DESIGN REFERENCE GUIDE

Residential Building & Landed Home

Version 3.0

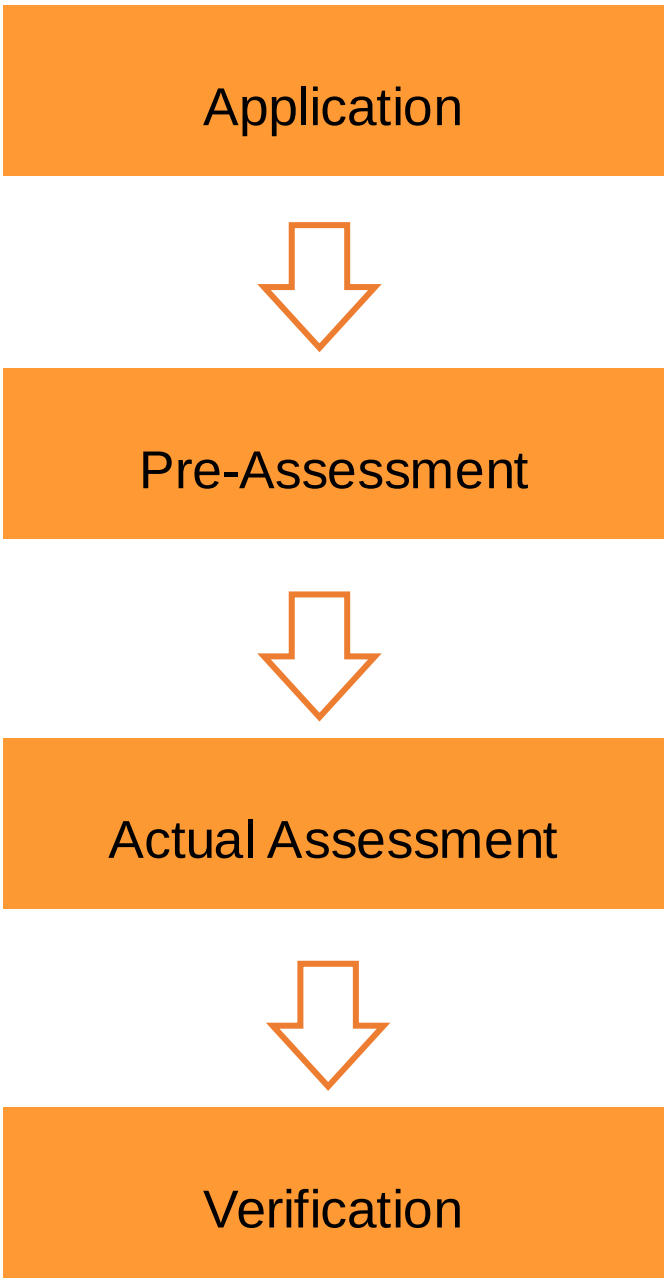
1st October 2015

Contents

List of Appendices

1. Certification Process

The GreenRE Residential Building & Landed Home certification process is as follows:



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

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

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

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

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

Site verification will be conducted upon project's completion.

Refer to page 6 for prerequisite requirements.

A certificate will be issued at this stage.

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

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

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

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

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

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

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

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

Energy Related Requirements consist of Part 1- Energy Efficiency where credits are allocated for the various energy efficient designs, practices and features used. A minimum of 30 credits must be obtained from this group to be eligible for certification. The number of points achievable for this group is capped at 50 points (exclude 16 bonus points that are obtainable under RB 1-8 – Renewable Energy).

