DESIGN REFERENCE GUIDE

Non-Residential Building

Version 3.0

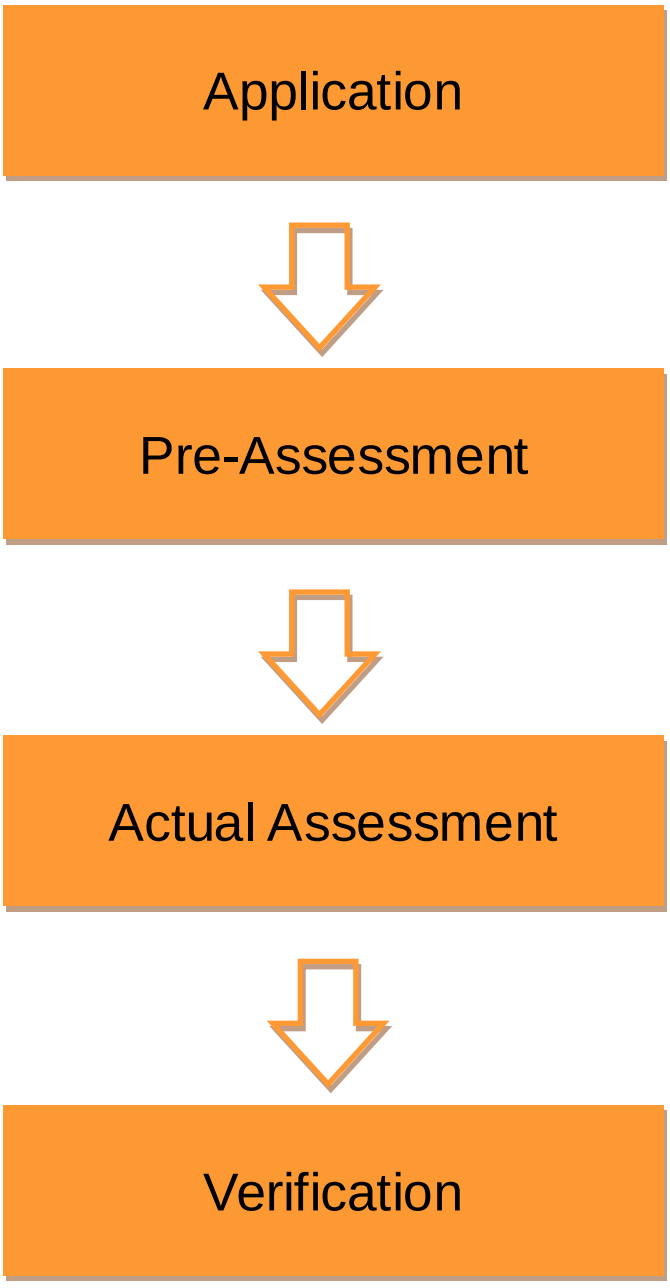
1ST October 2015

Contents

List of Appendices

1. Certification Process

The GreenRE Non-Residential Building certification process is as follows:



Submittal of application with relevant supporting documents for certification upon finalization of building design

A pre-assessment audit will be conducted to give the project team a better understanding of the criteria and evaluation of the certification level sought.

Actual assessment to be conducted once the design and documentary evidences (e.g. approved BP) are ready. After the actual assessment, our assessors will review the documents submitted and formalize report to management within four weeks.

Assessment process includes design and documentary reviews to verify if the building project meets

i. The intents of the criteria
ii. The prerequisite requirement for GreenRE Bronze, Silver, Gold and Platinum rating where applicable.
iii. Letter of award showing the GreenRE rating will be issued at this stage.

Site verification will be conducted upon project completion.

Refer to page 6 for prerequisite requirements.

A certificate will be issued at this stage.

GreenRE assessment criteria consist of six (6) environmental impact categories namely:

(a) Part 1 - Energy Efficiency: This category focuses on the approach that can be used in the building design and system selection to optimise the energy efficiency of buildings.

(b) Part 2 - Water Efficiency: This category focuses on the selection of fittings and strategies enabling water use efficiency during construction and building operation.

(c) Part 3 – Environmental Protection: This category focuses on the design, practices and selection of materials and resources that would reduce the environmental impacts of built structures.

(d) Part 4 - Indoor Environmental Quality: This category focuses on the design strategies that would enhance the indoor environmental quality which include air quality, thermal comfort, acoustic control and daylighting.

(e) Part 5 - Other Green Features: This category focuses on the adoption of green practices and new technologies that are innovative and have potential environmental benefits.

(f) Part 6 - Carbon Emission of Development: This category focuses on the use of carbon calculator to calculate the carbon emission of the development.

These environment impact categories are broadly classified under two main groups namely (I) Energy Related Requirements and (II) Other Green Requirements.

Energy Related Requirements consist of Part 1- Energy Efficiency where credits are allocated for the various energy efficient designs, practices and features used. A minimum of 30 credits must be obtained from this group to be eligible for certification. The number of points achievable for this group is capped at 50 points (exclude 20 bonus points that are obtainable under NRB 1-10 – Renewable Energy).

Other Green Requirements consist of Part 2 - Water Efficiency; Part 3 - Environmental Protection; Part 4 - Indoor Environmental Quality; Part 5 - Other Green Features and Part 6 - Carbon Emission of Development. Credits are allocated for the water efficient features, environmentally friendly design practices, innovative green features used and carbon emission of development. A minimum of 20 credits must be obtained from this group to be eligible for certification. The number of points achievable for this group is also capped at 50 points.

The maximum GreenRE score achievable for a project is capped at 100 points and this does not include 20 bonus points that are obtainable under Energy Related Requirements if a project uses renewable energy sources.

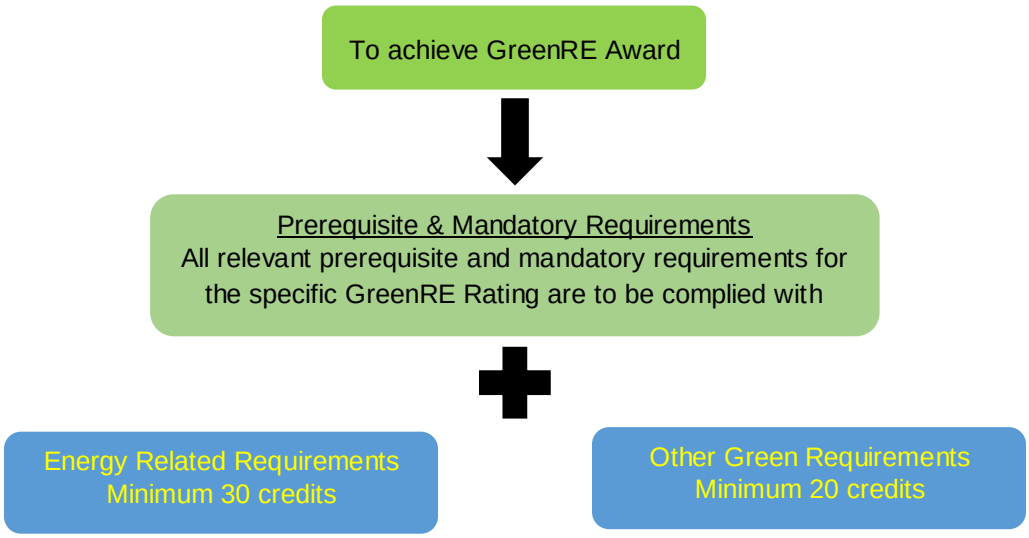
Under the non-residential building criteria, the environmental impact category Part 1 – Energy Efficiency applies to both air-conditioned and non air-conditioned spaces. Where there is a combination of air-conditioned and non air-conditioned spaces, the points allocated are to be prorated in accordance with the respective floor areas. For simplicity, points applicable to air-conditioned areas are accounted only if the aggregate air-conditioned areas exceed 500 m^2. Similarly, points applicable to non air-conditioned areas are accounted only if the aggregate non air-conditioned areas are more than 10% of the total floor areas excluding carparks.

2. GreenRE Award Rating

Score	Rating
90 and above	GreenRE Platinum
85 to < 90	GreenRE Gold
75 to < 85	GreenRE Silver
50 to < 75	GreenRE Bronze

3. GreenRE Assessment

3.1 Framework



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

Part 1 – Energy Efficiency

NRB 1-1 Thermal Performance of Building Envelope -OTTV
NRB 1-2 Air-Conditioning System
NRB 1-3 Building Envelope – Design/ Thermal Parameters
NRB 1-4 Natural Ventilation (exclude carparks)
NRB 1-5 Daylighting
NRB 1-6 Artificial Lighting
NRB 1-7 Ventilation in Carparks
NRB 1-8 Ventilation in Common Areas
NRB 1-9 Lift and Escalators
NRB 1-10 Energy Efficient Practices & Features
NRB 1-11 Renewable Energy

Elective Requirement for Other Areas
(Combination of the following items to meet 20 credits)

Part 2 - Water Efficiency

NRB 2-1 Water Efficient Fittings
NRB 2-2 Water Usage and Leak Detection
NRB 2-3 Irrigation System and Landscaping
NRB 2-4 Water Consumption of Cooling Tower

Part 3 – Environmental Protection

NRB 3-1 Sustainable Construction
NRB 3-2 Sustainable Products
NRB 3-3 Greenery Provision
NRB 3-4 Environmental Management Practice
NRB 3-5 Green Transport
NRB 3-6 Stormwater Management
NRB 3-7 Refrigerants

Part 4 - Indoor Environmental Quality

NRB 4-1 Thermal Comfort
NRB 4-2 Noise Level
NRB 4-3 Indoor Air Pollutants
NRB 4-4 Indoor Air Quality (IAQ) Management
NRB 4-5 High Frequency Ballasts

Part 5 – Other Green Features

NRB 5-1 Green Features & Innovations

Part 6 – Carbon Emission of Development

NRB 6-1 Carbon Emission of Development

3.2 Credits Allocation

Category			Credits Allocation
(I) Energy Related Requirements			
Minimum 30 credits	**Part 1: Energy Efficiency**		
	NRB 1-1 Thermal Performance of Building Envelope – OTTV NRB 1-2 Air – Conditioning System	Section (A) Applicable to air-cond. areas	15 27
	Sub -Total (A) – NRB 1-1 to 1-2		**42**
	NRB 1-3 Building Envelope – Design/ Thermal Parameters NRB 1-4 Natural Ventilation (exclude carparks)	Section (B) Applicable to non air- cond. areas	29 13
	Sub – Total (B) – NRB 1-3 to 1-4		**42**
	NRB 1-5 Daylighting NRB 1-6 Artificial Lighting NRB 1-7 Ventilation in Carparks NRB 1-8 Ventilation in Common Areas NRB 1-9 Lifts and Escalators NRB 1-10 Energy Efficient Practices & Features NRB 1-11 Renewable Energy	Section(C) Applicable to all areas	6 12 5 5 3 13 20
	Sub – Total (C) – NRB 1-5 to 1-11		**64**
	Category Score for Part 1 – Energy Efficiency [Prorate Subtotal (A) + Prorate Subtotal (B)] + Subtotal (C)		**106(MAX)**
(II) Other Green Requirements			
Minimum 20 credits	**Part 2: Water Efficiency**		
	NRB 2-1 Water Efficient Fittings NRB 2-2 Water Usage and Leak Detection NRB 2-3 Irrigation System and Landscaping NRB 2-4 Water Consumption of Cooling Tower		8 2 3 2
	Category Score for Part 2 – Water Efficiency		**15**
	Part 3: Environmental Protection		
	NRB 3-1 Sustainable Construction NRB 3-2 Sustainable Products NRB 3-3 Greenery Provision NRB 3-4 Environmental Management Practice NRB 3-5 Green Transport NRB 3-6 Stormwater Management NRB 3-7 Refrigerants		10 8 8 8 4 1 2
	Category Score for Part 3 – Environmental Protection		**41**
	Part 4: Indoor Environmental Quality		
	NRB 4-1 Thermal Comfort NRB 4-2 Noise Level NRB 4-3 Indoor Air pollutants NRB 4-4 Indoor Air Quality (IAQ) Management NRB 4-5 High Frequency Ballasts		2 2 2 2 2
	Category Score for Part 4: Indoor Environmental Quality		**10**
	Part 5: Other Green Features		
	NRB 5-1 Green Features & Innovations		7
	Category Score for Part 5: Other Green Features		**7**
	Part 6: Carbon Emission of Development		
	NRB 6-1 Carbon Emission of Development		4
	Category Score for Part 6: Carbon Emission of Development		**4**
	Category Score for Part 2 to Part 6 – Other Green Requirements		**77**
	GreenRE Non-Residential Building Score		**183**

3.3 Prerequisite Requirements

1) Air-Conditioned Buildings

- Building envelope design with Overall Thermal Transfer Value (OTTV) computed based on the methodology and guidelines stipulated in the MS1525:2014.

  GreenRE Gold – OTTV of 42 W/m^2 or lower
  GreenRE Platinum – OTTV of 40 W/m^2 or lower

- To demonstrate the stipulated energy savings over its reference model using an energy modelling framework set out. Details and submission requirements on energy modelling can be found in Appendix A of this Guideline.

  GreenRE Gold - At least 25% energy savings
  GreenRE Platinum - At least 30% energy savings

- Minimum score under NRB 3-1 Sustainable Construction

  GreenRE Gold ≥ 3 credits
  GreenRE Platinum ≥ 5 credits

2) Non Air-Conditioned Buildings

- To be eligible for GreenRE Platinum Rating, ventilation simulation must be carried out to identify the most effective building design and layout. The simulation results and the recommendations derived are to be implemented to ensure good natural ventilation. Details and submission requirements on ventilation simulation can be found in Appendix B of this Guideline
  .
- Minimum score under NRB 3-1 Sustainable Construction
  GreenRE Gold ≥ 3 credits
  GreenRE Platinum ≥ 5 credits

3.4 Mandatory Requirements

1. Building Envelope – OTTV

   - The OTTV of the building envelope for a building, having a total air-conditioned area exceeding 1000 m² and above should not exceed 50 W/m².

2. Roof

   - In the case of an air-conditioned building, the concept of Roof Thermal Transfer Value (RTTV) is applied if the roof is provided with skylight and the entire enclosure below is fully air-conditioned.

   - For roofs with skylight, the maximum recommended RTTV is 25 W/m².

3. Roof – U-Value

   - The roof of a conditioned space shall not have a thermal transmittance (U-Value) greater than that tabulated in Table 2-1.

Table 2-1 Maximum U-Value for Roof (W/m²K)

Roof Weight Group	Maximum U-Value (W/m²K)
Light (Under 50 kg/m²)	0.4
Heavy (Above 50 kg/m²)	0.6

3.5 Non-Residential Building Criteria

<table>
<tr><th>Part 1 - Energy Efficiency</th><th>GreenRE Credits</th></tr>
<tr><td colspan="2">(A) Applicable to Air-Conditioned Building Area
(with an aggregate air-conditioned areas > 1000m^2)</td></tr>
<tr><td><u>NRB 1-1 THERMAL PERFORMANCE OF BUILDING ENVELOPE - OTTV</u>

Enhance overall thermal performance of building envelope to minimise heat gain thus reducing the overall cooling load requirement.

<u>Baseline:</u>
Maximum permissible OTTV = 50 W/m^2

<u>Prerequisite Requirement:</u>
GreenRE Gold – OTTV of 42 W/m^2 or lower
GreenRE Platinum – OTTV of 40 W/m^2 or lower</td><td>2 credits for every reduction of 1 W/m^2 in OTTV from the baseline.

Credits scored = 100 – [2 x (OTTV)]
where OTTV ≤ 50 W/m^2
(Up to 15 credits)</td></tr>
<tr><td><u>NRB 1-2 AIR-CONDITIONING SYSTEM</u>

Enhance the use of better efficient air-conditioned equipment to minimise energy consumption.

<u>Baseline:</u> Minimum efficiency requirement of the air-conditioning system stated in MS 1525:2014 or SS 530 and SS CP 13.

The system to considered are as follows-

(a)(i) Air-Conditioned Plant:
• Chillers
• Chilled water pumps
• Condenser water pumps
• Cooling Towers

(a)(ii) Air Distribution System
• Air Handling Units (AHU)
• Fan Coil Units (FCU)

Baseline – Fan power limitation in air conditioning system

<table><tr><td colspan="2">Allowable nameplate motor power</td></tr><tr><td>Constant volume</td><td>Variable volume</td></tr><tr><td>1.7 kW/m^3/s</td><td>2.4 kW/m^3/s</td></tr></table>
Note (1): For building using district cooling system, there is no need to compute the plant efficiency under NRB 1-2 (a) (i). The credits obtained will be pro-rated based on the air distribution system efficiency under NRB 1-2(a) (ii).</td><td><u>(a)(i) Air-Conditioned Plant</u>
1.45 credits for every percentage improvement in the efficiency of chiller, chilled-water pump and condenser water pump.
Credits scored = 1.45 x (% improvement)

0.05 credit for every percentage improvement in the performance of cooling tower at rating condition.
Credits scored = 0.05 x (% improvement)

(Up to 20 credits)

<u>(a)(ii) Air Distribution System</u>
0.5 credits for every percentage improvement in the air distribution system efficiency above the baseline.

