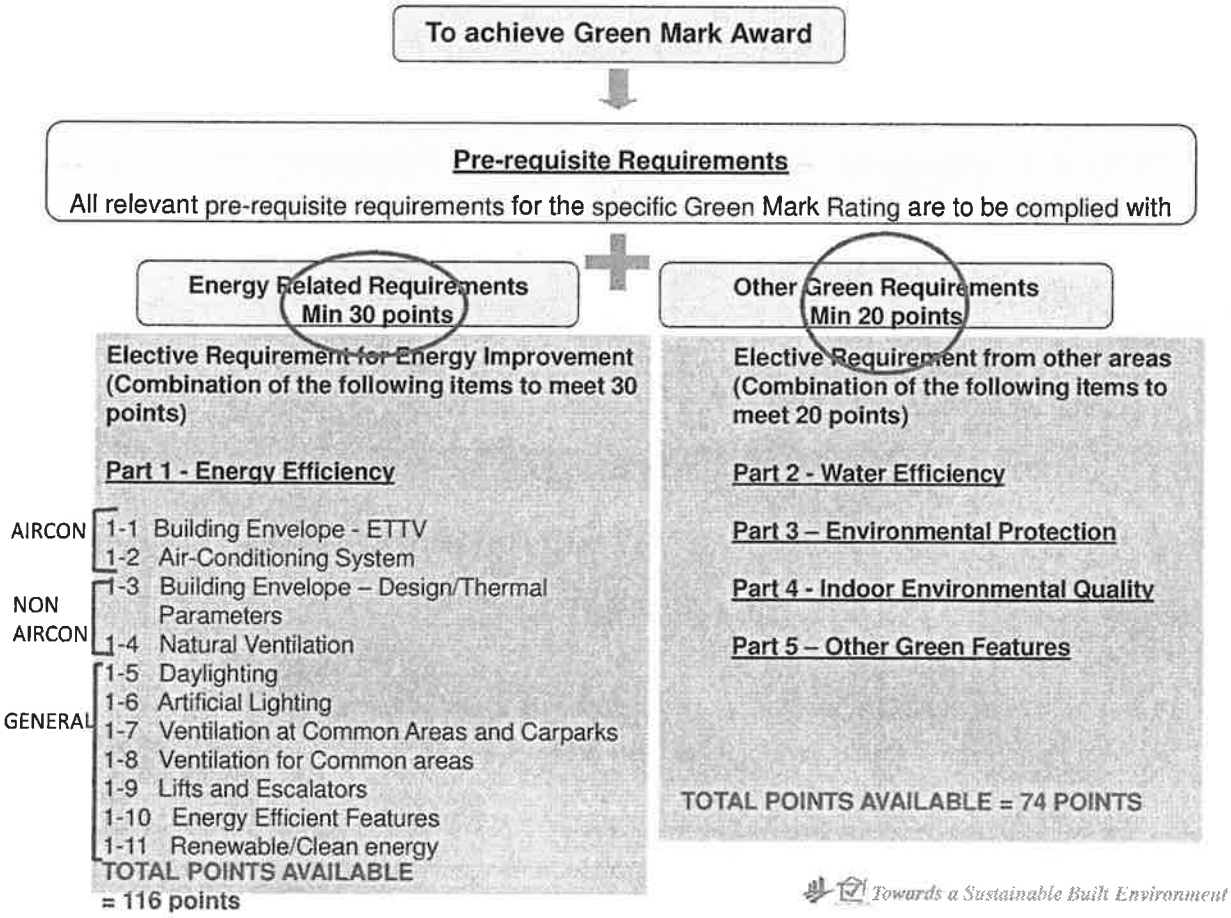
Building and Construction Authority

BCA GREEN MARK

BCA GREEN MARK CRITERIA
New Non-Residential Buildings
Version NRB /4.1

Technology Development Group, BCA
Green Mark Department



Towards a Sustainable Built Environment

Version 4 – Pre-requisite Requirements

For Air-Conditioned Buildings



1. Projects should achieve:

- GM Gold^{Plus} rating - ETTV of **42 W/m²** or lower
- GM Platinum rating - ETTV of **40 W/m²** or lower

