



BCA GREEN MARK

# GM TS: 2018

BCA GREEN MARK FOR TRANSIT STATIONS TS: 2018



*Image Courtesy of LTA In-house Design Team*

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## Green Mark for Transit Stations - Revision Log

Revision	Description	Date Effective
R0	Pilot Version	15/11/2018
R1	Official Launch – Final Version	01/11/2019

# Introduction to BCA Green Mark

The Building and Construction Authority (BCA) Green Mark scheme was launched in 2005 and is an internationally recognised green building rating system tailored for the tropical climate. Green Mark sets parameters and establishes indicators to guide the design, construction and operation of buildings towards increased energy effectiveness and enhanced environmental performance.

BCA Green Mark is developed in consultation with key stakeholders, providing a largely performance based and flexible framework of assessment to encourage positive environmental outcomes. It comprises a full suite of sustainability indicators with specific outcome requirement along with minimum standards of performance in key areas that are relevant to ensure fundamental environment issues are addressed.

BCA Green Mark is a third party green building certification system which comprises a number of distinct rating tools that, together, holistically rate the built environment for its environmental performance. These include:

- **New Buildings** including Non-Residential, Residential and Landed Housing
- **Existing Buildings** including Non-Residential, Residential and Schools
- **User Centric** including Healthier Workplaces, Retail, Supermarket, Restaurant, Data Centres, Laboratories
- **Beyond Buildings** including Districts, Parks, Rapid Transit System and Infrastructure

More recently, BCA Green Mark for Super Low Energy Buildings was introduced to give additional recognition for projects that achieve the best-in-class energy efficiency beyond the energy efficiency standard set for Green Mark Platinum rating.

## BCA Green Mark for Transit Stations TS: 2018

The BCA Green Mark for Transit Stations TS : 2018 scheme was developed with invaluable inputs and support from the Land Transport Authority (LTA), Singapore, to further advance sustainability in transit facilities. With the expansion of rail networks to meet the increasing demands, this new addition to the suite of Green Mark schemes will provide a holistic framework that helps ensure environmental sustainability in transit station developments, while enhancing commuters' experience. The certification applies to both elevated and underground transit stations.

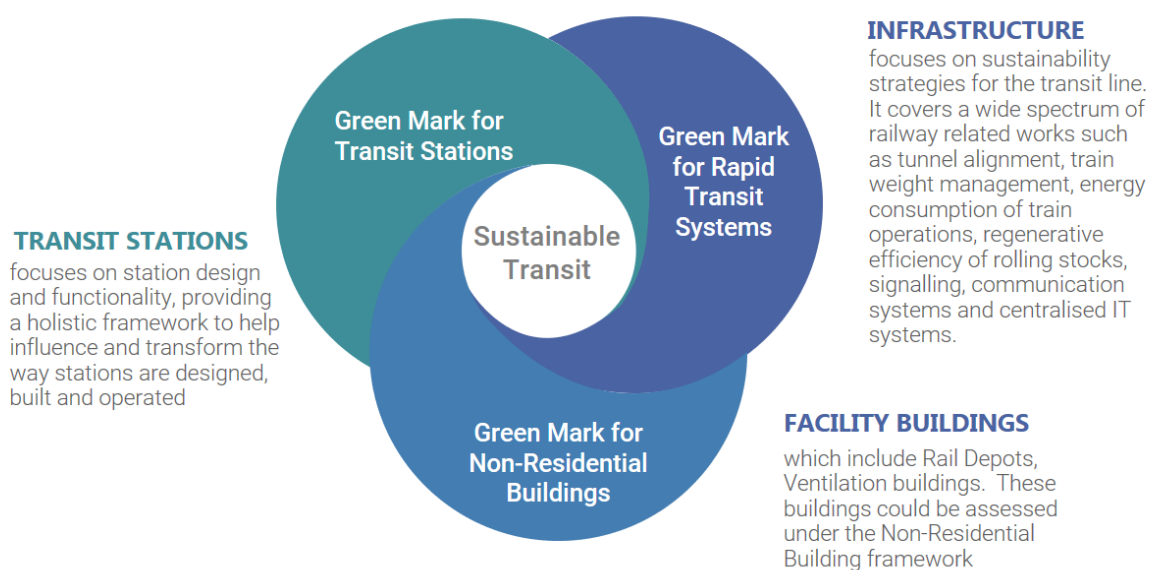


Figure 1: BCA Green Mark schemes that support sustainable transit

This scheme complements the other related schemes for transport facilities (shown in Figure 1). Leveraging different sustainability aspects of these schemes would minimise the environmental impact of transit stations and related facilities, while improving commuters' mobility.

## Certification Process

The BCA Green Mark certification process is as summarised below :



Figure 2: Green Mark Certification Process

## Assessment Framework

The environmental performance of a transit station shall be determined by the numerical scores (i.e. Green Mark points) achieved in accordance with the applicable criteria based on the scoring methodology stated. Under this assessment framework, points are awarded for incorporating sustainable design features and practices based on the degree of compliance with the applicable criteria, which would add up to a final Green Mark (GM) Score.

Depending on the level of sustainability performance and Green Mark Score, the transit station will be eligible for certification under one of the ratings namely BCA Green Mark Gold, Gold<sup>PLUS</sup> or Platinum. There will also be a need to fulfil the relevant minimum standards of performance, which are pre-requisites to meet the Green Mark certification requirement at different rating level. The corresponding Green Mark Scores to attain the respective Green Mark rating are as shown in Figure 3.



Figure 3: Green Mark Score Requirements for different GM ratings

# Criteria Overview

The criteria framework for Transit Stations is adapted from the BCA Green Mark for Non-Residential Buildings, with specific focus on the transit station's design, functionality and operations.

It comprises a list of pre-requisites along with a full suite of sustainability indicators with specific outcome requirement that are structured into 5 sections namely Section 1 – Responsive Urban Design, Section 2 - Energy Performance, Section 3 – Resource Stewardship, Section 4 – Smart and Healthy Features and Section 5 – Advanced Green Effort as shown in Figure 4. The total point is 140 points, inclusive of 20 points from Section 5: Advanced Green Efforts.



Figure 4: Criteria Framework for BCA Green Mark for Transit Stations

## Framework and Criteria Summary

Prerequisites	Applicability
P.01 Envelope and Roof Thermal Transfer	Building facades and roof of elevated stations
P.02 Air-Tightness and Leakage	Air-conditioning system provision
P.03 Ventilation Performance	Naturally Ventilated Functional Space (For projects to attain Green Mark Platinum rating)
P.04 Air-Conditioning System Efficiency	Air-conditioning system provision
P.05 Lighting Efficiency and Controls	Lighting provision
P.06 Vertical Transportation Efficiency	Provision of lifts and escalators
P.07 Energy Saving Requirements	Stations that are predominantly air-conditioned (For projects to attain Green Mark Gold <sup>PLUS</sup> or Platinum rating)
P.08 Water Efficient Fittings	All water fittings
P.09 Indoor Air Quality	Interior paint system
P.10 Refrigerants	Air-conditioning system provision
P.11 Measurement and Instrumentation Requirements	Central chilled water air-conditioning systems
P.12 Electrical Sub-Metering & Monitoring	Electrical systems

Elective Requirements	
<b>Section 1 – Responsive Urban Design</b>	<b>35 points</b>
<b>1.1 Leadership</b>	<b>10 points</b>
1.1a Sustainability Design Brief	1 point
1.1b Integrative Design Process	5 points
1.1c Environmental Credentials of Project Team	2 points
1.1d User Engagement	2 points
<b>1.2 Urban Harmony</b>	<b>20 points</b>
1.2a Sustainable Urbanism	17 points
1.2b Urban Greenery	3 points
<b>1.3 Tropicality</b>	<b>5 points</b>
1.3a Enhanced Thermal Performance	1 point
1.3b Ventilation Performance	4 points
<b>Section 2 – Energy Performance</b>	<b>30 points</b>
<b>2.1 Energy Efficiency</b>	<b>22 points</b>
2.1a Environmental Control System	16 points
2.1b Lighting System Efficiency	4 points
2.1c Transformer Efficiency	2 points
<b>2.2 Energy Effectiveness</b>	<b>6 points</b>
2.2a Optimal Cooling Load Provision	3 points
2.2b Energy Efficient Practices and Features	3 points

