DESIGN REFERENCE GUIDE

Non-Residential Building

Version 3.1

15th March 2018

Contents

List of Appendices

1. About GreenRE

GreenRE Sdn Bhd is a wholly owned subsidiary of the Real Estate and Housing Development Association (REHDA). The GreenRE rating tool has been developed for the purposes as mentioned herein and may be subject to updating and/or modification in the future.

GreenRE Sdn Bhd
Wisma Rehda,
No.2C, Jalan SS5/6D,
47301 Petaling Jaya,
Selangor, Malaysia

2. Introduction

The GreenRE assessment scheme was established in 2013 and is a recognized green building rating system tailored for the tropical climate. GreenRE sets parameters and establishes indicators to guide the design, construction and operation of buildings towards increased energy effectiveness and enhanced environmental performance.

The intent of this Design Reference Guide for Non-Residential Buildings (referred to as “this Guideline”) is to establish environmentally friendly practices for the planning, design and construction of buildings, which would help to mitigate the environmental impact of built structures.

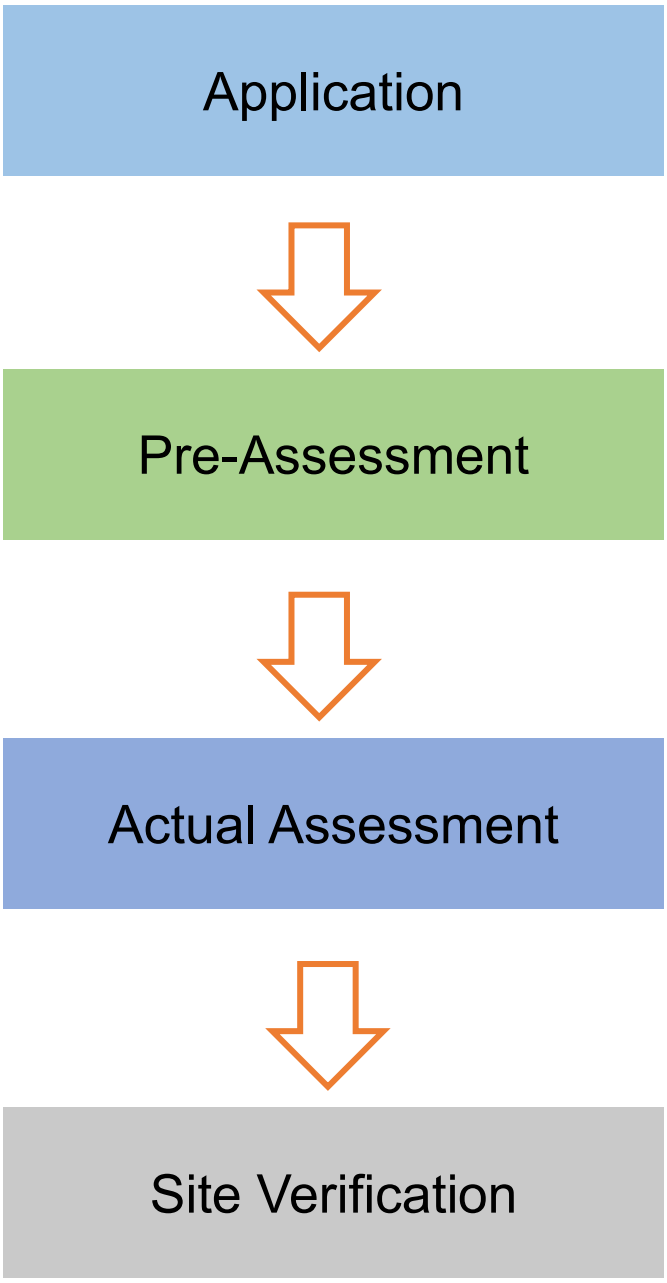
This Guideline is not intended to abridge safety, health, environmental or related requirements contained in other applicable laws, codes or policies administered by relevant authorities. Where there is a conflict between a requirement of this Guideline and such other regulations affecting the design, construction and operation of the project, the building regulations shall take precedence.

3. Revision Log

Revision	Description	Date Effective
1.1	Issued for Implementation	1st June 2013
1.2	Revised version of implementation	1st June 2014
2.0	Revised version of implementation	1st June 2015
3.0	Revised version of implementation	1st October 2015
3.1	Revised version of implementation	15th March 2018

4. GreenRE Assessment Stages

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



Submittal of application with relevant supporting documents for certification upon strategic inception of infrastructure project.

A pre-assessment can be conducted (optional) to give the project team a better understanding of the criteria and evaluation of the certification level sought. This should be performed upon selection of suitable design option to allow teams to identify and maximise opportunities at the earliest stages of the project.

Actual assessment to be conducted once the design and documentary evidences (e.g. approved plan) are ready. After the actual assessment, our assessors will review the documents submitted.

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

(i) The intents of the criteria
(ii) The pre-requisite requirement for GreenRE Bronze, Silver, Gold and Platinum rating where applicable.

Provisional Certificate will be issued upon completion of this stage.

Site verification to be conducted upon project completion.

Final Certificate will be issued upon completion of this stage.

5. GreenRE Non-Residential Building Rating System

Overview:

The GreenRE non-residential building rating system is divided into six (6) sections as follows:

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.

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

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.

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.

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.

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.

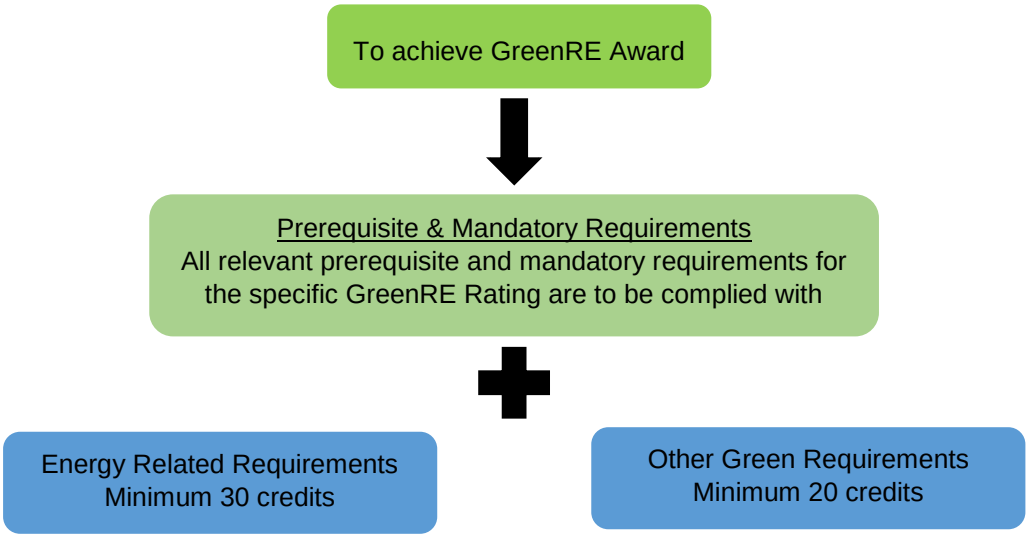
Energy Related Requirements consist of Part 1- Energy Efficiency where credits are allocated for the various energy efficient designs, practices and features used. A minimum of 30 credits must be obtained from this group to be eligible for certification. The number of credits achievable for this group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

The maximum GreenRE score achievable for a project is capped at 100 credits and this does not include 20 bonus credits 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 credits allocated are to be prorated in accordance with the respective floor areas. For simplicity, credits applicable to air-conditioned areas are accounted only if the aggregate air-conditioned areas exceed 500 m^2. Similarly, credits 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 and common areas.

