green star™

green building council australia

GREEN STAR
EDUCATION V1
STANDARD PRACTICE BENCHMARK SUMMARY

VERSION 1

AUGUST 2009

EXECUTIVE SUMMARY

The Green Star – Education v1 Standard Practice Benchmark document lays out the criteria against which all projects seeking a rating under this tool are assessed against. A summary of the benchmarks is included in Table 1 below.

Table 1: Education facility energy benchmarks by space type.

Space type		HVAC (Electricity) (kWh/m²/yr)	HVAC (Gas) (MJ/m²/yr)	Lighting (Electricity) (kWh/m²/yr)	Hot Water (Electricity) (kWh/m²/yr)	Lifts (Electricity) (kWh/m²/yr)	Total (Electricity) (kWh/m²/yr)	Total (Gas) (MJ/m²/yr)
Primary / High Schools	Classroom / Multipurpose Spaces	26.8	0	25.0	1.8	0	53.6	0
	Computer and Physics Labs	81.1	0	25.0	5.3	0	111.4	0
	Office and Staff Rooms	38.8	0	34.0	2.0	0	74.8	0
	Library	31.1	0	30.0	3.0	0	64.1	0
	Common Spaces	26.3	0	15.0	5.3	0	46.6	0
	Canteen	30.3	0	26.0	0.6	0	56.9	0
	Workshops	40.9	0	25.0	1.8	0	67.7	0
	Gymnasiums	0	0	41.5	9.9	0	51.4	0
	Car Parks	0	0	46.0	0	0	46	0
University Buildings	Teaching / Classroom Spaces	34.6	14.3	26.0	2.3	5.7	68.6	14.3
	Dry Labs, Specialty Learning Spaces and Libraries	41.1	7.2	26.0	2.3	5.7	75.1	7.2
	Office / Administrative Spaces	23.9	1.5	36.0	3.9	5.7	69.5	1.5
	Common Spaces	17.5	0.8	15.0	1.1	5.7	39.3	0.8
	Wet Labs	Dependent on Peak Exhaust Air Rate	4.4	47.0	1.1	5.7	Dependent on Peak Exhaust Air Rate	4.4
	Gymnasiums	43.6	0	68.0	8.9	5.7	126.2	0
	Car Parks	0	0	46.0	0	5.7	51.7	0

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Tool Version	Revision	Date Issued
Green Star – Education v1 Standard Practice Benchmark Summary - Release	v1	July 2009

1.0 – INTRODUCTION

1.1 – OVERVIEW OF THE STANDARD PRACTICE BENCHMARK BUILDINGS

The 'standard practice primary / high school building' was assumed to have the following:

- Mechanical ventilation with a reverse cycle system;
- Building fabric comprising of an aluminium roof; concrete external walls; clear float (6mm) glazing and a concrete (slab on ground) floor;
- Standard practice lighting fixtures, practices, and efficiency;
- An electric storage hot water heater;
- No lifts; and
- No on-site electricity generation.

The 'standard practice university building' was assumed to have the following:

- Mechanical ventilation with a water cooled chiller and gas fired boiler;
- Building fabric comprising of an aluminium roof; concrete external walls; high performance glazing and a concrete (slab on ground) floor;
- Standard practice lighting fixtures, practices, and efficiency;
- An electric storage hot water heater;
- 1 lift for every 3,000m² total GFA; and
- No on-site electricity generation.

Except for fume cupboards, there is no benchmark for energy use by educational equipment as this is not assessed in this credit.

1.2 – SOURCES OF INFORMATION

The 'standard practice primary / high school building' and 'standard practice university building' were developed with:

- The expertise of the Green Star – Education Technical Working Group;
- Reference to a GBCA Survey of 19 education facilities to inform the current practice benchmark. This survey asked facility managers to answer detailed questions based on the following:
  - Areas of each of the space types listed in Section 2.0;
  - Building fabric and façade materials;
  - Air conditioning systems and their operation;
  - Outside air supply;
  - Peak and average occupancies;
  - Lighting and its use;
  - Equipment and its use; and
  - Ancillary loads – such as lifts, escalators, hot water consumption.

2.0 – DEFINITION OF SPACE TYPES

Benchmarks have been developed for the following space types:

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 utilizes 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.

3.0 – HVAC BENCHMARKS

Benchmark HVAC system energy use was calculated using dynamic simulation software for each of the space types noted in the previous section. Modelling was undertaken with TAS thermal modelling software version 8.50. The software allows for full consideration of dynamic thermal performance and integrated prediction of multi-zone natural ventilation air movement. The weather file used was a Test Reference Year.