<b>2.3 Renewable Energy</b>	<b>2 points</b>
2.3a Solar Energy Feasibility Study	0.5 point
2.3b Solar Ready Roof	0.5 point
2.1b Adoption of Renewable Energy	1 point
<b>Section 3 – Resource Stewardship</b>	<b>30 points</b>
<b>3.1 Water</b>	<b>7 points</b>
3.1a Water Efficient Systems	3 points
3.1b Water Usage Monitoring	2 points
3.1c Alternative Water Sources	2 points
<b>3.2 Materials</b>	<b>21 points</b>
3.2a Sustainable Construction	12 points
3.2b Embodied Carbon	2 points
3.2c Sustainable Products	7 points
<b>3.3 Waste</b>	<b>2 points</b>
3.3a Environmental Construction Management	1 point
3.3b Construction Waste Minimisation Measures	1 point
<b>Section 4 – Smart &amp; Healthy Building</b>	<b>25 points</b>
<b>4.1 Indoor Air Quality</b>	<b>9 points</b>
4.1a User Comfort	2 points
4.1a Outdoor Air	4 points
4.1b Indoor Contaminants	3 points
<b>4.2 Spatial Quality</b>	<b>8 points</b>
4.2a Lighting	4 points
4.2b Acoustics	2 points
4.2c Wellbeing	2 points
<b>4.3 Smart Operations</b>	<b>8 points</b>
4.3a Energy Monitoring	2 points
4.3b Demand Control	1 point
4.3c Integration and Analytics	3 points
4.3d System Handover and Documentation	2 points
<b>Section 5 – Advanced Green Efforts</b>	<b>Bonus 20</b>
<b>5.1 Enhanced Performance</b>	<b>15 points</b>
5.1a Reference to Section 1 – Responsive User Design	
5.1b Reference to Section 2 – Energy Performance	
5.1c Reference to Section 3 – Resource Stewardship	
5.1d Reference to Section 4 – Smart and Healthy Building	
<b>5.2 Demonstrating Cost Effective Design</b>	<b>2 points</b>
<b>5.3 Complementary Certifications</b>	<b>1 point</b>
<b>5.4 Social Benefits</b>	<b>2 points</b>

# Pre-requisites

The pre-requisites set out the minimum environmental considerations that a project shall demonstrate based on industry norms. All pre-requisites listed are to be fulfilled where relevant, in order to be eligible to score Green Mark points under the elective requirements

P.01 Envelope and Roof Thermal Transfer

P.02 Air-Tightness and Leakage

P.03 Ventilation Effectiveness

P.04 Air-Conditioning System Efficiency

P.05 Lighting Efficiency and Controls

P.06 Vertical Transportation Efficiency

P.07 Energy Saving Requirements

P.08 Water Efficient Fittings

P.09 Indoor Air Quality

P.10 Refrigerants

P.11 Measurement and Instrumentation Requirements

P.12 Electrical Sub-Metering & Monitoring



Prerequisites		Applicability												
<b>P.01</b>	<b>Envelope and Roof Thermal Transfer</b>	Building facades and roofs of elevated stations  Note: The requirement under (a) and (b) will only apply to elevated stations that are designed with predominantly air-conditioned spaces												
Minimise heat gain through building envelope and roof to enhance indoor thermal comfort. The following performance indicators are to be met. <ul style="list-style-type: none"> <li>(a) Maximum Envelope Thermal Transfer Value (ETTV) of 50 W/m<sup>2</sup>.</li> <li>(b) For roof with skylights, the maximum Roof Thermal Transfer Value (RTTV) of 50 W/m<sup>2</sup>.</li> <li>(c) For roof without skylights, the average thermal transmittance (U-Value) of roof shall not exceed the prescribed limits as stated below :</li> </ul> <table border="1" style="margin-left: 40px;"> <thead> <tr> <th>Roof Weight Group</th> <th>Weight Range (kg/m<sup>2</sup>)</th> <th>Maximum U- value (W/m<sup>2</sup>k)</th> </tr> </thead> <tbody> <tr> <td>Light</td> <td>&lt;50</td> <td>0.5</td> </tr> <tr> <td>Medium</td> <td>50 to 230</td> <td>0.8</td> </tr> <tr> <td>Heavy</td> <td>&gt;230</td> <td>1.2</td> </tr> </tbody> </table> <p>The ETTV and RTTV are to be computed based on the methodology stated in the Code on Envelope Thermal Performance for Buildings.</p>			Roof Weight Group	Weight Range (kg/m <sup>2</sup> )	Maximum U- value (W/m <sup>2</sup> k)	Light	<50	0.5	Medium	50 to 230	0.8	Heavy	>230	1.2
Roof Weight Group	Weight Range (kg/m <sup>2</sup> )		Maximum U- value (W/m <sup>2</sup> k)											
Light	<50	0.5												
Medium	50 to 230	0.8												
Heavy	>230	1.2												
<b>P.02</b>	<b>Air-Tightness and Leakage</b>	Air-conditioned space provision												
<b>P.03</b>	<b>Ventilation Performance</b>	For station developments to be eligible for Green Mark Platinum Rating  Applicable for functional space such as platform areas of elevated stations, public and civic spaces that are naturally ventilated.												
In order for the project to be eligible for Green Mark Platinum rating, the thermal comfort threshold as stated in the following table is to be met in at least 70% of the naturally ventilated functional spaces using the following Predicted Mean Vote (PMV) equation.  $PMV = -9.252 + 0.343 \times DBT - 0.747V$ <table border="1" style="margin-left: 40px;"> <thead> <tr> <th>Green Mark Platinum Rating</th> <th>Thermal Comfort Threshold using Predicted Mean Vote (PMV)</th> </tr> </thead> <tbody> <tr> <td></td> <td style="text-align: center;">-0.8 &lt; PMV &lt; +0.8</td> </tr> </tbody> </table> <p>where PMV is Predicted Mean Vote            DBT is indoor air temperature (°C). Baseline of DBT is 31°C            V is indoor wind velocity (m/s)</p> <p>Note :</p> <ul style="list-style-type: none"> <li>(1) DBT can be derived from simulation results considering solar radiation and thermal load suitable for the context.</li> <li>(2) The indoor wind velocity can be derived using the thermal comfort modelling that can be found in Annex A on Computational Fluid Dynamics Simulation Methodology and Requirements outlined in the Green Mark NRB: 2015 Technical Guide and Requirement.</li> </ul> <p>Alternatively, to conduct CFD simulation study on the effectiveness of weather protection measures against wind driven rain with implementation of mitigation measures for platform areas.</p>			Green Mark Platinum Rating	Thermal Comfort Threshold using Predicted Mean Vote (PMV)		-0.8 < PMV < +0.8								
Green Mark Platinum Rating	Thermal Comfort Threshold using Predicted Mean Vote (PMV)													
	-0.8 < PMV < +0.8													

**P.04 Air-Conditioning System Efficiency**

Reduce energy required to provide and distribute conditioned air within the space by having energy efficient air-conditioning system that meet the following energy performance standard.