Credits scored = 0.5 x (% improvement)

(Up to 5 credits)</td></tr>
</table>

OR (b) Unitary Air-Conditioners/Condensing Units: • single-split units • multi-spilt units • variable refrigerant flow (VRF) system Note (2): Where is a combination of centralised air-conditioning system with unitary air-conditioned system, the computation for the credits scored will only be based on the air-conditioning system with a larger aggregate capacity. (c) Sensors or similar automatic control devices are used to regulate outdoor air flow rate to maintain concentration of carbon dioxide below 1000 ppm.	OR (b) Unitary Air-Conditioners/Condensing Units: 1.5 credits for every average percentage improvement in the efficiency of unitary air-conditioners/ condensing units above the baseline. Credits Scored: 1.5 x (% improvement) (Up to 25 credits) 2 credits
Sub-Total (A):	Sum of GreenRE credits obtained from NRB1-1 to 1-2

Part 1-Energy Efficiency	GreenRE Credits
(B) Applicable to Non Air-Conditioned Building Areas (with an aggregate non air-conditioned areas > 10% of total floor area excluding carparks and common areas)	
NRB 1-3 BUILDING ENVELOPE – DESIGN/THERMAL PARAMETERS Enhance the overall thermal performance of building envelope to minimise heat gain which would improve indoor thermal comfort and encourage natural ventilation.	
(a) Minimum direct west facing façade through building design orientation. Note (3): Orientation of façade that falls within the range of 22.5° N of W and 22.5° S of W will be defined as west facing façade. Core walls for lift or staircases and toilets that are located within this range are exempted in computation.	Credits scored = 10 – [0.2 x (% of west facing façade areas over total façade areas)] (Up to 10 credits) Where there is no west facing façade, the total credits scored for this item will be 24 credits; the NRB 1-3 b (i), b (ii) and (c) as listed below will not be applicable.
(b)(i) Minimum west facing window opening.	Credits scored = 10 – [0.1 x (% of west facing window areas over total west facing façade areas)]
(b)(ii) Effective sun shading provision for windows on the west façade with minimum shading of 30%.	Credits scored = 0.1 x (% of west facing window areas with sun shading devices over total west facing façade areas) (Up to 10 credits for NRB 1-3(b)(i) &(b)(ii))
(c) Better thermal transmittance (U-value) of external west facing walls. The U-value of external west facing wall should be equal or less than 2W/m^2K	Credits scored = 0.04 x (% of the external west facing walls areas with U-value of 2 W/m^2K or less over the total west facing façade areas) (Up to 4 credits)

<table>
<tr>
<td>(d) Better thermal transmittance (U-value) of roof.

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

<table>
<tr><th>Roof Weight Group (kg/m^2)</th><th>Maximum U-value (W/m^{2}K)</th></tr>
<tr><td>Light (Under 50)</td><td>0.4</td></tr>
<tr><td>Heavy (Over 50)</td><td>0.6</td></tr>
</table>
</td>
<td>2 credits for every 0.1 W/m^{2}K reduction
(Up to 5 credits)</td>
</tr>
<tr>
<td><u>NRB 1-4 NATURAL VENTILATION (EXCLUDE CARPARKS)</u>

Enhance building design to achieve good natural ventilation.

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

(b) Use of ventilation simulation software to identify the most effective building design and layout to achieve good natural ventilation.

<u>Prerequisite Requirement:</u>
Ventilation simulation must be carried out to be eligible for GreenRE Platinum rating.</td>
<td>0.8 credit for every 10% of units/ rooms with window openings facing north and south directions
Credits scored = 0.8 x (% of units / 10)
(Up to 8 credits)

Credits can only be scored if the recommendations from ventilation simulations are implemented
(5 credits)</td>
</tr>
<tr>
<td>Sub-Total (B):</td>
<td>Sum of GreenRE credits obtained from NRB 1-3 to 1-4</td>
</tr>
</table>

<table>
<tr><th>Part 1 – Energy Efficiency</th><th>GreenRE Credits</th></tr>
<tr><td colspan="2">(C) General</td></tr>
<tr><td><u>NRB 1-5 DAYLIGHTING</u>

Encourage design that optimises the use of effective day lighting to reduce energy use for artificial lighting.
a) Use of daylight simulation analysis or any relevant calculation to verify that 50% or more of all habitable spaces achieve adequate daylight illuminance levels as specified in MS 1525:2014. Areas with illuminance levels below or above the range do not comply.

b) Daylighting in the following common areas:

i. Lift lobbies and corridors
ii. Staircases
iii. Carparks</td><td><table><tr><th>Percentage of Habitable Spaces with Adequate Ambient Lighting Level</th><th>Credits Allocation</th></tr><tr><td>50% - 75%</td><td>1</td></tr><tr><td>76% - 90%</td><td>2</td></tr><tr><td>>90%</td><td>3</td></tr></table>(Up to 3 credits)

1 credit
1 credit
1 credit</td></tr>
<tr><td><u>NRB 1-6 ARTIFICIAL LIGHTING</u>

Encourage the use of better efficient lighting to minimise energy consumption from lighting usage while maintaining proper lighting level.

<u>Baseline:</u> Luminance level stated in MS 1525:2014</td><td>0.3 credit for every percentage improvement in the lighting power budget

Credits scored = 0.3 x (% improvement)
(Including tenant lighting provision)
(Up to 12 credits)

(Excluding tenant lighting provision)
(Up to 5 credits)</td></tr>
<tr><td><u>NRB 1-7 VENTILATION IN CARPARKS</u>

Encourage the use energy efficient design and control of ventilation systems on carparks.

(a) Carparks designed with natural ventilation.
(b) CO sensors are used to regulate the demand for mechanical ventilation (MV).

Note (4): Where there is a combination of different ventilation mode adopted for car park design, the credits scored under this requirement will be prorated accordingly.</td><td>Naturally ventilated carparks – 5 credits

Credits scored based on the mode of mechanical ventilation provided

Fume extract- 2.5 credit

MV with or without supply – 2 credits
(Up to 5 credits)</td></tr>
</table>

NRB 1-8 VENTILATION IN COMMON AREAS Encourage the use of energy efficient design and control of ventilation systems in the following common areas: • Toilets • Staircases • Lift Lobbies • Corridors • Atriums	Extent of coverage: At least 90% of each applicable area Credits scored based on the mode of ventilation provided in the applicable areas. Natural vent. – 1.5 credits for each area Mechanical vent. – 0.5 credit for each area (Up to 5 credits)
NRB 1-9 LIFTS AND ESCALATORS Encourage the use of energy efficient lifts and escalators. (a) Lifts with the following energy efficient features: i. AC variable voltage and variable frequency (VVVF) motor drive or equivalent. ii. Sleep mode features or equivalent. (b) Escalators with energy efficient features such as motion sensors.	Extent of Coverage: All lifts and/or escalators 1 credit 1 credit 1 credit
NRB 1-10 ENERGY EFFICIENT PRACTICES & FEATURES Encourage the use of energy efficient practices and features which are innovative and have positive environmental impact (a) Computation of energy consumption based on design load in the form of Energy Efficiency Index (EEI) (b) Use of vertical greenery system on east and west facade to reduce heat gain through building envelope. (c) Use of energy efficient features: Examples: • Heat recovery system • Ductless fan for basement ventilation • Motion sensors for staircases half landing • Sun pipes • Etc	1 credit 1 credit for high impact 0.5 credit for low impact 3 credits for every 1% energy saving over the total building energy consumption (Up to 13 credits)

NRB 1-11 RENEWABLE ENERGY Encourage the use of renewable energy sources in buildings	5 credits for every 1% replacement of electricity (based on total electricity consumption) by renewable energy OR 3 credits for every 1% replacement of electricity (based on the total electricity consumption excluding tenant's usage) by renewable energy (Up to 20 credits)
Sub-Total (C):	Sum of GreenRE credits obtained from NRB 1-5 to 1-11
PART 1 – ENERGY EFFICIENCY CATEGORY SCORE:	Sub-Total (A) X $\frac{\text{Air-Conditioned Building Floor Area}}{\text{Total Floor Area}}$ + Sub-Total (B) X $\frac{\text{Non Air-Conditioned Building Floor Area}}{\text{Total Floor Area}}$ + Sub-Total (C) Where : Sub-Total (A) = Sum of GreenRE Credits obtained Under Section (A) that is NRB 1-1 to 1-2 Sub-Total (B) = Sum of GreenRE Credits obtained Under Section (B) that is NRB 1-3 to 1-4 Sub-Total (C) = Sum of GreenRE Credits obtained Under Section (C) that is NRB 1-5 to 1-11 If either Section (A) or Section (B) is not applicable, no pro-rating of areas is required for the score computation. Total floor area includes air-conditioned area and non air-conditioned area but excluding car park and common area.

<table>
<tr><th>Part 2 – Water Efficiency</th><th>GreenRE Credits</th></tr>
<tr><td><u>NRB 2-1 WATER EFFICIENT FITTINGS</u>

Encourage the use of water efficient fittings that are certified under the Water Efficiency Products Labelling Scheme (WEPLS).

a) Basin taps and mixers
b) Flushing cistern
c) Shower taps and mixers or showerheads
d) Sink/bib taps and mixers
e) Urinals and urinal flush valve</td><td><table><tr><td colspan="3">Rating Based on Water Efficiency Products Labelling Scheme (WEPLS)</td></tr><tr><td>Efficient *</td><td>Highly Efficient **</td><td>Most Efficient ***</td></tr><tr><td>4 credits</td><td>6 credits</td><td>8 credits</td></tr></table>
Credits can be scored based on the number and water efficiency rating of the fitting type used.
(Up to 8 credits)</td></tr>
<tr><td><u>NRB 2-2 WATER USAGE AND LEAK DETECTION</u>

Promote the use of sub-metering and leak detection system for better control and monitoring

(a) Provision of sub-meters for major water uses which includes irrigation, cooling towers and tenant’s usage

(b) Linking all sub-meters to Building Management System (BMS) for leak detection.</td><td>

1 credit

1 credit</td></tr>
<tr><td><u>NRB 2-3 IRRIGATION SYSTEM AND LANDSCAPING</u>

Provision of suitable systems that utilise rainwater or recycled water for landscape irrigation to reduce potable water consumption.

(a) Use of non-potable water including rainwater for landscape irrigation

(b) Use of water efficient irrigation system with rain sensor

(c) Use of drought tolerant plants that require minimal irrigation</td><td>

1 credit

Extent of Coverage: At least 50% of the landscape areas are served by the system
1 credit

Extent of Coverage : At least 80%& of the landscape areas
1 credit</td></tr>
</table>

<u>NRB 2-4 WATER CONSUMPTION OF COOLING TOWER</u> Reduce potable water consumption for cooling purpose. (a) Use of cooling tower water treatment system which can achieve 6 or better cycles of concentration at acceptable water quality (b) Use of recycled water from approved sources for cooling purpose	 1 credit 1 credit
PART 2 – WATER EFFICIENCY CATEGORY SCORE:	Sum of GreenRE credits obtained from NRB 2-1 to 2-4

<table>
<tr><th>Part 3 – Environmental Protection</th><th>GreenRE Credits</th></tr>
<tr><td>

NRB 3-1SUSTAINABLE CONSTRUCTION

Encourage recycling and the adoption of building designs, construction practices and materials that are environmentally friendly and sustainable.

(a) Use of sustainable and recycled materials;

Green Cements with approved industrial by-product (such as Ground Granulated Blast furnace Slag (GGBS), silica fume, fly ash) to replace Ordinary Portland Cement (OPC).

(b) Concrete Usage Index (CUI)

Encourage more efficient concrete usage for building components.

Prerequisite Requirement:
Minimum score under NRB 3-1 :
GreenRE Gold ≥ 3 credits
GreenRE Platinum ≥ 5 credits

</td><td>

% Replacement of ordinary concrete by green concrete	Credits Allocation
10	1
30	2
50	3
70	4
80	5

(Up to 5 credits)

Project CUI (m^3/m^2)	Credits Allocation
≤ 0.70	1
≤ 0.60	2
≤0.50	3
≤0.40	4
≤0.35	5

(Up to 5 credits)

</td></tr>
<tr><td>

NRB 3-2 SUSTAINABLE PRODUCTS

Encourage the use of products that are environmentally friendly and sustainable

</td><td>

Extent of Environmental Friendliness of Product	Weightage for Credit Allocation
Good	1
Very Good	1.5
Excellent	2

Credits scored will be based on the weightage, extent of coverage and impact.
(Up to 8 credits)

</td></tr>
</table>

NRB 3-3 GREENERY PROVISION

Encourage greater use of greenery and restoration of existing trees to reduce heat island effect.

(a) Green Plot Ratio (GnPR) is calculated by considering the 3D volume covered by plants using the Leaf Area Index (LAI).

GnPR	Credits Allocation
1.0 to < 2.0	1
2.0 to < 3.0	2
3.0 to < 4.0	3
4.0 to < 5.0	4
5.0 to < 6.0	5
≥ 6.0	6

(b) Restoration of trees on site, conserving or relocating of existing trees on site.

1 credit

(c) Use of compost recycled from horticulture waste.

1 credit

NRB 3-4 ENVIRONMENTAL MANAGEMENT PRACTICE

Encourage the adoption of environmental friendly practices during construction and building operation.

(a) Implement effective environmental friendly programmes including monitoring and setting targets to minimise energy use, water use and construction waste.

1 credit

(b) Main builder that has good track records in the adoption of sustainable, environmental friendly and considerate practices during construction.

1 credit

(c) Building quality is assessed under the Quality Assessment System In Construction (QLASSIC) or Construction Quality Assessment System (CONQUAS).

1 credit

(d) Developer, main builder, M&E consultant and architect are ISO 14000 certified.

0.25 credit for each firm
(Up to 1 credit)

(e) Project team comprises one Certified GreenRE/Green Mark Manager (GM) and/or one Certified GreenRE/Green Mark Professional (GP).

1 credit for certified GRM/GMM
2 credits for certified GRP/GMP
(Up to 2 credits)

(f) Provision of building users' guide including details of the environmental friendly facilities and features within the building and their uses in achieving the intended environment performance during the building operation.

1 credit

(g) Provision of facilities or recycling bins for collection and storage of different recyclable waste such as paper, glass, plastic etc.	1 credit
NRB 3-5 GREEN TRANSPORT Promote environmental friendly transport options and facilities to reduce pollution from individual car use. (a) Good access (<800m walking distance) to public transport networks such as MRT/LRT stations or bus stops. (b) Provision of covered walkway to facilitate connectivity and the use of public transport. (c) Provision of hybrid/electric vehicle charging stations and priority parking lots within the development. (d) Provision of covered / sheltered bicycles parking lots with adequate shower and changing facilities.	 1 credit 1 credit 1 credit Extent of Coverage : Minimum 10 numbers and cap at 50 numbers of bicycle parking lots (1 credit)
NRB 3-6 STORMWATER MANAGEMENT Encourage the treatment of stormwater runoff through provision of infiltration or design features before discharge to public drains. Provision of infiltration features or design features for new development and redevelopment.	 1 credit
NRB 3-7 REFRIGERANTS Reduce the potential damage to the ozone layer and the increase in global warming through the release of ozone depleting substances and greenhouse gases. (a) Refrigerants with ozone depleting potential (ODP) of zero **OR** with global warming potential (GWP) of less than 100. (b) Use of refrigerant leak detection system at critical areas of plant rooms containing chillers and other equipment with refrigerants.	 1 credit 1 credit
PART 3–ENVIRONMENTAL PROTECTION CATEGORY SCORE:	Sum of GreenRE credits obtained from NRB 3-1 to 3-7

Part 4 – Indoor Environmental Quality	GreenRE Credits
NRB 4-1 THERMAL COMFORT Air-conditioning system is designed to allow for cooling load variations due to fluctuations in ambient air temperature to ensure consistent indoor conditions for thermal comfort. Indoor temperature between 23°C to 26°C Relative Humidity between 50% to 70%	2 credits
NRB 4-2 NOISE LEVEL Building is designed to achieve ambient internal noise level as specified: • 55 dB (6am – 10pm) L_{Aeq} • 45 dB (10pm – 6am) L_{Aeq}	2 credits
NRB 4-3 INDOOR AIR POLLUTANTS Minimise airborne contaminants, mainly from inside sources to promote a healthy indoor environment. a) Use of low volatile organic compounds (VOC) paints certified under local/international certification body. b) Use adhesives certified under local/international certification body for composite wood products.	Extent of Coverage: A at least 90% of the internal wall areas 1 credit 1 credit
NRB 4-4 INDOOR AIR QUALITY (IAQ) MANAGEMENT Ensure that building ventilation systems are designed and installed to provide acceptable IAQ under normal operating hours. a) Provision of filtration media and differential pressure monitoring equipment in Air Handling Units (AHUs). b) Implement effective IAQ management plan to ensure that building ventilation systems are clean and free from residuals left over from construction activities.	1 credit 1 credit

NRB 4-5 HIGH FREQUENCY BALLASTS Applicable to offices, classrooms and training rooms and the like. Improve workplace lighting quality by avoiding low frequency flicker associated with fluorescent lighting with the use of high frequency ballasts in the fluorescent luminaries.	Extent of Coverage: At least 90% of all applicable areas that are served by fluorescent luminaries 2 credits
Part 4 – INDOOR ENVIRONMENTAL QUALITY CATEGORY SCORE:	Sum of GreenRE credits obtained from NRB 4-1 to 4-5

Part 5 – Other Green Features	GreenRE Credits
NRB 5-1 GREEN FEATURES & INNOVATIONS Encourage the use of green features which are innovative and have positive environmental impact. Examples: • Pneumatic waste collection system • Rainwater harvesting • Dual chute system • Self cleaning façade system • Infiltration trenches • Integrated storm water retention/treatment into landscaping • Etc	2 credits for high impact item 1 credit for medium impact item 0.5 credit for low impact item (Up to 7 credits)
PART 5 – OTHER GREEN FEATURES CATEGORY SCORE:	Sum of GreenRE credits obtained from NRB 5-1

Part 6- Carbon Emission of Development	GreenRE Credits
NRB 6-1 CARBON EMISSION OF DEVELOPMENT Recognise the carbon emission based on carbon footprint computation of the building comprising energy and water consumption.	0.1 x (% improvement) (Up to 4 credits)
PART 6- CARBON EMISSION DEVELOPMENT **CATEGORY SCORE:**	Sum of GreenRE credits obtained from NRB 6-1

GreenRE Score (Non- Residential)

GreenRE Score (NRB) = ∑Category score [(Part 1-Energy Efficiency)+
(Part 2-Water Efficiency)+
(Part 3-Environmental Protection)+
(Part 4-Indoor Environmental Quality)+
(Part 5-Other Green Features)+
(Part 6-Carbon Emission of Development)]

Where :
Category Score for Part 1≥ 30 credits and
∑Category score for Part 2 to Part 6 ≥ 20 credits