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/Mechanical Ventilation
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

Credit Allocation:

Category			Credits Allocation
	(I) Energy Related Requirements		
Minimum 30 credits	**Part 1: Energy Efficiency**		
	NRB 1-1 Thermal Performance of Building Envelope – OTTV	Section (A) Applicable to air-cond. areas	15
	NRB 1-2 Air – Conditioning System		33
	Sub -Total (A) – NRB 1-1 to 1-2		**48**
	NRB 1-3 Building Envelope – Design/ Thermal Parameters	Section (B) Applicable to non air- cond. areas	30
	NRB 1-4 Natural Ventilation/Mechanical Ventilation		20
	Sub – Total (B) – NRB 1-3 to 1-4		**50**
	NRB 1-5 Daylighting	Section(C) Applicable to all areas	6
	NRB 1-6 Artificial Lighting		12
	NRB 1-7 Ventilation in Carparks		4
	NRB 1-8 Ventilation in Common Areas		5
	NRB 1-9 Lifts and Escalators		3
	NRB 1-10 Energy Efficient Practices & Features		13
	NRB 1-11 Renewable Energy		20
	Sub – Total (C) – NRB 1-5 to 1-11		**63**
	Category Score for Part 1 – Energy Efficiency [Prorate Subtotal (A) + Prorate Subtotal (B)] + Subtotal (C)		**114 (MAX)**
	(II) Other Green Requirements		
Minimum 20 credits	**Part 2: Water Efficiency**		
	NRB 2-1 Water Efficient Fittings		8
	NRB 2-2 Water Usage and Leak Detection		2
	NRB 2-3 Irrigation System and Landscaping		3
	NRB 2-4 Water Consumption of Cooling Tower		2
	Category Score for Part 2 – Water Efficiency		**15**
	Part 3: Environmental Protection		
	NRB 3-1 Sustainable Construction		10
	NRB 3-2 Sustainable Products		8
	NRB 3-3 Greenery Provision		8
	NRB 3-4 Environmental Management Practice		10
	NRB 3-5 Green Transport		4
	NRB 3-6 Stormwater Management		3
	NRB 3-7 Refrigerants		2
	Category Score for Part 3 – Environmental Protection		**45**
	Part 4: Indoor Environmental Quality		
	NRB 4-1 Thermal Comfort		2
	NRB 4-2 Noise Level		1
	NRB 4-3 Indoor Air pollutants		2
	NRB 4-4 Indoor Air Quality (IAQ) Management		2
	NRB 4-5 High Frequency Ballasts		2
	Category Score for Part 4: Indoor Environmental Quality		**9**
	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		3
	Category Score for Part 6: Carbon Emission of Development		**3**
	Category Score for Part 2 to Part 6 – Other Green Requirements		**78**
	GreenRE Non-Residential Building Score:		**193 (MAX)**

6. GreenRE Non-Residential Building Rating System Scoring

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

7. GreenRE Non-Residential Building Rating System Criteria

Pre-requisites:

1) Air-Conditioned Buildings

General

- 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

- Minimum score under NRB 3-2 Sustainable Products
  GreenRE Gold ≥ 3 credits
  GreenRE Platinum ≥ 4 credits

Minimum System Efficiency

- Minimum Design System Efficiency/Operating System Efficiency (DSE/OSE)

(i) For buildings using Water-Cooled Chilled Water Plant

GreenRE Rating	Building Cooling Load (RT)	
	< 500	≥ 500
	Efficiency (kW/RT)	
Bronze	0.85	0.75
Silver	0.80	0.70
Gold	0.75	0.68
Platinum	0.70	0.65

(ii) For buildings using Air-Cooled Chilled Water Plant or Unitary Air-Conditioner

GreenRE Rating	Building Cooling Load (RT)	
	< 500	≥ 500
	Efficiency (kW/RT)	
Bronze	1.1	1.0
Silver	1.0	Not applicable[(i)]
Gold	0.85	
Platinum	0.78	

(i) For building with building cooling load of more than 500RT, the use of air cooled central chilled water plant or other unitary air-conditioners are not applicable for Silver and higher ratings. In general, the system efficiency of the air cooled central chilled-water plant and other unitary air-conditioners are to be comparable with the stipulated efficiency for water-cooled central chilled-water plant. Buildings that are designed with air cooled systems and for higher GreenRE rating will be assessed on a case by case basis.

Note: The performance of the overall air-conditioning system for the building is based on the Operating System Efficiency (OSE) of the system during normal building operating hours as defined below:

Office Building Monday to Friday: 9am to 6pm Retail Mall: Monday to Sunday: 10am to 9pm Institutional: Monday to Friday: 9am to 5pm	Hotel and Hospital: 24-hour Industrial and Other Building Types: To be determined based on the operating hours

Chiller Plant M&V Instrumentation

- Provision of permanent measuring instruments for monitoring of water-cooled chilled-water system and air-cooled chilled water system operating system efficiency. The installed instrumentation shall have the capability to calculate resultant plant operating system efficiency (i.e. kW/RT) within 5% of its true value and in accordance with ASHRAE Guide 22 and AHRI 550/590. Heat balance test for water-cooled chilled water system is required for verification of the accuracy of the Measurement and Verification (M&V) instrumentation.

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

- Minimum score under NRB 3-2 Sustainable Products
  GreenRE Gold ≥ 3 credits
  GreenRE Platinum ≥ 4 credits

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

<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>

Applicable to Air-conditioned Building Areas (with an aggregate air-conditioned areas > 1000m^2)

Encourage the use of better efficiency air-conditioned equipment to minimize the energy consumption.
(System efficiency in kW/ton)

<u>(a) Water-Cooled Chilled-Water Plant:</u>
i. Water-Cooled Chiller
ii. Chilled water pump
iii. Condenser water pump
iv. Cooling tower

<table>
<tr><td rowspan="2">Baseline</td><td colspan="2">Building Cooling Load</td></tr>
<tr><td>< 500 RT</td><td>≥ 500 RT</td></tr>
<tr><td><u>Prerequisite Requirements</u>
Minimum system efficiency of central chilled-water plant</td><td>0.85 kW/RT</td><td>0.75 kW/RT</td></tr>
</table>
</td><td><u>(a) Water-Cooled Chilled-Water Plant:</u>

Building cooling load < 500RT

14 credits for achieving plant efficiency of 0.85 kW/ton

0.3 credit for every percentage improvement in the chiller plant efficiency better than 0.85 kW/ton

Credit scored = 0.3 x (% improvement)

Building cooling load ≥ 500RT

14 credits for achieving plant efficiency of 0.75 kW/ton

0.35 credit for every percentage improvement in the chiller plant efficiency better than 0.75 kW/ton

Credit scored = 0.35 x (% improvement)

(up to 20 credits)</td></tr>
</table>

OR

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

Air cooled Chilled-Water Plant:

- Air-Cooled Chiller
- Chilled Water Pump

Unitary Air-Conditioners:

- Variable Refrigerant Flow (VRF) System
- Water-Cooled Package Unit
- Single-Split Unit
- Multi-Split Unit

Baseline	Building Cooling Load	
	< 500 RT	≥ 500 RT
Prerequisite Requirements Minimum system efficiency of air cooled chilled water plant or unitary conditioners	1.1 kW/RT	1.0 kW/RT

Note(1): 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.

(c) Air Distribution system:

- Air Handling units (AHUs)
- Fan Coil Units (FCUs)

Baseline – Fan power limitation in air conditioning system

Allowable nameplate motor power	
Constant volume	Variable volume
1.7 kW/m^3/s	2.4 kW/m^3/s

Note (2): For buildings using district cooling system, there is no need to compute the plant efficiency under Part 1-2 (a) and (b). The credits obtained will be pro-rated based on the air distribution system efficiency under Part 1-2(c).

OR

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

Building cooling load < 500RT

14 credits for achieving plant efficiency of 1.1 kW/ton

0.2 credit for every percentage improvement in the chiller plant efficiency better than 1.1 kW/ton

Credit scored = 0.2 x (% improvement)

Building cooling load ≥ 500RT

14 credits for achieving plant efficiency of 1.0 kW/ton

0.25 credit for every percentage improvement in the chiller plant efficiency better than 1.0 kW/tom

Credit scored = 0.25 x (% improvement)

(up to 20 credits)

(c) Air Distribution system:

0.15 credits for every percentage improvement in the air distribution system efficiency over the baseline

Credit scored = 0.15 x (% improvement)

(up to 8 credits)