<b>Water-Cooled Chilled-Water Plant</b>		
Green Mark Rating	Peak Building Cooling Load	
	< 500 RT	≥ 500RT
	Minimum Design System Efficiency (DSE) in kW/RT	
Gold	0.75	0.67
Gold <sup>PLUS</sup>	0.7	0.65
Platinum	0.68	0.65

<b>Air-Cooled Chilled-Water Plant/ Unitary Air-Conditioners</b>		
Green Mark Rating	Peak Building Cooling Load	
	< 500 RT	≥ 500RT
	Minimum Design System Efficiency (DSE) in kW/RT	
Gold	0.9	To be assessed on a case to case basis
Gold <sup>PLUS</sup>	0.85	
Platinum	0.78	

<b>District Cooling System (DCS) operated by supplier of district cooling services registered under the Energy Conservation Act</b>	
Green Mark Rating	Minimum DCS Plant Efficiency in kW/RT <small>see note</small>
Gold	0.65
Gold <sup>PLUS</sup>	
Platinum	

Note:

- (1) The DCS plant efficiency refers to the annual electricity consumption of a DCS plant (kWh) over annual cooling consumption (RTh) of the DCS plants. The operation hours are assumed to be 24 hrs operation per day x 365 days.
- (2) The relevant equipment for the computation of the DCS plant efficiency includes all equipment that are within the DCS plant boundary. That is chillers, chilled water pumps, condenser water pumps, cooling towers, network pumps, thermal storage, heat exchangers, renewable energy or energy recovery systems within the plant vicinity.
- (3) For stations with cooling provision served by existing DCS plants that were commissioned before Oct 2016, the considerations for minimum design system efficiency can be excluded and based on the requirements agreed upon by the supplier which arrangement classified as Path B as outlined in GM NRB: 2015.

Air-conditioning system and cooling provisions

This will also apply to stations that are tapping on existing chilled water plants from other transit stations, neighbouring buildings or from district cooling supplier registered under the Energy Conservation Act unless otherwise stated.

<b>P.05</b>	<b>Lighting Efficiency and Controls</b>										
<p>Reduce energy required to illuminate a space with the provision of energy efficient lighting system and controls.</p> <p>Lighting provision must be at least 10% more energy efficient than the prescribed lighting power budget stated in SS 530 :2014 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment.</p>		Lighting provision									
<b>P.06</b>	<b>Vertical Transportation Efficiency</b>										
<p>Reduce energy consumption by installing energy efficient vertical transportation systems that are equipped with variable voltage variable frequency (VVVF) drives and sleep mode features.</p>		Lifts and escalators									
<b>P.07</b>	<b>Energy Saving Requirements</b>										
<p>Facilitate energy load reduction strategies and cost effective design decision at early design stage.</p> <p><u>Station development with air-conditioned areas <math>\geq 5000 \text{ m}^2</math></u></p> <p>To demonstrate that the station design and provisions meet the minimum percentage energy savings as compared with its reference model through energy modelling. The stipulated percentage energy savings for the higher Green Mark (GM) rating are as follows :</p>		<p>For station that are air-conditioned to be eligible for GM Platinum or GM Gold<sup>PLUS</sup> Rating</p> <p>This will also apply to stations that are tapping on existing chilled water plants from other transit stations, neighbouring buildings or from district cooling supplier registered under the Energy Conservation Act unless otherwise stated.</p>									
<table border="1"> <thead> <tr> <th data-bbox="193 936 534 1025">Green Mark (GM) Rating</th> <th data-bbox="534 936 1099 1025">Minimum Energy Savings over its Reference Model</th> </tr> </thead> <tbody> <tr> <td data-bbox="193 1025 534 1075">Gold<sup>PLUS</sup></td> <td data-bbox="534 1025 1099 1075">25%</td> </tr> <tr> <td data-bbox="193 1075 534 1122">Platinum</td> <td data-bbox="534 1075 1099 1122">30%</td> </tr> </tbody> </table>		Green Mark (GM) Rating	Minimum Energy Savings over its Reference Model	Gold <sup>PLUS</sup>	25%	Platinum	30%				
Green Mark (GM) Rating	Minimum Energy Savings over its Reference Model										
Gold <sup>PLUS</sup>	25%										
Platinum	30%										
<p><u>Station development with air-conditioned areas <math>&lt;5000 \text{ m}^2</math></u></p> <p>Detailed calculation on the estimated annual energy consumption of building services and equipment as compared with the baseline energy consumption can be provided in place of energy modelling to justify compliance with the the minimum percentage energy savings for the respective Green Mark rating as stated in the above table..</p>											
<p><u>Station development with cooling provision served by DCS plants</u></p> <p>If the cooling provision is to be served by District Cooling System (DCS) plants that were commissioned after Oct 2016 (which arrangement is classified as Path A in the Green Mark NRB: 2015 guidelines), the minimum percentage energy savings for the respective Green Mark ratings as stated above will apply.</p> <p>If the cooling provision is to be served by existing DCS plants that were commissioned before Oct 2016, which arrangement classified as Path B and cleared by BCA as outlined in the Green Mark NRB: 2015 guidelines, the minimum percentage energy savings to be demonstrated through energy modelling (excluding the energy consumption of the DCS plant) are as follows:</p>											
<table border="1"> <thead> <tr> <th data-bbox="193 1771 534 1921">Green Mark (GM) Rating</th> <th data-bbox="534 1771 703 1921">Cooling Load Savings</th> <th data-bbox="703 1771 1062 1921">Minimum Energy Savings over its reference model (excluding DCS plant)</th> </tr> </thead> <tbody> <tr> <td data-bbox="193 1921 534 1971">Gold<sup>PLUS</sup></td> <td data-bbox="534 1921 703 1971">10%</td> <td data-bbox="703 1921 1062 1971">27%</td> </tr> <tr> <td data-bbox="193 1971 534 2045">Platinum</td> <td data-bbox="534 1971 703 2045">15%</td> <td data-bbox="703 1971 1062 2045">33%</td> </tr> </tbody> </table>		Green Mark (GM) Rating	Cooling Load Savings	Minimum Energy Savings over its reference model (excluding DCS plant)	Gold <sup>PLUS</sup>	10%	27%	Platinum	15%	33%	
Green Mark (GM) Rating	Cooling Load Savings	Minimum Energy Savings over its reference model (excluding DCS plant)									
Gold <sup>PLUS</sup>	10%	27%									
Platinum	15%	33%									

### Energy modelling framework

The energy modelling shall be conducted in accordance with the framework set out in accordance with Annex C – Energy Modelling Methodology and Requirements from the Technical Guide and Requirements of GM NRB: 2015.

Other than the derivation of the energy savings, the normalised Energy Efficiency Index (EEI) and the Energy Use Intensity based on the proposed energy model result shall be computed as spelled in Annex C.

The reference baseline set that could be adjusted in the energy modelling to cater to the relevant design limitation and constraints for station development and as listed.

<b>Components</b>	<b>Baseline Standard and Minimum Requirements</b>
(i) Building Envelope Design	NA
(ii) Air-conditioning and Mechanical Ventilation (ACMV) Fan Systems	<p>For outdoor air intakes and exhaust where the vertical stack duct run is considerably long, the fan power limitation pressure drop adjustment can be considered. It shall be limited to the air flow rate for fresh air and corresponding exhaust according to SS 553 :2016 Table 2b – Fan power limitation pressure drop adjustment.</p> <p>For horizontal long duct run for AHU or MV fan supply / return, the pressure adjustment will be limited to duct run of a minimum of 70 m at 2 Pa/m run.</p>
(iii) Receptacle Loads	<p>Plug loads in relation to station operation and service transformers are considered as receptacle loads and can be limited to 25% of the reference model total consumption. Receptacle load from train operation such as train traction load and transfer loss can be excluded in the computation.</p>
(iv) Indoor Thermal Comfort Conditions	Same as proposed design
(v) Transformers	The energy saving can be accounted for the provision of better low loss transformers with reference to the minimum requirement stipulated in SS 530 :2014.