Part 1- Energy Efficiency

NRB 1-1 Thermal Performance of Building Envelope-OTTV
NRB 1-2 Air-Conditioning System
NRB 1-3 Building Envelope – Design / Thermal Parameters
NRB 1-4 Natural Ventilation (exclude carparks)
NRB 1-5 Daylighting
NRB 1-6 Artificial Lighting
NRB 1-7 Ventilation in Carparks
NRB 1-8 Ventilation in Common Areas
NRB 1-9 Lift and Escalators
NRB 1-10 Energy Efficient Practices & Features
NRB 1-11 Renewable Energy

NRB 1-1 THERMAL PERFORMANCE OF BUILDING ENVELOPE - OTTV

Objectives	Enhance overall thermal performance of building envelope to minimise heat gain thus reducing the overall cooling load requirement.
Applicability	Applicable to air-conditioned building spaces with aggregate areas > 1000m^2.
Baseline Standard	Maximum permissible OTTV = 50 W/m^2 OTTV stands for Overall Thermal Transfer Value. Maximum permissible RTTV = 25 W/m^2 RTTV stands for Roof Thermal Transfer Value. In the case of an air-conditioned building, the concept of Roof Thermal Transfer Value (RTTV) is applied if the roof is provided with skylight and the entire enclosure below is fully air-conditioned. The computation of OTTV & RTTV shall be based on the methodology specified in the MS 1525:2014.
Requirements	Up to 15 credits can be scored for building envelope with better thermal performance than the baseline standard: 2 credits for every reduction of 1 W/m^2 in OTTV from the baseline. Credits scored = 100 – [2 x (OTTV)] where OTTV ≤ 50 W/m^2 For developments consisting of more than one building, the weighted average of the OTTVs based on the façade areas of these buildings shall be used as the basis for credits allocation. That is: $OTTV_{\text{weighted average}} = \sum (OTTV_{bldg} \times A_{bldg}) / A_{devt}$ where $OTTV_{bldg}$ = OTTV for building (W/m^2) A_{bldg} = Summation of all façade areas that enclose all the air-conditioning areas (m^2) in a building A_{devt} = Summation of total applicable façade areas of all buildings within the development (m^2) (i.e. $\sum A_{bldg}$)
Prerequisite Requirements	GreenRE Gold – OTTV of 42 W/m^2 or lower GreenRE Platinum – OTTV of 40 W/m^2 or lower

Documentary Evidences	• Architectural elevation drawing showing the composition of the different façade or wall systems that are relevant for the computation of OTTV; • Architectural plan layouts and elevations showing all the air-conditioning areas; • Extracts of the tender specification or materials schedules showing the salient data of the materials properties that are to be used for the façade or external wall systems; and • OTTV & RTTV calculation.
References	MS1525:2014- Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings - Code of Practice

NRB 1-2 AIR-CONDITIONING SYSTEM

Objectives	Encourage the use of better efficient air-conditioned equipment to minimise energy consumption.
Applicability	Applicable to air-conditioned building areas where its aggregate air-conditioned areas > 500m^2. Scope covers all air-conditioned equipment for the buildings as listed: • Chillers • Chilled water pumps • Condenser water pumps • Cooling Towers • Air Handling Units (AHU) • Fan Coil Units (FCU) • Unitary Air-Conditioners/ Condensing Units which include single-split units, multi-spilt units and variable refrigerant flow (VRF) system
Baseline Standard	Minimum efficiency requirement of the air-conditioning system stated in MS 1525:2014 or SS 530 & SS CP 13 1-2(a)(i) Air-Conditioned Plant • Chiller – Refer Table 23 of MS 1525:2014. • Chilled water pump efficiency and condenser water pump efficiency – Refer to Clause 8.2.5 in MS 1525:2014 which states that for chilled water or condenser water pumping system operating for more than 750 hours a year, the pump efficiency shall be: a) > 70% for flowrate between 50 m^3/h to 100 m^3/h b) > 73% for flowrate between 100 m^3/h to 270 m^3/h c) >80% for flowrate exceeding 270 m^3/h This data can be collect during Testing & Commissioning (T&C) • Cooling tower performance at the rating condition stated in Table 3 SS 530. Rating condition is as follows: 35°C Entering water 29°C Leaving water 24°C Wet Bulb Outdoor air <u>Propeller and axial fan cooling tower:</u> With heat rejected from every 3.23 L/s of condenser water per 1 kW of fan power rating: Cooling tower performance ≤ 1kW / 3.23 L/s ≤ 0.310 kW/ L/s <u>Centrifugal fan cooling tower:</u> With heat rejected from every 1.7 L/s of condenser water per 1kW of fan power rating: Cooling tower performance ≤ 1kW / 1.7 L/s ≤ 0.588 kW / L/s

	1-2(a) (ii) Air Distribution System – Refer to Clause 7.11.5 in CP 13. 1-2(b) Unitary Air-Conditioners / Condensing Units – Refer Table 21 of MS 1525:2014.
Requirements	<u>1-2(a)(i) Air-Conditioned Plant (Up to 20 credits)</u> 1.45 credits for every percentage improvement in the efficiency of chiller, chilled-water pump and condenser water pump. Credits scored = 1.45 x (% improvement) 0.05 credit for every percentage improvement in the performance of cooling tower at rating condition. Credits scored = 0.05 x (% improvement) <u>1-2 (a)(ii) Air Distribution System (Up to 5 credits)</u> 0.5 credits for every percentage improvement in the air distribution system efficiency above the baseline. Credits scored = 0.5 x (% improvement) Note (1): For building using district cooling system, there is no need to compute the plant efficiency under item (a) (i). The credit obtained will be pro-rated based on the air distribution system efficiency under NRB 1-2(a)(ii). **OR** <u>1-2(b) Unitary Air-Conditioners/Condensing Units (Up to 25 credits)</u> 1.5 credits for every percentage improvement in the efficiency of unitary air-conditioners units above the baseline. Credits Scored: 1.5 x (% improvement) Note (2): Where there is a combination of centralised air-con system with unitary air-conditioned system, the computation for the credits scored will only be based on the air-conditioning system with a larger aggregate capacity. <u>1-2(c) Unitary Air-Conditioners/Condensing Units</u> 2 credits can be scored if sensors or similar automatic control devices are used to regulate outdoor air flow rate to maintain the concentration of carbon dioxide (CO_2) below 1000ppm.

Documentary Evidences	For 1-2(a) and 1-2(b) • Detailed calculations of the overall improvement in equipment/system efficiency of the air-conditioning plants/ units and air distribution system in the tabulated formats showing the design cooling system capacity and the system efficiency (including individual equipment efficiency). • Calculation and technical data of the designed system efficiency of chillers at part load condition; and • Technical product information of all air-conditioning and system. For 1-2(c) • Extracts of the tender specification showing the requirements to incorporate these control devices; and • Plan layouts showing the locations and the types of control devices used to regulate fresh air intake.
References	(a) MS 1525:2014 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice (b) SS 530 – Code of Practise for Energy Efficiency Standard for Building Services and Equipment. (c) SS CP 13 – Code of Practice for Mechanical Ventilation and Air-Conditioning in Buildings.
Worked Example	**Case: District Cooling Plant (DCP)** For 1-2(a) (ii) An air-conditioned building equipped with only AHU and FCU. Whilst its chiller, cooling tower and pumps are placed outside the building. The AHU performance system is 8 %. 0.5 credit for AHU improvement; 0.5 x 8 % = 4 credits For NRB 1-2(a) (i), The pro-rate calculation shall be; $\frac{4 \text{ credits}}{5 \text{ credits}} \times 20 \text{ credits} = 16 \text{ credits}$ Total credits scored for part 1-2(a)(i) and 1-2(a)(ii) = 4 + 16 = 20 credits

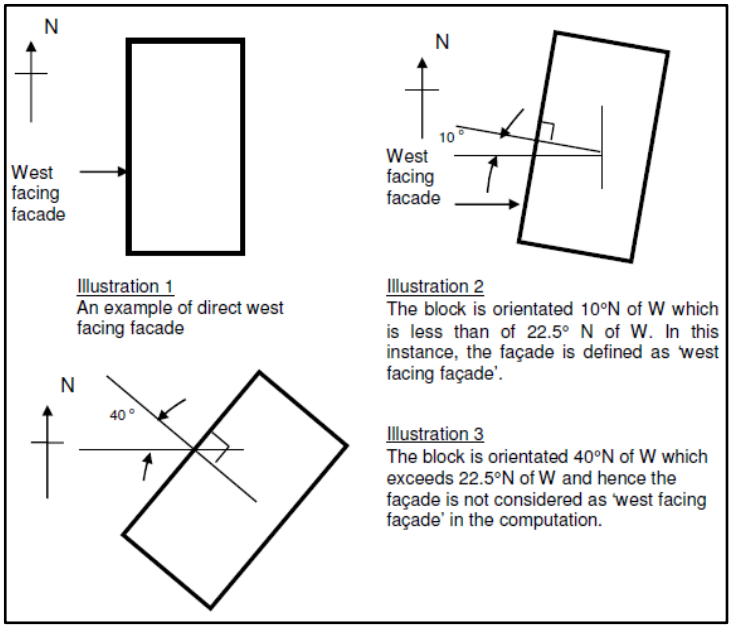
NRB 1-3 BUILDING ENVELOPE – DESIGN/THERMAL PARAMETERS

<table>
<tr><td>Objectives</td><td>Enhance the overall performance of building envelope to minimise heat gain which would improve indoor thermal comfort and encourage natural ventilation.</td></tr>
<tr><td>Applicability</td><td>Applicable to non air-conditioned building spaces with aggregate areas > 10% of the total floor areas excluding carparks.</td></tr>
<tr><td>Baseline Standard</td><td>Baseline standard for 1-3(d) – U-value for roof:

Table 1-3.1: Maximum U-value for roof
<table><tr><th>Roof Weight Group</th><th>Maximum U-Value (W/m²K)</th></tr><tr><td>Light (Under 50 kg/m²)</td><td>0.4</td></tr><tr><td>Heavy (Above 50 kg/m²)</td><td>0.6</td></tr></table></td></tr>
<tr><td>Requirements</td><td>1-3(a) Up to 10 credits can be scored if the building envelope is designed with minimum direct west facing façade by having better building orientation. Where there is no west facing façade, the credits scored will be 24 credits and the requirements under 1-3 (b)(i),b(ii) and (c) will not be applicable for scoring.

Credits scored = 10 – [0.2 x (% of west facing façade areas over total façade areas)]

Note: Orientation of façade that falls within the range of 22.5° N of W and 22.5° S of W will be defined as <u>west facing façade</u> (see illustration below). Core walls for lift or staircases and toilets that are located within this range are exempted in computation.

Illustration 1-3.1: Orientation of facade
 
</td></tr>
</table>

1-3(b) Up to 10 credits can be scored for design with (i) minimum west facing window opening and/or (ii) having effective sun shading provision for windows with minimum shading of 30% on the west façade.

For 1-3 (b)(i) Credits scored = 10 – [0.1 x (% of west facing window areas over total west facing façade areas)]

For 1-3 (b)(ii) Credits scored = 0.1 x (% of west facing window areas with sun shading devices over total west facing façade areas)

Notes: For 1-3 (b)(ii), credits can only be scored if the sun shading devices meet at least a shading of 30% as tabulated in Table 1-3.2 below:

Table 1-3.2 : Minimum Requirement on Shading Devices for West Façade

Types of Sunshading Devices	Angle of inclination	Desired Shading			
		30%	40%	50%	60%
Horizontal Shading (R_1)	**0°**	0.6	0.9	1.5	
	20°	0.4	0.6	0.9	1.8
	40°	0.4	0.5	0.7	1.1
Vertical Shading (R_2)	**0°**	2.1			
	20°	1.1	1.7	2.5	
	40°	0.7	1	1.4	
	50°	0.6	0.9	1.1	2.8

Where

Horizontal Shading/ Projections (R_1)

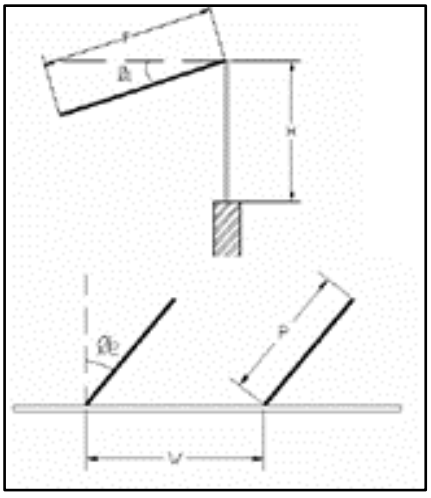
$R_1 = \frac{P}{H}$

$\varnothing_1$ = Angle of inclination

Vertical Shading/ Projections (R_2)

$R_2 = \frac{P}{W}$

$\varnothing_2$ = Angle of inclination



1-3(c) Up to 4 credits can be scored for external west facing wall that are designed with better thermal transmittance that is U-value of wall equal or less than 2W/m^2K.

Credits scored = 0.04 x (% of the external west facing walls areas with U-value of 2 W/m^2K or less over the total west facing façade areas)

1-3(d) Up to 5 credits can be scored for roof design with better thermal transmittance that is U-value of roof than the baseline standard.

Credits scored = 2 credits for every 0.1 W/m^2K reduction from the baseline.

Prerequisite Requirements

Ventilation simulation and its recommendation must be carried out using the prescribed methodology stated in Ventilation Simulation Methodology and Requirements to be eligible for GreenRE Platinum rating.

Documentary Evidences

For 1-3(a)

- Architectural plan layouts and elevation drawings of the façade of all blocks. Highlight those areas that are considered as west facing façade; and
- Calculation showing the percentage of west facing façade areas in the prescribed tabulated format as shown in Table 1-3(a).

Table 1-3(a) Minimum direct west facing external façade

	Area of west facing external façade (m^2) (a)	**Total area of external façade (b)**	**% of west facing external facade**
Block 1			∑ (a)/ ∑(b) x 100
Block 2			
Block 3			
Total			

Credits scored for 1-3(a)= 10 – [0.2 x (∑ (a)/ ∑(b) x 100)]

For 1-3(b)(i) and (ii)

- Architectural plan layouts and elevation drawing of west facing façade and window openings;
- Sectional drawing showing the details of the sunshading devices. Highlight those sunshading devices that meet the 30% shading requirement;
- Window schedules or drawing showing the areas of the west facing windows; and
- Calculation showing the percentage of west facing window areas in the prescribed tabulated format as shown in Table 1-3(b)(i) and (ii).

Table 1-3(b)(i) : Minimum west facing windows openings

Description	Area of west facing window area (m^2) (a)	Total area of west facing external façade (m^2) (b)	% of west facing window areas over total west facing external façade areas
Block 1			∑ (a)/ ∑(b) x 100
Block 2			
Block 3			
Total			

Credits scored for 1-3(a) = 10 – [0.1 x (∑ (a)/ ∑(b) x 100)]

Table 1-3(b)(ii) : Effective sunshading provisions for west facing window with minimum 30% shading

Description	Area of west facing window with effective sunshading provision(m^2) (a)	Total area of west facing external façade (m^2) (b)	% of west facing window areas over total west facing external façade areas
Block 1			∑ (a)/ ∑(b) x 100
Block 2			
Block 3			
Total			

Credits scored for 1-3(a) = 0.1 x [(∑ (a)/ ∑(b)) x 100)]

For 1-3(c)

- Architectural drawings highlighting the material types and walls areas which are of better thermal transmittance (U-value);
- Detailed sectional drawings showing the wall composition and the respective U-values;
- Extracts of the tender specification which states the thermal transmittance properties to be adopted for west facing walls; and
- Technical product information and relevant calculation on the U-value of the wall materials used.
- Calculation showing the percentage of west facing window areas in the prescribed tabulated format as shown in Table 1-3(c).

Table 1-3(c) : Better thermal transmittance of external west facing walls

Description	Area of external west facing walls with U-value of 2W/m^2K or less (m^2) (a)	Total area of west facing external façade (m^2) (b)	% of external west facing wall areas with prescribed U values over total west facing external façade areas
Block 1			∑ (a)/ ∑(b) x 100
Block 2			
Block 3			
Total			

Credits scored = 0.04 x [(∑ (a)/ ∑(b)) x 100)]

<table>
<tr><td></td><td>
<u>For 1-3(d)</u>

Plan layout and sectional details of the different roof types of the development;
Extracts of the tender specification which states the thermal transmittance properties of roof and calculation showing the average reduction as shown in Table 1-3(d);

Table 1-3(d): Better thermal transmittance of roof
<table>
<tr><th>Roof Type</th><th>Weight Group</th><th>Weight range (kg/m^2)</th><th>Maximum Thermal Transmittance (w/m^{2}K)</th><th>Designed U-value (W/m^{2}K)</th><th>Reduction (W/m^{2}K)</th></tr>
<tr><td>Roof 1</td><td>Light</td><td>Under 50</td><td>0.4</td><td></td><td></td></tr>
<tr><td>Roof 2</td><td>Heavy</td><td>Above 50</td><td>0.6</td><td></td><td></td></tr>
</table>

Detailed sectional drawings showing the roof composition and the respective U-values; and
Technical product information and relevant calculation of the U-value of the roof.

