am	0.00	0.00	0	2.50	0.50	Off
5am	0.00	0.00	0	2.50	0.50	Off
6am	0.00	0.00	0	2.50	0.50	Off
7am	0.00	0.00	0	2.50	0.50	Off
8am	0.70	0.60	100	25.00	3.50	On
9am	1.40	1.20	50	25.00	3.50	On
10am	1.40	1.20	50	25.00	3.50	On
11am	1.05	0.90	67	25.00	3.50	On
12pm	1.75	1.50	40	25.00	3.50	On
1pm	1.75	1.50	40	25.00	3.50	On
2pm	1.05	0.90	67	25.00	3.50	On
3pm	1.05	0.90	67	25.00	3.50	On
4pm	1.05	0.90	67	25.00	3.50	On
5pm	1.05	0.90	67	25.00	3.50	On
6pm	0.35	0.30	200	25.00	3.50	On
7pm	0.35	0.30	200	25.00	3.50	Off
8pm	0.00	0.00	0	2.50	0.50	Off
9pm	0.00	0.00	0	2.50	0.50	Off
10pm	0.00	0.00	0	2.50	0.50	Off
11pm	0.00	0.00	0	2.50	0.50	Off

Table 22: Showroom Profile

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	10%
0700-1900	100%
1900-0000	10%

Table 23: Retail Lighting Energy Consumption Profile

Workshop

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.

Default Inputs:

(Can be altered to suit the building and system design):

Upper Temperature Limit: None

Lower Temperature Limit: None

Air change rate: In accordance with AS1668.2 or engineered design

HVAC Model Operational Profile

Operational Profile applicable for 7 days/week						
Time	Occupancy Gains (W/m ²)		Occupancy (m ² /person)	Lighting (W/m ²)	Equipment (W/m ²)	Plant Operation
	Sensible	Latent				
12am	0.00	0.00	0	1.00	0.50	Off
1am	0.00	0.00	0	1.00	0.50	Off
2am	0.00	0.00	0	1.00	0.50	Off
3am	0.00	0.00	0	1.00	0.50	Off
4am	0.00	0.00	0	1.00	0.50	Off
5am	0.00	0.00	0	1.00	0.50	Off
6am	0.00	0.00	0	1.00	0.50	Off
7am	0.00	0.00	0	1.00	0.50	Off
8am	0.37	0.62	300	10.00	2.50	On
9am	0.74	1.24	150	10.00	5.00	On
10am	3.70	6.20	30	10.00	5.00	On
11am	3.70	6.20	30	10.00	5.00	On
12pm	3.70	6.20	30	10.00	5.00	On
1pm	0.93	1.55	120	10.00	2.50	On
2pm	3.70	6.20	30	10.00	5.00	On
3pm	3.70	6.20	30	10.00	5.00	On
4pm	3.70	6.20	30	10.00	5.00	On
5pm	3.70	6.20	30	10.00	5.00	On
6pm	0.19	0.31	600	10.00	2.50	On
7pm	0.19	0.31	600	1.00	0.50	Off
8pm	0.00	0.00	0	1.00	0.50	Off
9pm	0.00	0.00	0	1.00	0.50	Off
10pm	0.00	0.00	0	1.00	0.50	Off
11pm	0.00	0.00	0	1.00	0.50	Off

Table 24: Workshop Profile

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	10%
0700-1800	100%
1800-0000	10%

Table 25: Workshop Lighting Energy Consumption Profile

Cool Room / Freezer – Short and long term storage and distribution centres

Note: The HVAC energy benchmarking is intended for temperatures up to 15°C. 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.