<b>P.08</b>	<b>Water Efficient Fittings</b>	<p>Reduce water consumption through the provision of water efficient fitting as stated below :</p> <table border="1" data-bbox="248 315 971 562"> <thead> <tr> <th data-bbox="248 315 667 360">Type of water fittings</th> <th data-bbox="667 315 971 360">WELS Rating</th> </tr> </thead> <tbody> <tr> <td data-bbox="248 360 667 405">Basin taps and mixers</td> <td data-bbox="667 360 971 405">3 ticks</td> </tr> <tr> <td data-bbox="248 405 667 450">Sink taps and mixers</td> <td data-bbox="667 405 971 450">2 ticks</td> </tr> <tr> <td data-bbox="248 450 667 517">Shower taps and mixers or showerheads</td> <td data-bbox="667 450 971 517">2 ticks</td> </tr> <tr> <td data-bbox="248 517 667 562">Dual flush cisterns</td> <td data-bbox="667 517 971 562">2 ticks</td> </tr> </tbody> </table> <p>All water fittings except for automatic flush valves, bib taps and fittings that are meant for special functional purposes</p>	Type of water fittings	WELS Rating	Basin taps and mixers	3 ticks	Sink taps and mixers	2 ticks	Shower taps and mixers or showerheads	2 ticks	Dual flush cisterns	2 ticks
Type of water fittings	WELS Rating											
Basin taps and mixers	3 ticks											
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Shower taps and mixers or showerheads	2 ticks											
Dual flush cisterns	2 ticks											
<b>P.09</b>	<b>Indoor Air Quality</b>	<p>Reduce concentration of volatile organic compound indoor by using paint systems of acceptable VOC emission and certified by an approved local certification body.</p> <p>Interior paint systems</p>										
<b>P.10</b>	<b>Refrigerants</b>	<p>Reduce the level of ozone depleting and greenhouse gas emission by using air-conditioning systems that contain refrigerants with ozone depleting potential (ODP) of 0 or global warming potential (GWP) of less than 100.</p> <p>A leak detection system shall also be installed in critical areas of plant rooms containing chillers and/or other equipment using refrigerants.</p> <p>Air-conditioning system</p>										
<b>P.11</b>	<b>Measurement and Instrumentation Requirements</b>	<p>Facilitate energy management and monitoring of chilled water air-conditioning system operating efficiency with the provision of permanent instrumentation.</p> <p>The instrumentation must have the capability to calculate the resultant efficiency within 5% of its true value in accordance with SS 591: 2013. Each measurement system shall include sensors, any signal conditioning, data acquisition system and the wiring connecting these components.</p> <p>The measuring instruments and devices are to be located within reach to facilitate verification and maintenance. They must be installed in accordance with the manufacturers' recommendation and SS 591: 2013. The measurement systems provided shall also comply with the following requirement:</p> <ul style="list-style-type: none"> <li>• All data logging with capability to trend at 1-minute sampling time interval, and recorded to the 3rd decimal digit;</li> <li>• Building management system (BMS), standalone energy monitoring system (EMS) or local sequential controller (LSC) shall have capability to compute and display of key indicators including overall system energy efficiency and calculated heat balance of the chilled water system;</li> <li>• Magnetic in-line flow meter, with 1% uncertainty and capable of electronic in-situ verification to within <math>\pm 2\%</math> of its original factory calibration. If installation of magnetic in-line meters is not possible, ultrasonic flow meters or other flow meters that can meet the indicated performance may be used;</li> </ul> <p>Chilled water air-conditioning systems</p> <p>This will also apply to stations that are tapping on existing chilled water plants from other transit stations, neighbouring buildings or from district cooling supplier registered under the Energy Conservation Act unless otherwise stated.</p>										

<ul style="list-style-type: none"> <li>• Temperature sensors are to be provided for chilled water and condenser water loop and shall have an end-to-end measurement uncertainty within <math>\pm 0.05^{\circ}\text{C}</math> over the entire measurement range. Each temperature measurement location shall have 2 spare thermo-wells located in close proximity of the temperature sensor (with minimum flow interference differential) for verification of measurement accuracy. Thermo-wells shall be installed in a manner that enables the sensors to be in direct contact with fluid flow. There shall be valid justification will be assessed on a case by case basis if direct immersion of the temperature sensor(s) is/are not possible; and</li> <li>• Dedicated power meters (of IEC Class 1 or better) and metering current transformers, where applicable, of Class 1 or better, are to be provided for each of the following groups of equipment where applicable: chillers, chilled water pumps, condenser water pumps and cooling towers.</li> </ul> <p>After project completion, a heat balance-substantiating test is to be carried out to ascertain the overall accuracy of the measurement result of the permanent instrumentation provided for the central chilled water system. To meet the accuracy requirement, more than 80% of the heat balance (%) derived over the entire normal operating hours is to be within <math>\pm 5\%</math> over a period of one (1) week.</p>	
<b>P.12 Electrical Sub-Metering &amp; Monitoring</b>	
<p>Facilitate measurement and monitoring of major energy end uses for energy management and audit.</p> <p>Separate energy sub-meters shall be provided and are linked to a monitoring system that can store, measure energy consumption data for the following systems:</p> <ul style="list-style-type: none"> <li>(a) Lighting system for public areas</li> <li>(b) Air-conditioning system (including VRF systems)</li> <li>(c) Mechanical ventilation system</li> <li>(d) Vertical transportation system</li> </ul>	<p>Systems that serve major end uses</p>

# Elective Requirements

A suite of key sustainability indicators can be found in the following five (5) sections for consideration.

Section 1 : Responsive Urban Design

Section 2 : Energy Performance

Section 3 : Resource Stewardship

Section 4 : Smart and Healthy Building

Section 5 : Advanced Green Efforts

Points will be accorded for incorporating sustainable design features and practices given in the five (5) sections, which would add up to a Green Mark Score. The total number of points allocated is 120 points. It does not include the 20 bonus points assigned under Section 5, which give recognition for the implementation of strategies, designs or processes that demonstrate exceptional levels of sustainable performance and innovations.

## Elective Requirements

Section 1 – Responsive Urban Design	35 points
<b>1.1 Leadership</b>	<b>10 points</b>
<p>1.1a Sustainability Design Brief (Max 1 point)</p> <p>Encourage project team to integrate environmental sustainability in the design brief. The brief should include client’s sustainability aspirations, target settings and tracking of specific sustainable outcomes and indicators, in addition to the project’s target Green Mark rating.</p>	1 point
<p>1.1b Integrative Design Process (Cap 5 points)</p> <p>Promote collaborative efforts among key stakeholders to optimise opportunities for design and system synergies that create better-integrated, cost-effective sustainability outcome and building performance.</p> <p>(i) Integrative Approach to Station Design            (ii) Maintainability Design Considerations            (iii) Collaborative BIM            (iv) Green BIM</p>	<p>2 points            2 points            1 point            1 point</p>
<p>1.1c Environmental Credentials of Project Team (Cap 2 points)</p> <p>Recognise contributions from key project team members and firms (that is developer, main builder, architect, M &amp; E engineers, C &amp; S Engineers, ESD consultants) with green credentials.</p> <p><u>Green Professionals:</u></p> <p>(i) Green Mark Accredited Professional [GMAP] or Green Mark Accredited Professional (Facilities Management) [GMAP (FM)]            (ii) Green Mark Advanced Accredited Professional [GMAAP] or Green Mark Advanced Accredited Professional (Facilities Management) [GMAAP (FM)]</p> <p><u>Green Companies:</u></p> <p>(iii) ISO 14001 certified            (iv) SGBC Green Services Certified Firms            (v) Main builder that is certified under the Green and Gracious Builder Scheme</p> <ul style="list-style-type: none"> <li>• 0.5 point for Certified or Merit rating</li> <li>• 1 point for Excellent or Star rating</li> </ul>	<p>0.25 point each            0.5 point each            0.25 point each            0.5 point each            Up to 1 point</p>
<p>1.1d User Engagement (Cap 2 points)</p> <p>Provision of relevant guidance on the green features implemented in an effort to encourage the involvement and contribution of users and operators in reducing the overall carbon footprint.</p> <p>(i) Building User Guide            (ii) Display of Green Building Credential            (iii) Green Fit-out Guidelines</p>	<p>0.5 point            1 point            1 point</p>