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

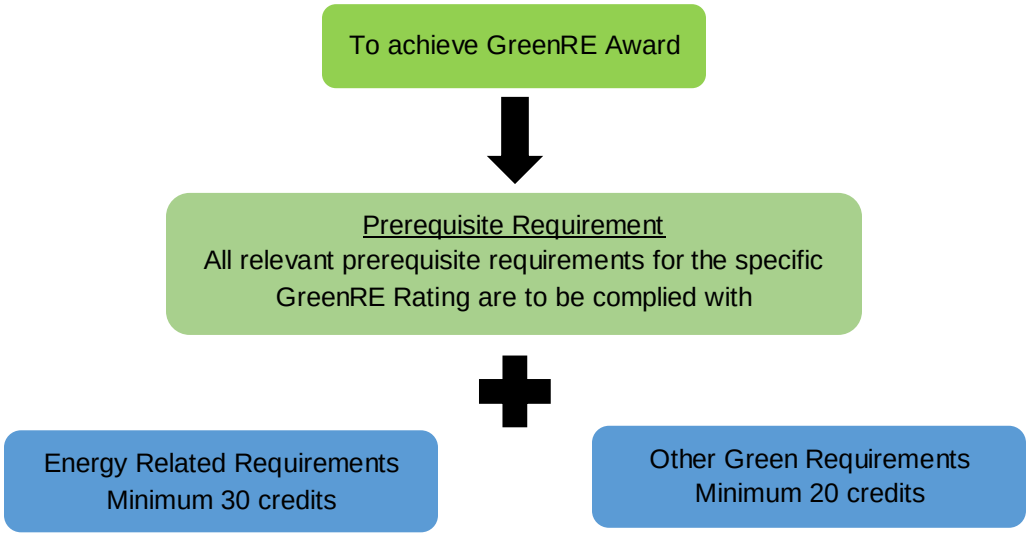
The maximum GreenRE score achievable for a project is capped at 100 points and this does not include 16 bonus points that are obtainable under Energy Related Requirements if a project uses renewable energy sources.

2. GreenRE Award Rating

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

3. GreenRE Assessment

3.1 Framework



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

Part 1 – Energy Efficiency
RES 1-1 Thermal Performance of Building Envelope -RETV
RES 1-2 Naturally Ventilated Design and Air-Conditioning System
RES 1-3 Daylighting
RES 1-4 Artificial Lighting
RES 1-5 Ventilation in Carparks
RES 1-6 Lifts
RES 1-7 Energy Efficient Features
RES 1-8 Renewable Energy

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

Part 2 - Water Efficiency
RES 2-1 Water Efficient Fittings
RES 2-2 Water Usage Monitoring
RES 2-3 Irrigation System and Landscaping

Part 3 – Environmental Protection
RES 3-1 Sustainable Construction
RES 3-2 Sustainable Products
RES 3-3 Greenery Provision
RES 3-4 Environmental Management Practice
RES 3-5 Green Transport
RES 3-6 Stormwater Management
RES 3-7 Community Connectivity

Part 4 - Indoor Environmental Quality
RES 4-1 Noise Level
RES 4-2 Indoor Air Pollutants
RES 4-3 Waste Disposal
RES 4-4 Indoor Air Quality in Wet Areas

Part 5 – Other Green Features
RES 5-1 Green Features & Innovations

Part 6 – Carbon Emission of Development
RES 6-1 Carbon Emission of Development

3.2 Credits Allocation

Category		Credits Allocation
(I) Energy Related Requirements		
Minimum 30 credits	**Part 1: Energy Efficiency**	
	RES 1-1 Thermal Performance of Building Envelope -RETV	15
	RES 1-2 Naturally Ventilated Design and Air-Conditioning System	22
	RES 1-3 Daylighting	6
	RES 1-4 Artificial Lighting	10
	RES 1-5 Ventilation in Carparks	6
	RES 1-6 Lifts	1
	RES 1-7 Energy Efficient Features	7
	RES 1-8 Renewable Energy	16
	Category Score for Part 1 – Energy Efficiency	**83**
(II) Other Green Requirements		
Minimum 20 credits	**Part 2: Water Efficiency**	
	RES 2-1 Water Efficient Fittings	10
	RES 2-2 Water Usage Monitoring	1
	RES 2-3 Irrigation System and Landscaping	3
	Category Score for Part 2 – Water Efficiency	**14**
	Part 3: Environmental Protection	
	RES 3-1 Sustainable Construction	10
	RES 3-2 Sustainable Products	8
	RES 3-3 Greenery Provision	8
	RES 3-4 Environmental Management Practice	8
	RES 3-5 Green Transport	4
	RES 3-6 Stormwater Management	1
	RES 3-7 Community Connectivity	1
	Category Score for Part 3 – Environmental Protection	**40**
	Part 4: Indoor Environmental Quality	
	RES 4-1 Noise Level	1
	RES 4-2 Indoor Air Pollutants	2
	RES 4-3 Waste Disposal	1
	RES 4-4 Indoor Air Quality in Wet Areas	2
	Category Score for Part 4 – Environmental Quality	**6**
	Part 5: Other Green Features	
	RES 5-1 Green Features & Innovations	7
	Category Score for Part 5 – Other Green Features	**7**
	Part 6: Carbon Emission of Development	
	RES 6-1 Carbon Emission of Development	4
	Category Score for Part 6 – Carbon Emission of Development	**4**
	Category Score for Part 2 to Part 6 – Other Green Requirements	**71**
	GreenRE Residential Building & Landed Home Score	**154 (MAX)**