(d) *Prerequisite requirements:* Provision of permanent measuring instruments for monitoring of water-cooled chilled water plant and air-cooled chilled water plant efficiency. The installed instrumentation shall have the capability to calculate resultant plant efficiency (i.e. kW/RT) within 5% of its true value and in accordance with ASHRAE Guide 22 and AHRI 550/590. The following instrumentation and installation are also required to be complied: • Location and installation of the measuring devices to meet the manufacturer's recommendation. • Data acquisition system to have a minimum resolution of 16 bit. • All data logging with capability to trend at 1minute sampling time interval. • Dedicated digital power meters shall be provided for the following groups of equipment: chiller(s), chilled water pump(s), condenser water pump(s) and cooling tower(s). • Flow meters to be provided for chilled-water and condenser water loop and shall be of ultrasonic / full bore magnetic type or equivalent. • Temperature sensors are to be provided for chilled water and condenser water loop and shall have an end-to-end measurement uncertainty not exceeding ± 0.05°C over entire measurement or calibration range. All thermo-wells shall be installed in a manner that ensures that the sensors can be in direct contact with fluid flow. Provisions shall be made for each temperature measurement location to have two spare thermo-wells located at both side of the temperature sensor for verification of measurement accuracy.	Applicable only to buildings with provision of water-cooled chilled water plants 2 credits
(e) *Prerequisite requirements*: Verification of central water cooled chilled-water plant instrumentation: Heat Balance – substantiating test for water cooled chilled-water plant to be computed in accordance with AHRI 550/590. The operating system efficiency and heat	1 credit

balance to be submitted to GreenRE upon commissioning. (f) Provision of variable speed controls for chiller plant equipment such as chilled-water pumps and cooling tower fans to ensure better part-load plant efficiency. (g) Sensors or similar automatic control devices are used to regulate outdoor air flow rate to maintain the concentration of carbon dioxide. Indoor carbon dioxide acceptable range ≤700 ppm above outdoor concentration.	1 credit 1 credit
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 or mechanical 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 25 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)]

<table>
<tr>
<td>(b)(ii) Effective sun shading provision for windows on the west façade with minimum shading of 30%.

(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^{2}K

(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>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))

Credits scored = 0.05 x (% of the external west facing walls areas with U-value of 2 W/m^{2}K or less over the total west facing façade areas)

(Up to 5 credits)

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 / MECHANICAL VENTILATION</u>

(a) <u>Natural Ventilation</u>
Encourage building that facilitates good natural ventilation.

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

(ii) Use of ventilation simulation modelling and analysis or wind tunnel testing to identify the most effective building design and layout to ensure good natural ventilation.

<u>Prerequisite requirement:</u> Green Mark Platinum: Ventilation simulation modelling and analysis are to be carried out to ensure good natural ventilation</td>
<td>1 credit for every 10% of NV areas with window openings facing north and south directions and cross ventilation
Credits scored = 1 x (% units/10)
(Up to 10 credits)

5 credits
(Additional 5 credits if the recommendations are implemented and meet air-flow requirements – up to 10 credits)</td>
</tr>
</table>

<table>
<tr><td>with minimum weighted average wind velocity of 0.6m/s within the functional spaces or units.

OR

(b) <u>Mechanical Ventilation</u>
Encourage energy efficient mechanical ventilation system as the preferred ventilation mode to non-air-conditioning in buildings.

Baseline: Fan power limitation in mechanical ventilation systems:

<table><tr><th colspan="2">Allowable nameplate motor power</th></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 (3): Where there is a combination of naturally ventilated and mechanical ventilated spaces, the credits scored will only be based on the predominant ventilation modes of normally occupied spaces.</td><td>OR

0.6 credit for every subsequent 1% improvement from the baseline
Credits scored = 0.6 x (% improvement)

(Up to 15 credits)</td></tr>
<tr><td>Sub-Total (B):</td><td>Sum of GreenRE credits obtained from NRB 1-3 to 1-4</td></tr>
<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 normally occupied areas 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>
</table>

<table>
<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

Note: For retail applications, the following lighting power budget baselines shall be used:
<table><tr><th>Retail type</th><th>Baseline</th></tr><tr><td>Fashion</td><td>≤36.0 W/m^2</td></tr><tr><td>Specialty</td><td>≤50.0 W/m^2</td></tr><tr><td>General</td><td>≤25.0 W/m^2</td></tr></table>
Fashion – Clothing, shoes, apparel,
Specialty – Jewelry, watch, electrical, IT and optical
General – Books, media, banks, new-agents etc.</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 – 4 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 4 credits)</td>
</tr>
<tr>
<td><u>NRB 1-8 VENTILATION IN COMMON AREAS</u>

Encourage the use of energy efficient design and control of ventilation systems in the following common areas:
• Toilets
• Staircases
• Lift Lobbies
• Corridors
• Atriums</td>
<td>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)</td>
</tr>
</table>

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 11 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 OR 3 credits for every 10% of roof area used for solar panels. (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 50% 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 OPC by approved industrial by-products	Credits Allocation
10	1
20	2
30	3
40	4
>50	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.

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

</td><td>

Extent of use of environmentally friendly product	Weightage for Credit Allocation
Low Impact	0.5
Medium impact	1
High Impact	2

Credits scored will be based on the extent of use of environmentally friendly product.

(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. (at least 20%)

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) To performs IBS content scoring based on CIDB IBS scoring scheme.

1 credit for IBS score ≥ 50%

2 credits for IBS score ≥ 70%

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

0.25 credit for each firm
(Up to 1 credit)

(f) Project team comprises one Certified GreenRE/Green Mark Manager (GM)

1 credit for certified GRM/GMM

(g) 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
(h) Provision of green fit out guidelines to detail recommended minimum environmental standards to assist building users' in making sustainable fit-out decisions.	1 credit
(i) 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.	1 credit
(b) Provision of covered walkway to facilitate connectivity and the use of public transport.	1 credit
(c) Provision of infrastructure for electric charging stations to at least 10% of available parking spaces.	1 credit
(d) Provision of hybrid/electric vehicle charging stations and priority parking lots within the development.	Extent of coverage: Minimum 1 number priority parking bays for every 100 carpark lots. EV chargers – 1 for every 200 parking bays. (Cap at 3) (1 credit)
(e) Provision of covered / sheltered bicycles parking lots (i.e with rack / bar) and adequate shower and changing facilities.	Extent of Coverage : Minimum 10 number and maximum 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.	Reduce post development stormwater peak discharge rate and quantity from exceeding pre-development peak discharge rate and quantity:

Provision of infiltration features or design features for new development and redevelopment in accordance with MSMA.	5 - 15% - 1 credit 16 - 25% - 2 credits > 25% - 3 credits (Up to 3 credits)
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% Note: Additional 1 credit will be awarded for room temperature and humidity displays in all applicable areas.	1 credit 1 credit (Up to 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}	1 credit
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).	1 credit

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
<u>NRB 4-5 HIGH FREQUENCY BALLASTS / LED DRIVERS</u> Improve workplace lighting quality by avoiding low frequency flicker associated with fluorescent lighting with the use of high frequency ballasts in the fluorescent luminaries. Use of driver with output frequency < 200Hz and < 30% flicker for LED lighting.	Extent of Coverage: At least 90% of all applicable areas that are served by fluorescent luminaries 1 credits 1 credit
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 • 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 Footprint of Development	GreenRE Credits
RES 6-1 CARBON FOOTPRINT OF DEVELOPMENT Recognise the carbon emission based on operational carbon footprint computation of the building comprising energy and water consumption To identify carbon debt and quantify environmental impact and embodied energy, as well as allow benchmarking of projects over time using BCA's online embodied carbon calculator.	1 credit 1 credit – Carbon footprint calculation of any four (4) building materials listed 2 credits – complete carbon footprint calculation for all building materials listed. (up to 2 credits)
PART 6- CARBON FOOTPRINT OF 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

(I) Energy Related Requirements

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	• Site plan with clearly demarcated the orientation of the building. • Architectural elevation drawings showing the composition of the different façade or wall systems that are relevant for the computation of OTTV. • Glazing specification showing the U Value and SC Value. • Window and door schedule. • Detailed area (m2) tabulation of fenestration and wall for every façade showing the window to wall ratio (WWR). • Calculation of U Value for all type of external walls. • Calculation of the Shading Coefficient for external shading device. • OTTV calculation for each facing wall. • A drawing showing the cross-sections of typical parts of the roof construction, giving details of the type and thickness of basic construction materials, insulation and air space. • The U-value of the roof assembly and technical specification of the roof insulation (if any). *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.* • RTTV Calculation (if applicable) • Skylight specification showing the U Value and SC Value.
References	MS1525:2014- Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings - Code of Practice

NRB 1-2 AIR-CONDITIONING SYSTEM

<table>
<tr><td>Objectives</td><td>Encourage the use of better efficient air-conditioned equipment to minimise energy consumption.</td></tr>
<tr><td>Applicability</td><td>Applicable to air-conditioned building areas where its aggregate air-conditioned areas > 1000m^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</td></tr>
<tr><td>Baseline Standard</td><td>Minimum efficiency requirement of the air-conditioning system stated in MS 1525:2014 or SS 530 & SS CP 13.