1.2 Urban Harmony	20 points										
<p>1.2a Sustainable Urbanism (Cap 17 points)</p> <p>Encourage the development of a sustainable, accessible and contextual response that supports reductions in per-capita transport energy use and minimises environmental impact.</p> <p>(i) Environmental Impact Assessment 1 point</p> <p>(ii) Response to Site Context (Cap at 1 point) 0.5 point</p> <ul style="list-style-type: none"> <li>• Level 1 – Concept design studies 1 point</li> <li>• Level 2 – Iterative massing studies using macro simulations</li> </ul> <p>(iii) Site Planning and Selection to minimise land uptake for station development so that land areas that are not under the road reserve can be optimised for other purposes. Up to 3 points</p> <table border="1" data-bbox="288 730 1126 943"> <thead> <tr> <th>% of Land Uptake of Station Development that are within Road Reserve (LR)</th> <th>Point allocated</th> </tr> </thead> <tbody> <tr> <td>90% and above</td> <td>3</td> </tr> <tr> <td>80% to &lt; 90%</td> <td>2</td> </tr> <tr> <td>70% to &lt; 80%</td> <td>1</td> </tr> </tbody> </table> <p>(iv) Complementary Transport Facilities (Cap at 4 points) Up to 4 points</p> <ul style="list-style-type: none"> <li>• Bicycle parking lots – 0.5 point for every 50 parking lots 2 points</li> <li>• Dedicated circulation routes for cyclists to access bicycle parking and end of trip facilities</li> </ul> <p>(v) Seamless Connectivity and Accessibility (Cap at 4 points) Up to 2 points</p> <ul style="list-style-type: none"> <li>• Linkages to all other public transport nodes 2 points</li> <li>• Linkages to neighbouring development within 400 m radius 2 points</li> <li>• Additional entrances to other networks such as park connectors - 1 point for each additional provision</li> </ul> <p>(vi) Future Integration (Cap at 4 points) 2 points</p> <ul style="list-style-type: none"> <li>• Provisions for all future connections 2 points</li> <li>• Structural provisions for building development 2 points</li> <li>• Provisions for expansion 2 points</li> </ul>	% of Land Uptake of Station Development that are within Road Reserve (LR)	Point allocated	90% and above	3	80% to < 90%	2	70% to < 80%	1			
% of Land Uptake of Station Development that are within Road Reserve (LR)	Point allocated										
90% and above	3										
80% to < 90%	2										
70% to < 80%	1										
<p>1.2b Urban Greenery (Cap at 3 points)</p> <p>Encourage greater use of greenery, tree conservation and landscape management to enhance biodiversity and reduce urban heat island effects.</p> <p>(i) Greenery Provision Up to 2 points</p> <ul style="list-style-type: none"> <li>• Points scored based on the greenery provision (GnPR) calculated by considering the 3 D volume covered by plants using the prescribed Leaf Area Index (LAI)(Refer to <a href="http://florafaunaweb.nparks.gov.sg">http://florafaunaweb.nparks.gov.sg</a>) and the site area (based on boundary or 2.5 times of designated planted areas).</li> </ul> <table border="1" data-bbox="360 1906 1142 2007"> <thead> <tr> <th>GnPR</th> <th>0.5 to &lt;1.0</th> <th>1.0 to &lt;1.5</th> <th>1.5 to &lt;2.0</th> <th>&gt; 2.0</th> </tr> </thead> <tbody> <tr> <th>Points Allocated</th> <td>0.5</td> <td>1.0</td> <td>1.5</td> <td>2.0</td> </tr> </tbody> </table>	GnPR	0.5 to <1.0	1.0 to <1.5	1.5 to <2.0	> 2.0	Points Allocated	0.5	1.0	1.5	2.0	
GnPR	0.5 to <1.0	1.0 to <1.5	1.5 to <2.0	> 2.0							
Points Allocated	0.5	1.0	1.5	2.0							

<p>1.2b Urban Greenery (Cap at 3 points) (Cont'd)</p> <p>(ii) Tree Conservation</p> <ul style="list-style-type: none"> <li>• Preservation of existing trees on-site to prevent disturbance to established habitats.</li> <li>• Replanting of an equivalent number of trees that are to be felled.</li> </ul> <p>(iii) Sustainable Landscape</p> <ul style="list-style-type: none"> <li>• Adoption of native species of greenery.</li> <li>• Use of organic composts from horticultural wastes.</li> </ul>	<p>0.5 point</p> <p>0.5 point</p> <p>0.5 point</p> <p>0.5 point</p>						
<p><b>1.3 Tropicality</b></p>	<p><b>5 points</b></p>						
<p>1.3a Enhanced Thermal Performance (Max 1 point)</p> <p>Provision of roof with better thermal transmittance (U value) to reduce heat gain, which help enhance indoor comfort.</p> <ul style="list-style-type: none"> <li>• 0.5 point for every 25% improvement over the prescribed limits stated in P.01.</li> </ul> <p>1.3b Ventilation Performance (Cap at 4 points)</p> <p>(i) Enhance thermal comfort of users through the provision of good ventilation strategies that meet the stipulated Predicted Mean Vote (PMV) using the following PMV equation.</p> <p><math>PMV = -9.252 + 0.343 \times DBT - 0.747V</math></p> <table border="1" data-bbox="288 1061 1086 1229"> <thead> <tr> <th>Thermal Comfort Threshold using Predicted Mean Vote (PMV)</th> <th>Point allocation</th> </tr> </thead> <tbody> <tr> <td>-1.0 &lt; PMV &lt; +1.0</td> <td>3 points</td> </tr> <tr> <td>-0.8 &lt; PMV &lt; +0.8</td> <td>4 points</td> </tr> </tbody> </table> <p>where PMV is Predicted Mean Vote  DBT is indoor air temperature (°C). Baseline of DBT is 31°C  V is indoor wind velocity (m/s)</p> <p>Note :</p> <ol style="list-style-type: none"> <li>(1) DBT can be derived from simulation results considering solar radiation and thermal load suitable for the context.</li> <li>(2) The indoor wind velocity considering the provision of mechanical fan system can be derived using the thermal comfort modelling methodology that can be found in Annex A on Computational Fluid Dynamics Simulation Methodology and Requirements under the Green Mark NRB: 2015 Technical Guide and Requirement.</li> </ol> <p>(ii) Provision of suitable ventilation means or strategies to enhance thermal comfort in the platform areas.</p> <p>(iii) Enhance the effectiveness of weather protection measures through the provision of mitigation measures identified from Computational Fluid Dynamics (CFD) modelling and simulation study.</p>	Thermal Comfort Threshold using Predicted Mean Vote (PMV)	Point allocation	-1.0 < PMV < +1.0	3 points	-0.8 < PMV < +0.8	4 points	<p>Up to 1 point</p> <p>Up to 4 points</p> <p>1 point</p> <p>4 point</p>
Thermal Comfort Threshold using Predicted Mean Vote (PMV)	Point allocation						
-1.0 < PMV < +1.0	3 points						
-0.8 < PMV < +0.8	4 points						

**Section 2 – Energy Performance**

**30 points**

**2.1 Energy Efficiency**

**22 points**

2.1a Environmental Control System Efficiency (Max 16 points)

Encourage the use of better energy efficient air-conditioned and mechanical ventilation systems to minimise energy consumption.

Up to 10 points

(i) Water Cooled Chilled Water Plant

0.75 point for every percentage improvement in the chilled-water plant efficiency from the following baseline.

Baseline	Peak Building Cooling Load	
	≥ 500 RT	< 500 RT
Minimum Design System Efficiency (DSE) for Central Chilled Water Plant	0.67 kW/RT	0.75 kW/RT

(ii) Air Cooled Chilled-Water Plant/ Unitary Air-Conditioners

0.75 point for every percentage improvement in the chilled-water plant efficiency from the following baseline.