Default Inputs:

(Can be altered to suit the building and system design):

Upper Temperature Limit: As per design

Lower Temperature Limit: As per design

Air change rate: infiltration only, unless the space is constantly occupied; in this event air change rate input in accordance with AS1668.2 or engineered design

HVAC Model Operational Profile

Operational Profile applicable for 3 days/week for short term storage and 1 day/week for long term – for all other days, lighting load is at 10% of peak, with no equipment, occupant or infiltration load.						
Time	Occupancy Gains (W/m ²)		Occupancy (m ² /person)	Lighting (W/m ²)	Equipment (W/m ²)	Plant Operation
	Sensible	Latent				
12am	0.00	0.00	0	0.80	0.00	On
1am	0.00	0.00	0	0.80	0.00	On
2am	0.00	0.00	0	0.80	0.00	On
3am	0.00	0.00	0	0.80	0.00	On
4am	0.00	0.00	0	0.80	0.00	On
5am	1.05	0.00	67	4.80	7.20	On
6am	7.00	0.00	10	8.00	18.00	On
7am	7.00	0.00	10	8.00	18.00	On
8am	7.00	0.00	10	8.00	18.00	On
9am	2.10	0.00	33	8.00	10.80	On
10am	0.00	0.00	0	0.80	0.00	On
11am	0.00	0.00	0	0.80	0.00	On
12pm	0.00	0.00	0	0.80	0.00	On
1pm	0.00	0.00	0	0.80	0.00	On
2pm	0.00	0.00	0	0.80	0.00	On
3pm	0.00	0.00	0	0.80	0.00	On
4pm	0.00	0.00	0	0.80	0.00	On
5pm	0.00	0.00	0	0.80	18.00	On
6pm	7.00	0.00	10	8.00	18.00	On
7pm	7.00	0.00	10	8.00	18.00	On
8pm	7.00	0.00	10	8.00	18.00	On
9pm	1.05	0.00	67	4.80	7.00	On
10pm	0.00	0.00	0	0.80	0.00	On
11pm	0.00	0.00	0	0.80	0.00	On

Table 26: Cool Room/Freezer Profile – Short and Long Term Storage
Date Issued: February 2009

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0400	10%
0400-0500	60%
0500-0900	100%
0900-1700	10%
1700-2000	100%
2000-2100	60%
2100-0000	10%

Table 27: Cool Room/Freezer – Short and Long Term Storage Lighting Energy Consumption Profile

HVAC Model Operational Profile

Operational Profile applicable for 7 days/week						
Time	Occupancy Gains (W/m ²)		Occupancy (m ² /person)	Lighting (W/m ²)	Equipment (W/m ²)	Plant Operation
	Sensible	Latent				
12am	0.70	0.00	100	3.20	1.75	On
1am	0.00	0.00	0	0.80	0.00	On
2am	0.00	0.00	0	0.80	0.00	On
3am	0.00	0.00	0	0.80	0.00	On
4am	0.00	0.00	0	0.80	0.00	On
5am	1.05	0.00	67	4.80	7.20	On
6am	7.00	0.00	10	8.00	18.00	On
7am	7.00	0.00	10	8.00	18.00	On
8am	7.00	0.00	10	8.00	18.00	On
9am	0.35	0.00	200	8.00	1.80	On
10am	0.35	0.00	200	8.00	1.80	On
11am	0.35	0.00	200	8.00	1.80	On
12pm	5.60	0.00	13	8.00	18.00	On
1pm	5.60	0.00	13	8.00	18.00	On
2pm	5.60	0.00	13	8.00	18.00	On
3pm	0.35	0.00	200	8.00	1.80	On
4pm	0.35	0.00	200	8.00	1.80	On
5pm	0.35	0.00	200	8.00	1.80	On
6pm	0.35	0.00	200	8.00	1.80	On
7pm	7.00	0.00	10	8.00	18.00	On
8pm	7.00	0.00	10	8.00	18.00	On
9pm	7.00	0.00	10	8.00	18.00	On
10pm	7.00	0.00	10	8.00	18.00	On
11pm	0.70	0.00	100	3.20	1.80	On

Table 28: Cool Room/ Freezer Profile – Distribution CentreProfile

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0400	10%
0400-0500	60%
0500-2200	100%
2200-0000	40%

Table 29: Cool Room/Freezer – Distribution Centre Lighting Energy Consumption Profile

Laboratory

Note: The HVAC energy benchmarking is valid for equipment gain up to 200W/m². For equipment loads within this range, use inputs as per design. For equipment loads above 200W/m², use 200W/m² in the HVAC Modelling. 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 lighting power densities as per the lighting specifications.