3.3 Prerequisite Requirements

1) Building envelope design with Residential Envelope Transmittance Value (RETV) computed based on the methodology and guides stipulated in the Code on Envelope Thermal Performance for Buildings, BCA and this GreenRE Design Reference Guide.

   GreenRE Gold - RETV of 22 W/m^2 or lower
   GreenRE Platinum - RETV of 20 W/m^2 or lower

2) To be eligible for GreenRE Platinum rating,
   - It is a requirement to perform ventilation simulation modelling and achieve minimum 70% of the selected typical dwelling units with good natural ventilation by demonstrating a wind velocity of 0.60 m/s. Common areas are to be designed as naturally ventilated spaces. Where ventilation simulation modelling is not performed, it is a requirement to achieve ≥ 14 credits under RES 1-2 (a) Option 2 (i) and (ii).

3) Prescribed system efficiency of air-conditioning system for all dwelling units to be as follows:

   GreenRE Gold, GreenRE Platinum } Air conditioners with excellent performance, COP at 100% and weighted COP

4) Minimum score under RES 2-1 Water Efficient Fittings
   GreenRE Gold ≥ 6 credits
   GreenRE Platinum ≥ 8 credits

5) Minimum score under RES 3-1 Sustainable Construction
   GreenRE Gold ≥ 3 credits
   GreenRE Platinum ≥ 5 credits

3.4 Residential Building & Landed Home Criteria

Part 1 - Energy Efficiency	GreenRE Credits
RES 1-1 THERMAL PERFORMANCE OF BUILDING ENVELOPE – RETV Enhance overall thermal performance of building envelope to minimise heat gain thus reducing the overall cooling load requirement. Baseline : Maximum permissible RETV = 25W/m^2 *Prerequisite Requirement:* *GreenRE Gold - RETV of 22 W/m^2 or lower* *GreenRE Platinum - RETV of 20 W/m^2 or lower*	3 credits for every reduction of 1 W/m^2 in RETV from the baseline. Credits scored = 75 – [3 x (RETV)] where RETV ≤ 25 W/m^2 (Up to 15 credits)
RES 1-2 NATURALLY VENTILATED DESIGN AND AIR-CONDITIONING SYSTEM (a) Dwelling Unit Indoor Comfort Enhance building design to achieve good natural ventilation for better indoor comfort or through the use of better efficient air-conditioners if needed. Option 1 – Ventilation Simulation Modelling and Analysis Use of ventilation simulation modelling and analysis or wind tunnel testing to identify the most effective building design and layout to achieve good natural ventilation for all unit types. *Prerequisite Requirement:* *GreenRE Platinum - Minimum 70% of the selected typical dwelling units with good natural ventilation. Common areas are to be designed as naturally ventilated spaces* OR	0.2 credits for every percentage of typical units with good natural ventilation Credits scored = 0.2 x (% of typical units with good natural ventilation) (Up to 20 credits) OR

<table>
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<td>

Option 2 – Ventilation Design (without the use of ventilation simulation modelling) and Efficient Use of Air-Conditioning System

(i) Air flow within Dwelling Units

- Building layout design: Proper design of building layout that utilises prevailing wind conditions to achieve adequate cross ventilation.

- Dwelling unit design: Good ventilation in indoor units through sufficient openings

(ii) Provision air-conditioning system;
Use of the air-conditioners that are certified under Energy Commission (Suruhanjaya Tenaga) or Singapore Energy Labelling Scheme

Note (1): Option 2(ii) is not applicable for developments where air-conditioners are not provided. Credits can be scored and prorated accordingly under Option 2(i).