Baseline	Peak Building Cooling Load	
	≥ 500 RT	< 500 RT
Minimum Design System Efficiency (DSE) for Air Cooled Chilled-Water Plant or Unitary Air-Conditioners	0.80 kW/RT	0.90 kW/RT

Note :

- (1) Same baseline for stations with air-conditioning provision from supplier with district cooling plants that were commissioned after Oct 2016 (which arrangement is classified as Path A under GM NRB: 2015).
- (2) For district cooling plants that were commissioned before Oct 2016 which arrangement could be considered under Path B as classified under GM NRB: 2015 and with clearance from BCA, the scoring can be pro-rated based on the air distribution system efficiency provided by the project team.
- (3) Where there is a combination of central chilled water plant with unitary conditioners, the points scored will be pro-rated in proportion of the peak cooling load designed for each system.

2.1a Environmental Control System Efficiency (Max 16 points) (Cont'd)

(iii) Air-Distribution System (Max 3 points)

1 point for the computation of the energy efficiency standard of the air-distribution system in kW/RT. Additional 0.2 point for every percentage improvement in the air-distribution system efficiency from the respective baselines stipulated in the following tables.

Up to 3 points

Option 1 – Fan System Motor Nameplate kW

Baseline : SS 553 : 2016 – Fan Power Limitation and as prescribed below

<b>Baseline</b> <b>Air Distribution System Type</b>	<b>Option 1</b>	
	<b>Allowable nameplate motor power</b>	
<i>Fan systems with nameplate motor power ≥ 4kW</i>	(kW/m <sup>3</sup> /s)	(W/CMH)
Air Handling Units (AHUs) /Fan Coil Units (FCUs) (Constant Volume)	1.7	0.47
Air Handling Units (AHUs) /Fan Coil Units (FCUs) (Variable Volume)	2.4	0.67
<i>Fan systems with nameplate motor power &lt; 4 kW</i>	No baseline	

Option 2 – Fan System Input kW

Baseline : SS 553 : 2016 – Fan Power Limitation and as prescribed below

<b>Baseline</b> <b>Air Distribution System Type</b>	<b>Option 2</b>	
	<b>Allowable fan system power</b>	
<i>Fan systems with nameplate motor power ≥ 4kW</i>	(kW/m <sup>3</sup> /s)	(W/CMH)
Air Handling Units (AHUs) /Fan Coil Units (FCUs) (Constant Volume)	1.5	0.42
Air Handling Units (AHUs) /Fan Coil Units (FCUs) (Variable Volume)	2.1	0.58
<i>Fan systems with nameplate motor power &lt; 4 kW</i>	0.6	0.17
Note: Applicable pressure drop adjustments can be considered based on SS 553 :2016 and are subject to BCA's evaluation.		

<p>2.1a Environmental Control System Efficiency (Max 16 points) (Cont'd)</p> <p>(iv) Mechanical Ventilation System (Max 3 points)</p> <p>0.2 point for every percentage improvement in the mechanical fan system efficiency from the respective baselines in the following tables :</p> <p><u>Option 1 – Fan System Motor Nameplate kW</u></p> <p>Baseline : Fan Power Limitations as prescribed below</p> <table border="1" data-bbox="268 495 1182 936"> <thead> <tr> <th rowspan="2">Baseline Mechanical Ventilation System</th> <th colspan="2">Applicable to Constant Volume or Variable Volume</th> </tr> <tr> <th>≥ 4kW</th> <th>&lt; 4kW</th> </tr> </thead> <tbody> <tr> <td>Option 1 : Fan system allowable nameplate motor power (W/CMH)</td> <td>0.35</td> <td>No baseline</td> </tr> <tr> <td>Option 2 : Fan system input (W/CMH)</td> <td>0.3</td> <td>0.17</td> </tr> <tr> <td colspan="3">Note: Applicable pressure drop adjustments can be considered based on SS 553 : 2016 and are subject to BCA's evaluation.</td> </tr> </tbody> </table>	Baseline Mechanical Ventilation System	Applicable to Constant Volume or Variable Volume		≥ 4kW	< 4kW	Option 1 : Fan system allowable nameplate motor power (W/CMH)	0.35	No baseline	Option 2 : Fan system input (W/CMH)	0.3	0.17	Note: Applicable pressure drop adjustments can be considered based on SS 553 : 2016 and are subject to BCA's evaluation.			<p>Up to 3 points</p>
Baseline Mechanical Ventilation System		Applicable to Constant Volume or Variable Volume													
	≥ 4kW	< 4kW													
Option 1 : Fan system allowable nameplate motor power (W/CMH)	0.35	No baseline													
Option 2 : Fan system input (W/CMH)	0.3	0.17													
Note: Applicable pressure drop adjustments can be considered based on SS 553 : 2016 and are subject to BCA's evaluation.															
<p>2.1b Lighting System Efficiency (Max 4 points)</p> <p>Encourage the use of better energy efficient lighting system to minimise energy consumption from lighting usage while maintaining proper lighting level</p> <ul style="list-style-type: none"> <li>0.2 point for every percentage improvement in lighting power budget from the baseline stated in P.05 and SS530</li> </ul>	<p>Up to 4 points</p>														
<p>2.1c Transformer Efficiency (Max 2 points)</p> <p>Encourage the provision of better energy efficient service transformers to minimise energy loss during operation.</p> <ul style="list-style-type: none"> <li>1 point for every 0.1 percentage improvement in efficiency standard at 50% load from the baseline stated in SS530</li> </ul>	<p>Up to 2 points</p>														
<p><b>2.2 Energy Effectiveness</b></p>		<p><b>6 points</b></p>													
<p>2.2a Optimal Cooling Load Provision (Max 3 points)</p> <p>Facilitate right sizing of chiller plant system through a more in-depth study of the operational needs and receptacle load requirement.</p> <p>(i) Enhanced cooling load estimate with detailed heat load calculation taking into consideration diversity, projected ridership, historical operational data, benchmarking studies and trends.</p> <p>(ii) Receptacle load management by way of procuring energy efficient equipment or implementing plug load reduction measures, which could help reduce the receptacle load by at least 10%.</p>	<p>2 points</p> <p>1 point</p>														

<p>2.2b Energy Efficient Practices and Features (Cap 3 points)</p> <p>Encourage the adoption of energy efficient practices and features, which have positive impacts on energy savings and environment.</p> <p>(i) Calculation of Energy Efficiency Index (EEI) and Energy Use Intensity (EUI)</p> <p>(ii) Provision of energy efficient features or equipment with extent of coverage of more than 80% –max 1 point for each feature or equipment type</p>	<p>1 point</p> <p>Up to 3 points</p>
<p><b>2.3 Renewable Energy</b></p>	<p><b>2 points</b></p>
<p>2.3a Solar Energy Feasibility Study (Max 0.5 point)</p> <p>Conduct of the feasibility study into the possibility of harnessing solar energy for station development to facilitate decision-making.</p>	<p>0.5 point</p>
<p>2.3b Solar Ready Roof (Max 0.5 point)</p> <p>Encourage roof to be designed with due consideration for structural, electrical and spatial readiness to facilitate future photovoltaic installation.</p>	<p>0.5 point</p>
<p>2.3c Adoption of Renewable Energy (Max 1 point)</p> <p>Promote on-site generation of renewable energy which reduce electricity consumption and associated carbon emissions</p> <ul style="list-style-type: none"> <li>• 0.5 point for every percentage of electricity consumption for station operation comes from renewable energy source</li> </ul>	<p>Up to 1 point</p>