2. Projects should achieve:

- GM Gold^{Plus} rating – At least 25% energy savings
- GM Platinum rating - At least 30% energy savings



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Version 4 –Pre-requisite Requirements con't

3. Prescribed design system efficiency (DSE) of air-conditioning system

(i) For Buildings using Water-cooled Central Chilled-Water Plant:

Green Mark Rating	Cooling Load (ton)	
	< 500	≥ 500
	Efficiency (kW/ton)	
Certified	0.80	0.70
Gold	0.80	0.70
Gold^{Plus}	0.70	0.65
Platinum	0.70	0.65

(ii) For Buildings using Air-cooled Chilled-Water Plant or Unitary Air-Conditioners:

Green Mark Rating	Cooling Load (ton)	
	< 500	≥ 500
	Efficiency[1] (kW/ton)	
Certified	0.90	0.80
Gold	0.90	Not applicable[2]
Gold^{plus}	0.85	
Platinum	0.78	

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❑ Non Air-Conditioned Buildings

1) Simulation or wind tunnel testing to ensure good natural ventilation for **Green Mark Platinum** Rating

2) Minimum points to be scored under NRB 3-1 Sustainable Construction

- Green Mark Gold^{Plus} ≥ 3 points
- Green Mark Platinum ≥ 5 points

3) Minimum points to be scored under NRB 3-2 Sustainable Products

- Green Mark Gold^{Plus} ≥ 3 points
- Green Mark Platinum ≥ 4 points

4) Permanent Instrumentation for Central Chilled-Water Plant Efficiency



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❑ Building with more than 30% Non Air-conditioned Spaces

Pre-requisite requirements for building with a combination of ventilation mode and with non-A/C spaces of more than 30% of the total constructed floor areas (excluding carparks and common areas).

For development that require energy modeling and CFD simulation to fulfill Higher tier award requirement.

Aggregate Non Air-Conditioned Spaces (m^2)	Aggregate Air-Conditioned Spaces (m^2)	Ventilation Simulation Requirement See Note (a)	Energy Modeling Requirement See Note (b)	Justification on Energy Savings See Note (c)
≥ 2000	≥ 5000	Yes	Yes	No
< 2000	≥ 5000	No	Yes	No
≥ 2000	< 5000	Yes	No	Yes
< 2000	< 5000	No	No	Yes



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Air-Con Areas vs Non Air-Con Areas

	Air-Con		Non Air-Con	
Requirement	Applicable to Air-Conditioned Building Areas (with an aggregate air-conditioned areas > 500 m²)		Applicable to Non Air-Conditioned Building Areas (with an aggregate non air-conditioned areas > 10 % of total floor area excluding carparks)	
Criteria	1-1 Building Envelope – ETTV	12 pts	1-3 Building Envelope – Design / Thermal Parameters	35 pts
	1-2 Air-Conditioning System	30 pts	1-4 Natural Ventilation (exclude carparks)	20 pts
	Total points	42 pts	Total points	55 pts

Prorate based on areas if both are applicable

1-1 Building Envelope (Aircon)

- **AIM**

  To enhance overall thermal performance of building envelope to minimize heat gained through external walls and windows of a building thus reducing the overall cooling load requirement.

- **REQUIREMENTS**

  Baseline : Maximum Permissible ETTV = 50 W/m²

  1.2 points for every reduction of 1 W/m² in ETTV from the baseline (*up to 12 points*)

  i.e. full 12 points for ETTV of 40 W/m2

Part 1 – Energy Efficiency

NRB 1- 2 Air-conditioning System – Air-Conditioned Plant (Water-Side)

***(a) Water-Cooled* Chilled-Water Plant**

•**Prescribed** Min. Central Chilled Water Plant Efficiency

• For Peak Building Cooling Load **≥ 500 RT: 0.70 kW/RT**

• For Peak Building Cooling Load **< 500 RT: 0.80 kW/RT**
(Compliance to the **latest SS for all chiller plant equipment** is required)

•Air-con system efficiency assessed basing on design system efficiency.