Default Inputs:

(Can be altered to suit the building and system design):

Upper Temperature Limit: 24°C

Lower Temperature Limit: 21°C

Air change rate: in accordance with AS1668.2 or engineered design

HVAC Model Operational Profile

Operational Profile applicable for 5 days/week						
Time	Occupancy Gains (W/m ²)		Occupancy (m ² /person)	Lighting (W/m ²)	Equipment (W/m ²)	Plant Operation
	Sensible	Latent				
1am	0.00	0.00	0	1.50	2.10	Off
2am	0.00	0.00	0	1.50	2.10	Off
3am	0.00	0.00	0	1.50	2.10	Off
4am	0.00	0.00	0	1.50	2.10	Off
5am	0.00	0.00	0	1.50	2.10	Off
6am	0.00	0.00	0	1.50	2.10	Off
7am	0.00	0.00	0	1.50	2.10	Off
8am	1.05	0.90	67	6.00	5.25	On
9am	4.20	3.60	17	12.00	14.70	On
10am	7.00	6.00	10	15.00	21.00	On
11am	7.00	6.00	10	15.00	21.00	On
12pm	7.00	6.00	10	15.00	21.00	On
1pm	7.00	6.00	10	15.00	21.00	On
2pm	7.00	6.00	10	15.00	21.00	On
3pm	7.00	6.00	10	15.00	21.00	On
4pm	7.00	6.00	10	15.00	21.00	On
5pm	7.00	6.00	10	15.00	21.00	On
6pm	3.50	3.00	20	12.00	12.60	On
7pm	1.05	0.90	67	9.00	5.25	Off
8pm	0.35	0.30	200	6.00	3.15	Off
9pm	0.35	0.30	200	3.00	3.15	Off
10pm	0.00	0.00	0	1.50	2.10	Off
11pm	0.00	0.00	0	1.50	2.10	Off

Table 30: Laboratory Profile

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	10%
0700-0800	40%
0800-0900	80%
0900-1700	100%
1700-1800	80%
1800-1900	60%
1900-2000	40%
2000-2100	20%
2100-0000	10%

Table 31: Laboratory Lighting Energy Consumption Profile

Clean Room

Note: The HVAC energy has been benchmarked for variable equipment gain. 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 lighting power densities as per the lighting specifications.

Default Inputs:

(Can be altered to suit the building and system design):

Upper Temperature Limit: 24°C

Lower Temperature Limit: 20°C

Air change rate: in accordance with AS1668.2 or engineered design

HVAC Model Operational Profile

Operational Profile applicable for 5 days/week						
Time	Occupancy Gains (W/m ²)		Occupancy (m ² /person)	Lighting (W/m ²)	Equipment (W/m ²)	Plant Operation
	Sensible	Latent				
12am	0.00	0.00	0	1.50	2.10	Off
1am	0.00	0.00	0	1.50	2.10	Off
2am	0.00	0.00	0	1.50	2.10	Off
3am	0.00	0.00	0	1.50	2.10	Off
4am	0.00	0.00	0	1.50	2.10	Off
5am	0.00	0.00	0	1.50	2.10	Off
6am	0.00	0.00	0	1.50	2.10	Off
7am	0.00	0.00	0	1.50	2.10	Off
8am	0.53	0.45	133	6.00	5.25	On
9am	2.10	1.80	33	12.00	14.70	On
10am	3.50	3.00	20	15.00	21.00	On
11am	3.50	3.00	20	15.00	21.00	On
12pm	3.50	3.00	20	15.00	21.00	On
1pm	3.50	3.00	20	15.00	21.00	On
2pm	3.50	3.00	20	15.00	21.00	On
3pm	3.50	3.00	20	15.00	21.00	On
4pm	3.50	3.00	20	15.00	21.00	On
5pm	3.50	3.00	20	15.00	21.00	On
6pm	1.75	1.50	40	12.00	12.60	On
7pm	0.53	0.45	133	9.00	5.25	Off
8pm	0.18	0.15	400	6.00	3.15	Off
9pm	0.18	0.15	400	3.00	3.15	Off
10pm	0.00	0.00	0	1.50	2.10	Off
11pm	0.00	0.00	0	1.50	2.10	Off

Table 32: Clean Room Profile

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0700	10%
0700-0800	40%
0800-0900	80%
0900-1700	100%
1700-1800	80%
1800-1900	60%
1900-2000	40%
2000-2100	20%
2100-0000	10%

Table 33: Clean Room Lighting Energy Consumption Profile

Kitchen

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.