Section 3 – Resource Stewardship	30 points
<b>3.1 Water</b>	<b>7 points</b>
<p>3.1a Water Efficient Systems (Max 3 points)</p> <p>Encourage design of water efficient mechanical systems and strategies that help minimise potable water consumption during operation.</p> <p>(i) Landscape Irrigation</p> <ul style="list-style-type: none"> <li>• 0.25 point for every 25% of the landscape areas that are served by water efficient irrigation systems</li> <li>• 0.25 point for every 20% of the landscape areas that comprises drought tolerant plants</li> </ul> <p>(ii) Water Consumption of Cooling Towers</p> <ul style="list-style-type: none"> <li>• Provision of cooling tower water treatment system along with effective filtration system to facilitate 7 or more cycles of concentration at acceptable water quality</li> <li>• Provision of effective drift eliminator with minimum efficiency of 0.002%</li> </ul>	<p>0.5 point</p> <p>0.5 point</p> <p>1 point</p> <p>1 point</p>
<p>3.1b Water Usage Monitoring (Max 2 points)</p> <p>Facilitate better control and monitoring of water consumption</p> <p>(i) Provision of private meters for all major water uses</p> <p>(ii) Provision of smart remote metering system with alert features for leak detection</p>	<p>1 point</p> <p>1 point</p>
<p>3.1c Alternative Water Sources (Cap at 2 points)</p> <p>Promote use of alternative water sources to offset the demand of potable water for general application.</p> <p>(i) AHU condensate collection of at least 50% of total condensate generated</p> <p>(ii) NEWater supply</p> <p>(iii) Rainwater harvesting</p> <p>(iv) On-site recycled water</p> <p>Note : It is a requirement to seek approval from NEA on the use of alternative water sources for cooling tower operation.</p>	<p>1 point</p> <p>1 point</p> <p>1 point</p> <p>1 point</p>
<b>3.2 Materials</b>	<b>21 points</b>
<p>3.2a Sustainable Construction (Max 12 points)</p> <p>Encourage the adoption of building systems, materials and construction practices that are environmentally friendly and sustainable.</p> <p>(i) Resource Recovery by facilitating the use of suitable excavated soil on-site or in other projects.</p> <p>(ii) Computation of the Concrete Usage Index (CUI) for station box.</p> <p>(iii) Use of sustainable alternatives which can be fabricated off-site with minimal concrete usage and wet trade for entrance structures.</p>	<p>1 point</p> <p>1 point</p> <p>1 point</p>

<p>3.2a Sustainable Construction (Max 12 points) (Cont'd)</p> <p>(iv) Low carbon concrete</p> <ul style="list-style-type: none"> <li>• Use of concrete containing clinker of <math>\leq 400 \text{ kg/m}^3</math> for grades up to C50/60 for at least 80% of the structural works. 1 point for every 10% reduction in clinker content.</li> <li>• Replacement of coarse and fine aggregates with recycled concrete aggregates and / or washed copper slag (WCS) from approved sources for the concrete mix of main non-structural elements. 0.5 point for every 10% replacement by mass.</li> <li>• Use of recycled concrete aggregates, incinerated bottom ash or reclaimed asphalt pavement for road construction.</li> </ul>	<p>Up to 5 points</p> <p>Up to 3 points</p> <p>1 point</p>												
<p>3.2b Embodied Carbon (Max 2 points)</p> <p>Facilitate understanding of the environmental impact and carbon footprint of station development, which help create awareness among key stakeholders on the need to reduce resource use and associated cost of the development.</p> <p>Computation of embodied carbon footprint using BCA carbon calculator of key materials namely concrete, glass and steel.</p>	<p>2 points</p>												
<p>3.2c Sustainable Products (Max 7 points)</p> <p>Encourage the use of sustainable products for non-structural building components and construction such as environmentally friendly products that are certified by an approved local certification body.</p> <p>Points scored based on the weightage and the extent of coverage and impact. 1 point for high impact item and 0.5 point for low impact item.</p> <table border="1" data-bbox="279 1164 1161 1339"> <thead> <tr> <th colspan="4">Weightage based on the extent of environmental friendliness of products</th> </tr> <tr> <th>Good</th> <th>Very Good</th> <th>Excellent</th> <th>Leader</th> </tr> </thead> <tbody> <tr> <td>0.5</td> <td>1.5</td> <td>2</td> <td>2.5</td> </tr> </tbody> </table> <p>Note : The use of environmental friendly products for main building elements or functional spaces will be considered as high impact item if the quantities used by percentage are more than 50% of the total quantities used for the same intended purpose. Products for external works or items that do not meet the minimum coverage of 50% will be considered as low impact.</p>	Weightage based on the extent of environmental friendliness of products				Good	Very Good	Excellent	Leader	0.5	1.5	2	2.5	<p>Up to 7 points</p>
Weightage based on the extent of environmental friendliness of products													
Good	Very Good	Excellent	Leader										
0.5	1.5	2	2.5										
<p><b>3.3 Waste</b></p>		<p><b>2 points</b></p>											
<p>3.3a Environmental Construction Management (Max 1 point)</p> <p>Facilitate effective implementation of an environmental construction management plan, which covers specific target setting, monitoring of energy, water use and construction waste.</p>	<p>1 point</p>												
<p>3.3b Construction Waste Minimisation Measures (Max 1 point)</p> <p>Incorporate strategies, which can reduce substantial amount of waste produced on site such as modular design, off-site construction methods, use of products with high recycled content or upcycling arrangement, review procedures on material estimate and /or material reuse on site.</p>	<p>1 point</p>												



Section 4 – Smart & Healthy Building	25 points
<b>4.1 Indoor Air Quality</b>	<b>9 points</b>
<p>4.1a User Comfort (Max 2 points)</p> <p>Encourage design consideration and evaluation of indoor air quality parameters to enhance user comfort.</p> <p>(i) Indoor Thermal Environmental Conditions Design for optimum comfort of the space in consideration, by way of appropriate dry-bulb temperature and humidity control.</p> <p>(ii) Indoor Air Quality (IAQ) audit Conduct IAQ audit before occupancy as recommended in SS554 : 2015 Clause 6.2.</p>	<p>1 point</p> <p>1 point</p>
<p>4.1b Outdoor Air (Max 4 points)</p> <p>Encourage provision of adequate and proper ventilation in conditioned spaces to prevent build-up of contaminant concentration.</p> <p>(i) Ventilation Rates</p> <ul style="list-style-type: none"> <li>• Measurement and monitoring of outdoor airflow volume in accordance with desired ventilation rates for all AHUs and FCUs.</li> <li>• Use of demand control ventilation strategies such as carbon dioxide sensors to regulate the quantity of fresh air and ventilation in accordance with the space requirements.</li> </ul> <p>(ii) Filtration Media</p> <ul style="list-style-type: none"> <li>• Permanent provision of outdoor air filtration media that meet the Minimum Efficiency Reporting Value (MERV) of 14 or equivalent.</li> <li>• Provision of differential pressure monitoring equipment in air-handling units (AHUs) to monitor the condition of air filters.</li> </ul>	<p>1 point</p> <p>1 point</p> <p>1 point</p> <p>1 point</p>
<p>4.1c Indoor Contaminants (Cap at 3 points)</p> <p>Encourage the implementation of air treatment strategies and controls to minimise indoor contaminants.</p> <p>(i) System Cleanliness Inspection and Measures Implementation of appropriate checks such as internal surface condition tests to ensure that ACMV systems are clean and free from undesirable contamination or residuals left over from construction activities as recommended in SS 554: 2015 Clause H.1.2.</p> <p>(ii) Air Purging System and Management Plan Commitment to maintain an acceptable indoor air quality by replacing contaminated indoor air with outdoor fresh air on a regular basis.</p> <p>(iii) Ultraviolet Germicidal Irradiation (UVGI) System Provision of UVGI system in AHUs to combat possible microbial contamination.</p>	<p>2 points</p> <p>1 point</p> <p>1 point</p>