The operational profiles that were used are included in the **Green Star – Education Energy Calculator Guide** Appendices B and C.

3.1 – HVAC SYSTEM DETAILS

Primary and High Schools

A direct expansion (DX) reverse cycle system was selected to condition each of the primary and high school space types.

Fan Design Total Pressure (kPa)	0.5
Full Load Compressor Coefficient of Performance (COP)	2.6

Note that the energy consumption of mechanical ventilation in gymnasiums was modelled, however the resultant energy use was negligible (the figure, when rounded to one decimal place equalled zero).

University Buildings

A water cooled chiller with a gas heating system was selected to condition each of the university building space types.

Fan Design Total Pressure (kPa)	0.5
Full Load Chiller Coefficient of Performance (COP)	5.88
Boiler Thermal Efficiency	0.8
Boiler Distribution Efficiency	0.8
Minimum turndown (L/s/m²)	4.5

3.2 – BUILDING FABRIC DETAILS

Table 2: Building fabric details

Building Element	Makeup	Performance Characteristics
Roof	Aluminium (20mm) / insulation (105mm) / Air (100mm) / Plywood (15mm)	U-Value: 0.3125W°/m².K
External Walls	Concrete (200mm) / Insulation (70mm) / Wood (30mm)	U-Value: 0.5W°/m².K
Glazing – Primary / High Schools	Clear Float (6mm)	Shading Coefficient: 0.959 U-Value: 5.753 W/m².°K Solar Transmission: 84%
Glazing – University Buildings	High performance glazing (6 mm)	Shading Coefficient: 0.4 U-Value: 3.845 W/m².°K Solar Transmission: 35% Visual Transmission: 49%
Floor	Concrete (300mm), slab on ground.	N/A

3.3 – HVAC BENCHMARK FOR FUME CUPBOARDS IN WET LABS IN UNIVERSITY BUILDINGS

The energy consumption of fume cupboards in laboratory spaces has been included in the standard practice university building. The modelling process was based on the density of fume cupboards in the laboratory space. The fume cupboard characteristics and operational profiles are:

Fan Type	*Single speed fan*
System resistance	*350kPa*
Motor efficiencies	*90%*
Fan efficiency	*80%*
Length of cupboard	*2000 m*
Exhaust velocity	*0.5m/s*
Minimum sash height	*100 mm*
Maximum sash height	*500 mm*

Modelling showed that the energy consumption increased linearly as the peak air extraction rate in the space increased. This is shown graphically below.The equation of the line is used in the calculator to determine HVAC energy consumption in wet labs. This means that wet lab areas with a high density of fume cupboards will not be penalised.