1-2(a) <u>Water-Cooled Chilled Water Plant</u>

<table>
<tr><td rowspan="2">Baseline</td><td colspan="2">Building Cooling Load</td></tr>
<tr><td>< 500 RT</td><td>≥ 500 RT</td></tr>
<tr><td><u>Prerequisite Requirements</u>
Minimum system efficiency of central chilled-water plant</td><td>0.85 kW/RT</td><td>0.75 kW/RT</td></tr>
</table>

i. Water-Cooled Chiller – Refer Table 23 of MS 1525:2014 to calculate Its Coefficient of Performance (COP)

ii & iii. Chilled-water pump 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)

iv. Cooling tower performance at the rating condition states in Table 3 SS 530.

<u>Rating condition is as follows</u>: 35°C Entering water
29°C Leaving water
24°C Wet Bulb Outdoor air

<u>Propeller and axial fan cooling tower:</u></td></tr>
</table>

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

Centrifugal fan cooling tower:
With heat rejected from every 1.7L/s of condenser water per 1kW of fan power rating:

Cooling tower performance ≤ 1kW / 1.7 L/s
≤ 0.588 kW / L/s

OR

1-2(b) Air-Cooled Chilled-Water Plant / Unitary Air-Conditioners

Baseline	Building Cooling Load	
	< 500 RT	≥ 500 RT
Prerequisite Requirements Minimum system efficiency of air cooled chilled water plant or unitary conditioners	1.1 kW/RT	1.0 kW/RT

- Air-cooled chilled water plant - Refer Table 23 of MS 1525:2014 to calculate its Coefficient of Performance (COP).
- Unitary Air-Conditioners / Condensing Units – Refer Table 21 of MS 1525:2014.

Note: If the specific type of air conditioned is not found in MS 1525:2014, please refer to SS 530 to make the calculation on COP. Priority given to MS 1525:2014.

1-2(c) Air Distribution System – Refer to Clause 7.11.5 in CP 13

- For fan systems which are able to vary system air volume (VAV) automatically as a function of load, the power required by the motors for the combined fan system at the design conditions shall not exceed 2.4 kW/m^3/s of supply air
- For Constant Air Volume (CAV), the motors for fan system shall not exceed 1.7 kW/m^3/s of supply air.

Allowable nameplate motor power	
Constant volume	Variable volume
1.7 kW/m^3/s	2.4 kW/m^3/s

1-2(d) Provision of permanent measuring instruments to monitor water-cooled and air-cooled chilled water plant

- The instrumentation installed in the system shall have capability to calculate resultant plant efficiency within ± 5% of its true value – Refer ASHRAE Guide 22 and AHRI 550/590.
- The following instrumentation accuracy as follow can be considered for monitoring central water-cooled chilled plant efficiency.

Description	Measurement error
<u>Temperature sensors</u> - 10K/30K Thermistor - Platinum Resistance Thermometers	± 0.03 – 0.05 °C at 0°C
<u>Floor Sensor Meter</u> - Ultrasonic - Full bore magnetic	± 0.5 – 1.0 % over entire measurement range
Power meter	ANSI C12.1-2008, Class 1 ±1%

1-2(e) <u>Verification of central chilled water plant instrumentation – Heat Balance substantiating test</u>

- Substantiating test shall be conducted as accordance to AHRI 550/590
- The heat balance shall be conducted over entire normal operating hours with more than 80% of the computed balance within ± 5% over the audit period

Heat balance is denoted by below equation:

$q_{condenser} = q_{evaporator} + W_{input}$

Where;

$q_{condenser}$ = heat rejected (in kW or RT)
$q_{evaporator}$ = cooling load (in kW or RT)
W_{input} = measured electrical power input to compressor

1-2(f) Provisioning of variable speed controls for chiller plant equipment

1-2(g) Provisioning of automatic control devices or sensors to regulate outdoor air flow rate to maintain the concentration of Carbon Dioxide at acceptable range ≤700 ppm above outdoor concentration.

Requirements

<u>1-2(a) Air-Conditioned Plant (Up to 20 credits)</u>

- **Building cooling load ≥ 500RT** :

14 credits for achieving plant efficiency of 0.75 kW/ton

	0.35 credit for every percentage improvement in the chiller plant efficiency better than 0.75 kW/ton Credit scored = 0.35 x (% improvement) • **Building cooling load < 500RT:** 14 credits for achieving plant efficiency of 0.85 kW/ton 0.3 credit for every percentage improvement in the chiller plant efficiency better than 0.85 kW/ton Credit scored = 0.3 x (% improvement) (up to 20 credits) **OR** <u>1-2(b) Air-Conditioned Plant (Up to 20 credits)</u> • **Building cooling load ≥ 500RT** : 14 credits for achieving plant efficiency of 1.0 kW/ton 0.25 credit for every percentage improvement in the chiller plant efficiency better than 1.0 kW/ton Credit scored = 0.25 x (% improvement) • **Building cooling load < 500RT:** 14 credits for achieving plant efficiency of 1.1 kW/ton 0.2 credit for every percentage improvement in the chiller plant efficiency better than 1.1 kW/ton Credit scored = 0.2 x (% improvement) (up to 20 credits) <u>1-2 (c) Air Distribution System (Up to 8 credits)</u> 0.15 credits for every percentage improvement in the air distribution system efficiency above the baseline. Credits scored = 0.15 x (% improvement) Note (1): For building using district cooling system, there is no need to compute the plant efficiency under item ENRB 1-2(a). The credit obtained will be pro-rated based on the air distribution system efficiency under ENRB 1-2(c). 1-2 (d) 2 credit can be scored for the provision of permanent measuring

	instruments for monitoring of water cooled chilled-water plant and air-cooled chilled water plant efficiency 1-2 (e) 1 credit can be scored for verification of central water cooled chilled-water plant instrumentation: Heat Balance – substantiating test for water cooled chilled-water plant to be computed in accordance with AHRI 550/590. The operating system efficiency and heat balance to be submitted to GreenRE upon commissioning. 1-2(f) 1 credit can be scored if variable speed controls for chiller plant equipment such as chilled-water pumps and cooling tower fans are provided to ensure better part-load plant efficiency. 1-2(g) 1 credit 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) ≤ 700 ppm above outdoor.
Documentary Evidences	<u>For 1-2 (a) and 1-2 (b)</u> • Detailed calculations of the overall improvement in equipment/system efficiency of the air-conditioning plants/ units 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. • Technical product information of all air-conditioning and system which included chillers, chilled water pumps, condenser water pumps, cooling towers. • Schematic drawings showing the air-conditioning system. • Schedules of the air-conditioning system. <u>For 1-2 (c)</u> • Detailed calculations of the overall improvement for air distribution system. • Technical product information of all AHUs, FCUs, and etc. • AHUs and FCUs schedule and schematic drawing. <u>For 1-2 (d)</u> • Instrument's calibration certificates from accredited laboratory or batch calibration certificates from manufacturer. • Schematic drawing showing the location of the digital power meters, flow meters and temperature sensors. • Summary of instruments, standard and measurement accuracy to be presented in the following format:

	<table><tr><th>Instruments</th><th>Instruments calibration standard</th><th>Quantity</th><th>Measurement Error (% of reading)</th><th>Resultant Error (% kW/RT)</th><th>Type/Brand/ Model</th></tr><tr><td>Temperature/ Sensors</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Flow meter/ Sensors</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>Power Meter</td><td></td><td></td><td></td><td></td><td></td></tr></table> • Technical specification of the digital power meters, flow meters and temperature sensors. <u>For 1-2 (e)</u> • Computation of the percent heat balance that is the total heat gain and total heat rejected must be within ± 5% for 80% of the sampled credits over the normal building operations hours accordance with AHRI550/590. • Detailed calculations of the overall uncertainly of measurement of the resultant chiller plant efficiency in kW/RT to be within ± 5% of the true value based on instrumentation specification. <u>For 1-2 (f) and 1-2 (g)</u> • Extracts of the tender specification showing the requirements to incorporate these control devices. • Plan layouts showing the locations and the types of control devices used to regulate fresh air intake. • Technical product specification of the control devices.
References	(a) MS 1525:2014 – Energy efficient and use of renewable energy for non-residential building – Code of Practice (b) SS 530 – Code of Practice 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)** <u>For 1-2(a) (ii)</u> An air-conditioned building equipped 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 <u>For 1-2(a) (i),</u> The pro-rate calculation shall be; <u>4 credits</u> x 20 credits = 16 credits 5 credits Total credits scored for part 1-2(a)(i) and 1-2(a)(ii) = 4 + 16 = 20 credits