<b>4.2 Spatial Quality</b>	<b>8 points</b>
<p>4.2a Lighting (Max 4 points)</p> <p>Encourage the use of daylighting, which could bring about positive effect to the indoor environment.</p> <p>(i) Daylighting in public areas</p> <ul style="list-style-type: none"> <li>• Elevated station – Provision of effective daylighting and mitigation of overlit areas OR</li> <li>• Underground station – Provision of natural lighting in public areas such as concourse and platform</li> </ul> <p>(ii) Daylighting provision at entrance areas</p>	<p>2 points</p> <p>2 points</p>
<p>4.2b Acoustics (Max 2 points)</p> <p>Acoustic considerations and treatments to ensure that the public and working spaces are free from reverberation and excessive noises, which could affect the comfort of occupants and audibility of station announcements.</p>	<p>2 points</p>
<p>4.2c Wellbeing (Cap at 2 points)</p> <p>Enhanced user comfort and experience with the following provisions</p> <p>(i) Biophilic Design Elements</p> <p>Architectural or interior design that reinforces the attributes and experience of nature.</p> <p>(ii) Innovative Aesthetic Attributes</p> <p>Visual components or design idea that help create delightful experiences.</p> <p>(iii) Intuitive Navigation Tools</p> <p>Wayfinding plan incorporating clear directional signage systems, easy-to-follow paths and digital platform to help commuter in finding their way around the station.</p>	<p>1 point</p> <p>1 point</p> <p>1 point</p>
<b>4.3 Smart Operations</b>	<b>8 points</b>
<p>4.3a Energy Monitoring (Max 2 points)</p> <p>Provision of means to track energy consumption data and pattern to help establish energy saving measures and reduction targets.</p> <p>(i) Energy Portal and Dashboard</p> <p>Display metered data, trending of energy consumption and relevant parameters.</p> <p>(ii) Local Sequential Controller (LSC) with Open Protocol</p> <p>Provision of local sequential controller that comes with the capability to export selected data points to commonly used file formats and integrated with open protocol as the network backbone.</p>	<p>1 point</p> <p>1 point</p>
<p>4.3b Demand Control (Max 1 point)</p> <p>Provision of occupancy based controls to regulate and maintain appropriate temperature and lighting level to meet the required demand.</p> <p>(i) ACMV Demand Control</p> <p>Binary sensing controls for 80% of the transient and normally occupied areas.</p>	<p>0.5 point</p>

<p>4.3b Demand Control (Max 1 point) (Cont'd)</p> <p>(ii) Lighting Demand Control</p> <p>Use of occupancy/vacancy sensors or controls to moderate brightness of the luminaries for 80% of the transient and normally occupied areas.</p>	<p>0.5 point</p>
<p>4.3c Integration and Analytics (Max 3 points)</p> <p>Provision of salient integration and analytics features to make available relevant data to maintain the effectiveness of systems performance and reliability.</p> <p>(i) Basic fault detection and diagnostics (FDD) of sensors to detect sensors failure or anomalous sensor data.</p> <p>(ii) Equipment exception monitoring to identify systems that deviates from expected performance, setting and operating hours.</p> <p>(iii) Provision of adaptive control algorithms, which facilitate intuitive responses from related systems for better overall system performance.</p> <p>(iv) Use of BIM or similar applications that provide location-based visualization of the operating conditions of the station.</p>	<p>0.5 point</p> <p>1 point</p> <p>0.5 point</p> <p>1 point</p>
<p>4.3d System Handover and Documentation (Max 2 points)</p> <p>Proper system verification and handover of higher order functional and system level performance of building control systems, mechanical and electrical systems.</p>	<p>2 points</p>

Section 5 – Advanced Green Efforts	Bonus 20 points
5.1 Enhanced Performance	Cap at 15 points
<p>5.1a Reference to Section 1 – Responsive User Design</p> <ul style="list-style-type: none"> <li>(i) Building Information Model (BIM) with 4D, 5D or 6D <i>(Under Criteria 1.1a – Integrative Design Process)</i></li> <li>(ii) Design for Manufacture and Assembly (DFMA) <i>(Under Criteria 1.1a – Integrative Design Process)</i></li> <li>(iii) Land Use Optimization <i>(Under Criteria 1.2a – Sustainable Urbanism)</i></li> <li>(iv) Creation of Possible New Ecology and Natural Ecosystems <i>(Under Criteria 1.2a – Sustainable Urbanism)</i></li> <li>(v) Provision of Green Roof <i>(Under Criteria 1.2a – Sustainable Urbanism)</i></li> <li>(vi) Provision of Vertical Greening <i>(Under Criteria 1.2a – Sustainable Urbanism)</i></li> <li>(vii) Innovative Bicycle Parking Provision/Mechanical Bicycle Storage System <i>(Under Criteria 1.2a – Sustainable Urbanism)</i></li> </ul>	<p>2 points for all criterion listed with the following exceptions :</p> <ul style="list-style-type: none"> <li>• 1 point for criterion 5.1a(vi), 5.1c</li> <li>• 3 points for criterion 5.1b (ii)</li> <li>• Case specific basis for criterion 5.1e</li> </ul>
<p>5.1b Reference to Section 2 – Energy Performance</p> <ul style="list-style-type: none"> <li>(i) Provision in consideration of any possible low load condition. <i>(Under Criteria 2.2a – Optimal cooling Load Provision)</i></li> <li>(ii) 1.5 points can be scored for every additional percentage beyond the electricity replacement by renewable energy source under Criteria 2.3c. (Up to 3 points). <i>(Under Criteria 2.3c – Adoption of Renewable Energy)</i></li> <li>(iii) Provision to channel energy recovered from the train’s regenerative breaking system for station utilisation. <i>(Under Criteria 2.2 – Energy Effectiveness)</i></li> </ul>	
<p>5.1c Reference to Section 3 – Resource Stewardship</p> <ul style="list-style-type: none"> <li>(i) Better Water Efficient Fittings <i>(provided that there is no provision of automatic flush valves for toilet facilities that are not meant for public use).</i> <i>(Under P.08 – Water Efficient Fittings)</i></li> <li>(ii) Derivation of Concrete Usage Index (CUI) for station box from Building Information Model <i>(Under Criteria 3.2a – Sustainable Construction)</i></li> <li>(iii) Provision of Emission Factors with Source Justification</li> <li>(iv) Computation of embodied carbon footprint using BCA calculator of four (4) additional materials <i>(Under Criteria 3.2b – Embodied Carbon)</i></li> </ul>	

<p>5.1c Reference to Section 3 – Resource Stewardship (Cont'd)</p> <p>(v) Computation of embodied carbon footprint of entire project (Under Criteria 3.2b – Embodied Carbon)</p>	
<p>5.1d Reference to Section 4 – Smart and Healthy Buildings</p> <p>(i) Indoor Air Quality Trending of temperature, relative humidity or common indoor air pollutants (Under Criteria 4.1b – Indoor Contaminants)</p> <p>(ii) Measurement and Verification Instrumentation for VRF systems (Under Criteria 4.3a Energy Monitoring)</p> <p>(iii) Advanced Integration and Analytical Features (Under Criteria 4.3c Integration and Analytics)</p> <p>(iv) Expanded Post Occupancy Performance Verification by a 3<sup>rd</sup> party (Under Criteria 4.3d System Handover and Documentation)</p> <p>(v) Energy Performance Contracting (Under Criteria 4.3d System Handover and Documentation)</p>	
<p>5.1e Green Features and Innovation that are not listed (To be submitted for assessment. Points accorded will depend on the extent of environmental impact and on a case specific basis)</p>	
<p><b>5.2 Demonstrating Cost Effective Green Design</b> Projects that can demonstrate high level of environmental performance at no added cost or at a neutral cost to the developments, taking into consideration life cycle perspectives, as compared with the norm.</p>	<b>2 points</b>
<p><b>5.3 Complementary Certifications</b> Project that demonstrates exemplary performance that is certified by a local or international complementary certification in recognition of the effort that are not covered under this criteria</p>	<b>1 point</b>
<p><b>5.4 Social Benefits</b> Project that demonstrates how social sustainability has been incorporated beyond the core functionality of the station development. This can include efforts that demonstrate considerations to improve on the wellbeing of users or help facilitate community integration.</p>	<b>Up to 2 points</b>

Note : The following guidelines and tool will be of relevance in meeting the criteria intent under the BCA Green Mark for Transit Stations :

- Green Mark NRB: 2015 Technical Guide and Requirements
- BCA Carbon Calculator