Prerequisite requirement:
GreenRE Gold / *GreenRE Platinum* } *Air Conditioners with Excellent performance*

(b) Natural Ventilation in Common Areas

Design for natural ventilation in following common areas:

i. Lift lobbies and corridors
ii. Staircases

</td>
<td>

0.6 credits for every 10% of units with window opening facing north and south directions
Credits scored = 0.6 x (% of units/10)

0.6 credits for every 10% of living rooms and bedrooms design with true cross ventilation
Credits scored = 0.6 x (% of rooms/10)

(Up to 12 credits)

Extent of coverage: All 100% of air-conditioners used in all dwelling units are energy labelled.

Very Good	4 credits
Excellent	8 credits

Extent of coverage: At least 80% of the applicable areas

1 credit
1 credit

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</table>

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<tr>
<td><u>RES 1-3 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 calculations to verify that 50% or more of all habitable spaces achieve adequate daylight illuminance levels as specified in MS 1525:2014. Areas with illuminance levels below or above the range do not comply.

b) Daylighting in the following common areas:

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

Extent of coverage: At least 80% of the applicable areas

1 credit
1 credit
1 credit</td>
</tr>
<tr>
<td><u>RES 1-4 ARTIFICIAL LIGHTING</u>

Encourage the use of energy efficient lighting to minimise energy consumption from lighting usage.

<u>Baseline:</u>
Luminance level stated in MS1525:2014.</td>
<td>0.25 credits for every percentage improvement in the lighting power budget.

Credits scored
= 0.25 x (% improvement)

(Up to 10 credits)</td>
</tr>
<tr>
<td><u>RES 1-5 VENTILATION IN CARPARKS</u>

Encourage the use of energy efficient design and control of ventilation systems in car parks.
(a) Car park spaces that are fully naturally ventilated.

(b) CO sensors are used to regulate the demand for mechanical ventilation (MV)

Note (2): Where there is a combination of different ventilation modes adopted for car park design, the credits scored under this requirement will be prorated accordingly.</td>
<td>Naturally ventilated carparks – 6 credits

Credits scored based on the mode of mechanical ventilation provided

Fume extract – 4 credits
MV with or without supply – 3 credits

(Up to 6 credits)</td>
</tr>
</table>

RES 1-6 LIFTS Encourage the use of lift with energy efficient features such as AC variable voltage and variable frequency (VVVF) motor drive and energy efficient features such as sleep mode.	1 credit
RES 1-7 ENERGY EFFICIENT FEATURES Encourage the use of energy efficient features that are innovative and have positive environmental impact in term of energy saving. (a) Use of energy efficient equipment or product that are certified by approved local certification body (b) Use of the following energy efficient features: • Heat recovery devices • Regenerative lifts • Cool paints • Gas water heaters • Calculation of Energy Efficiency Index (EEI) • Provision of vertical greenery systems that helps to reduce heat gain to buildings.	Extent of coverage: At least 90% of the applicable equipment type or product 0.5 credits for each eligible certified equipment or product (Up to 2 credits) 2 credits for high impact item 1 credit for medium impact item 0.5 credits for low impact item (Up to 5 credits)
RES 1-8 RENEWABLE ENERGY Encourage the use of renewable energy sources in buildings such as solar energy.	3 credits for every 1% replacement of electricity (based on annual electricity consumption exclude household's usage) by renewable energy (Up to 16 credits) Note: The credits scored for renewable energy provision shall not result in a double grade jump in GreenRE rating (i.e. from GreenRE Bronze to Silver to Gold to Platinum).
Part 1 – ENERGY EFFICIENCY CATEGORY SCORE:	Sum of GreenRE credits obtained from RES 1-1 to 1-8

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

Encourage the use of water efficient fittings covered under the Water Efficiency Product Labelling Scheme (WEPLS) or Water Efficiency Labelling Scheme (WELS).