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Part 1 – Energy Efficiency

NRB 1- 2 Air-conditioning System – Air-Conditioned Plant (*Water-Side*)

(b) Air-Cooled* Chilled-Water Plant/ *Unitary Air-Conditioners

•**Prescribed** Min. Chilled Water Plant/ Unitary Air-Conditioners Efficiency

• For Peak Building Cooling Load **≥ 500 RT: 0.80 kW/RT**

• For Peak Building Cooling Load **< 500 RT: 0.90 kW/RT**
(Compliance to the **latest SS for all chiller plant equipment** is required)

•Air-con system efficiency assessed basing on design system efficiency.



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Part 1 – Energy Efficiency *Part 1-2 Air-con Plant Point Scoring*

Water-Cooled Chilled Water Plant:

Peak Building Cooling Load	Pre-scribed Baseline Efficiency (kW/ton)	Points Awarded	Required Efficiency (kW/ton) for *Max* 20 Points
≥ 500 tons	0.70	15	**0.56** **(0.25 pts for every % improvement)** (20% improvement)
< 500 tons	0.80	12	**0.66** **(0.45 pts for every % improvement)** (17.5% improvement)

Air-Cooled Chilled Water Plant/ Unitary Air-Conditioners:

Peak Building Cooling Load	Pre-scribed Baseline Efficiency (kW/ton)	Points Awarded	Required Efficiency (kW/ton) for *Max* 20 Points
≥ 500 tons	0.80	12	**0.75** **(1.3 pts for every % improvement)** (6.25% improvement)
< 500 tons	0.90	10	**0.75** **(0.6 pts for every % improvement)** (16.7% improvement)

1-2 Air-Conditioning System

- REQUIREMENTS

(a)(ii)Air Distribution System

Baseline : SS 553 : 2009 Table 2 – Fan Power limitation in air-conditioning system.

Option 1

Baseline Air Distribution System Type	Allowable Motor Nameplate Power	
	(kW/m³/s)	(W/CMH)
AHUs/FCUs ≥ 4kW (Constant Volume)	1.7	0.47
AHUs ≥ 4kW (Variable Volume)	2.4	0.67
Fan systems with nameplate motor power < 4 kW	No baseline	

Option 2

Baseline Air Distribution System Type	Allowable Fan System Input Power*	
	(kW/m³/s)	(W/CMH)
AHUs/FCUs ≥ 4kW (Constant Volume)	1.5	0.42
AHUs ≥ 4kW (Variable Volume)	2.1	0.58
Fan systems with nameplate motor power < 4 kW	0.6	0.17

* Applicable pressure drop adjustments can be considered based on ASHRAE 90.1 Table 6.5.3.1.1B and are subject to BCA's evaluation

Points awarded = 0.2 x (% improvement) (up to 6 points)

30% improvement = 6 pts

Part 1 – Energy Efficiency

NRB 1- 2 Air-conditioning System – Air-Conditioned Plant

For water cooled chilled water system.

(d) Provision of Permanent measuring instruments for monitoring of water water-cooled chilled-water plant efficiency in accordance to ASHRAE Guide 22 – ***1 Pre-requisite point***
The installed instrumentation shall have a resultant plant efficiency within 5% of the true value

Detail Requirements

1) Location and installation of the measuring devices to meet the manufacturer's recommendation.
2) Data acquisition system i.e. Analog-to-digital or A/D converter used should have a minimum resolution of 16-bit.
3) Data Logging Software interval: All Data should be trended at 1 minute sampling time interval.
4) Flow meters: The flow meter should be ultrasonic or full bore magnetic type, or equivalent in terms of accuracy.
5) Provisions shall be made for each temperature measurement location to have 2 spare thermo-wells so that sensors can be placed side-by-side for verification of accuracy

(e) Central Chilled-Water Plant Efficiency Verification: Heat balance - substantiating test - *1 point*

1-2 Air-Conditioning System

- REQUIREMENTS

Variable Speed Controls

1 point Provision of VSD controls for chilled-water pumps and cooling tower fans to ensure better part-load plant efficiency.