</td></tr>
<tr><td>References</td><td>-</td></tr>
</table>

NRB 1-4 NATURAL VENTILATION (EXCLUDE CARPARKS)

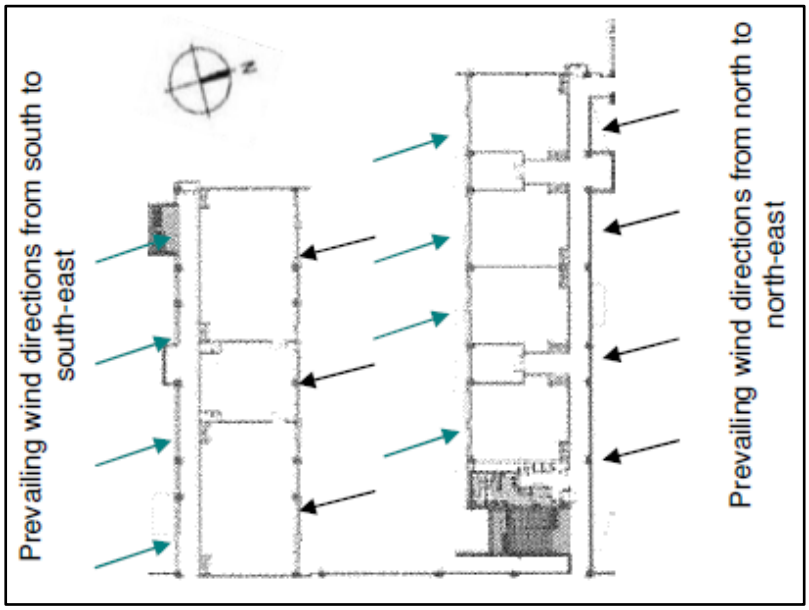
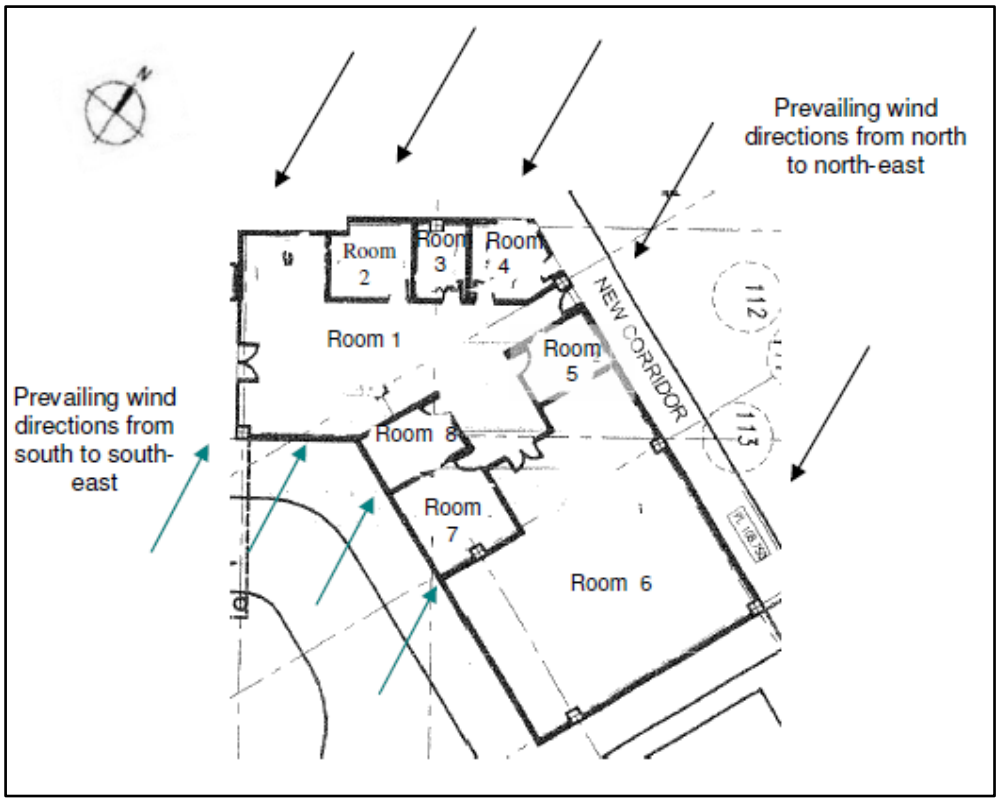
Objectives	Enhance building design to achieve good natural ventilation.
Applicability	Applicable to non air-conditioned building spaces with aggregate areas > 10% of the total floor areas excluding carparks.
Baseline Standard	-
Requirements	1-4(a) Up to 8 credits can be scored for building design that utilises prevailing wind conditions to achieve adequate cross ventilation. 0.8 credit for every 10% of units/ rooms with window openings facing north and south directions Credits scored = 0.8 x (% of units / 10) Note: In Malaysia, the prevailing wind comes from two predominant directions; that is the north to north-east during the Northeast monsoon season and south to south-east during the South-west monsoon season. Hence, buildings designed with window openings facing the north and south directions have the advantages of the prevailing wind conditions which would enhance indoor thermal comfort. Meteorological data on the more precise wind direction and velocity of the site location can also be used as the basis for the design. It is not necessary for the window openings to be located perpendicularly to the prevailing wind direction. An oblique angle is considered acceptable (see illustrations below). **Illustration 1-4.1:Building layout with adequate cross ventilation**  Building layout shows all rooms with window openings facing the north and south directions.

Illustration 1-4.2: Building layout with adequate cross ventilation



Building layout shows not all rooms with window facing the north and south directions. Room 2 to Room 5 would only have prevailing wind in one direction. Only Room 1 and 6 can be considered meeting requirement 1-4(a)

Alternative compliance: The application of ventilation simulation can be used to prove that the building layout utilises prevailing wind conditions and could achieve adequate cross ventilation within the indoor units through sufficient window openings. The ventilation simulation should be carried in the same conditions outlined in paragraph 1-4(b) below. Credits should only be scored if the recommendations from the simulation are implemented.

1-4(b) 5 credits for the use of ventilation simulation software to identify the most effective building design and layout in achieving good natural ventilation. The design should provide an average wind velocity within the space of at least 0.6 m/s or more. Credits can only be scored if the recommendations from the ventilation simulation are implemented. The ventilation simulation shall be carried out in accordance with the methodology stated in Appendix B.

<table>
<tr><td>Documentary Evidences</td><td>
<u>For 1-4(a)</u>

Architectural plan layouts showing the units / rooms of all blocks with highlights of those with window openings in the N-S direction and / or with air-conditioned systems;
Calculation showing the percentage of units or rooms with window openings facing north and south directions in the prescribed formats as shown in the Table 1-4.1.

Table 1-4.1:Percentage of units with window opening in N-S direction
<table>
<tr><th>Ref.</th><th>Description</th><th>Units/Rooms with window opening in the N-S direction
(a)</th><th>Total no. of naturally ventilated units/room
(b)</th><th>% of units/ rooms with window opening in N-S direction</th></tr>
<tr><td>1</td><td>Classroom Block A & A1</td><td></td><td></td><td rowspan="4">∑ (a) / ∑(b) x 100</td></tr>
<tr><td>2</td><td>Classroom Block B</td><td></td><td></td></tr>
<tr><td>3</td><td>Offices, meeting rooms and computer rooms with air-conditioning</td><td></td><td></td></tr>
<tr><td colspan="2">Total:</td><td></td><td></td></tr>
</table>
Credits scored = 0.8 x (% of units / 10)
= 0.8 x [(∑ (a) / ∑(b) x 100) / 10]

<u>For 1-4(b)</u>

Ventilation simulation reports summarising the analysis and simulation results for each typical space as well as the recommendation for design as specified in Appendix B.

</td></tr>
<tr><td>References</td><td>-</td></tr>
</table>

NRB 1-5 DAYLIGHTING

<table>
<tr><td>Objectives</td><td>Encourage design that optimises the use of effective day lighting to reduce energy use for artificial lighting.</td></tr>
<tr><td>Applicability</td><td>1-5(a) Applicable to all normally occupied areas within the development.

1-5(b) Applicable to all common areas within the development.</td></tr>
<tr><td>Baseline Standard</td><td>1-5(a) The minimum illuminance level for day lighting shall be in accordance with MS1525:2014.</td></tr>
<tr><td>Requirements</td><td>1-5(a) Up to 3 credits can be scored for the use of daylight simulation analysis or any relevant calculation documents to verify that 50% or more of all habitable spaces achieve adequate daylight illuminance levels as specified in Clause 5.4.2 in MS 1525:2014.

The scoring will be based on percentage of habitable spaces with adequate ambient lighting level.

Table 1-5.1:Credits allocation according to Habitable Spaces
<table>
<tr><th>Percentage of Habitable Spaces with Adequate Ambient Lighting Level</th><th>Credits Allocation</th></tr>
<tr><td>50% - 75%</td><td>1</td></tr>
<tr><td>76% - 90%</td><td>2</td></tr>
<tr><td>>90%</td><td>3</td></tr>
</table>
1-5(b) (i) 1 credit for provision of day lighting for lift lobbies and corridors.

1-5(b) (ii) 1 credit for provision of day lighting for staircases.

1-5(b) (iii) 1 credit for provision of day lighting for car parks.</td></tr>
<tr><td>Documentary Evidences</td><td><u>For 1-5(a)</u>
• Schedules showing the total number of living and dining areas in the development and those with effective daylighting; and
• Daylight simulation report summarizing the analysis and modelling results for each living and dining area that meets the requirement.

<u>For 1-5(b)</u>
• Extracts of the tender specification or drawings showing the use of day lighting for lift lobbies and corridors, staircases and car parks where applicable.</td></tr>
<tr><td>References</td><td>MS 1525:2014 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice</td></tr>
</table>

Worked Example 1-5(a)

Proposed development comprises a 20 storey apartments consists of 250 units with 7 typical layouts. Daylight and glare simulation has been conducted for the development. Based on simulation, a tabulation of daylight factor for each of the habitable rooms according to 7 typical layouts as schedule below:

Table 1-5.2: Daylight factor for each of the room in every type of layout

	Room 1	Room 2	Room 3	Room 4	Room 5	Family	Living/Dining
Type A	3.9	4.1	2.1	NA	NA	NA	2.8
Type B	3.9	4.1	2.1	NA	NA	NA	2.8
Type C	3.3	2.5	2.3	1.9	NA	NA	3.8
Type D	3.3	2.5	2.3	1.9	NA	NA	3.8
Type E	3.3	2.5	2.3	1.9	NA	NA	3.8
Type F	4.5	1.1	2.6	2.3	NA	1.7	4.0
Type G	3.3	3.5	3	2.5	2.1	1.6	4.7

Total no. of habitable rooms calculated based on each type of units = 36

Total no. of habitable rooms with 1.0% to 3.5% DF = 26

Total % of habitable rooms with 1.0% to 3.5% DF = 26/36 x 100 = 72%

Credits scored for 1-5(a) = 1 credits

Worked Example 1-5(b)

Proposed non-residential development with the following provision:

All lift lobbies (including private lift lobbies), corridors and staircases are designed to have adequate day lighting that would eliminate the need for artificial lighting during daytime. 75% of the car park areas have day lighting provision while the other 25% of the car park areas need to employ the use of artificial lightings during anytime to maintain proper lighting level.

Table 1-5.3: Credits Allocation

No.	Criteria	Credit Allocated	Credit
1-5(b) (i)	Lift lobbies and corridors	1	1
1-5(b) (ii)	Staircases	1	1
1-5(b) (iii)	Day lighting for carparks.	1	0
		TOTAL	2

No credit for car park as it does not meet the minimum 80% of the applicable areas

Therefore, credits scored for 1-5(b) = 2 credits

NRB 1-6 ARTIFICIAL LIGHTING

Objectives	Encourage the use of better efficient lighting to minimise energy consumption from lighting usage while maintaining proper lighting level.
Applicability	Applicable to lighting provisions that designed in accordance to the luminance level as recommended in MS 1525: 2014.
Baseline Standard	Luminance level stated in MS 1525:2014 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice.
Requirements	Up to 12 credits if tenants' light is provided **OR** Up to 5 credits if tenants' light is excluded for the improvement in the lighting power consumption. 0.3 credit for every percentage improvement in the lighting provisions over the baseline standard. That is Credits scored = 0.3 x (% improvement) Display lighting and specialised lighting are to be included in the calculation of lighting power budget. The design service illuminance, lamp efficiencies and the light output ratios of luminaries shall be in accordance with in MS 1525:2014 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice.
Documentary Evidences	• Lighting layout plan; • Lighting schedules showing the numbers, location and types of lighting luminaries used; • Calculation of the proposed lighting power budget and the percentage improvement in the tabulated format as shown in the worked example 1-6; • Tabulation showing the designed lux level and the minimum lux level based on code requirement for the respective areas; and • Technical product information of the lighting luminaries used.
References	MS 1525:2014 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice
Worked Example 1-6	a) Determine the total power consumption based on the lighting layout design for each area and light fitting types used. b) Calculate the total power consumption based on the maximum lighting power budget stated in MS 1525:2014. c) Calculate the percentage improvement in the total power consumption.

Table 1-6-1 : Total power consumption based on each fitting type

Description	Area (m^2) (A)	Light Fitting Type (B)	Power Consumption per fitting (W) (C)	Ballast Loss (W) (D)	No. of Fittings (E)	Total power consumption based on fitting type [(C)+(D)] x E
Office Space 1	1500	T5	2x28	3	245	14455
Office Space 2	1250	T5	2x28	3	210	12390
Meeting Room	75	T8	1x36	3	15	585
		Surface downlight	2x36	0	8	416
Corridors 1	150	T5	2x28	3	15	885
Corridors 2	205	T5	2x28	3	15	885
		Surface downlight	1x70	0	9	630
Atrium	850	T8	2x36	3	87	6525
		Surface downlight	1x150	0	10	1500
Carparks	7500	T5	2x28	3	436	25724
Staircase	300	T5	2x28	3	20	1180
					Total:	65175

Table 1-6-2 : Total power consumption based on design and MS 1525:2014

Description	Area (m^2) (A)	Design Data		MS 1525:2014 Requirements	
		Total Power Consumption (by area)(W) (F)	Design Lighting Power Budget (W/m^2) (F/A)	Reference Lighting Power Budget (W/m^2) (H)	Reference Total Power Consumption (by area)(W) (H x A)
Office Space 1	1500	14455	9.64	14	21000
Office Space 2	1250	12390	9.91	14	17500
Meeting Room	75	1001	13.35	14	1050
Corridors 1	150	885	5.90	5	750
Corridors 2	205	1515	7.39	5	1025
Atrium	850	8025	9.44	5	4250
Carparks	7500	25724	3.43	5	37500
Staircase	300	1180	3.93	5	1500
Total:		65175			84575

	% improvement in the lighting power consumption = [Σ (H x A) – Σ(F)] / Σ (H x A) x 100% =(84575-65175)/84575 x 100% =22.94% Credits scored = 0.3 x 22.94% = 6.88 credits Therefore, credits scored should be 6.88 credits if tenant's lighting is included: and credits scored should be 5 credits (max) if tenant's light is excluded.

NRB 1-7 VENTILATION IN CARPARKS

Objectives	Encourage the use energy efficient design and control of ventilation systems on carparks.
Applicability	Applicable to all carparks spaces in the development.
Baseline Standard	-
Requirements	1-7(a) 4 credits can be scored if the carparks spaces that are fully naturally ventilated 1-7(b) For carparks that have to be mechanically ventilated, credits can be s scored for the use of carbon monoxide (CO) sensors in regulating such demand based on the mode of mechanical ventilation (MV) used; 2.5 credits for carparks using fume extract system and 2 credits for those with MV with or without supply. Note: Where there is a combination of different ventilation mode adopted for carparks design, the credits scored under this requirement will be prorated accordingly.
Documentary Evidences	For 1-7 (a) and (b) • Plan layouts showing all carparks provisions for the development with highlights of the carparks spaces that are designed to be naturally ventilated and/or mechanical ventilated; • Plan layouts indicating the locations of CO sensors and the mode of ventilation adopted for the design; and • Calculation showing the credits allocation if there is a combination of different ventilation modes adopted for the carparks design.
References	MS 1525:2014 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice
Worked Example 1-7	Proposed development has a 6-storey naturally ventilated carparks and one level of mechanically ventilated basement carparks with CO sensor to be installed to regulate MV. Areas of naturally ventilated carparks = 6 x 600 = 3600 m² Areas of basement carparks = 600 m² Total areas = 4200 m² Credits scored for 1-7 = (3600/4200) x 4 + (600/4200) x 2 = 3.71 credits

NRB 1-8 VENTILATION IN COMMON AREAS

Objectives	Encourage the use of energy efficient design and control of ventilation systems in common areas.
Applicability	Applicable to the following common areas of the development. • Toilets • Staircases • Corridors • Lift Lobbies • Atriums
Baseline Standard	-
Requirements	Up to 5 credits can be scored for the use of natural ventilation as an effective passive cooling design strategy to reduce the energy used by air- conditioning systems in these common areas. Extent of coverage: At least 90% of each applicable area (by numbers). Credits are scored based on the mode of ventilation provided in these applicable areas. Natural ventilation – 1.5 credits for each area Mechanical ventilation – 0.5 credit for each area
Documentary Evidences	• Plan layouts showing the applicable areas and the respective modes of ventilation; and • Schedules showing the numbers, locations of the applicable areas and the modes of ventilation used.
References	MS 1525:2014 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice
Worked Example 1-8	Proposed development has the following details : No. of toilet = 45; where 10 units are designed with air-conditioning. % of toilet units with natural ventilation = (45-10)/45 = 77.8% Hence, it is less than 90% ; no credit for this item No. Of staircases = 100 ; all are mechanical ventilated – 0.5 credit No. Of lift lobbies = 22 ; all are naturally ventilated – 1.5 credits Credits scored for 1-8 = 0.5 + 1.5 = 2 credits < 5 credits (max)

NRB 1-9 LIFTS AND ESCALATORS

Objectives	Encourage the use of energy efficient lifts and escalators.
Applicability	Applicable to **ALL** lifts and/or escalators in the development.
Baseline Standard	-
Requirements	1 credit can be scored for the use of lifts with energy efficient features such as AC variable voltage and variable frequency (VVVF) motor drive or equivalent. 1 credit can be scored for the use if lifts with sleep mode features. 1 credit can be scored for the use of escalators with motion sensors to regulate usage.
Documentary Evidences	Extracts of the tender specification indicating the types of lifts, escalators and related features.
References	-
Worked Example 1-9	Proposed development has the following provision : Two lift types : Type L1 with VVVF motor drive and sleep mode features Type L2 with VVVF motor drive and sleep mode features Two escalator types : Type E1 with VVVF motor drive and motion sensors Type E2 without VVVF motor drive and motion sensors 1 credit for the use of lifts with VVVF motor drive; and 1 credit for the use of lifts with sleep mode features No credits for escalators as not all escalators are designed with motion sensors Credits scored for 1-9 = 2 credits (out of 3 credits)

NRB 1-10 ENERGY EFFICIENT PRACTICES & FEATURES

Objectives	Encourage the use of energy efficient practices and features which are innovative and have positive environmental impact in terms of energy saving.
Applicability	1-10(a) Applicable to all developments 1-10(b) Applicable to practices and features that are not listed in the requirements under Part 1 – Energy Efficiency.
Baseline Standard	-
Requirements	1-10(a) 1 credit can be scored for the practice of using Energy Efficient Index (EEI) as a building performance indicator to measure the building's unit area energy consumption for future monitoring and improvements. Calculation of EEI: EEI = [(TBEC – DCEC) / (GFA – DCA)] X (NF/OH) Where: (a) TBEC : Total building energy consumption (kWh/year) (b) DCEC : Data centre energy consumption (kWh/year) (c) GFA : Gross Floor Area (exclude car park area)(m^2) (d) DCA : Data centre area (m^2) (e) NF : Normalising factor based on a typical weekly operating hour that is 55hr/week (f) OH : Weighted weekly operating hours (hrs/week) Note: (1) EEI is based on 100% occupancy rate for consistency. (2) All major energy consumption equipments are to be included in the estimation of total building energy consumption. (3) For industrial buildings, process load should be excluded. 1-10(b) Up to 1 credit can be scored for the provision of greenery system on east and west facade to reduce the heat gain through the building envelope. 1 credit for high impact where provision is more than 50% of applicable facade areas. 0.5 credit for low impact where provision is at 25% of the same. 1-10(c) Up to 11 credits can be scored for the use of the following approved energy efficient features depending on the potential energy saving. • Thermal storage system • Heat recovery devices • Light shelves • Motion sensors for staircases half landing and toilets • Sun pipes for natural lighting • Ductless fans for cleaning system • Auto-condenser tube cleaning system • Photo sensors to maximize the use of daylighting Note: For features that are not listed NRB 1-10(c) above, the QP is required to submit the details showing the positive environmental impacts and potential energy savings of the proposed features to GreenRE assessment.