Default Inputs:

(Can be altered to suit the building and system design):

Upper Temperature Limit: None

Lower Temperature Limit: None

Air change rate: In accordance with AS1668.2 or engineered design

HVAC Model Operational Profile

Operational Profile applicable to 5, 6 or all 7 days depending on the Actual Design							
Time	Occupancy Gains (W/m ²)		Occupancy (m ² /person)	Lighting (W/m ²)	Equipment Sensible (W/m ²)	Equipment Latent (W/m ²)	Plant Operation
	Sensible	Latent					
12am	0	0	0	0.5	10	4.5	Off
1am	0	0	0	0.5	10	4.5	Off
2am	0	0	0	0.5	10	4.5	Off
3am	0	0	0	0.5	10	4.5	Off
4am	0	0	0	0.5	10	4.5	Off
5am	0	0	0	2	10	4.5	Off
6am	1.6	1.6	50	10	20	9	On
7am	4	4	20	10	80	36	On
8am	8	8	10	10	20	9	On
9am	8	8	10	10	40	18	On
10am	8	8	10	10	200	90	On
11am	8	8	10	10	200	90	On
12pm	8	8	10	10	20	9	On
1pm	8	8	10	10	40	18	On
2pm	8	8	10	10	40	18	On
3pm	8	8	10	10	20	9	On
4pm	6.4	6.4	12.5	10	20	9	On
5pm	1.6	1.6	50	10	20	9	On
6pm	1.6	1.6	50	10	10	4.5	On
7pm	0	0	0	5	10	4.5	Off
8pm	0	0	0	0.5	10	4.5	Off
9pm	0	0	0	0.5	10	4.5	Off
10pm	0	0	0	0.5	10	4.5	Off
11pm	0	0	0	0.5	10	4.5	Off

Table 34: Kitchen Profile

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0500	5%
0500-0600	20%
0600-1900	100%
1900-2000	50%
2000-0000	5%

Table 35: Kitchen Lighting Energy Consumption Profile

Common Area

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.

Default Inputs:

(Can be altered to suit the building and system design):

Upper Temperature Limit: None

Lower Temperature Limit: None

Air change rate: In accordance with AS1668.2 or engineered design

HVAC Model Operational Profile

Operational Profile applicable for 5 days/week						
Time	Occupancy Gains (W/m ²)		Occupancy (m ² /person)	Lighting (W/m ²)	Equipment (W/m ²)	Plant Operation
	Sensible	Latent				
12am	0.00	0.00	0	0.30	0	Off
1am	0.00	0.00	0	0.30	0	Off
2am	0.00	0.00	0	0.30	0	Off
3am	0.00	0.00	0	0.30	0	Off
4am	0.00	0.00	0	0.30	0	Off
5am	0.00	0.00	0	1.20	0	Off
6am	0.00	0.00	0	6.00	0	Off
7am	5.60	3.60	25	6.00	0	On
8am	0.70	0.45	10	6.00	0	On
9am	11.20	7.20	100	6.00	0	On
10am	0.00	0.00	0	6.00	0	On
11am	2.10	1.35	100	3.00	0	On
12pm	0.70	0.45	6	0.90	0	On
1pm	0.00	0.00	5	0.30	0	On
2pm	0.00	0.00	100	0.30	0	On
3pm	0.00	0.00	0	0.30	0	On
4pm	0.00	0.00	10	0.30	0	On
5pm	0.00	0.00	0	0.30	0	On
6pm	0.00	0.00	25	0.30	0	On
7pm	0.00	0.00	25	0.30	0	On
8pm	0.00	0.00	0	0.30	0	On
9pm	0.00	0.00	0	0.30	0	Off
10pm	0.00	0.00	0	0.30	0	Off
11pm	0.00	0.00	0	0.30	0	Off

Table 36: Common Area Profile

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0500	5%
0500-0600	20%
0600-1900	100%
1900-2000	50%
2000-0000	5%

Table 37: Common Area Lighting Energy Consumption Profile

Car Parks

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. If all space types modelled have different days of operation, the car park profile should concur with the space type functional for the most number of days per week.