Sensor / Automatic Control Devices

To regulate outdoor air flow rate to maintain the concentration of carbon dioxide in accordance to SS 554 : 2009.

1 points awarded for use of carbon dioxide sensors

1-2 Air-Conditioning System

- District Cooling

For buildings using district cooling system, there is no need to compute the plant efficiency under item (a)(i).

The points obtained will be pro-rated and based on the air distribution system efficiency under item (a)(ii).

1-2 Air-Conditioning System

- Bdgs with Different Air-con system

Total Air-Conditioned areas (m^2)	25,000
Total Air-Conditioned areas (m^2) using chiller plant	90%
Total Air-Conditioned areas (m^2) using unitary air-conditioners	10%
Total designed Cooling Capacity (kW) of chiller plant	3517
~~Total designed Cooling Capacity (kW) of unitary air-conditioners~~	~~200~~

1-3 Building Envelope

- AIM

  To enhance overall thermal performance of building envelope to minimize heat gained though external walls and windows of a building which encourage natural ventilation.

- REQUIREMENTS

  Applicable for Non Air-Conditioned Building (with non-aircon areas > 10% of GFA).

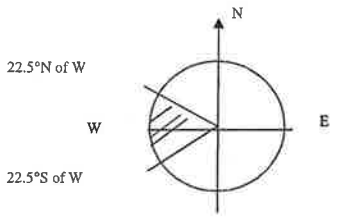
30 pt
- (a) Minimal west facing facade through orientation. (up to 15 points)
- (b)(i) Minimum west facing window
- (b)(ii) Sunshading provision for west windows

  } Up to 10 pts
- (c) Better U-value west wall. (up to 5 points)
- (d) Better U-value of roof. (up to 5 points)

1-3 Building Envelope

- REQUIREMENTS

  (a) Minimum direct west facing external facade through building design orientation



Points awarded = 15 – 0.3 x (% of direct west facing facade areas over total façade areas)

(Up to 15 points)

i.e. 50% = 50 pts

0% = 15 pts

1-3 Building Envelope

- REQUIREMENTS

(bi) Minimum west facing window openings.

Points awarded = 10 – 0.1 x (% of west facing window areas over total west facing façade area)

i.e. 0%=10pts, 10%=9pts .....90%= 1pts

(bii) Effective sunshading (30% shading) on west facing window openings.

Points awarded = 0.1 x (% of west facing window areas with effective sunshade over total west facing façade area)

i.e. 0%=0pts, 10%=1pts .....90%= 9pts

max 10 pts for b(i) and b(ii)

1-3 Building Envelope

- REQUIREMENTS

(c) Better thermal transmittance (U-value) of west facing external walls

The U-value of west facing external walls should be equal or less than 2 W/m2K

Points awarded=0.05 X (% of ext wall with U-value<2W/m2k over total west facing facade area)

(up to 5 points)

i.e. 100% = 5pts
0% = 0pts

1-3 Building Envelope

- REQUIREMENTS

(d) Thermal Transmittance (U-value) of roof

Baseline: U-value for roof stated below depending on the weight range of roof structure:

Weight Group	Weight range (kg/m^2)	Maximum Thermal Transmittance (W/m^2K)
Light	Under 50	0.8
Medium	50 to 230	1.1
Heavy	Over 230	1.5

1 point for every 10% reduction from the baseline

(Up to 5 points)

Towards a Sustainable Built Environment

1-4 (A) Natural Ventilation

- AIM

To encourage the design of natural ventilation to reduce the needs of mechanical ventilation (exclude carparks). (up to 20 points)

- REQUIREMENTS

(a) Proper design of building layout that utilizes prevailing wind conditions to achieve adequate cross ventilation. (up to 10 points)

- *1 point for every 10% of units/rooms with window openings facing north and south directions*
- *Points awarded = 1 x (% of units/10)*

(b) Use of ventilation simulation software or wind tunnel testing to identify the most effective building design and layout to achieve good natural ventilation. (5 points)