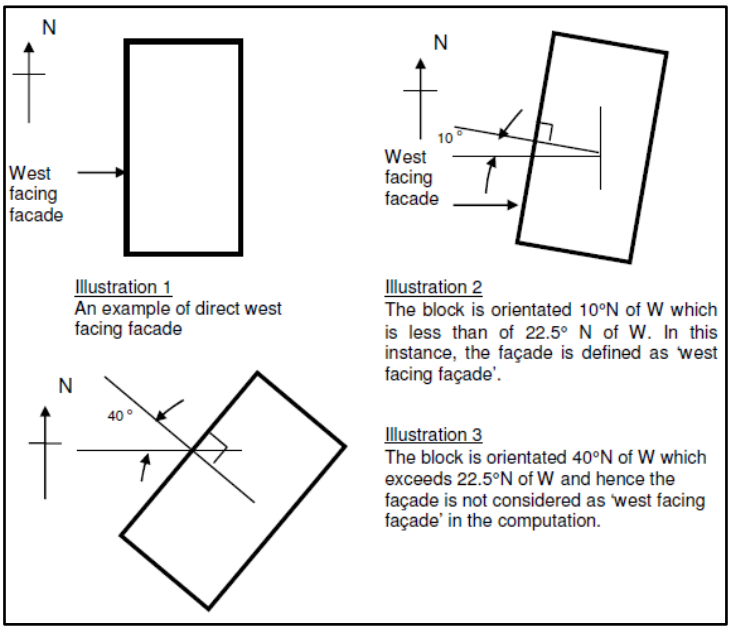
NRB 1-3 BUILDING ENVELOPE – DESIGN/THERMAL PARAMETERS

<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

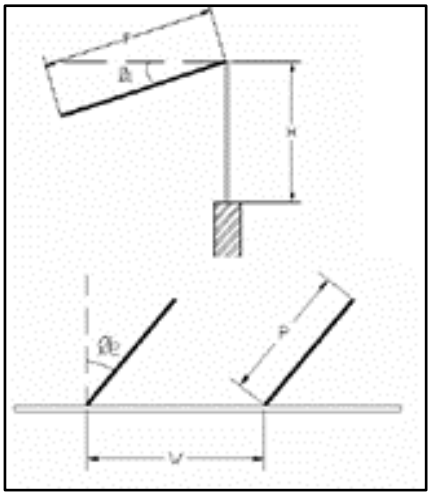
Types of Sunshading Devices	Angle of inclination	Desired Shading			
		30%	40%	50%	60%
Horizontal Shading (R_1)	**0°**	0.6	0.9	1.5	
	20°	0.4	0.6	0.9	1.8
	40°	0.4	0.5	0.7	1.1
Vertical Shading (R_2)	**0°**	2.1			
	20°	1.1	1.7	2.5	
	40°	0.7	1	1.4	
	50°	0.6	0.9	1.1	2.8

Where

Horizontal Shading/ Projections (R_1)

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

$Ø_1$ = Angle of inclination



Vertical Shading/ Projections (R_2)

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

$Ø_2$ = Angle of inclination

1-3(c) Up to 5 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^{2}K.

Credits scored = 0.04 x (% of the external west facing walls areas with U-value of 2 W/m^{2}K 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^{2}K 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 all façade. Highlight those areas that are considered as west facing façade.
- 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 highlight the window openings.
- Sectional drawing showing the details of the sun shading devices. Highlight those sun shading devices that meet the 30% shading requirement.
- Window schedules.
- Calculation showing the percentage of west facing window areas in the prescribed tabulated format.

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

Description	**Area of west facing window area (m^2)**	**Total area of west facing external façade (m^2)**	**% of west facing window areas over total west facing**

	(a)	(b)	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)]

- Calculation showing the percentage of west facing window with the provision of sun shading devices meet at least of 30%.

For 1-3(c)

- Architectural drawings highlighting the material types and walls.
- Detailed sectional drawings showing the wall composition and the respective U-values calculation.
- Extracts of the tender specification which states the thermal transmittance (K-value) properties to be adopted for west facing walls.
- Technical product information of the insulation materials (if applicable).
- 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)]

For 1-3(d)

- Roof layout and sectional details of the development.
- Extracts of the tender specification which states the thermal transmittance properties of roof.
- Detailed sectional drawings showing the roof composition and the respective U-values and calculation showing the average reduction.
- Technical product information of the insulation materials (if applicable).

Table 1-3(d): Better thermal transmittance of roof

Roof Type	Weight Group	Weight range (kg/m^2)	Maximum Thermal Transmittance (w/m^2K)	Designed U-value (W/m^2K)	Reduction (W/m^2K)
Roof 1	Light	Under 50	0.4		
Roof 2	Heavy	Above 50	0.6		

References

-

NRB 1-4 NATURAL VENTILATION / MECHANICAL VENTILATION

<table>
<tr><td>Objectives</td><td>Encourage building that facilitates good natural ventilation. Encourage energy efficient mechanical ventilation system as the preferred ventilation mode to air-conditioning in buildings.</td></tr>
<tr><td>Applicability</td><td>Applicable to Non Air-Conditioned Building Areas (with an aggregate non air-conditioned areas > 10% of total floor area excluding carparks and common areas) for Natural Ventilation.</td></tr>
<tr><td>Baseline Standard</td><td>Fan power limitation in mechanical ventilation systems:

<table>
<tr><th colspan="2">Allowable nameplate motor power</th></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>
</td></tr>
<tr><td>Requirements</td><td><u>1-4(a) Natural Ventilation</u>

Up to 20 credits will be awarded for natural ventilation in the building.

10 base credits will be awarded for use of natural ventilation,

Up to 10 credits can be scored for building design that utilises prevailing wind conditions to achieve adequate cross ventilation.

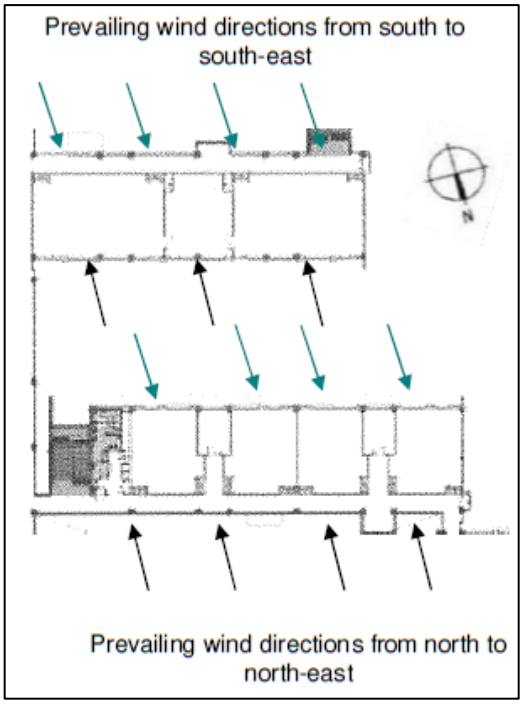
1 credits for every (10% of units/ rooms with window openings facing north and south directions)

Credits scored = 1 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.

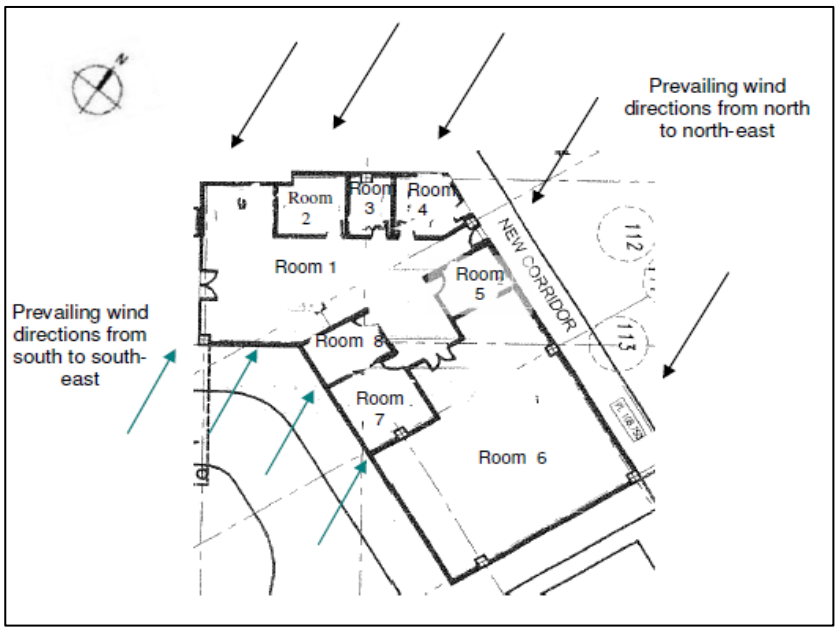
It is not necessary for the window openings to be located perpendicularly to the prevailing wind direction. An oblique angle is considered acceptable (see illustrations as shown in the next page).</td></tr>
</table>

Illustration 1-3.1: Orientation of facade facing North and South



Building layout shows all rooms with window openings facing the North and South directions.