<table>
<tr><td>Documentary Evidences</td><td><u>For 1-10(a)</u>
• Calculation of the Energy Efficiency Index (EEI) in the prescribed tabulated format as shown in the worked example Table 1-10.1.

<u>For 1-10(b)</u>
• Plan layouts showing the vertical greenery provision and building elevations; and
• Calculation showing the extent of the vertical greenery provision over the east and west facade areas as shown in Table 1-10.2.

<u>For 1-10(c)</u>
• Extracts of the tender specification showing the provision of the proposed energy efficient features and the extent of implementation where applicable;
• Technical product information on the energy efficient features used ; and
• Calculation of the potential energy savings that could be reaped from the use of these features.</td></tr>
<tr><td>References</td><td>-</td></tr>
<tr><td>Worked Example 1-10</td><td><u>For 1-10(a):</u>
(1) Determine the total annual building electricity consumption (TBEC) based on the estimated electricity consumption and usage pattern in term of operation hours of all the major energy consumption systems and equipments
(2) Compute the EEI of the building

Background info:
Assume a proposed development with GFA of 86000 m², operational hours per week is 55 hours at 100% occupancy rate. No data centre in the building.

Table 1-10.1 : Total Building Electricity Consumption per year
<table>
<tr><th>System/Equipment</th><th>Total Annual Building Electricity Consumption (kWh)/year</th></tr>
<tr><td>Lighting (air-conditioned space)</td><td>3094380</td></tr>
<tr><td>Lighting (non air-conditioned space)</td><td>236321</td></tr>
<tr><td>Exterior Lighting</td><td>405800</td></tr>
<tr><td>Air-conditioned Plant</td><td>7924425</td></tr>
<tr><td>Air System Fans</td><td>632293</td></tr>
<tr><td>Mechanical Ventilation Fans</td><td>207571</td></tr>
<tr><td>Lifts</td><td>792966</td></tr>
<tr><td>Escalators</td><td>45865</td></tr>
<tr><td>Receptacle Equipment *(16W/m²)</td><td>3936517</td></tr>
<tr><td>Domestic Water Pump Systems</td><td>226088</td></tr>
<tr><td>Hot Water Systems</td><td>93789</td></tr>
<tr><td>Others</td><td>-</td></tr>
<tr><td>Total :</td><td>17596015</td></tr>
</table></td></tr>
</table>

*For tenant receptacle load, the nominal values shown in the following table can be adopted.

Receptacle Loads	Nominal Values
Computer intensive offices	22 W/m²
General office areas	16 W/m²
Large conference areas	11 W/m²
Server/Computer rooms	540 W/m²

Source: ASHRAE STD 90.1:1999

Total annual Building Electricity Consumption (TBEC) = 17596015 kWh/year
Therefore, the EEI of the building is as follows:

EEI = (TBEC/GFA) x (NF/OH)
= (17596015/86000) x (55/55)
= 204.6 kWh/m²/yr

Credit scored for 1-10(a) = 1 credit

For 1-10(b):
The same proposed development has incorporated vertical greenery systems on the east and west facade to reduce heat gain to the building.

Table 1-10.2 : Total vertical greenery on east and west facade

Areas of vertical greenery systems = 2000 m²	Percentage = 2000/4800 = 42% < 50%
Total east and west facade areas = 4800 m²	Therefore, credits scored for 1-10(b) = 0.5 credit

For 1-10(c):
The same proposed development has included the use of motion sensors for all staircases and toilets
(i) Toilets
Total light fittings to be controlled by motion sensors = 2 x 350 nos.
Power consumption by light fitting = 2 x 350 x 36 W = 25200 W
Assume 5 hours per day that the light fittings are off when it is not occupied.
Electricity saving = 25200 W x 5 hours = 126 kWh
Annual electricity saving = 126 x 365 = 45990 kWh

(ii) Staircases
Total light fittings to be controlled by motion sensors = 2 x 180 nos.
Power consumption by light fitting = 2 x 180 x 18 W = 6480 W
Assume 10 hours per day that the light fittings are off when it is not used
Electricity saving = 6480 W x 10 hours = 64.8 kWh
Annual electricity saving = 64.8 x 365 = 23652 kWh

Total annual electricity saving using motion sensors = 45990+23652
= 69642 kWh
% energy savings = 69642/17596015 = 0.396%

Credits scored for 1-10(c) = 3 credits for every 1% energy saving
= 3 x 0.396% = 1.19 credit

NRB 1-11 RENEWABLE ENERGY

Objectives	Encourage the use of renewable energy sources in buildings.
Applicability	Includes all renewable energy sources.
Baseline Standard	-
Requirements	Up to 20 credits can be scored based on the percentage replacement of electricity by the renewable energy source: 5 credits for every 1% replacement of electricity (based on total electricity consumption) by renewable energy. **OR** 3 credits for every 1% replacement of electricity (exclude tenant's usage) by renewable energy.
Documentary Evidences	• Extracts of the tender specification and plans showing the location of the renewable energy system and the extent of implementation; • Technical product information on the salient features of the renewable energy system and the expected renewable energy generated; and • Calculation of the percentage replacement of electricity and the total annual electricity consumption of the development.
References	-

Part 2 – Water Efficiency

NRB 2-1 Water Efficient Fittings
NRB 2-2 Water Usage and Leak Detection
NRB 2-3 Irrigation System
NRB 2-4 Water Consumption of Cooling Tower

NRB 2-1 WATER EFFICIENT FITTINGS

<table>
<tr><td>Objectives</td><td>Reduce to use of potable water by using water efficient fittings covered under the Water Efficiency Products Labelling Scheme (WEPLS) or Water Efficiency Labelling Scheme (WELS).</td></tr>
<tr><td>Applicability</td><td>Applicable to all water fittings covered by the WEPLS or WELS as follows:
Basin taps and mixers
Sink/taps and mixers
Dual Flush Low Capacity Flushing Cisterns
Showerheads
Shower taps and mixers
Urinals and Flush Valves</td></tr>
<tr><td>Baseline Standard</td><td>As specified under Water Efficiency Products Labelling Scheme (WEPLS) or Water Efficiency Labelling Scheme (WELS).</td></tr>
<tr><td>Requirements</td><td>Up to 8 credits can be scored based on the number and water efficiency rating of the fitting type used.<table><tr><td colspan="3">Rating Based on Water Efficiency Products Labelling Scheme (WEPLS)</td></tr><tr><td>Efficient *</td><td>Highly Efficient **</td><td>Most Efficient ***</td></tr><tr><td>4 credits</td><td>6 credits</td><td>8 credits</td></tr></table></td></tr>
<tr><td>Documentary Evidences</td><td>Extracts of the tender specification showing all the water fitting provisions for the development;
Water fitting schedules showing the numbers, types and the approved rating of the proposed fittings
Calculation showing the percentage of proposed water fittings that are approved under WEPLS as shown in Table 2-1.</td></tr>
<tr><td>References</td><td>For more information about WEPLS, refer to
http://www.span.gov.my/index.php?option=com_content&view=article&id=580%3Aabout-us1&catid=175%3Awepls&Itemid=457&lang=en

Or WELS, refer to
(http://www.pub.gov.sg/wels/Pages/default.aspx)</td></tr>
</table>

Worked Example 2-1

Example of a water fitting schedule showing the numbers, types and the approve rating of the proposed fitting for a residential development (including common facilities such as clubhouse toilets).

Table 2-1.1: Computation of the percentage of water fittings

Ref.	Water Fitting Type	WEPLS rating			Not Rated	Total
		Efficient	Highly Efficient	Most Efficient		
1	Shower taps and mixers	0	45	0	0	45
2	Basin taps and mixers	0	0	55	0	55
3	Sink/bib taps and mixers	0	70	0	0	70
4	Flushing cisterns	0	0	50	0	50
5	Others - Urinals for club house	0	0	0	5	5
Total no. based on rating (A)		0	115	105	5	∑A = 225
Weightage (B)		4	6	8	0	
Total (AxB)		0	690	840	0	∑(AxB) = 1530

Credits scored = ∑(A x B) / ∑A
= 1530 / 225
= 6.8 credits

Percentage of fittings with water efficiency rating = 220/225 = 97.7%

NRB 2-2 WATER USAGE AND LEAK DETECTION

Objectives	Promote the use of sub-meter and leak detection system for better control and monitoring of water usage
Applicability	Applicable to sub-metering provisions for major water uses of the building developments.
Baseline Standard	-
Requirements	2-2(a) 1 credit can be scored if sub-meters are provided for **ALL** major water uses i.e. irrigation system, cooling towers and tenant's usage where applicable. 2-2(b) 1 credit can be scored if all sub-meters are linked to the Building Management System (BMS) for monitoring and leak detection. The BMS should have specific alert features that can be set and triggered to detect the possibility of water leakage during operation.
Documentary Evidences	For 2-2(a) • Extracts from the tender specification stating the provision of sub-metering for all major water uses. • Schematic drawings of cold water distribution system showing the location of the sub-metering provided. For 2-2(b) • Extracts from the tender specification and schematic drawings showing the location of sub-metering and its linkage to the BMS.
References	-

NRB 2-3 IRRIGATION SYSTEM AND LANDSCAPING

Objectives	Reduce potable water consumption by provision of suitable systems that utilise rainwater or recycled water for landscape irrigation.
Applicability	Applicable to development with landscaping provision.
Baseline Standard	-
Requirements	2-3(a) 1 credit can be scored for the use of non-potable water including rainwater for landscape irrigation. 2-3(b) 1 credit can be scored if more than 50% of the landscape areas are served by water efficient irrigation system with features such as automatic sub-soil drip irrigation system with rain sensor control. 2-3(c) 1 credit can be scored if at least 80% of the landscape areas consist of drought tolerant plants or plants that require minimal irrigation.
Documentary Evidences	For 2-3(a) • Extracts of the tender specification showing how the non-potable water source is to be provided; • Relevant drawings showing the location and design of the non-potable water source; and For 2-3(b) • Extracts of the tender specification showing the provision and details of water efficient irrigation system; • Relevant layout plans showing the overall landscape areas and the areas that would be served using the system; and • Calculation showing the percentage of the landscape areas that would be served using the system. For 2-3(c) • Relevant layout plans showing the overall landscape areas and the areas that use drought tolerant plants or plants that require minimal irrigation; and • Calculation showing the percentage of the landscape areas that use drought tolerant plants or plants that require minimal irrigation.
References	1. Manual Saliran Mesra Alam Malaysia(MSMA) (2000), Ministry of Natural Resources and Environment 2. "Rainwater – Guideline for Installing A Rainwater Collection and Utilization System",KPKT (1999) 3. "Rainwater Harvesting – Guidebook Planning and Design" Department of Irrigation and Drainage, Ministry of Natural Resources and Environment. 4. The list of drought tolerant or resistant plant species may be obtained from the online website : http://florafaunaweb.nparks.gov.sg/

NRB 2-4 WATER CONSUMPTION OF COOLING TOWER

Objectives	Reduce potable water consumption for cooling purpose.
Applicability	Applicable to building development with water-cooled central chillers systems and water cooled package units.
Baseline Standard	-
Requirements	2-4(a) 1 credit can be scored for the use of cooling tower water treatment system which can achieve 7 or better cycles of concentration at acceptable water quality. 2-4(b) 1 credit can be scored for the use of recycled water from approved sources to meet the water demand for cooling purpose.
Documentary Evidences	For 2-4(a) • Extracts of the tender specification showing the requirements to incorporate with the cooling tower designs to achieve seven cycles of concentration; • Details showing how the cooling towers have been designed to achieve at least six cycles of concentration; and • Relevant drawings showing the location of the cooling towers and other supporting systems that are required to achieve the designed concentration. For 2-4(b) • Extracts of the tender specification showing how the recycled water source is to be provided.
References	-

Part 3 – Environmental Protection	**NRB 3-1 Sustainable Construction**
	NRB 3-2 Sustainable Products
	NRB 3-3 Greenery Provision
	NRB 3-4 Environmental Management Practice
	NRB 3-5 Green Transport
	NRB 3-6 Stormwater Management
	NRB 3-7 Refrigerants

NRB 3-1 SUSTAINABLE CONSTRUCTION

<table>
<tr><td>Objectives</td><td>Encourage the adoption of building designs, construction practices and materials that are environmentally friendly and sustainable.</td></tr>
<tr><td>Applicability</td><td>Generally applicable to all building developments.</td></tr>
<tr><td>Baseline Standard</td><td>-</td></tr>
<tr><td>Requirements</td><td>3-1(a) Up to 5 credits can be scored with the use of sustainable and recycled materials

Credits can be scored for use of Green Cements with approved industrial by-product such as Ground Granulated Blast furnace Slag (GGBS), silica fume, and fly ash to replace Ordinary Portland Cement (OPC) based on percentage replacement of ordinary concrete by Green Concrete:

Table 3-1.1 : Credits allocation according to replacement percentage
<table><tr><th>Replacement of ordinary concrete by Green Concrete (%)</th><th>Credit Allocation</th></tr><tr><td>10</td><td>1</td></tr><tr><td>30</td><td>2</td></tr><tr><td>50</td><td>3</td></tr><tr><td>70</td><td>4</td></tr><tr><td>80</td><td>5</td></tr></table>
3-1(b) Up to 5 credits are allocated to encourage more efficient concrete usage for building components based on the percentage reduction in the prescribed Concrete Usage Index (CUI) limit.

Table 3-1.2 : Credits allocation for project CUI
<table><tr><th>Project CUI (m^3/m^2)</th><th>Credits Allocation</th></tr><tr><td>≤ 0.70</td><td>1</td></tr><tr><td>≤ 0.60</td><td>2</td></tr><tr><td>≤0.50</td><td>3</td></tr><tr><td>≤0.40</td><td>4</td></tr><tr><td>≤0.35</td><td>5</td></tr></table>
Note: Concrete Usage Index (CUI) is an indicator of the amount of concrete used to construct the superstructure that includes both the structural and non-structural elements. CUI does not include the concrete used for external works and sub-structural works such as basements and foundations. CUI is defined as the volume of concrete in cubic metres needed to cast a square metre of constructed floor area. It is expressed as :

Concrete Usage Index = $\frac{\text{Concrete Volume } (m^3)}{\text{Constructed Floor Area } (m^2)}$</td></tr>
</table>

<table>
<tr><td>Documentary Evidences</td><td><u>For 3-1(a)</u>
• Extract of tender specification showing the requirements to use Green Concrete.

<u>For 3-1(b)</u>
• Architectural and structural plan layout, elevation and sectional plans showing the type of wall system used, the dimensions and sizes of all the building and structural elements; and
• Calculation showing the quantity of concrete used for each floor level</td></tr>
<tr><td>Worked Example 3-1(a)</td><td>Proposed development comprises a 15 storey residential block with a basement car park and the following details:

Gross Floor Areas (GFA) = 10,000 m^2

Total concrete usage with replacement of coarse and fine aggregate with recycled concrete aggregate and wash copper slag = 6 000 m^3

Use of Green Cements to replace 10% of OPC for superstructural works

Credits scored = 1 credit

Credits scored for 3-1(a) should be 1 credits</td></tr>
<tr><td>Worked Example 3-1(b)</td><td>Proposed development comprises a 15 storey residential block with a basement carpark and the following details:

Table 3-1.3 : Concrete usage and constructed floor areas
<table><tr><th>Concrete usage for the superstructure</th><th>Constructed floor areas</th></tr><tr><td>For 1st storey = 587 m^3
For 2nd to 15th storey (including roof level) = 5400 m^3

Therefore,
Total concrete usage = 5987 m^3</td><td>For 1st storey = 1000 m^2
For 2nd to 15th (including roof level) = 14000 m^2

Therefore,
Total constructed floor area = 15000m^2</td></tr></table>
Note: The concrete usage for foundation and two basements are not required to be included.