- Additional 5 *Points will be awarded provided if recommendations from ventilation simulations are implemented*

(up to 10 points)

Towards a Sustainable Built Environment

1-4(b) Mechanical Ventilation

- REQUIREMENTS

  (a)(ii)Mechanical Ventilation

  Baseline : SS 553 : 2009 Table 2 – Fan Power limitation in air-conditioning system. (no variable speed baseline)

Option 1

Baseline Air Distribution System Type	Allowable Motor Nameplate Power	
	(kW/m³/s)	(W/CMH)
AHUs/FCUs ≥ 4kW (Constant Volume)	1.7	0.47
AHUs ≥ 4kW (Variable Volume)	2.4	0.67
Fan systems with nameplate motor power < 4 kW	No baseline	

Option 2

Baseline Air Distribution System Type	Allowable Fan System Input Power*	
	(kW/m³/s)	(W/CMH)
AHUs/FCUs ≥ 4kW (Constant Volume)	1.5	0.42
AHUs ≥ 4kW (Variable Volume)	2.1	0.58
Fan systems with nameplate motor power < 4 kW	0.6	0.17

* Applicable pressure drop adjustments can be considered based on ASHRAE 90.1 Table 6.5.3.1.1B and are subject to BCA's evaluation

Points awarded = 0.6 x (% improvement) (up to 15 points)

25% improvement = 15 pts

1-5 Daylighting

- AIM

  Encourage design that optimises the use of effective daylighting to reduce energy use for artificial lighting.

  (same scoring as RB)

- Highlights

  Require evidence of automated control to switch off artificial lighting to utilise daylighting.

1-6 Artificial Lighting

- AIM

  To encourage the use of better efficient lighting to minimize energy consumption from lighting usage while maintaining proper lighting level.

- REQUIREMENTS

  Applicable to all - Baseline : Minimum efficiency requirement of the air-conditioning system stated in SS530:2006.

  0.3 point for every percentage improvement above the baseline (up to 12 points)

  Note : If tenant lightings are **not** included in the lighting power budget computation, the points awarded will be **capped at 5 points**

1-6 Artificial Lighting

- HYPOTHETICAL EXAMPLE

Type of usage	Total Area (A)	Proposed Design W/m² (B)	Reference Design (SS530) W/m² (C)	Proposed Design Load (A x B)	Reference Design Load (A x C)
Office	20,000	12	15	240,000	300,000
Lobbies and corridors	2,000	7	10	14,000	20,000
Stairs	900	5	6	4,500	5,400
Car parks	800	3.5	5	2,800	4,000
~~Exterior lighting~~	~~1500~~	~~3~~	~~5~~	~~4,500~~	~~7,500~~
			Total	265,800 Σ(AxB)	336,900 Σ(AxC)

NRB - No need this →

~~21.1%~~ 20.7% improvement above the baseline

Points awarded = 0.3 x ~~(21.1%)~~ 20.7%

= ~~6.33~~ 6.21 points

CAP at 5 points (if tenant lighting excluded)

Towards a Sustainable Built Environment

1-8 Ventilation for Common Areas

- AIM

  To encourage common areas to be designed for natural or mechanical ventilation – toilets, staircases, corridors, lift lobbies, atriums

- REQUIREMENTS

(a) Natural ventilation – 1.5 points for each area

(b) Mechanical ventilation – 0.5 points for each area

Extent of coverage: at least 90% of the applicable areas

(up to 5 points)

1-9 Lifts and Escalators

- AIM

  To encourage the use of energy efficient lifts & escalators.

- REQUIREMENTS

(a) Lifts with energy efficient features such as AC variable voltage and variable frequency (VVVF) motor drive (1point) and sleep mode features. (1point)

(b) Escalators with energy efficient features such as motion sensors . (1point)



Lift Motor



VVVF Inverter



Lift Controller

1-10 Energy Efficient Features

- AIM

  To encourage other energy efficient green features not stated in the previous section which are innovative and have positive environmental impact

- REQUIREMENTS

  a) Computation of energy consumption based on design load in the form of energy efficiency index (EEI). (1 point)

  b) Use of vertical greenery system on east and west facade to reduce heat gain through building envelope. (1 point)

  c) Use of energy efficient equipment or product that are certified by approved local certification body. (0.5 point each, Up to 2 points)

  b) 3 points for every 1% reduction in the total energy consumption of the building.