Illustration 1-3.2: Orientation of facade facing North and South



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 1-3(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(a) below. Credits should only be scored if the recommendations from the simulation are implemented.

1-4(a) 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. And additional 5 credits 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.

1-4(b) Mechanical Ventilation

Up to 15 credits for the use of mechanical system in order to promote adequate ventilation between indoor and outdoor air.

0.6 credits for every subsequent 1% improvement in the baseline.

Documentary Evidences

1-4(a)(i) Building layout with the cross ventilation

- Architectural plan layouts showing the units / rooms of all blocks with highlights of those with north and south window openings.
- Calculation showing the percentage of units or rooms with window openings facing north and south directions in the prescribed formats as shown in Table 1-4(a).

Table 1-4(a) – Percentage of units with window opening in N-S direction

Ref	Description	Units/Rooms with window opening in the N-S direction (a)	Total no. of naturally ventilated units/room (b)	% of units/ rooms with window opening in N-S direction
1	Classroom Blk A & A1			∑ (a) / ∑(b) x 100
2	Classroom Blk B			
3	Offices, meeting rooms and computer rooms with air-conditioning			
	Total:			

Credits scored = 1.0 x (% of units / 10)
= 1.0 x [(∑ (a) / ∑(b) x 100) / 10] + 20 (for use of NV)

1-4(a)(ii) Ventilation simulation modelling

	• Ventilation simulation modelling result and analysis or wind tunnel testing to identify the most effective building design and layout which achieve average wind velocity at least 0.6m/s or more. • A summary of the recommendation from the ventilation simulation report. • Architectural plan layout highlights the implementation base on the recommendation from the report. <u>1-4(b) Mechanical Ventilation</u> • Plan layout demarcate the area with mechanical ventilation system. • The overall design and drawings for mechanical ventilation system to make up the required outdoor air quantity into the building at desire fan power limit. • Detailed calculations showing the fan power improvement. • Product catalogue of the fan power used.
References	SS CP 13 – Code of Practice for Mechanical Ventilation and Air-Conditioning Buildings

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 5.4.1 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 floor area of the habitable spaces in the development.
• Daylight simulation / calculation report summarizing the analysis and modelling results for each habitable space area that meets the requirement.
• Architectural plan layout showing glazing/window area for each habitable space.

<u>For 1-5(b)</u>
• Architectural plan layout showing the window/ glazing at the lift lobby, corridors, staircases and car parks (where applicable).
• Calculation showing the 80% of each common area with the daylight provision.</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>

<table>
<tr><td>Worked Example 1-5(a)</td><td>Tabulate occupied spaces and daylight factor achieved for all areas.

Calculate % of occupied areas achieving daylight factor between 1-3.5%

e.g % occupied areas with DF 1-3.5% = 60%

Credits scored for 1-5(a) = 1 credits</td></tr>
<tr><td>Worked Example 1-5(b)</td><td>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
<table><tr><th>No.</th><th>Criteria</th><th>Credit Allocated</th><th>Credit</th></tr><tr><td>1-5(b) (i)</td><td>Lift lobbies and corridors</td><td>1</td><td>1</td></tr><tr><td>1-5(b) (ii)</td><td>Staircases</td><td>1</td><td>1</td></tr><tr><td>1-5(b) (iii)</td><td>Day lighting for carparks.</td><td>1</td><td>0</td></tr><tr><td></td><td></td><td>TOTAL</td><td>2</td></tr></table>
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</td></tr>
</table>

NRB 1-6 ARTIFICIAL LIGHTING

<table>
<tr><td>Objectives</td><td>Encourage the use of better efficient lighting to minimise energy consumption from lighting usage while maintaining proper lighting level.</td></tr>
<tr><td>Applicability</td><td>Applicable to lighting provisions that designed in accordance to the luminance level as recommended in MS 1525: 2014.</td></tr>
<tr><td>Baseline Standard</td><td>Luminance level stated in MS 1525:2014 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice.</td></tr>
<tr><td>Requirements</td><td>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.

For retail applications, the following lighting power budget baselines shall apply:
<table><tr><td>Retail type</td><td>Baseline</td></tr><tr><td>Fashion</td><td>≤36.0 W/m^2</td></tr><tr><td>Specialty</td><td>≤50.0 W/m^2</td></tr><tr><td>General</td><td>≤25.0 W/m^2</td></tr></table>
Fashion – Clothing, shoes, apparel,
Specialty – Jewelry, watch, electrical, IT and optical
General – Books, media, banks, new-agents etc.</td></tr>
<tr><td>Documentary Evidences</td><td>• Lighting layout plan.
• Lighting schedules showing the numbers, locations and types of luminaries used.
• Calculation of the proposed lighting power budget and the percentage of improvement in the prescribed tabulated format shown in Table 1-6-1 and 2.
• Extract tender specification of lighting fittings used.
• Technical product information of the lighting luminaries used.
• Lux simulation result for all the spaces showing compliance with illuminance level in table 10, MS1525:2014.</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 1-6

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	<u>For 1-7 (a)</u> • Plan layouts showing all car park provision for the development with highlights of the car park spaces that are designed to be naturally ventilated. • Calculation showing the openings at the carpark level to meet the UBBL requirement. <u>For 1-7(b)</u> • Plan layouts showing all car park provision for the development with highlights of the car park spaces that are designed to be mechanical ventilated. • Plan layout indicating the location of CO sensors and the mode of ventilation adopted for the design. • Calculation showing the credits allocation if there is a combination of different ventilation mode adopted for the car park design. • Technical product information of CO sensors and mechanical ventilation.
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. 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 with proper demarcation of the opening. • Schedules showing the numbers, locations of the applicable areas and the mode of ventilation used. • Technical product information of mechanical ventilation system. (if applicable) of ventilation used • Schematic drawing of the mechanical ventilation system. • Calculation showing the credits allocation if there is a combination of different ventilation modes adopted for the applicable areas.
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 used. • Plan layout showing the location of the lifts and escalators. • Schedules showing the total number of lifts & escalators and its power consumption. • Technical information of the lifts & escalators.
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) using the pre-determined daily usage pattern.
• Detail calculation including operation hours for the estimated energy load for each component in the building etc.: lighting, air conditioning system, pump, receptacle load.
• Technical product information and related drawing on the energy efficient features.
• List of the assumption for the EEI calculation.

<u>For 1-10(b)</u>
• Landscape plan layout showing the vertical greenery provision and building elevation.
• Calculation showing the extent of the vertical greenery provision over the east and west façade areas.

<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 and related drawing on the energy efficient features used.
• Calculation of the percentage energy saving 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>
</table>
</td></tr>
</table>

Domestic Water Pump Systems	226088
Hot Water Systems	93789
Others	-
Total :	17596015

*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. **OR** 3 credits for every 10% of roof area used for solar panels.
Documentary Evidences	• Extract of the tender specification of the renewable energy system and the extent of implementation.Technical product information for the renewable energy system and the expected renewable energy generated.Calculation of the percentage replacement of electricity and the total annual electricity consumption of the development. • Architectural plan and elevations marking out areas allocated a renewable energy.
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

Objectives	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).