Default Inputs:

(Can be altered to suit the building and system design):

Upper Temperature Limit: None

Lower Temperature Limit: None

Air change rate: In accordance with AS1668.2 or engineered design

Operational Profile

Operational Profile applicable for 5, 6, 7 days/week					
Time	Occupancy Gains (W/m ²)		Lighting (W/m ²)	Equipment (W/m ²)	Plant Operation
	Sensible	Latent			
12am	0	0	0.5	0	On
1am	0	0	0.5	0	Off
2am	0	0	0.5	0	Off
3am	0	0	0.5	0	Off
4am	0	0	0.5	0	Off
5am	0	0	2.0	0	On
6am	0	0	5.0	0	On
7am	0	0	5.0	0	On
8am	0	0	5.0	0	On
9am	0	0	5.0	0	On
10am	0	0	5.0	0	On
11am	0	0	4.0	0	On
12pm	0	0	3.0	0	On
1pm	0	0	2.0	0	On
2pm	0	0	1.0	0	On
3pm	0	0	0.5	0	On
4pm	0	0	0.5	0	On
5pm	0	0	0.5	0	On
6pm	0	0	0.5	0	On
7pm	0	0	0.5	0	On
8pm	0	0	0.5	0	On
9pm	0	0	0.5	0	On
10pm	0	0	0.5	0	On
11pm	0	0	0.5	0	On

Table 38: Car Park Profile

Lighting Energy Consumption Profile

Time	Artificial Lighting
0000-0400	10%
0400-0500	40%
0500-1900	100%
1900-2000	80%
2000-2100	60%
2100-2200	40%
2200-2300	20%
2300-0000	5%

Table 39: Car Park Lighting Energy Consumption Profile

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; and
- Escalators/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.

Note that the consumption benchmarked in the table below is calculated in concurrence with the Potable Water Calculator assuming Tra-3 *Cyclist Facilities* compliance with 3 star showers. As the energy calculator assesses 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.

Space Type	Occupancy (m ² /person/day)	Domestic Hot Water Requirement per person (L/person/day)	Domestic hot water requirement per square meter (L/m ² /day) <i>Rounded to 3d.pl.</i>
Warehouse	100	0.68	0.007
Office	15	0.68	0.045
Kitchen	10	0.68	0.068
Common Area	5	0.68	0.136
Workshop	30	0.68	0.023
Showroom	10	0.68	0.068
Laboratory	10	0.68	0.068
Clean Room	20	0.68	0.034
Manufacturing / Process	5	4.50	0.900

Table 40: Benchmarks for Hot Water Energy Consumption

Note 1: 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.

Note 2: The numbers in *italic* are constant; for spaces that do not have variable occupancy profiles.

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 industrial 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 per metre length of pipe should be applied.
3. Multiply the Daily Domestic Hot Water Energy Requirement by the number of days that the space is operational² to calculate the Yearly Hot Water Energy Requirement. This is the figure to be entered into the **Green Star – Industrial PILOT 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/m ² /day)	TOTAL AREA (m ²)	HOT WATER REQUIREMENTS (L/day)	DAILY ENERGY REQUIRED TO HEAT HOT WATER (kWh/day)	YEARLY ENERGY REQUIRED TO HEAT HOT WATER (kWh/year)
Manufacturing	0.9	500	450	24.3	8,869.5

Table 41: Example of How to Calculate Hot Water Energy Consumption

The figure to be entered into the Energy Calculator is **8,869.5**

² The days of occupation for all space types should match the input selected in the tool for HVAC energy benchmarking.

Protocol for calculating lift energy use

Please Note that the description below demonstrates the method of calculation only. The actual figures for standard number of trips per year and time for each trip for the facility modelled should be provided and justified. Also the number of trips and typical time for each trip would vary based on if the lifts are intended for passenger use or to ferry goods. If both types of lifts are incorporated then each would need to be calculated separately.