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

<u>Prerequisite Requirement:</u>
Minimum score under RES 2-1
GreenRE Gold ≥ 6 credits
GreenRE Platinum ≥ 8 credits</td><td>Credits scored based on the number and water efficiency rating of the fitting type used
(Up to 10 credits)

Extent of coverage: At least 90% of the water fittings

<table><tr><td colspan="3">Rating Based on WEPLS or WELS</td></tr><tr><td>Efficient *</td><td>Highly Efficient **</td><td>Most Efficient ***</td></tr><tr><td>0.5 credit</td><td>1 credit</td><td>2 credits</td></tr></table></td></tr>
<tr><td><u>RES 2-2 WATER USAGE MONITORING</u>

Provision of private meters to monitor the major water usage such as irrigation, swimming pools and other water features.</td><td>1 credit</td></tr>
<tr><td><u>RES 2-3 IRRIGATION SYSTEM AND LANDSCAPING</u>

Provision of suitable systems that utilities rainwater or recycled water for landscape irrigation and use of plants that require minimal irrigation to reduce potable water consumption.

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

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

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

1 credit

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

Extent of Coverage : At least 80% of the landscape areas
1 credit</td></tr>
<tr><td>PART 2 – WATER EFFICIENCY CATEGORY SCORE:</td><td>Sum of GreenRE credits obtained from RES 2-1 to 2-3</td></tr>
</table>

<table>
<tr><th>Part 3 – Environmental Protection</th><th>GreenRE Credits</th></tr>
<tr><td><u>RES 3-1 SUSTAINABLE CONSTRUCTION</u>

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, and fly ash to replace Ordinary Portland Cement (OPC).

(b) Concrete Usage Index (CUI)

Encourage more efficient concrete usage for building components.

<u>Prerequisite Requirement:</u>
Minimum score under RES 3-1 :
GreenRE Gold ≥ 3 credits
GreenRE Platinum ≥ 5 credits</td><td>
<table>
<tr><th>% Replacement of OPC by green cement</th><th>Credits Allocation</th></tr>
<tr><td>10</td><td>1</td></tr>
<tr><td>30</td><td>2</td></tr>
<tr><td>50</td><td>3</td></tr>
<tr><td>70</td><td>4</td></tr>
<tr><td>80</td><td>5</td></tr>
</table>
(Up to 5 credits)

<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>
(Up to 5 credits)
</td></tr>
<tr><td><u>RES 3-2 SUSTAINABLE PRODUCTS</u>

Promote use of environmentally friendly products that are certified by approved local certification body and are applicable to non-structural and architectural related building components.</td><td>
<table>
<tr><th>Extent of Environmental Friendliness of Product</th><th>Weightage for Credit Allocation</th></tr>
<tr><td>Good</td><td>1</td></tr>
<tr><td>Very Good</td><td>1.5</td></tr>
<tr><td>Excellent</td><td>2</td></tr>
</table>
Credits scored will be based on the weightage, extent of coverage and impact.

(Up to 8 credits)
</td></tr>
</table>

RES 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, conservation or relocation of existing trees on site.

1 credit

(c) Use of compost recycled from horticulture waste

1 credit

RES 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 has good track records in completing internationally recognized accredited Green Buildings and adoption of sustainable, environmentally friendly and considerate practices during construction.

1 credit

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

1 credit

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

0.25 credit each
(Up to 1 credit)

(e) Project team comprises Certified GreenRE Manager/ Green Mark Manager and Certified GreenRE Professional/ Green Mark Professional.	1 credit for Certified GRM/ GMM 2 credits for Certified GRP/GMP (Up to 2 credits)
(f) 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.	1 credit
(g) 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.	1 credit
RES 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 electric vehicle charging stations and priority parking lots within the development.	1 credit
(d) Provision of covered / sheltered bicycles parking lots.	Extent of Coverage : Minimum 10 numbers and cap at 50 numbers of bicycle parking lots (1 credit)

RES 3-6 STORMWATER MANAGEMENT Encourage the treatment of stormwater runoff through provision of infiltration or design features before discharge to public drains. Provision of infiltration features or design features for new development and redevelopment.	1 credit
RES 3-7 COMMUNITY CONNECTIVITY Encourage development in urban area with existing infrastructure to minimise the use of private mode of transportation. Basic Services include, but are not limited to: • Bank • Beauty • Laundry • Day care • Fire Station • Hardware • Convenience/ Grocery • Hardware • Laundry • Library • Police station • Park • Restaurant • School • Clinic	1 credit can be scored for project located within 1km of at least 10 Basic Services.
PART 3 – ENVIRONMENTAL PROTECTION CATEGORY SCORE:	Sum of GreenRE credits obtained from RES 3-1 to 3-7