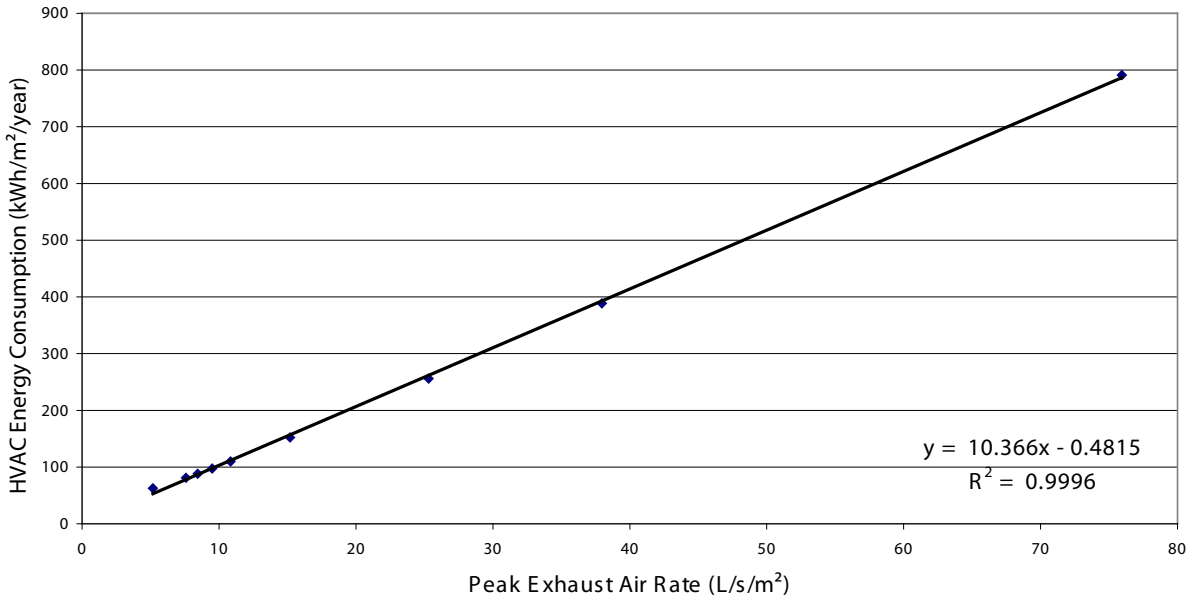

Figure 1: Wet Lab HVAC Energy Consumption. (Based on the peak air flow rate per square metre)

3.4 – HVAC BENCHMARKS FOR ALL SPACE TYPES

Table 3: Benchmark annual HVAC energy consumption

Space type		Electrical energy consumption (kWh/yr)	Gas energy consumption (kWh/yr)	Area in surveyed zone (m²)	HVAC benchmark (electricity component) (kWh/m²/yr)	HVAC benchmark (gas component) (MJ/m²/yr)
Primary / High Schools	Classroom / Multipurpose Spaces	8587	0	320	26.8	0
	Computer and Physics Labs	25958	0	320	81.1	0
	Office and Staff Rooms	12407	0	320	38.8	0
	Library	9949	0	320	31.1	0
	Common Spaces	8430	0	320	26.3	0
	Canteen	9702	0	320	30.3	0
	Workshops	13099	0	320	40.9	0
	Gymnasiums	0	0	320	0	0
	Car Parks	0	0	320	0	0
University Buildings	Teaching / Classroom Spaces	11061	1274	320	34.6	14.3
	Dry Labs, Specialty Learning Spaces and Libraries	13160	643	320	41.1	7.2
	Office / Administrative Spaces	7646	134	320	23.9	1.5
	Common Spaces	5614	71	320	17.5	0.8
	Wet Labs	Varies based on air extraction rate	389	320	Varies based on air extraction rate	4.4
	Gymnasiums	13953	0	320	43.6	0
	Car Parks	0	0	320	0	0

4.0 – LIGHTING BENCHMARKS

The yearly lighting energy consumption in each space type was determined using the lighting schedules for each space type given in the Green Star – Education v1 Energy Calculator Guide Appendices B and C.

Table 4: Lighting benchmarks

Space type		Lighting benchmark (kWh/m²/year)
Primary / High Schools	Classroom / Multipurpose Spaces	25.0
	Computer and Physics Labs	25.0
	Office and Staff Rooms	34.0
	Library	30.0
	Common Spaces	15.0
	Canteen	26.0
	Workshops	25.0
	Gymnasiums	41.5
	Car Parks	46.0
University Buildings	Teaching / Classroom Spaces	26.0
	Dry Labs, Specialty Learning Spaces and Libraries	26.0
	Office / Administrative Spaces	36.0
	Common Spaces	15.0
	Wet Labs	47.0
	Gymnasiums	68.0
	Car Parks	46.0

5.0 – HOT WATER BENCHMARK

The hot water system used in the both standard practice benchmark buildings is an electric storage system. Each space type's water demand has been calculated based on outputs from the Green Star – Education v1 water calculator. It was assumed that the standard practice benchmark building achieved the maximum points in Tra-3 'Cyclist Facilities' and used WELS 3 star showers. Surveyed data was used to justify this model and the occupancy of such building. From the results of the water consumption outputs, half of the water consumption demand was assumed to be hot.

5.1 – HOT WATER DEMAND

The hot water demand was calculated with the water usage assumptions used in the Green Star – Education v1 water calculator, along with the occupancy of each space type taken from the GBCA survey, for each space type. For office areas, an additional 4L/person/day was added to this figure based on the GBCA survey results. No water use has been assigned to car parks.