To calculate lift energy use:

1. Determine the lift power ratings **R** in kW from supplier specifications;
2. Determine the **Standby** power from car lights and lift control system in kW from supplier specifications; and then
3. Calculate the annual **Energy** 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 **Energy** 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 = **S**tandby power – car lights and lift control systems (kW)

Hrs = number of **h**ours 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 kW, 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 – Industrial PILOT Energy Calculator**.

Equation Symbol	Description	Lift
R	Lift Power Rating (kW)	40
S	Number of starts per year	219,000
T	Typical Trip Time (s)	5
St	Standby Power Rating (kW)	0.1
Hrs	Lift operating hours (hrs/day)	24 (lift does not have 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 42: Example parameters for lift energy consumption

$$E = \left(\frac{40 \times 219,000 \times 5 (100\% + 15\%)}{3600} + (0.1 \times 24 \times 260) \right) \times 3$$

$$E = 43,847 \text{ kWh/yr}$$

The figure to be entered into the Green Star – Industrial PILOT Energy Calculator for this example is **43,847kWh/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

$$E = R \times U \times \text{Hrs/Year} \times \text{No. Escalators or Travelators}$$

Where:

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

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

U = **U**sage 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	2,080	66,560
8kW (with sensor)	0.75	2	2,080	24,960
TOTAL YEARLY ENERGY CONSUMPTION (kWh/year)				91,520

Table 43: Example of How to Calculate Escalator or Travelator Energy Consumption

The figure to be entered into the Green Star – Industrial PILOT Energy Calculator is **91,520.kWh/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).

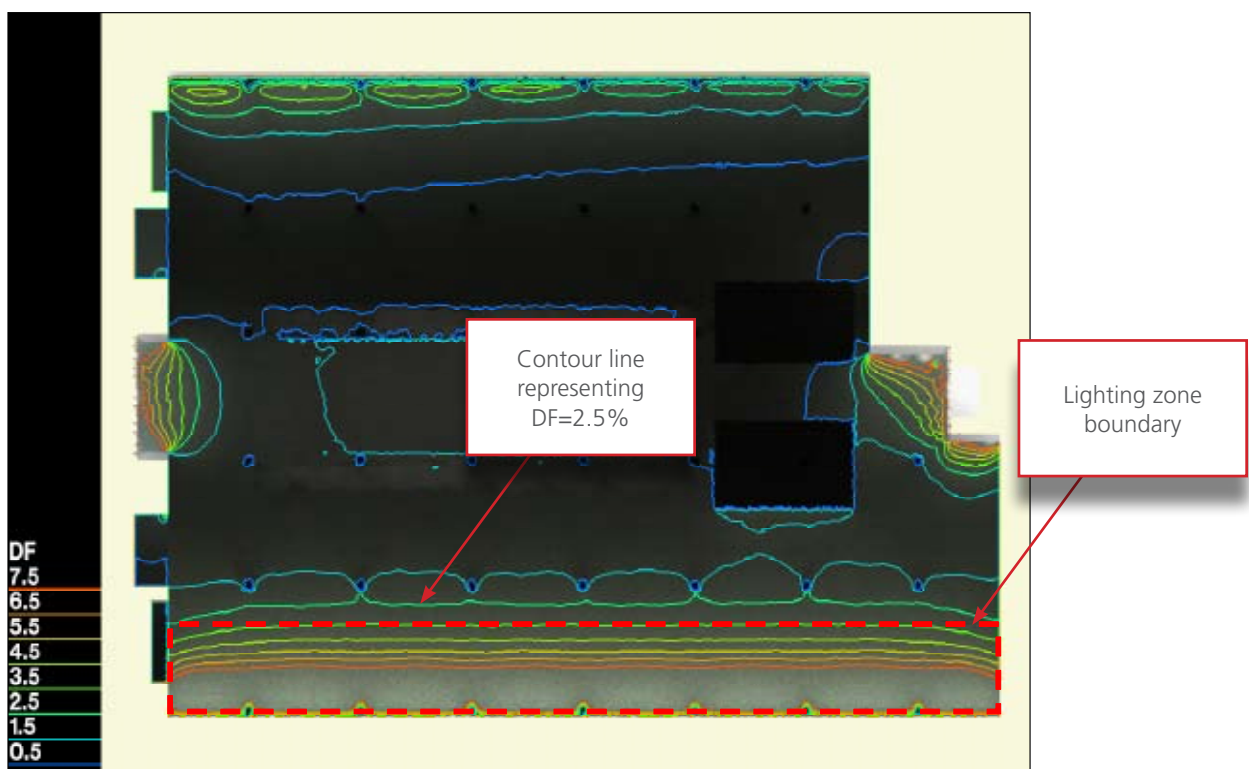
The calculation methodology for use of daylight dimming or switching should be submitted to the GBCA in the form of a CIR prior to submission.