<table>
<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 in the prescribed tabulated format shown in the Table 2.1-1.
Schematic drawing of cold water and sanitary plumbing.
WEPLS or WELS product specification or certificate. In the event no product recognition from WEPLS or WELS, product catalogue and test report from local or international body that equivalent to the SIRIM standard of testing is required.</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>
<tr><td>Worked Example 2-1</td><td>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
<table><tr><th>Ref.</th><th></th><th>WEPLS rating</th><th></th><th>Total</th></tr></table></td></tr>
</table>

	Water Fitting Type	Efficient	Highly Efficient	Most Efficient	Not Rated	
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 locations and provision of sub meters for all major water uses. • List of a submeter and its location. • Schematic drawings of cold water distribution system showing the location of the sub meters provided. For 2-2(b) • Extracts from the tender specification and schematic drawing showing the location of sub-metering and its linkage to the Building Management System (BMS). • List of input and output point of the Building Management System (BMS) with highlighted the submeter point. • Write up on the specific alert features that can be triggered and detect the water leakage during operation.
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 50% of the landscape areas consist of drought tolerant plants or plants that require minimal irrigation.
Documentary Evidences	<u>For 2-3(a)</u> • 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 <u>For 2-3(b)</u> • 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 (at least 50%) • Product technical information of the irrigation system. <u>For 2-3(c)</u> • Relevant layout plans showing the overall landscape areas and the areas that use drought tolerant plants or plants that require minimal irrigation. • Calculation showing the percentage of the landscape areas that use drought tolerant plants or plants that require minimal irrigation (at least 50%). • Plant species showing the minimum water requirement.
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	<u>For 2-4(a)</u> • Extracts of the tender specification showing the requirements to incorporate with the cooling tower designs to achieve six cycles of concentration. • Details showing how the cooling towers have been designed to achieve at least six cycles of concentration. • Relevant drawings showing the location of the cooling towers and other supporting systems that are required to achieve the designed concentration. <u>For 2-4(b)</u> • Extracts of the tender specification showing how the recycled water source is to be provided. • Details of the recycled water system. • Schematic system showing the recycling system.
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 OPC by approved industrial by-products (%)</th><th>Credit Allocation</th></tr><tr><td>10</td><td>1</td></tr><tr><td>20</td><td>2</td></tr><tr><td>30</td><td>3</td></tr><tr><td>40</td><td>4</td></tr><tr><td>>50</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 :

$\text{Concrete Usage Index} = \frac{\text{Concrete Volume } (m^3)}{\text{Constructed Floor Area } (m^2)}$</td></tr>
<tr><td>Documentary Evidences</td><td><u>For 3-1(a)</u></td></tr>
</table>

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

Extract of tender specification showing the requirements to use of Green Cement / Concrete.
Certificate of products showing the recycled content.
Calculation of estimated quantity of replacement by mass of Green Cement / Concrete.

<u>For 3-1(b)</u>

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.
Bill of quantities showing the volume of concrete to be used.
Detail Concrete Usage Index (CUI) calculation showing the quantity of concrete 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 = 5400 m^3
(including roof level)

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

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

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

	Therefore, credits scored = 4 credits

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	2nd storey to 30th 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 2nd to 15th storey		360x15=5400	
	Total constructed floor area for 2nd to 15th 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 extent of use of environmentally friendly product.

The environmentally friendly product proposed must be approved by a valid international or local certification body and is subject to GreenRE’s evaluation.

Table 3-2.1 : Weightage for credits allocation
<table><tr><th>Extent of use of environmentally friendly product</th><th>Weightage for Credits Allocation</th></tr><tr><td>Low impact</td><td>0.5</td></tr><tr><td>Medium impact</td><td>1</td></tr><tr><td>High Impact</td><td>2</td></tr></table>
The use of environmental friendly products or recycled materials used for all main building elements or functional spaces of the development will be considered as high impact (2 credits) on condition that quantities used by percentage are more than 50% (i.e extent of coverage as compared to total quantities used for same intended purpose. If not met, it will be classified as medium impact (1 credit).

Items that are used for all common areas, external works and communal facilities are considered as medium impact (1 credit) if quantities used by percentage are more than 80% (i.e extent of coverage as compared to total quantities used for same intended purpose in common areas If not met, it will be classified as low impact (0.5 credit)

Notes:
(1) The impact categories listed above generally apply to main building elements – e.g internal / external wall, floor, ceiling, roof, doors, etc. Singular products – e.g termite treatment system, playground equipment, gym flooring etc will be classed as low impact. All applications will be subject to GreenRE's evaluation.

(2) 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>
</table>

<table>
<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 and rating within validity period.
Technical product information on the sustainable products.
Calculation of products and extent of coverage.

</td></tr>
<tr><td>Reference</td><td>https://www.myhijau.my/directory/</td></tr>
<tr><td>Worked Example 3-2</td><td>
Determine if the environmentally 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 or medium impact. Products that are meant for common areas and external works such as toilets, lobbies and landscaping areas are considered as medium impact or 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 by an approved certification body.
(c) Precast concrete road kerbs. Product is rated by approved local certification body. – (Singular product)
(d) Use of roof waterproofing coating. Product is rated by approved local certification body.
(e) Use of wooden doors for all areas. Product is rated by approved local certification body.

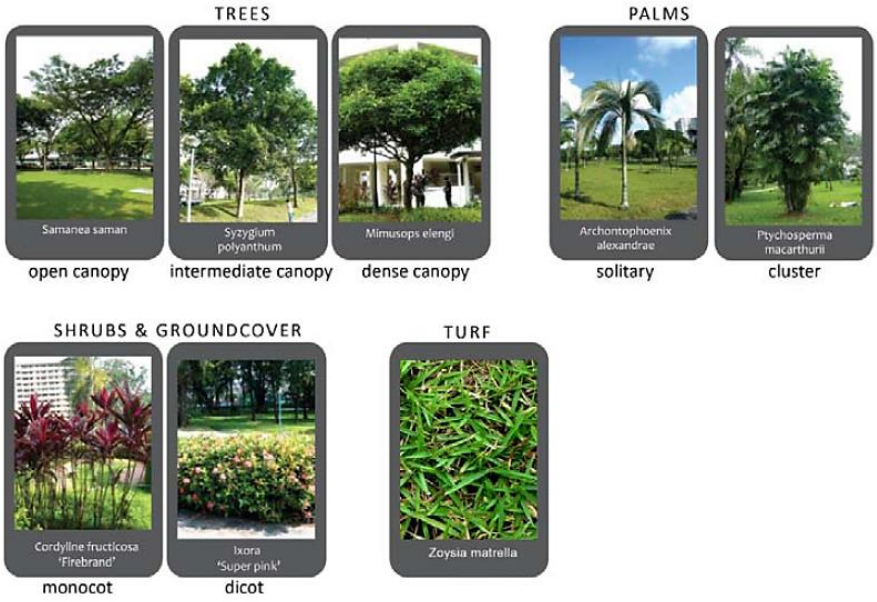
<table>
<tr><th colspan="2">Products and Extent of coverage</th><th>With approved certification</th><th>Extent of use category</th><th>Credits scored</th></tr>
<tr><td>(a)</td><td>Carpets for all office spaces</td><td>No</td><td>N/A</td><td>0</td></tr>
<tr><td>(b)</td><td>Panel boards as internal partition for more than 50% of office spaces</td><td>Yes</td><td>2</td><td>2</td></tr>
<tr><td>(c)</td><td>Precast road kerbs</td><td>Yes</td><td>0.5</td><td>0.5</td></tr>
<tr><td>(d)</td><td>Roof waterproofing</td><td>Yes</td><td>1</td><td>1</td></tr>
<tr><td>(e)</td><td>Wooden doors for all areas</td><td>Yes</td><td>2</td><td>2</td></tr>
</table>

Therefore, credits scored for 3-2 = 2 + 0.5 + 1 + 2 = 5.5 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. (at least 20%)

3-3 (c) 1 credit for the use of compost recycled from horticulture waste.

Documentary Evidences

For 3-3 (a)

- 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).
- Calculation showing the extent of the greenery provision in the prescribed tabulated formats.
- The plant species sub categories and its LAI values obtained from the online website: http://florafaunaweb.nparks.gov.sg/.

For 3-3 (b)

- Site layouts showing the existing and final locations (where applicable) and number of the trees to be restored or conserved or relocated.
- Documentary evidence showing the relocation or restoration activities.

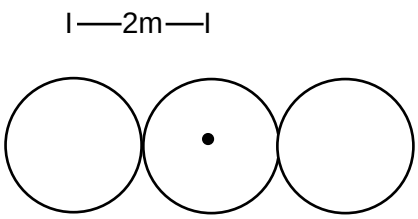
For 3-3 (c)

- Extracts of the tender specification showing the requirements to use compost recycled from horticulture waste.
- Product specifications.
- Method statement with details steps of composting process (if applicable).