5.2 – ENERGY CONSUMPTION FROM THE DHW SYSTEM TO HEAT ONE LITRE OF WATER

An electric storage system (assumed for this model) requires 10% more energy than an instantaneous electric hot water system, due to the energy loss through the storage tank. A instantaneous electric hot water system would use 0.049kWh of energy to heat 1L of water to 60°C supply temperature from 18°C ground temperature. This is derived from the following equations:

$$Q = M \times C \times \Delta T$$

$$= 1 \times 4.18 \times (60-18)$$
$$= 174.56kJ$$
$$= 0.049kWh$$

Where:
Q = Energy, KJ for a 100% efficient system
M = Mass of water, kg
C = Specific Heat of water, J/kg°C
ΔT= Change in temperature, °C

This means an electric water storage heating system would use 0.054kWh of energy to heat 1L of water to 60°C supply temperature from 18°C ground temperature as shown below.

$$Q_{\text{for an electric storage heater}} = \textit{0.49kWh} \times 110\%$$

$$= \textbf{0.54kWh}$$

5.3 – CALCULATION OF THE HOT WATER BENCHMARKS

The table below presents the occupancy and daily hot water consumption per person assumed to calculate the daily hot water supply per square meter. This figure is then multiplied by the energy required to heat one litre of water to 60°C supply temperature from 18°C ground temperature, as described above, and by the assumed operational days per year, which is 260.

Table 5: Benchmark hot water energy consumption

Space type		Occupancy (m²/person)	DHW demand (L/person/day)	Hot Water Demand (L/m²/day)	Benchmark hot water energy consumption (kWh/m²/year)
Primary / High Schools	Classroom / Multipurpose Spaces	12	1.5	0.13	1.76
	Computer and Physics Labs	4	1.5	0.38	5.27
	Office and Staff Rooms	39	5.5	0.15	1.98
	Library	7	1.5	0.22	3.01
	Common Spaces	4	1.5	0.38	5.27
	Canteen	33	1.5	0.05	0.64
	Workshops	12	1.5	0.13	1.76
	Gymnasiums	17	12	0.71	9.91
	Car Parks	0	0	0	0
University Buildings	Teaching / Classroom Spaces	9	1.5	0.17	2.3
	Dry Labs, Specialty Learning Spaces and Libraries	9	1.5	0.17	2.3
	Office / Administrative Spaces	20	5.5	0.28	3.9
	Common Spaces	20	1.5	0.08	1.1
	Wet Labs	20	1.5	0.08	1.1
	Gymnasiums	19	12	0.64	8.9
	Car Parks	0	0	0	0

6.0 – LIFT ENERGY BENCHMARK

Lifts are not considered standard practice within primary and high schools; therefore the benchmark school does not include a lift. The lift energy benchmark for universities has been based on the following assumptions:

1. There is 1 lift for every 3,000m² total GFA in university buildings (excluding car parks). This is based on a building with a 'standard' floorplate of around 1000m² will put in a lift when the building is 3 floors.
2. A standard passenger lift has a power consumption of 40kW
3. A lift in a education facility will typically use 300,000 starts per year
4. A standard passenger lift has 4 x 20W halogen light bulbs and 20W of lift control gear. This equates to 100W of standby power
5. All lifts have a power off feature and regenerative breaking

The formula to calculated energy consumption is:

$$E = \frac{(R \times S \times T)}{3600} + (St \times 18 \times 260)$$

Where:
E = annual **E**nergy usage (kWh/year)
R = Power **R**ating of the motor (kW)
S = number of **S**tarts per year
For the purposes of Green Star – Education v1 benchmark, this number of starts per year has been assumed to be 300,000.
T = typical **T**rip time (seconds)
For the purposes of Green Star – Education v1 benchmark, this typical trip time has been assumed to be 5 seconds.
St = standby power – car lights and lift control systems (kW)

N.B.: 3600 takes the first half of the equation, which is in seconds, and coverts it to kWh
The 18 x 260 takes the standby power and multiplies it by operational hours and days in a year to get annual energy consumption.

The yearly energy consumption is:

$$E = \frac{(40 \times 300{,}000 \times 5)}{3600} + (0.1 \times 18 \times 260)$$

$$= \textbf{17,135kWh/yr per lift}$$

As there is assumed to be one lift per 3000m², this figure is divided by 3000 to give the benchmark figureof 5.7kWh/m²/yr.

Table 6: Lift benchmarks

Building type	Lift energy benchmark (kWh/m²/year)
Primary/high school	0
University	5.7

7.0 – EQUIPMENT ENERGY USE AND ON-SITE ELECTRICITY GENERATION

- Equipment energy use (except for fume cupboards) is not required to be modelled or entered into the Green Star – Education v1 Energy Calculator. Therefore, there is no benchmark for equipment energy use in schools or universities.
- On-site electricity generation is not yet considered standard practice; therefore the benchmark development does not include any electricity generating equipment.