(Up to 11 points for this section)

1-11 Renewable/Clean Energy

- AIM

  To recognize and encourage the use of renewable or clean energy in order to reduce the needs of fossil fuel energy use

- REQUIREMENTS

Expected Energy Efficiency Index (EEI)	Every 1% replacement of electricity (based on total building electricity consumption) by renewable energy source.	
	Include tenant's usage	Exclude tenant's usage
≥30 kWh/m²/yr	5 points	3 points
<30 kWh/m²/yr	3 points	1.5 points

(up to 20 points)

Energy Efficient Features

Summary

- Total Points from Criteria 1-1 to 1-11 is 116
- Minimum 30 points must be achieved

Part 1- Energy Efficiency – Points Computation

$$\text{Sub-Total(A) X } \frac{\text{Air-Conditioned Building Floor Area}}{\text{Total Floor Area}} + \text{Sub-Total(B) X } \frac{\text{Non Air-Conditioned Building Floor Area}}{\text{Total Floor Area}} + \text{Sub-Total(C)}$$

Elective Requirement for Energy Improvement (Combination of the following items to meet 30 points)

Part 1 - Energy Efficiency

A	1-1	Building Envelope - ETTV
	1-2	Air-Conditioning System
B	1-3	Building Envelope – Design/Thermal Parameters
	1-4	Natural Ventilation
	1-5	Daylighting
	1-6	Artificial Lighting
	1-7	Ventilation at Common Areas and Carparks
C	1-8	Ventilation for Common areas
	1-9	Lifts and Escalators
	1-10	Energy Efficient Features
	1-11	Renewable/Clean energy

item 2-1 for RB and NRB are the same.
2-3

2-2 Water Usage & Leak Detection

- AIM

  To ensure water systems are capable of being monitored and managed.

- REQUIREMENTS

Sub-meters for major water usage such as irrigation, cooling tower and tenants.(1point)

Linking all sub-meters to BMS to provide a leak detection system. (1point)

2-4 Water Consumption of Cooling Tower

- AIM

  To reduce potable water use for cooling purpose.

- REQUIREMENTS

Applicable for Buildings with Water-based Building Cooling Systems

(a) Use of cooling tower water treatment which can achieve 7 or more cycles of concentration (1 point)

(b) Use of NEWater onsite or recycled water. (1 point)

3-5 Refrigerants

- AIM

  To reduce the impact of refrigerants on environmental sustainability.

- REQUIREMENTS

Applicable for Buildings with Air-Conditioning System

Use of refrigerant leak detection system at critical areas of plant rooms containing chillers and other equipments with refrigerants.
(1point)

Refrigerants with zero ozone depletion potential (ODP) or with global warming potential of less than 100.
(1point)

4-1 Thermal Comfort

- AIM

  To optimize thermal comfort level for occupants.

- REQUIREMENTS

Applicable if there are aggregate air-conditioned areas of more than 500 m^2

Indoor operative temp between 25 ± 1° C
Relative Humidity < 65%
(SS554:2009)

(1 point)

4-2 Noise Level

- AIM

  To noise levels are maintained at an appropriate level.

- REQUIREMENTS

Applicable for aggregate air-conditioned areas > 500 m2

Occupied spaces in buildings are designed with good ambient sound levels as recommended in SS 553.

(1 point)

4-4 Indoor Air Quality (IAQ) Management

- AIM

  To ensure that Building ventilation systems are designed and installed to provide acceptable IAQ under normal operating conditions

- Requirements

(a) Provision of filtration media and DP monitoring in AHU as per SS 554 Clause 4.3.4.5 – ***1 point***

(b) Implement effective IAQ management plan after construction inclusive of internal surface condition testing – ***1 point***

- Deposit thickness test
- Vacuum test

4-5 High Frequency Ballasts

- AIM

  To enhance the visual performance of the environment.