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).



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) 1 credit can be scored for IBS content scoring ≥ 50% based on CIDB IBS scoring scheme. 1 credits can be scored for IBS content scoring ≥ 70% based on CIDB IBS scoring scheme. 3-4(e) 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(f) 1 credit if the project team comprises Certified GreenRE Manager/ Green Mark Manager 3-4(g) 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(h) 1 credit can be scored for provision of green fit out guidelines (to be included in management committee bylaws) to detail recommended minimum environmental standards to assist building users' in making sustainable fit-out decisions. 3-4(i) 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) • Main builder's track records details 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 QLASSIC where applicable. For 3-4(d) • A copy of CIDB IBS Score form. • Copy of structural drawings. For 3-4(e) • A certified true copy of the ISO 14000 certificate of developer, main contractor, M & E consultant and architect where applicable. For 3-4(f) • A certified true copy of the certificate of GreenRE Manager/ Green Mark Manager where applicable and a confirmation of their involvement performance in a project development. For 3-4(g) • 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(h) • A copy of the green fit out guide containing the details of recommended minimum environmental standards to assist building users' in making sustainable fit-out decisions. For 3-4(i) • Plan layout showing the location of the recycling bins for collection and storage of different recyclable waste. • Product catalogue showing the size of recycle bins.
References	www.cidb.gov.my/index.php/my/bidang-utama/teknologi-dan-inovasi/ibs https://www.iso.org/iso-14001-environmental-management.html

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 infrastructure for electric charging stations to at least 10% of available parking spaces. 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 with rack / locking bar.
Documentary Evidences	<u>For 3-5(a)</u> • Site layout plan in the context of the surrounding area showing the location of the development site and walking path to the location of the MRT/LRT stations and bus stops not more than 800m. • Proposed bus-stop details drawing. <u>For 3-5(b)</u> • Site layout plan showing the connection of covered walkway from the development to the MRT/LRT stations or bus stops. • Extracts of the tender specification showing the requirement to provide covered walkway. <u>For 3-5(c)</u> • Extracts of the tender specification showing the requirement to provide electric charging stations. • Plan layout showing the location of the electric charging station in the development. • Calculation showing electric charging stations is at least 10% of available parking spaces. <u>For 3-5(d)</u> • Extracts of the tender specification showing the requirement to provide hybrid/electric vehicle refuelling/recharge stations and priority parking bays. • Plan layout showing the location of the electric vehicle charging station in the development.

	• Product technical information. <u>For 3-5(e)</u> • 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. • Plan layout showing the location of the covered/sheltered bicycle parking lots and rack/locking bar.
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	Up to 3 credit can be scored for the provision of infiltration features or design features for new development and redevelopment whereby the post development stormwater peak discharge rate and quantity is lower than the pre-development peak discharge rate and quantity. **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	• Urban Storm Water Management (MSMA) report showing reduction of post development stormwater peak discharge rate and quantity from exceeding pre-development peak discharge rate and quantity. • 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.
References	MSMA – Urban Storm Water Management

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 of the tender specification showing the requirement for all refrigerants to have ODP of zero OR GWP of less than 100. • Technical product information highlighted refrigerants to have ODP of zero OR GWP of less than 100. For 3-7(b) • Extracts of the tender specification showing the requirement to incorporate a refrigerant leak detection system. • Schematic drawing showing the location of the refrigerant leak detection system at critical areas of plant room containing chillers and others equipment with refrigerants. • Product technical information of the 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	1 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% Additional 1 credit will be awarded for provision of room temperature and humidity display.
Documentary Evidences	For 4-1 (a) • Extracts of the tender specification showing the requirement to design the air-conditioning systems which would provide consistent indoor conditions for thermal comfort. • Design brief of the air-conditioning system highlighted room temperature and humidity requirement. For 4-1 (b) • Extracts of the tender specification showing the requirements to provide the room temperature and humidity display. • Plan layout showing the location of the room temperature and humidity display.
References	-

NRB 4-2 NOISE LEVEL

<table>
<tr><td>Objectives</td><td>Recognise buildings that are designed to consider the potential noise levels within the dwelling units are maintained at an appropriate level. All building partitions to shall be in accordance with required STC ratings.</td></tr>
<tr><td>Applicability</td><td>Generally applicable to building developments.</td></tr>
<tr><td>Baseline Standard</td><td>ASTEM E413 or equivalent</td></tr>
<tr><td>Requirements</td><td>1 credit can be scored if the building is designed to achieve ambient internal noise level as specified:

• 55dB (6am – 10pm) L_{Aeq}
• 45dB (10pm – 6 am) L_{Aeq}

This can be achieved by adhering to the following STC values for residential building partitions

<table>
<tr><td>Description</td><td>Sound Transmission Class (STC)</td></tr>
<tr><td>Separation between functional spaces within dwelling units and in-between adjacent dwelling units.</td><td>40 - 50</td></tr>
<tr><td>Spaces between mechanical and equipment spaces and occupied spaces</td><td>50 - 60</td></tr>
</table>

For developments that are in close proximity to road with heavy traffic, flyover or highway, it is necessary to have a detailed analysis conducted by the acoustic consultant. Credits can only be scored if the recommendations from the acoustic consultant are implemented.</td></tr>
<tr><td>Documentary Evidences</td><td>• Extracts of the tender specification showing the requirement to design the occupied space with partitions meeting the required STC ratings as per table below:
<table>
<tr><td>Location</td><td>STC rating of partitions</td></tr>
<tr><td>Between General Office Space</td><td>40 - 50</td></tr>
<tr><td>Hotel Rooms, Classrooms, Lecture Theaters, Meeting Rooms, Conference Rooms and spaces where confidential speech is required</td><td>50 - 60</td></tr>
<tr><td>Between Mechanical / Equipment spaces and occupied spaces</td><td>50 - 60</td></tr>
</table>
• Architectural & structural plan layout, elevation and sectional plans showing types of wall system used, dimensions and size of all building and structural elements with STC ratings.
OR</td></tr>
</table>

	• A report of detail analysis and recommendations from acoustic consultant (if applicable).
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 requirement to use low VOC paints that are certified by approved local/ international certification body or equivalent. • Product catalogue. • Product certificate with validity expiry. <u>For 4-3(b)</u> • Extracts of the tender specification showing the requirement to use adhesive with low emission formaldehyde and are certified by approved local/ international certification body. • Product catalogue. • Product certificate with validity expiry.
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 report value (MERV 8-12) parameters of the filter. • 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 and LED low flicker LED drivers to improve the workplace lighting quality.
Applicability	Generally applicable to workplace such as offices, classrooms and training rooms and the like.
Baseline Standard	-
Requirements	1 credit 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. 1 credit can be scored for the use of LED driver with output frequency < 200Hz and < 30% flicker for LED lighting in at least 90% of the applicable areas served by LED lighting.
Documentary Evidences	• Extracts of the tender specification showing the requirement to have high frequency ballasts or LED driver. • A summary sheet listing all fluorescent and LED luminaries used for the developments. • Electrical lighting layout indicating all the fittings with high frequency ballasts or LED lighting. • Product catalogue specifying high frequency ballast for fluorescent luminaries. (if applicable) • Product catalogue specifying the LED driver with output frequency <200 Hz and <30% flicker for LED lighting. (if applicable) • Calculation showing at least 90% of the applicable areas that are served by high frequency ballast or LED lighting.
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. <u>Water efficiency</u> 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. <u>Environmental Protection</u> 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 external wall 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.

	• 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>1 credit 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.
Up to 2 credits can be scored for identifying embodied carbon of building materials used for construction.</td></tr>
<tr><td>Documentary Evidences</td><td><u>For 6-1 (a)</u>
• Detail calculation for the estimated energy load for each component in the building e.g.: lighting, air-conditioning system, pump, receptacle load.
• Details calculation for estimated water consumption of the building e.g.: water fittings, landscape, water features.
• Technical product information on the energy efficient features and water efficient features used.
• Summary tabulation of estimated total energy savings and total water savings of the development for the year.
• Carbon emission calculation.

<u>For 6-1 (b)</u>
• Embodied carbon footprint calculation based on BCA’s online calculator.</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.</td></tr>
</table>

	Percentage savings = (2,101,689 - 1,381,963) / 2,101,689 = 34.25% Credits scored for 6-1 (a) = 1 credit

6. 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/m²)	50 W/m²	

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