Concrete Usage Index (CUI) = $\frac{5987}{15000}$ = 0.4 m^3/m^2

Based on the calculation shown in Table 3-1.4

CUI of 0.4 $m^3/m^2 \leq$ 0.4 m^3/m^2

Therefore, credits scored = 4 credits

Refer to the following Table 3-1.4 for more details</td></tr>
</table>

Table 3-1.4 – Concrete Usage Index

COMPUTATION OF CONCRETE USAGE INDEX			RESIDENTIAL BLDG	
Project Reference No.: AXXXX-00001-2007			Total no. of storey for the project: 15	
Block No: A				
Structural System		**Thickness (mm) or size (mm x mm)**	**Volume of concrete (m^3)**	**Remark ***
1	**1st storey**			
	1.1 Columns	200x400, 200x200	72	Precast
	1.2 Beams	200x400,200x500	145	Precast
	1.3 Slabs	150,200	265	Post-tensioned
	1.4 Staircases	150	30	Precast
	1.5 Suspended structures like planter boxes, bay windows, ledges etc	150	10	Precast
	1.6 Parapets	150	5	RC
	1.7 External walls – load bearing walls	Nil	0	-
	1.8 External walls – non-load bearing walls	125	15	RC
	1.9 Internal walls – load bearing walls	200	40	RC
	1.10 Internal walls – non-load bearing walls	Nil	0	Light weight concrete
	1.11 Others (kerbs, ramps, services risers, etc)	Not required	5	RC
	Total volume of concrete for this storey (m^3)		587	
	Total constructed floor area for this storey (m^2)		1000	
2	**Typical floor layout**			
	2.1 Columns	200x400, 200x200	55	Precast
	2.2 Beams	200x400, 200x500	45	Precast
	2.3 Slabs	150,200	160	Post-tensioned
	2.4 Staircases	150	30	Precast
	2.5 Suspended structures like planter boxes, bay windows, ledges etc	150	10	Precast
	2.6 Parapets	150	5	RC
	2.7 External walls – load bearing walls	Nil	0	-
	2.8 External walls – non-load bearing walls	125	15	RC

COMPUTATION OF CONCRETE USAGE INDEX				RESIDENTIAL BLDG
Project Reference No. : AXXXX-00001-2007 Total no. of storey for the project: 15				
Block No : A				
Structural System		Thickness (mm) or size (mm x mm)	Volume of concrete (m^3)	Remark *
2	2^{nd} storey to 30^{th} storey (Typical floor layout)			
	2.9 Internal walls – load bearing walls	200	40	RC
	2.10 Internal walls – non-load bearing walls	Nil	0	-
	2.11 Others (kerbs, ramps, services risers etc)	Nil	0	-
	Volume of concrete for one storey (m^3)		360	
	Constructed floor area for one storey		933.3	
	Total volume of concrete for 2^{nd} to 15^{th} storey		360x15=5400	
	Total constructed floor area for 2^{nd} to 15^{th} storey (m^2) (including roof level)		933.3x15=14000	
Total volume of concrete for this project (m^3)			5987	
Total constructed floor area for this project (m^2)			15000	
Concrete Usage Index (CUI in m^3/m^2)			0.4	

*To indicate if the structural elements is of precast concrete, post-tensioned concrete, high strength concrete(>Grade 60) or reinforced concrete (RC) under the 'Remarks' column

Notes: The quantities of the concrete for all the structural and non-structural elements for each floor level are computed. All the elements listed in the table such as columns, beams, slabs, suspended structures (like planter boxes, bay windows and ledges etc), parapets, walls and others (service risers, kerbs, ramps etc) are to be included. The concrete usages for foundation and basement works are excluded in CUI computation.

NRB 3-2 SUSTAINABLE PRODUCTS

<table>
<tr><td>Objectives</td><td>Encourage the use of products that are environmentally friendly and sustainable.</td></tr>
<tr><td>Applicability</td><td>Applicable to non-structural and architectural building components.</td></tr>
<tr><td>Baseline Standard</td><td>-</td></tr>
<tr><td>Requirements</td><td>Up to 8 credits are allocated to encourage the use of environmentally friendly products that are certified by approved local/international certification body. The criterion is only applicable for non-structural building components and construction. Credits scored will be based on the weightage, extent of coverage and impact.

The weightage given will be based on the extent of environmental friendliness and the ratings are determined by the approved local/international certification body and are subject to GreenRE’s evaluation.

Table 3-2.1 : Weightage for credits allocation
<table><tr><th>Extent of Environmental Friendliness of Product</th><th>Weightage for Credit Allocation</th></tr><tr><td>Good</td><td>1</td></tr><tr><td>Very Good</td><td>1.5</td></tr><tr><td>Excellent</td><td>2</td></tr></table>
The use of environmental friendly products or recycled materials used for the main building elements or functional spaces be considered as <u>high impact</u> (1 credit) if the quantities used by percentage are more than 50% (i.e. extent of coverage) as compared to the total quantities used for the same intended purpose. Items that do not meet the minimum coverage or are used in other common areas, external works etc will be considered as <u>low impact</u> (0.5 credits).

Note: The credit allocated for low volatile organic compound (VOC) paints and adhesives certified by approved local certification body can be found in NRB 4-3 and hence shall not be included in the scoring for NRB 3-2.</td></tr>
<tr><td>Documentary Evidences</td><td>• Extracts from the tender specification and drawings showing the requirements to incorporate the environmental friendly products that are certified and approved by local/international certification body;
• Certification details from approved local/international certification body such as the material certification standards, rating and details; and
• Technical product information.</td></tr>
</table>

<table>
<tr><td>References</td><td>For more info on product certification, refer to

http://www.sgbc.sg/green-certifications/onine_catalogue/

http://www.sec.org.sg/sgls/</td></tr>
<tr><td>Worked Example 3-2</td><td>Determine if the environmental friendly products selected are certified with approved local/international certification body. Check if the products used are meant for main building elements or functional spaces and can be considered high impact. Products that are meant for common areas and external works such as toilets, lobbies and landscaping areas are considered as low impact. If the selected products are potential high impact items, then determine the quantities used for these products as compared to the total quantities required for the same intended purpose. If the quantities of the products are more than 50% of the total requirement, it is considered as high impact. If it less than 50% of the total requirement then it should be considered as low impact.

Note: Certain products can have more environmentally friendly features than others. Other than recycled materials, they may have features like low VOC assembly or manufactured with resource efficient processes, durability etc that will render the products more environmental friendly than others. If the certified products selected are more environmental friendly and are given a better rating by the approved local/international certification body, a higher weightage can be considered in credit scoring.

Example of a proposed development with the following provisions:

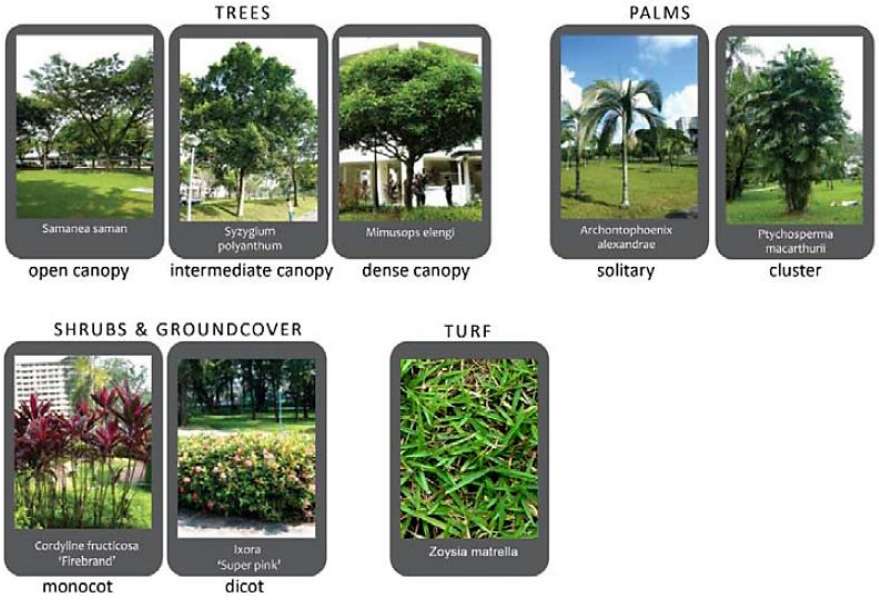
(a) Use of carpets for all office spaces. Product is not certified.
(b) Use of panel boards as internal partitions for more than 50% of the office spaces and the product is rated to be ‘Very Good’ by the approved certification body.
(c) Precast concrete road kerbs. Product is rated as ’Good’ by approved local certification body.
(d) Use of roof waterproofing coating. Product is rated as ‘Very Good’ by approved local certification body.
(e) Use of wooden doors for all areas. Product is rate as ‘Excellent’ by approved local certification body.

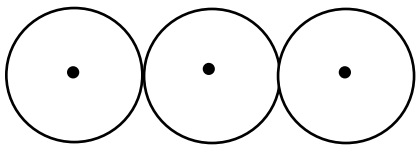
<table>
<tr><th colspan="2">Products and Extent of coverage</th><th>With approved certification</th><th>Credits allocated based on impact (A)</th><th>Weightage based on rating (B)</th><th>Credits scored (AxB)</th></tr>
<tr><td>(a)</td><td>Carpets for all office spaces</td><td>No</td><td>N/A</td><td>N/A</td><td>0</td></tr>
<tr><td>(b)</td><td>Panel boards as internal partition for more than 50% of office spaces</td><td>Yes</td><td>1</td><td>1.5</td><td>1.5</td></tr>
<tr><td>(c)</td><td>Precast road kerbs</td><td>Yes</td><td>0.5</td><td>1</td><td>0.5</td></tr>
<tr><td>(d)</td><td>Roof waterproofing</td><td>Yes</td><td>0.5</td><td>1.5</td><td>0.75</td></tr>
<tr><td>(e)</td><td>Wooden doors for all areas</td><td>Yes</td><td>1</td><td>2</td><td>2</td></tr>
</table>
Therefore, credits scored for 3-2 = 1.5 + 0.5 + 0.75 + 2 = 4.75 credits</td></tr>
</table>

NRB 3-3 GREENERY PROVISION

<table>
<tr><td>Objectives</td><td>Encourage greater use of greenery and restoration of existing trees reduce heat island effect.</td></tr>
<tr><td>Applicability</td><td>Applicable to building developments with landscaping areas.</td></tr>
<tr><td>Baseline Standard</td><td>-</td></tr>
<tr><td>Requirements</td><td>3-3(a) Up to 6 credits can be scored for the provision of greenery within the developments including roof top/ sky garden and green roof.

Green Plot Ratio (GnPR) is calculated by considering the 3D volume covered by plants using the following Leaf Area Index (LAI).

Table 3-3.1: Leaf Area Index (LAI)
<table>
<tr><th>Plant group</th><th>Trees</th><th>Palms</th><th>Shrubs & Groundcover</th><th>Turf</th></tr>
<tr><td>LAI</td><td>Canopy:
Open = 2.5
Intermediate = 3.0
Dense = 4.0</td><td>Solitary = 2.5
Cluster = 4.0</td><td>Monocot = 3.5
Dicot = 4.5</td><td>Turf = 2.0</td></tr>
<tr><td>Area</td><td>All = 60 m^2</td><td>Solitary = 20m^2
Cluster = 17m^2</td><td>Planted area</td><td>Planted area</td></tr>
</table>

</td></tr>
</table>

	Green Plot Ratio (GnPR) = Total Leaf Area / Site Area **Table 3-3.2 : Credits Allocation according to GnPR** | GnPR	Credits Allocation
1.0 to < 2.0	1
2.0 to < 3.0	2
3.0 to < 4.0	3
4.0 to < 5.0	4
5.0 to < 6.0	5
≥ 6.0	6 | 3-3 (b) 1 credit for restoration of trees on-site, conservation or relocation of existing trees on site. 3-3 (c) 1 credit for the use of compost recycled from horticulture waste.
Documentary Evidences	<u>For 3-3 (a)</u> • Plan layouts showing the site area as well as the greenery that is provided within the development (including a listing of the number of trees, palms, shrubs, turf and the respective sub category and LAI values; and • Calculation showing the extent of the greenery provision in the prescribed tabulated formats as in worked example 3-3(a). <u>For 3-3 (b)</u> • Site layouts showing the existing and final locations (where applicable) and number of the trees to be restored or conserved or relocated. <u>For 3-3 (c)</u> • Extracts of the tender specification showing the requirements to use compost recycled from horticulture waste.
Exceptions	**TREES AND PALMS SPACING (CENTRE-TO-CENTRE)** (a) If the selected trees and palms are to be planted at ≤ 2m from trunk-to-trunk as illustrated below, the leaf area shall be calculated as the product of LAI value and planted area (in m^2). I ——2m——I 

COLUMNAR TREES

(b) For trees that have tight, columnar crowns, the canopy area of 12m^2 is to be adopted for calculation of leaf area. These species include, but not limited to the following:

- Garciniacymosa forma pendula
- Garciniasubelliptica
- Polyalthialongifolia
- Carallia brachiate
- Gnetumgnemon

References

The plant species, its sub categories and LAI values may be obtained from the online website: http://florafaunaweb.nparks.gov.sg

Worked Example 3-3(a)

(1) Determine the number of trees, palms and the trees for shrubs and turfs and other greenery area.

(2) The Leaf Area Index (LAI) of the individual plant species and its canopy area are predetermined design parameters applicable for all developments.

(3) The plant species sub categories and its LAI values can be obtained from the online website: http://florafaunaweb.nparks.gov.sg/ (see example below) by searching the common / scientific names of the plants.

(4) Compute the green areas as shown in the Table 3-3.3 below

Table 3-3.3: Calculation of the Green Plot Ratio

Category	Sub category	(A) LAI value	(B) Canopy area	(C) Qty/Planted Area	(A)x(B)x(C) Leaf Area
Trees (no.)	Open Canopy	2.5	60 m^2	0 no.	0
	Intermediate Canopy	3.0	60 m^2	8 no.	1440
	Dense Canopy	4.0	60 m^2	12 no.	2880
Palms (no.)	Solitary	2.5	20 m^2	10 no.	500
	Cluster	4.0	17 m^2	10 no.	680
Shrubs (m^2)	Monocot	3.5	NA	0 m^2	0
	Dicot	4.5	NA	20 m^2	90
Turf(m^2)	Turf	2.0	NA	90 m^2	180
Vertical Greenery (m^2)	-	2.0	NA	10 m^2	20
				Total Leaf Area:	**5790**

Note: Green roof landscaping would be calculated as per illustrated above

Assume site area is 4000 m^2

Green Plot Ratio (GnPR) = total leaf area / site area

= 5790 / 4000 = 1.45

Where GnPR = 1.0 to < 2.0

Therefore, credits scored for 3-3(a) = 1 credit

NRB 3-4 ENVIRONMENTAL MANAGEMENT PRACTICE

Objectives	Encourage the adoption of environmental friendly practices during construction and building operation.
Applicability	Generally applicable to all building developments.
Baseline Standard	-
Requirements	3-4(a) 1 credit can be scored if effective implementation of environmental friendly programmes including monitoring and setting targets to minimise energy use, water use and construction waste are in place. 3-4(b) 1 credit can be scored if main builder has good track records in completing internationally recognized accredited Green Buildings and adoption of sustainable, environmentally friendly and considerate practices during construction 3-4(c) 1 credit can be scored if the building quality is assessed under the Quality Assessment System in Construction (QLASSIC) or Construction Quality Assessment System (CONQUAS). 3-4(d) Up to 1 credit if the developer, main builder, M&E consultant and architect are ISO 14000 certified. 0.25 credits are allocated for each firm that is certified. 3-4(e) Up to 2 credits if the project team comprises Certified GreenRE Manager/ Green Mark Manager (1 credit) and Certified GreenRE Professional/ Green Mark Professional (2 credit). 3-4(f) 1 credit can be scored for the provision of building users' guide with details of the environmental friendly facilities and features within the building and their uses in achieving the intended environment performance during building operation. 3-4(g) 1 credit can be scored for the provision of facilities or recycling bins at each block of development for collection and storage of different recyclable waste such as paper, glass, plastic etc.