Part 4 – Indoor Environmental Quality	GreenRE Credits
RES 4-1 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
RES 4-2 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 by approved local/ international certification body. (b) Use of environmentally friendly adhesives certified by approved local/ international certification body.	Extent of Coverage: At least 90% of the total internal wall areas 1 credit Extent of Coverage: At least 90% of the applicable areas 1 credit
RES 4-3 WASTE DISPOSAL Minimise airborne contaminants from waste by locating refuse chutes or waste disposal area at open ventilation areas such as service balconies or common corridors.	1 credit
RES 4-4 INDOOR AIR QUALITY IN WET AREAS Provision for adequate natural ventilation and day lighting in wet areas i.e. kitchens, bathroom and toilets	Credits scored based on the % of applicable areas with such provision 2 credits for more than 90% of all applicable areas. 1 credit for at least 50% to 90% of all applicable areas. (Up to 2 credits)
PART 4 – INDOOR ENVIRONMENTAL QUALITY CATEGORY SCORE:	Sum of GreenRE credits obtained from RES 4-1 to 4-4

Part 5 – Other Green Features	GreenRE Credits
RES 5-1 GREEN FEATURES & INNOVATIONS Encourage the use of green features that are innovative and have positive environment impact. Examples: • Self-cleaning facade system • Integrated basin/cistern pedestal system • Grey water recycling system • Dual chute system • Calculation of Concrete Usage Index (CUI) • Conservation of existing building structure • Water efficient washing machines with "Good" rating and above. • 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 RES 5-1

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

GreenRE Score (Residential Building & Landed Home)

GreenRE Score (RES) = ∑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 Development)]

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

(I) Energy Related Requirements

Part 1- Energy Efficiency

RES 1-1 Thermal Performance of Building Envelope-RETV
RES 1-2 Naturally Ventilated Design and Air-Conditioning System
RES 1-3 Daylighting
RES 1-4 Artificial Lighting
RES 1-5 Ventilation in Carparks
RES 1-6 Lifts
RES 1-7 Energy Efficient Features
RES 1-8 Renewable Energy

RES 1-1 THERMAL PERFORMANCE OF BUILDING ENVELOPE – RETV

Objectives	Enhance overall thermal performance of building envelope to minimise heat gain thus reducing the overall cooling load requirement.
Applicability	Applicable to all type of residential buildings; high-rise and landed home
Baseline Standard	Maximum permissible RETV = 25 W/m^2 RETV stands for Residential Envelope Transmittance Value. The computation of RETV shall be based on the methodology specified in the Code on Envelope Thermal Performance for Building issued by BCA.
Requirements	Up to 15 credits can be scored for building envelope with better thermal performance than the baseline standard: 3 credits for every reduction of 1 W/m^2 in RETV from the baseline. Credits scored = 75 – [3 x (RETV)] where RETV ≤ 25 W/m^2 For developments consisting of more than one residential building, the weighted average of the RETVs based on the façade areas of these buildings shall be used as the basis for credits allocation. That is: $RETV_{Weighted\ average} = \sum (RETV_{bldg} \times A_{bldg}) / A_{devt}$ Where: $RETV_{bldg}$= RETV for a residential building (W/m^2) A_{bldg}= Summation of all façade areas that enclose all living rooms, dining rooms, study rooms and bedrooms of a residential building.(m^2) A_{devt}= Summation of total applicable façade areas of all residential buildings within the development (m^2) (i.e. $\sum A_{bldg}$)
Prerequisite Requirements	GreenRE Gold - RETV of 22 W/m^2 or less GreenRE Platinum - RETV of 20 W/m^2 or less
Documentary Evidences	• Architectural elevation drawings showing the composition of the different façade or wall systems that are relevant for the computation of RETV; • Architectural plan layouts and elevation showing the living rooms, dining rooms, study rooms and bedrooms; • Extracts of the tender specification or material schedules showing the salient data of the material properties that are to be used for the façade or external wall system; and • RETV calculation.
References	Code on Envelope Thermal Performance for Building issued by BCA.