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

$$E_h = \frac{E_i}{\text{Daylight Factor}} \times 100\%$$

where:

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

E_h = 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 illuminance, E_h , that must occur to achieve an internal illuminance, E_i , of 320 lux at the working plane is calculated to be 12.8 kilo lux as below

$$E_h = \frac{E_i}{\text{Daylight Factor}} \times 100\%$$

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

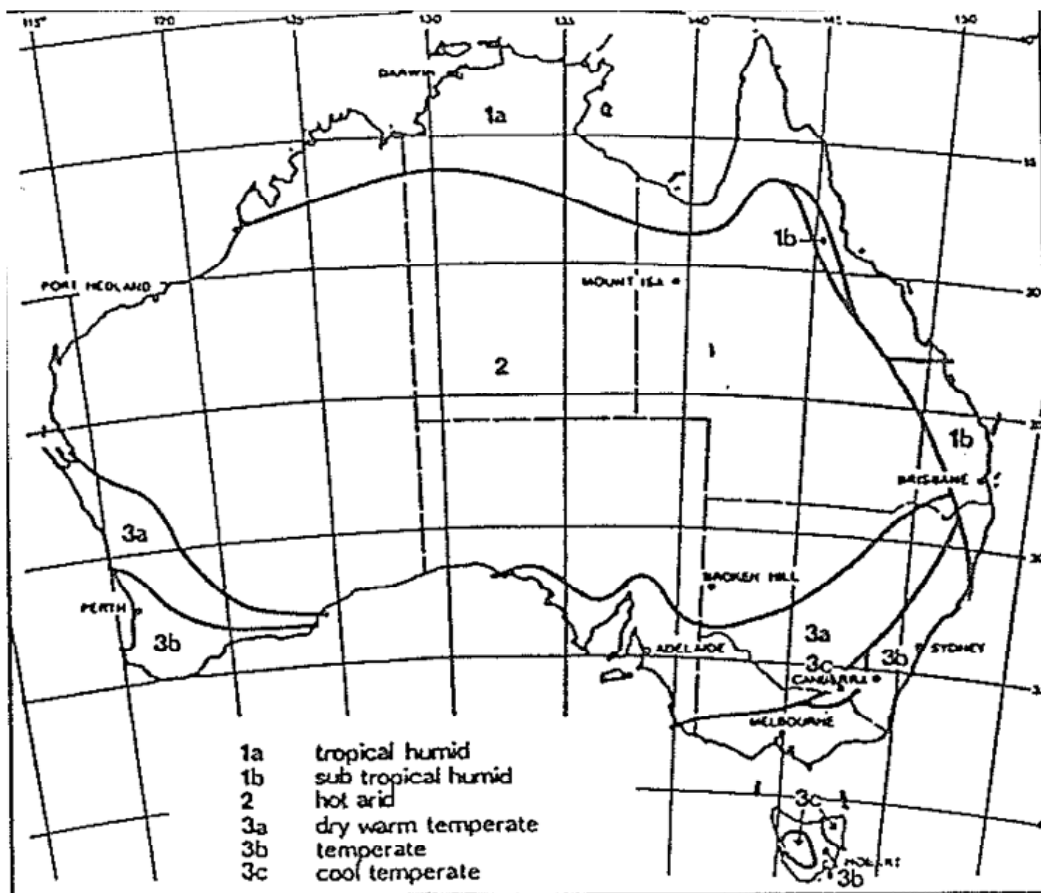
$$= 12.8 \text{ kilo lux}$$

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