Documentary Evidences	For 3-4(a) • Extracts of the tender specification showing the requirements for builder to provide and implement environmental friendly programmes to minimise energy use, water use and construction waste; and • Details of the environmental friendly programmes implemented. For 3-4(b) • A certified true copy of the main builder's Green award; or • Details of track records in the adoption of sustainable, environmentally friendly and considerate practices during construction. For 3-4(c) • Extracts of the tender specification showing the requirement to adopt Quality Assessment System in Construction (QLASSIC) or Construction Quality Assessment System (CONQUAS) where applicable. For 3-4(d) • A certified true copy of the ISO 14000/ISO certificate of developer, main contractor, M & E consultant and architect where applicable. For 3-4(e) • A certified true copy of the certificate of GreenRE Manager/ Green Mark Manager and GreenRE Professional/ Green Mark Professional where applicable and a confirmation of their involvement performance during building operation. For 3-4(f) • A copy of the building users' guide containing the details of the environmental friendly facilities and features within the building and their uses in achieving the intended environment performance during building operation. For 3-4(g) Plan layout showing the location of the recycling bins for collection and storage of different recyclable waste.
References	-

NRB 3-5 GREEN TRANSPORT

Objectives	Promote environmental friendly transport options and facilities to reduce pollution from individual car use.
Applicability	Generally applicable to all building developments.
Baseline Standard	-
Requirements	3-5(a) 1 credit can be scored for design that provides good access (<800m walking distance) to public transport networks such as MRT/LRT stations or bus stops. 3-5(b) 1 credit can be scored for provision of covered walkway to facilitate connectivity and the use of public transport. 3-5(c) 1 credit can be scored for provision of electric vehicle charging stations and priority parking lots within the development. 3-5(d) Up to 1 credit can be scored for the provision of covered/ sheltered bicycles parking lots. Minimum 10 numbers and maximum 50 numbers of bicycle parking lots
Documentary Evidences	For 3-5(a) • Site layout plan in the context of the surrounding area showing the location of the development site and the location of the MRT/LRT stations and bus stops. For 3-5(b) • Site layout plan showing the connection of covered walkway from the development to the MRT/LRT stations or bus stops; and • Extracts of the tender specification showing the requirement to provide covered walkway. For 3-5(c) • Extracts of the tender specification showing the requirement to provide hybrid/electric vehicle refuelling/ recharge stations. For 3-5(d) Extracts of the tender specification showing the requirement to provide covered/sheltered bicycles parking lots for the development and the total quantity of bicycles lots provided.
References	-

NRB 3-6 STORMWATER MANAGEMENT

Objectives	Encourage the treatment of stormwater runoff through provision of infiltration or design features before discharge to public drains.
Applicability	Generally applicable to building developments.
Baseline Standard	-
Requirements	1 credit can be scored for the provision of infiltration features or design features for new development and redevelopment. Note: The treatment of stormwater runoff shall be through provision of infiltration or design features as recommended in Urban Storm Water Management (MSMA).
Documentary Evidences	• Site layout plans indicating the total site area, total paved area within the site as well as the total catchment areas. Other information such as the total paved areas within the catchment areas, treatment areas and the hydraulic retention time of the design features area to be included where applicable. • Drainage plan, schematic plan, location plan and details of water features such as the specification of filtration layer, transition layer and drainage layer, sub-soil drainage system, overflow arrangement, plant list etc. Relevant design calculations and simulation/modelling results are to be provided where applicable.
References	Urban Storm Water Management (MSMA)

NRB 3-7 REFRIGERANTS

Objectives	Reduce the potential damage to the ozone layer and the increase in global warming through the release of ozone depleting substances and greenhouse gases.
Applicability	Generally applicable to all building developments with air-conditioning systems.
Baseline Standard	-
Requirements	3-7(a) 1 credit can be scored for the use of refrigerants with ozone depleting potential (ODP) of zero **OR** with global warming potential (GWP) of less than 100. 3-7(b) 1 credit can be scored for the use of refrigerant leak detection system at critical areas of plant rooms containing chillers and other equipment with refrigerants.
Documentary Evidences	For 3-7(a) • Extracts from the tender specification showing the requirement for all refrigerants to have ODP of zero **OR** GWP of less than 100. For 3-7(b) • Extracts from tender specification showing the requirements to incorporate a refrigerant leak detection system.
References	-

Part 4 – Indoor Environment Quality	**NRB 4-1 Thermal Comfort** **NRB 4-2 Noise Level** **NRB 4-3 Indoor Air Pollutants** **NRB 4-4 Indoor Air Quality (IAQ) Management** **NRB 4-5 High Frequency Ballasts**

NRB 4-1 THERMAL COMFORT

Objectives	Recognise buildings that are designed with good thermal comfort.
Applicability	Generally applicable to all building developments with air-conditioning systems.
Baseline Standard	-
Requirements	2 credits can be scored if the air-conditioning systems are designed to allow for cooling load variations due to fluctuations in ambient air temperature to ensure consistent indoor conditions for thermal comfort. Indoor dry-bulb temperature between 23°C to 26°C Relatively Humidity between 50% - 70%
Documentary Evidences	Extracts of the tender specification showing the requirement to design the air-conditioning systems which would provide consistent indoor conditions for thermal comfort as stated in the above requirement.
References	-

NRB 4-2 NOISE LEVEL

Objectives	Recognise buildings that are designed to control and keep the background noise in occupied spaces at levels appropriate to the intended use of the spaces.
Applicability	Generally applicable to all building developments.
Baseline Standard	"The Planning Guidelines for Environmental Noise Limits and Control " - Department of Environmental Malaysia, Ministry of Natural Resource and Environmental Malaysia
Requirements	2 credits can be scored if the occupied spaces in building are designed with the recommended ambient sound levels stated in "The Planning Guidelines for Environmental Noise Limits and Control".
Documentary Evidences	• Extracts of the tender specification showing the requirement to design the occupied space with the ambient sound levels to the recommendation stated in "The Planning Guidelines for Environmental Noise Limits and Control"; and • Detailed analysis, calculation and/or measurements to ensure that the designed ambient sound levels are met.
References	-

NRB 4-3 INDOOR AIR POLLUTANTS

Objectives	Minimise airborne contaminants, mainly from inside sources to promote a healthy indoor environment.
Applicability	Generally applicable to all building developments.
Baseline Standard	-
Requirements	4-3(a) 1 credit can be scored for the use of low volatile organic compounds (VOC) paints certified under local/international certification body for at least 90% of the internal wall areas. 4-3(b) 1 credit can be scored for the use of environmentally friendly adhesives certified by approved local/ international certification body for at least 90% of the applicable building works or areas.
Documentary Evidences	<u>For 4-3(a)</u> • Extracts of the tender specification showing the requirements to use low VOC paints that are certified under local/international certification body. • Technical product information <u>For 4-3(b)</u> • Extracts of the tender specification showing the requirement to use adhesive with low emission formaldehyde and are certified under local/international certification body for all composite wood products used. • Technical product information
References	-

NRB 4-4 INDOOR AIR QUALITY (IAQ) MANAGEMENT

Objectives	Ensure building ventilation systems are designed and installed to provide acceptable IAQ under normal operating conditions.
Applicability	Applicable to air-conditioned buildings
Baseline Standard	-
Requirements	4-4(a) 1 credit can be scored for the provision of filtration media and differential pressure monitoring equipment in Air Handling Unit (AHU) 4-4(b) 1 credit can be scored for implementing effective IAQ management plan to ensure that building ventilation systems are clean and free from residuals left over from construction activities.
Documentary Evidences	For 4-4(a) • Extracts of the tender specification showing the requirements of the filter media and pressure monitoring equipment. • Technical product information which should include the minimum efficiency reporting value (MERV) parameters of the filters; and • Technical product information of the differential pressure monitoring equipment For 4-4(b) • Extracts of the tender specification showing the requirement for builder to provide and implement effective IAQ management and the details of the management plan.
References	-

NRB 4-5 HIGH FREQUENCY BALLASTS

Objectives	Encourage the use of high frequency ballasts in fluorescent luminaries to improve the workplace lighting quality.
Applicability	Generally applicable to workplace such as offices, classrooms and training rooms and the like.
Baseline Standard	-
Requirements	2 credits can be scored for the use of high frequency ballasts in the fluorescent luminaries if it is adopted in at least 90% of the applicable areas that are served by fluorescent luminaries.
Documentary Evidences	• A summary sheet listing all fluorescent luminaries used for the developments and those with high frequency ballasts; and • Extracts of the tender specification showing the requirement to have high frequency ballasts are to be used in all fluorescent luminaries listed.
References	-

Part 5 – Other Green Features

NRB 5-1 GREEN FEATURES & INNOVATIONS

Objectives	Encourage the use of green features which are innovative and have positive environmental impact on water efficiency, environmental protection and indoor environmental quality of the buildings.
Applicability	Generally applicable to all building developments.
Baseline Standard	-
Requirements	Up to 7 credits are awarded for the use of the following green features depending on their potential environmental benefits or reduced environmental impacts. Water efficiency i. Use of self cleaning façade system • 2 credits for more than 75% of the external walls. • 1 credit for more than 50% of the external walls. • 0.5 credit for at least 25% of the external walls. ii. Use of grey water recycling system • 2 credits for all blocks of the development. • 1 credit for at least one block of the development. iii. Recycling of AHU condensate • 1 credit for more than 75% of the AHU condensate • 0.5 credit for at least of 50% of the AHU condensate iv. 0.5 credit for the use of membrane filtration system to recycle water during construction. v. 0.5 credit for the use of non-chemical water treatment for cooling tower. Environmental Protection i. Provision of green roof and roof top garden • 1 credit for more than 50% of the roof areas • 0.5 credit for at least 25% of the roof areas ii. Provision of vertical greening • 1 credit for more than 50% of the external wall areas • 0.5 credit for at least 25% of the roof areas iii. 1 credit for the provision of double refuse shuts for separating recyclable from non-recyclable waste

	iv. 0.5 credit for the use of non-chemical treatment system such as termite baiting system, anti-termite mesh. v. 0.5 credit for the provision of at least 5 nos. of compost bins to recycle organic waste. vi. 0.5 credit for the use on non-chemical water treatment system for swimming pools. vii. Up to 1 credit if at least 10% of the fine and/or coarse aggregate used for concrete production of structural application are replaced with recycled products from approved sources. 0.5 credit for each recycled product used. Credits can only be scored if the extent of implementation covers at least 50% of all concrete structural elements of the superstructures (by volume). <u>Indoor Air Quality</u> i. Use of Titanium Dioxide solutions to remove odour in toilets: • 1 credit for more than 50% of all toilets • 0.5 credit for at least 25% of all toilets ii. 1 credit for the use of pneumatic waste collection system. iii. 0.5 credit for the use of Ultraviolet light-C band (UV) emitters in <u>all</u> air handing units (AHUs) to improve indoor air quality. <u>Others</u> i. Provision of landscape drainage and infiltration trenches: • 1 credit for at least 25% of the green areas • 0.5 credit for less than 25% of the green areas ii. Provision of system to recycle surface runoff from the vertical green wall and sky garden: • 1 credit for at least 25% of green areas • 0.5 credit for less than 25% green areas iii. 0.5 credit for the use of siphonic rainwater discharge system at roof. iv. 0.5 credit for the provision of eco-pond. v. 0.5 credit for the provision of carpark guidance system. Note: For features that are not listed above, the QP is required to submit the details showing the positive environmental impacts, possible savings and benefits of the proposed features to GreenRE for assessment.

Documentary Evidences	• Extracts of the tender specification showing the provision of the specific green features used and the extent of implementation where applicable: • Technical product information (including drawings and supporting documents) of the green features; • A summary sheet listing the breakdown and the extent of implementation as well as the total requirements for the same intended purpose for the specific green features used; and • Quantified evidences on the potential environmental benefits that are features can bring to the development.
References	-

Part 6 – Carbon Emission of Development

NRB 6-1 CARBON EMISSION OF DEVELOPMENT

<table>
<tr><td>Objectives</td><td>To calculate the carbon emission resulted from the associated energy used during construction and operational phase of a development.</td></tr>
<tr><td>Applicability</td><td>Generally applicable to all building development.</td></tr>
<tr><td>Baseline Standard</td><td>-</td></tr>
<tr><td>Requirements</td><td>Up to 4 credits can be scored for the calculation of the carbon footprint report of the building comprising of energy and water consumption savings with comparison of the baseline parameters.

Credits scored = 0.1 x (% improvement)</td></tr>
<tr><td>Documentary Evidences</td><td>• Electricity bill of the development for the year
• Water bill of the development for the year
• Carbon footprint calculation</td></tr>
<tr><td>References</td><td>-</td></tr>
<tr><td>Worked Example 6-1</td><td>Energy Consumption
<table>
<tr><td rowspan="2">Type of usage</td><td>Design</td><td>Baseline</td></tr>
<tr><td>(kWh/yr)</td><td>(kWh/yr)</td></tr>
<tr><td>Lighting</td><td>819,498</td><td>1,151,575</td></tr>
<tr><td>Air-Conditioning</td><td>860,589</td><td>1,406,899</td></tr>
<tr><td>M/V System</td><td>25,550</td><td>25,550</td></tr>
<tr><td>Total Energy Usage</td><td>1,705,637</td><td>2,584,024</td></tr>
</table>
Water Consumption
<table>
<tr><td rowspan="2">Type of fixtures</td><td>Design</td><td>Baseline</td></tr>
<tr><td>(m^3/yr)</td><td>(m^3/yr)</td></tr>
<tr><td>Flow Fixtures</td><td>2,402</td><td>6,899</td></tr>
<tr><td>Flush Fixtures</td><td>5,366</td><td>5,161</td></tr>
<tr><td>Total Water Usage</td><td>7,768</td><td>12,060</td></tr>
</table>
Carbon Footprint
<table>
<tr><td rowspan="2">Type of usage</td><td>Design</td><td>Baseline</td></tr>
<tr><td>$kgCO_2e/yr$</td><td>$kgCO_2e/yr$</td></tr>
<tr><td>Energy</td><td>1,226,619</td><td>1,860,497</td></tr>
<tr><td>Water</td><td>155,344</td><td>241,192</td></tr>
<tr><td>Total Annual Carbon Footprint</td><td>1,381,963</td><td>2,101,689</td></tr>
</table>
*CO_2 conversion factor for energy = 0.72, water = 0.02.
Please use up-to-date CO_2 conversion factor for both energy and water.

Percentage savings = (2,101,689 - 1,381,963) / 2,101,689 = 34.25%

Credits scored for 6-1 (a) = 0.1 x 34.25%
= 3.43 credits</td></tr>
</table>

4. Documentation Requirements

All documents submitted for the REHDA GreenRE Assessment should be duly verified and signed by the Qualified Person (QP) and appropriate practitioners where applicable.

The documentation required for ventilation simulation and energy modelling should also be endorsed by the QP and appropriate practitioners as part of the documentary evidences for certification.

Table: Summary Checklist and the Corresponding Signatories for GreenRE Non-Residential Criteria

GreenRE Criteria	Required Signatories
Part 1 – Energy Efficiency	
NRB 1-1 Thermal Performance of Building Envelope - OTTV	PA
NRB 1-2 Air-Conditioning System	PE
NRB 1-3 Building Envelope – Design/ Thermal Parameters	PA
NRB 1-4 Natural Ventilation (exclude carparks)	PA
NRB 1-5 Daylighting	PA
NRB 1-6 Artificial Lighting	PE
NRB 1-7 Ventilation in Carparks	PE
NRB 1-8 Ventilation in Common Areas	PE
NRB 1-9 Lifts and Escalators	PE
NRB 1-10 Energy Efficient Practices & Features • Heat Recovery Devices • Motion Sensors/ Photo Sensors • Others	 PE PE S
NRB 1-11 Renewable Energy	S
Part 2 – Water Efficiency	
NRB 2-1 Water Efficient Fittings	PA
NRB 2-2 Water Usage and Leak Detection	PE
NRB 2-3 Irrigation System	PE
NRB 2-4 Water Consumption of Cooling Tower	PE
Part 3 – Environmental Protection	
NRB 3-1 Sustainable Construction	PE
NRB 3-2 Sustainable Products	PA
NRB 3-3 Greenery Provision	PE
NRB 3-4 Environmental Management Practice	PE
NRB 3-5 Green Transport	PA
NRB 3-6 Stormwater Management	PE
NRB 3-7 Refrigerants	PA
Part4 – Indoor Environmental Quality	
NRB 4-1 Thermal Comfort	PE
NRB 4-2 Noise Level	S
NRB 4-3 Indoor Air Pollutants	PA
NRB 4-4 Indoor Air Quality (IAQ) Management	PA
NRB 4-5 High Frequency Ballasts	PE
Part 5 – Other Green Features	
NRB 5-1 Green Features & Innovations	S
Part 6 – Carbon Emission of Development	
NRB 6-1 Carbon Emission of Development	S

1. PA refers to Professional Architect
2. PE refers to Professional Engineer, Landscape Architect, Planner and Quantity Surveyor (QS)
3. S refers to Specialist which includes Facilitator, Project Manager, Facilities Manager, Energy or Sustainable consultant and Commissioning Specialist

Appendix A

ENERGY MODELING METHODOLOGY AND REQUIREMENTS

A1 General

The energy modeling for evaluating the energy performance of a building should be carried out in a prescribed manner to quantify the potential savings over the Reference Model.

A2 Simulation Software

The simulation software used for energy modeling should meet the following criteria:

(a) It must have the capability to model the thermal performance of buildings in a multi-zone format and calculate the building's total energy consumption over a continuous 12-months period.

(b) It must be tested by a recognised institution in accordance to the Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs – **ANSI/ASHRAE STD 140** or other equivalent standard.

A3 Reference Model

The simulation model for calculating the baseline building performance (known as Reference Model) shall be developed in accordance with the requirements in the following Table A3.

Table A3: Baseline Standard

<table>
<tr><th>S/No.</th><th>Component</th><th>Baseline Standard</th><th>Minimum Requirement</th></tr>
<tr><td>1</td><td>Building Envelope Design</td><td>BCA Approved Document

Code on Envelope Thermal Performance for Buildings

MS 1525:2014 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice (Chapter 5.5 - Roofs)</td><td>(a) OTTV shall not exceed 50 W/m²

(b) For roof with skylight, RTTV shall not exceed 50 W/m²

(c) For roof with skylight, the average U value of the gross area of the roof shall not exceed the limit below :

Maximum Thermal Transmittance for Roof of air-conditioned buildings
<table><tr><th>Roof Weight Group</th><th>Maximum U-Value (W/m²K)</th></tr><tr><td>Light (Under 50 kg/m²)</td><td>0.4</td></tr><tr><td>Heavy (Above 50 kg/m²)</td><td>0.6</td></tr></table>
(d) All windows on the building envelope shall not exceed the air leakage rates specified in SS 212 – Specification for Aluminium Alloy Windows

(e) Where the door opening of any commercial unit is located along the perimeter of the building envelope, that unit shall:-

(i) be completely separated from the other parts of the building ; and

(ii) has its air-conditioning system separated from and independent of the central system</td></tr>
<tr><td>2</td><td>Chiller Efficiency</td><td>SS 530:2006</td><td>Minimum energy efficiency standard stated</td></tr>
</table>

S/No.	Component	Baseline Standard	Minimum Requirement
3	Pump Efficiency (for chilled water and condenser water)	CP 13:1999 – Code of Practice for mechanical ventilation and air conditioning in buildings (Cl 7.11.6 – Pump system design criteria)	Chiller Water Pump energy consumption shall not exceed 0.033 kW/kW Condenser Water Pump energy consumption shall not exceed 0.025 kW/kW 7.11.6 Pumping system design criteria (a) Piping systems should be designed at a friction pressure loss rate of no more than 4.0m of water per 100 equivalent metre of pipe (b) The water transport factor shall not be less than 30 for chilled water and 40 for the condensing water circuit, whether open or closed. (c) Water Transport factor – Heat Transfer to circulating water. (Pump power input)
4	Cooling Tower	SS 530:2006 – Energy Efficiency Standard for building services and equipment	Performance requirement for heat rejection equipment. *Propeller or axial fan cooling towers* Cooling Tower performance shall not be less than 3.24 L/s/kW *Centrifugal fan cooling towers* Cooling Tower performance shall not be less than 1.7 L/s/kW
5	Mechanical Fans	CP 13:1999 – Code of Practice for mechanical ventilation and air-conditioning in buildings (Cl 7.11.5 – Fan system design criteria)	Fan power shall not exceed 0.47 W per m^3/h and 0.74 per m^3/h for CAV and VAV system respectively. 7.11.5 Fan system design criteria (a) For fan systems which provide a constant air volume whenever the fans are running, the power required by the motor for the combined fan system at design conditions shall not exceed 0.47 W per m^3/h of supply air (b) For fan systems which are able to vary system air volume automatically as a function of load, the power required by the motors for the combined fan system at design conditions shall not exceed 0.74 per m^3/h of supply air.
6	Lighting	MS 1525:2014 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice	(a) Lighting power budget (b) Stipulated luminance level

Important notes:

1. Where no Baseline Standard is available, e.g. building with air-conditioned atrium space, receptacle loads, lift & escalator, Sanitary & plumbing, a. the same input parameters for good design practice should apply to both the Reference and Proposed Models.
b. Detail calculations to be provided to justify the savings in energy consumption by salient energy efficient features/equipment, e.g. if sensors or VVVF motors are used in the Proposed Models.