- REQUIREMENTS

Applicable for offices, classrooms and the like

High frequency ballasts installed in fluorescent luminaries.

At least 90% of Area covered by fluorescent lightings (2 points)

Towards a Sustainable Built Environment

Basic Certified Rating (Regulation Requirements)

Building and Construction Authority

GM Criteria – Certified Rating

(I) Energy Related Requirements	Points Allocation	Points Scored	Remarks
Part 1 : Energy Efficiency			
1-1 Building Envelope – ETTV	12	0	
1-2 Air-Conditioning System	30	19	• Peak building cooling load < 500 RT • Chiller plant efficiency of 0.80 kW/RT (12 points) • 20% improvement in air systems (4 points) • Instrumentation for monitoring of chiller plant efficiency (1 point) • VSD controls for chilled-water pumps and CT fans (1 point) • CO_2 sensors for regulating the outdoor air flow rate (1 point)
1-3 Thermal Performance of Building Envelope (non a /c)	35	---	
1-4 Natural Ventilation and/or Mechanical Ventilation (exclude carparks)	20	---	
1-5 Daylighting	6	0	
1-6 **Artificial** Lighting	12	9	• 30% improvement in lighting power budget
1-7 Ventilation in Car parks	4	0	
1-8 Ventilation in Common Areas	5	1	• Mode of ventilation for toilets: MV
1-9 Lift and Escalators	2	0	
1-0 Energy Efficient Practices & Features	12	1	• Computation of EEI
1-11 Renewable Energy	20	0	
Category Score for Part 1 – Energy Efficiency		30	

(II) Other Green Requirements	Point Allocations	Points Scored	Remarks
Part 2 : Water Efficiency			
2-1 Water Efficient Fittings	10	0	• Water fittings with WELS good rating
2-2 Water Usage and Leak Detection	2	1	• Provision of private metering to major water usage
2-3 Irrigation System and Landscaping	3	1	• Use of plants that require little watering
2-4 Water Consumption of Cooling Tower	2	1	• Cooling tower water treatment able to achieve 7 Cycle of Concentration
Category Score for Part 2 – Water Efficiency		3	
Part 3 : Environmental Protection			
3-1 Sustainable Construction	10	1	• CUI = 0.7 m^3/m^2
3-2 Sustainable Materials	8	2	• SGBC excellent certified internal partition (2)
3-3 Greenery Provision	8	2	• GnPR = 0.5 (1) • Use of horticulture waste (1)
3-4 Environmental Management Practice	8	4	• Effective environmental friendly programmes (1) • CONQUAS project (1) • Building user guide (1) • Provision of recycling bin (1)
3-5 Green Transport	4	1	• Within 500m from bus stop (1)
3-6 Refrigerants	2	2	• Refrigerant with 0 ODP or GWP < 100 • Refrigerant leak detection system
3-7 Stormwater Management	3	0	
Category Score for Part 3 – Environmental Protection		12	



Building and Construction Authority
Basic Certified Rating (Regulation Requirements)
GM Criteria – Certified Rating

(II) Other Green Requirements	Point Allocations	Points Scored	Remarks
Part 4 : Indoor Environmental Quality			
4-1 Thermal Comfort	1	1	• Design for thermal comfort
4-2 Noise Level	1	1	• Design occupied spaces as per SS 553 recommended ambient sound level
4-3 Indoor Air Pollutants	2	0	
4-4 IAQ Management	2	0	
4-5 High Frequency Ballasts	2	2	• Use of high frequency ballasts
Category Score for Part 4 – Indoor Environmental Quality		4	
Part 5 : Other Green Features			
5-1 Green Features & Innovations	7	1	•For computation of CUI
Category Score for Part 5 – Other Green Features		1	
Sub-total for other green requirements		20	



Thank You

Useful links:

https://www.bca.gov.sg/GreenMarkScoreCalculator/

http://www.bca.gov.sg/GreenMark/green_mark_buildings.html

www.greenmark.sg

Towards a Sustainable Built Environment

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