2. For receptacle loads, Table A below is for reference.

Table A : Receptacle Loads	Standard	Nominal Values
a. Computer intensive Offices b. General Office Areas c. Large Conference areas d. Server/Computer rooms	Source :- AHSRAE STD 90.1:1989	22.0 W/m² 16.0 W/m² 11.0 W/m 540.0 W/m²

A4 Energy Modelling Methodology

A4.1The simulation model of the proposed design (known as Proposed Model) shall be developed in accordance with the design parameters of the building. This includes:

(i) Building design layout in terms of shape, size and orientation.
(ii) Materials for walls, windows, roofs, floors, doors and permanent shading devices, internal partitions between conditioned and non-conditioned spaces.
(iii) Internal loads such as levels and schedules for occupancy, lighting systems, equipment, appliances and machinery within the building
(iv) ACMV equipments, controls and other associated components selected for use in the building

A4.2 The Reference Model shall be developed using similar data as stated in paragraph A4.1

A4.3 The simulations for the Proposed Model and Reference Model shall be calculated using

(i) The same software
(ii) The same weather data[1]
(iii) The same operating schedules
(iv) The same occupancy rates
(v) The same building design in terms of shape, size and orientation
(vi) The same receptacle loads
(vii) The same indoor environmental conditions in terms of thermal comfort level[2], and
(viii) The same internal illuminance levels (lux) for space lightings

A4.4 The overall energy consumption of the Reference Model is to be computed over a period of one (1) year using the building envelope and all energy consuming equipment that are selected during the design stage. This includes energy consumed by chillers, air handling systems, plant equipment (e.g. water pumps, cooling towers, tube cleaning devices, chillers, etc.), and non-ACMV systems such as lightings, lifts, escalators, ceiling fans and receptacle loads from equipment (e.g. photo copiers, printers, fax machines, computers, laptops, fridges, projectors, audio-cum video system, water heaters, dryers, washers, etc). Similarly, the overall energy consumption of the Proposed Model can be computed over a period of one (1) year.

[1]Appropriate up-to-date weather set should be used for energy modeling such as ASHRAE's International Weather for Energy Calculation data for Malaysia.
[2]If a different condition such as higher space temperature is used in the Proposed Model, there must be evidence to demonstrate that the overall thermal comfort level is not lower than that of the Reference Model.

A4.5 The improved performance of the proposed building design can then be obtained by making comparison of the overall energy consumption of the Reference Model against the Proposed Model.

A4.6 The Energy Efficiency Index for both the Proposed and Reference Models shall also be computed. The details are as follows:

Calculation of EEI:

$EEI = [(TBEC-DCEC)/(GFA_{\text{excluding carpark}} - DCA - GLV \times VCR)] \times (NF/OH)$

Where:

(a) TBEC : Total building energy consumption (kWh/year)
(b) DCEC : Data centre energy consumption (kWh/year)
(c) GFA : Gross floor area (exclude car park area)(m^2)
(d) DCA : Data centre area (m^2)
(e) GLA : Gross lettable area (m^2)
(f) VCR : Weighted floor vacancy rate of gross lettable area (%)
(g) NF : Normalizing factor based on a typical weekly operating hours that is 55 Hrs/week
(h) OH : Weighted weekly operating hours (hrs/week)

Reference: [1] NUS Centre for Total Building Performance:
http://www.bdg.nus.edu.sg/buildingenergy/e_energy/audit_results.html

A5 Documentation Requirements

A5.1 The Qualified Person (QP) and the appropriate practitioners shall certify that the energy modelling for the building has been carried out in accordance with the requirements using the Energy Modelling methodology. The appropriate practitioner shall ensure that the assumptions and inputs used for energy modelling are bona fide. Whilst the energy modelling specialist shall certify and be responsible for the correctness of the modelling included proper usage of the relevant software

A5.2 The QP and the appropriate practitioners shall ensure the following documents and records are available as evidences to demonstrate compliance with the energy modelling framework and validation of the potential energy savings during assessment. They are:

(a) Certification showing that the simulation software is tested an meet the criteria in accordance with the ASHRAE Standard 140
(b) Detailed drawings and other necessary information of proposed design
(c) Detailed system design calculation
(d) Summary of Space and OTTV of the Building Envelope as in Table A5.2-1(a) and Table A5.2-2(a)
(e) List of data such as
    i. Space input data for all zones comprising detail information on construction materials and their properties designed for each individual zone. For example, room area, walls, windows, doors, floors, partitions, sensible and latent loads (lightings, occupancy rates, receptacles loads, outdoor ventilation rates, misc. loads etc.)
    ii. Schedules for each individual operating zone (e.g. lighting, occupants, mechanical fans, AHUs, other mechanical and electrical equipment, etc.)
    iii. Executable input data files used in the generation of the energy estimates for the Proposed and Reference Models

iv. Output data on the monthly energy consumption by mechanical and electrical system components (e.g. Air-conditioned systems, Lighting systems, Receptacle equipment, Lifts, Escalators etc.)

(f) Detailed computation of the OTTV for both Reference and Proposed Models
(g) Comparison of Reference Model versus Proposed Model as in Table A5.2-1(c)
(h) Summary of Energy of End Use including Efficiency Indicators for both Reference and Proposed Models as in Table A5.2-1(b) and Table A5.2-2(b).
(i) Summary printouts of energy modelling software for the Reference Model including summary of weather data results
(j) Monthly energy consumption of mechanical and electrical system components such as air-conditioned system, lighting systems, receptacle equipments, lift and escalator etc.

A5.3 Similar documentation requirements as above will also be required to reflect the as-built condition upon project completion for validation.

Table A5.2-1(a) Summary of Space and OTTV of the Building Envelope

(A) Space Summary			
Building Use	Air-Conditioned Area (m^2)	Non Air-Conditioned Area (m^2)	Total Area (m^2)
1. Office			
2. Toilets			
3. Storage			
4. Corridor			
5. Atrium			
6. Food court			
7. Mechanical/Electrical			
8. Staircase			
9. Conference			
10. Retail Outlets			
11. Car park			
12. Others			
Total			
Note: The building use floor areas for both the Reference and Proposed Models must be the same.			

(B) Building Envelope Summary – OTTV			
Orientation of Facade	Gross Area of External Walls (m^2)	Reference Model OTTV (W/m^2)	Proposed Model OTTV (W/m^2)
North			
North-East			
East			
South-East			
South			
South-West			
West			
North-West			
Average OTTV of the Building Envelope (W/m^2)		50 W/m^2	

Table A5.2-1(b): Summary of Energy by End Use including Efficiency Indicators

End Use	Reference Model Energy Consumption (kWh)	Proposed Building Energy Consumption (kWh)	Tolerance (%)
Lighting – (Air-conditioned Space)			
Lighting – (Non Air-conditioned Space)			
[3] Air Conditioned Plant			
[4] Air System Fans			
Mechanical Ventilation Fans			
Lifts			
Escalators			
Domestic Water Systems			
Others			
Total Building Energy Consumption			

Renewable Energy Sources

End Use	**Energy Produced (kWh)**	**Reference Model Energy Consumption (kWh)**	**Proposed Building Energy Consumption (kWh)**	**Tolerance (%)**
Photovoltaic				
Others				
Total Building Energy Consumption Including Renewable Energy Sources				

Efficiency Indicators

Efficiency Indicators	**Reference Model**	**Proposed Model**
Energy Efficiency Index, EEI (kWh/m²/yr)		
System Efficiency of Air-Conditioned Plant (ikW/kW)		

[3] Chilled water system (chillers, water pumps and cooling towers)

[4] Chilled water Air handling and Fan Coil units

Table A5.2-1(c) Comparison of Reference Model versus Proposed Model

BUILDING ELEMENT	REFERENCE MODEL	PROPOSED MODEL
BUILDING ENVELOPE		
Wall Construction		
Opaque Doors		
Windows		
Floor		
Roof		
Window to Wall Ratio (WWR)		
Others		
ELECTRICAL SYSTEMS		
Lighting Power Density (W/m^2)		
Lighting Occupant Sensor Controls		
Receptacle Power (W/m^2)		
Lifts & Escalators		
Others		
Note: The Receptacle Loads for both the Reference and Proposed Models must be the same.		
RENEWABLE ENERGY SYSTEMS		
Photovoltaic		
Note : Always include a description of renewable energy systems used to reduce Proposed Model energy consumption		

BUILDING ELEMENT	REFERENCE MODEL	PROPOSED MODEL
SCHEDULES		
Occupancy, Lighting & Equipment		
HVAC		
Note : The Occupancy Rates and Operating Schedules for both the Reference and Proposed Models must be the same		
MECHANICAL & PLUMBING SYSTEMS		
HVAC System Type		
AHU Fan Properties		
Boiler Efficiency		
Central Plant Efficiency		
Note: Central plant efficiencies and capabilities for chillers and cooling towers should be listed whenever the central plant is included as part of the energy model.		
HVAC Circulation Loop Properties		
Domestic Water System		
Mechanical Ventilation Fans		
OTHERS		

Description of differences between the Reference Model and Proposed Model not documented on other forms

☐ Not Applicable ☐ Attached

Table A5.2-2(a): Summary of Space and OTTV of the Building Envelope
(Required if there is a change)

(A) Space Summary			
Building Use	Air-Conditioned Area (m^2)	Non Air-Conditioned Area (m^2)	Total Area (m^2)
1. Office			
2. Toilets			
3. Storage			
4. Corridor			
5. Atrium			
6. Food court			
7. Mechanical/Electrical			
8. Staircase			
9. Conference			
10. Retail Outlets			
11. Car park			
12. Others			
Total			
Note : The building use floor areas for both the Reference and Proposed Models must be the same			

(B) Building Envelope Summary – OTTV			
Orientation of Facade	Gross Area of External Walls (m^2)	Reference Model OTTV (W/m^2)	Proposed Model OTTV (W/m^2)
North			
North-East			
East			
South-East			
South			
South-West			
West			
North-West			
Average OTTV of the Building Envelope (W/m^2)		50 W/m^2	

Table A5.2-2(b): Summary of Energy by End Use including Efficiency Indicators

End Use	Reference Model Energy Consumption (kWh)	Actual Building Energy Consumption (kWh)	Tolerance (%)
Lighting – (Air-Conditioned Space)			
Lighting (Non Air-Conditioned Space)			
[5] Air Conditioned Plant			
[6] Air System Fans			
Mechanical Ventilation Fans			
Lift			
Escalators			
Receptacle Equipment			
Domestic Water Systems			
Others			
Total Building Energy Consumption			

Renewable Energy Sources

End Use	Energy Produced (kWh)	Reference Model Energy Consumption (kWh)	Actual Building Energy Consumption (kWh)	Tolerance (%)
Photovoltaic				
Others				
Total Building Energy Consumption Including Renewable Energy Sources				

Efficiency Indicators

Efficiency Indicators	Reference Model	Actual Building Model
Energy Efficiency Index, EEI (kWh/m²/yr)		
System Efficiency of Air-Conditioned Plant (ikW/kW)		

[5] Chilled Water System (chillers, water pumps and cooling towers)

[6] Chilled Water Air Handling and Fan Coil Units

Appendix B

VENTILATION SIMULATION METHODOLOGY AND REQUIREMENTS

B1 General

The natural ventilation simulation shall be carried out using computational fluid dynamics (CFD) modelling to identify the most effective building design and layout for the development. The simulation results and recommendations derived are to be adopted to meet the intent of the criteria.

B2 Simulation Software

The CFD modelling shall be carried out using well validated software. The CFD solver shall have the minimum capability of solving the Navier-Stokes fluid flow equations for a three-dimensional incompressible flow at steady state on a body conforming computational grid. Turbulence modelling shall also be included with the minimum requirement of using the standard k-ε turbulence model, coupled with standard wall function.

B3 Ventilation Simulation Methodology

B3.1 All simulation shall be carried out under isothermal condition of 33.0°C air temperature at steady state condition.

B3.2 The computational domain shall include the development of interest, the characteristics of the immediate surroundings and buildings reside within the proximity of minimum 3 times or more the length of the longest distance measured across the boundary of the development. In the event that the building and surrounding development are located within hilly terrain, the topography information shall also be included in the simulation models. The computational domain shall be further extended from the outer edge of the proximity regions to the boundary such that it would not result in non-physical airflow solution, after the solution has converged. The computational domain shall also be aligned along with the wind flow direction. The domain height shall be extended, approximately 3 times the height of the tallest building within the defined vicinity.

B3.3 The computational grid generated for all simulations should resolve the salient flow features in the apartment units and around the development. As a guide, the dimension of the computational elements should be set at 0.1 to 0.2m in the apartment unit, 0.5 to 1.0m at all buildings and ground level and 10m at the far field boundary with a minimum 50m away from the ground.

B3.4 Based on local climatic wind condition, meteorological data on the precise wind direction and velocity of the proposed site location for the month of December, March, June and September shall be used for the CFD simulation. The prevailing wind condition such as the mean speed and direction for Malaysia shall be taken from Table B3.4 below. The inbound vertical wind profile shall assume to be given by the Logarithmic Law reference height at 15.0m

Table B3.4: Tabulation of Prevailing Wind Direction & Speed obtained from Malaysian Meteorological Department (MMD) over a period of 18 years.

Wind Direction	Mean Speed (m/s)
North	2.0
North-East	2.9
South	2.8
South-East	3.2

B3.5 There shall have two large scale simulation models using the specified computational domain and grid stated in paragraph B3.2 and B3.3, to assess the wind flow conditions and air-flow pattern within the development and units. The simulation modelling can be conducted based on the two best prevailing wind directions for the building development that is North or North-East (N or NE) and South or South-East (S or SE).

Stage 1 CFD Simulation model for development	i. Determine up to five (5) typical unit design layouts that have the majority number of units. If the proposed building development comprises less than 5 typical types, all the typical unit design layout are to be selected for the simulation. ii. Conduct a large scale CFD simulation to assess the wind flow conditions around the proposed building development and adjacent buildings. Natural ventilated corridor linked to the unit should be taken into consideration for the simulation models. iii. From the simulation results, determine the wind pressure taken at 0.5m from every assumed opening of all units at mid height level (capped at 20 storey height) and the pressure difference (i.e. the difference of the maximum and minimum wind pressure) of each unit. In instances, where all or some of the typical unit layouts are not designed at mid-height level, the average wind pressure and respective pressure differences should be determined for these typical units located at the level closest to the mid-height level.

	iv. Derive the average pressure difference of all units at mid-height or selected level. v. Select the unit with pressure difference that is closest to the average pressure difference derived in B3.5 (iv) from each typical unit design layout as determined in B3.5 (i) for Stage 2 simulation. The maximum allowable margin of ± 10% difference from the average pressure difference is deemed acceptable.
Stage 2 CFD Simulation model for units	vi. Conduct a large scale CFD simulation to assess the air flow conditions of these five (5) selected units. All living or functional spaces in the unit are to be included in the simulation modelling except for enclosed spaces such as storeroom or CD shelter. For the simulation model, all windows and doors are assumed to be fully opened except for the main door, which is assumed to be closed at all time. vii. From the simulation results, determine the area-weighted average wind velocity of each selected unit by considering the air flow conditions of the applicable areas.

B3.6 The selected unit is deemed to have good natural ventilation if the area-weighted average wind velocity of the unit is not less than 0.6 m/s. The overall percentage of units achieving good natural ventilation is given by:

$$\frac{\sum(\text{No. of Selected Units for Each Layout} \times \text{Area-Weighted Average Wind Velocity})}{\text{Total Number of Selected Units} \times 0.60\ \text{m/s}} \times 100$$

B4 Documentation Requirements

B4.1 The Qualified Person (QP) and the other appropriate practitioners shall ensure that the following report is available as evidences to demonstrate compliance with the ventilation simulation framework. The report should comprise the following items:

i. Cover page with a proper title, photo of development, developers' information (including developers' name and address and person-in-charge), Consultant's detail (including the principal's name and authorized signature, firm's address and person-in-charge)

ii. Table of Content

iii. Executive Summary
- Background of the development
- Main findings
- Concluding remarks

iv. Background/Introduction

v. Methodology
- Describe methodology used in the study
- Provide the rationale for the units selection as well as salient information such as the total no. of units and different design units layout and location

vi. Geometrical Model should include
- Isometric view of the development from various angles
- Domain size used
- Plan and 3D isometric model of units from various angles

vii. Simulation settings
- Boundary conditions
- CFD software/models used/numerical scheme
- Mesh/cell sizing
- Solution control-converge criteria

viii. Result and discussions

- Simulation results for development for all directions showing the main graphical plots of the plan pressure and velocity vector and salient findings
- Tabulation showing the listing and details of all typical unit types and the selected unit types as well as the corresponding number of units and the area-weighted average wind velocity within each selected unit where applicable.
- Calculation of percentage of units with good natural ventilation and area-weighted average wind velocity of 0.60 m/s or more.

ix. Conclusion

x. The following plots are to be placed in the appendixes

- Simulation results for the development (done for each direction)
  - Static pressure (plan view-ground & mid elevation, isometric views on building facade)
  - Velocity vectors and contour showing the plan view at ground & mid elevation and a few isometric sectional cut plans to show air-flow patterns across the development
- Simulation results for the units for each direction
  - Static pressure (plan view-ground & mid elevation)
  - Velocity vectors and contour showing the plan view at ground & mid elevation