Worked Example 1-1	Example 1 RETV = 22 W/m^2 Credits scored = 75 – [3 x (RETV)] = 75 – [3 x (22)] = 9 credits Therefore, credits scored should be 9 credits Example 2 RETV = 19 W/m^2 Credits scored = 75 – [3 x (RETV)] = 75 – [3 x (19)] = 18 credits > 15 credits (max) Therefore, credits scored should be 15 credits (Max) Example 3 A proposed building development comprises three residential building blocks. The individual RETV of the each residential computed are as follows: $RETV_{bldg1}$ = 20 W/m^2 A_{bldg}= 4000 m^2 $RETV_{bldg2}$ = 25 W/m^2 A_{bldg}= 3600 m^2 $RETV_{bldg3}$ = 19 W/m^2 A_{bldg}= 5000 m^2 A_{devt}= 4000 + 3600 + 5000 = 12600 m^2 Therefore; $RETV_{Weighted\ average} = \sum (RETV_{bldg} \times A_{bldg}) / A_{devt}$ $= \frac{(RETV_{bldg1} \times A_{bldg1}) + (RETV_{bldg2} \times A_{bldg2}) + (RETV_{bldg3} \times A_{bldg3})}{A_{devt}}$ $= \frac{(20 \times 4000) + (25 \times 3600) + (19 \times 5000)}{12600}$ = 21.03 W/m^2 Credits scored = 75 - [3 X (RETV)] = 75 – [3 X (21.03)] = 11.91 credits Note: Refer to the Code on Envelope Thermal Performance for Buildings, BCA for more detailed examples on how to compute the RETV.

RES 1-2 NATURALLY VENTILATED DESIGN AND AIR-CONDITIONING SYSTEM

Objectives	Enhance building design to achieve good natural ventilation for better indoor comfort or through the use of better efficient air-conditioners if needed.
Applicability	Applicable to all dwelling units within the development.
Baseline Standard	1-2 (a) Option 1 - Ventilation simulation modelling and analysis shall be based on the methodology specified in Appendix A – Ventilation Simulation Methodology and Requirements. 1-2 (a) Option 2(ii) – As specified under the Energy Commission (Suruhanjaya Tenaga) or Singapore Energy Labelling Scheme for air-conditioners.
Requirements	1-2 (a) Dwelling Unit Indoor Comfort For Option 1 – Ventilation Simulation Modelling and Analysis Up to 20 credits can be scored for the use of ventilation simulation modelling & analysis or wind tunnel testing to identify the most effective building design and layout to achieve good natural ventilation for all unit types. All typical dwelling unit types should be included in the ventilation simulation (up to maximum of 5 types). If there are more than 5 typical dwelling unit types, the selection of the units for simulation will be based on extent of coverage that is the five typical dwelling units with most number of units. The units is deemed to have good natural ventilation if the area-weighted average wind velocity within the unit is not less than 0.60 m/s based on the ventilation simulation analysis. The percentage of units achieving good natural ventilation is given by: $\frac{\sum(\text{No. of Selected Units for Each Layout} \times \text{Area-Weighted Average Wind Velocity}) \times 100\%}{\text{Total Number of Selected Units} \times 0.60 \text{ m/s}}$ 0.2 credit for every percentage of typical units with good natural ventilation Credits scored = 0.2 x (% of typical units with good natural ventilation)

For Option 2 – Ventilation Design (without the use of ventilation simulation modelling) and Efficient Use of Air-Conditioning System
Up to 12 credits can be scored for the following design

Option 2(i) Air flow within Dwelling Units

- **Building layout design** that utilises prevailing wind conditions to achieve adequate cross ventilation.

  0.6 credit for every 10% of units with window opening facing north and south directions

  Credits scored = 0.6 x (% of units/10)

- **Dwelling unit design** that allows for true cross ventilation in the living room and bedrooms of the dwelling units

  0.6 credit for every 10% of living rooms and bedrooms design with true cross ventilation

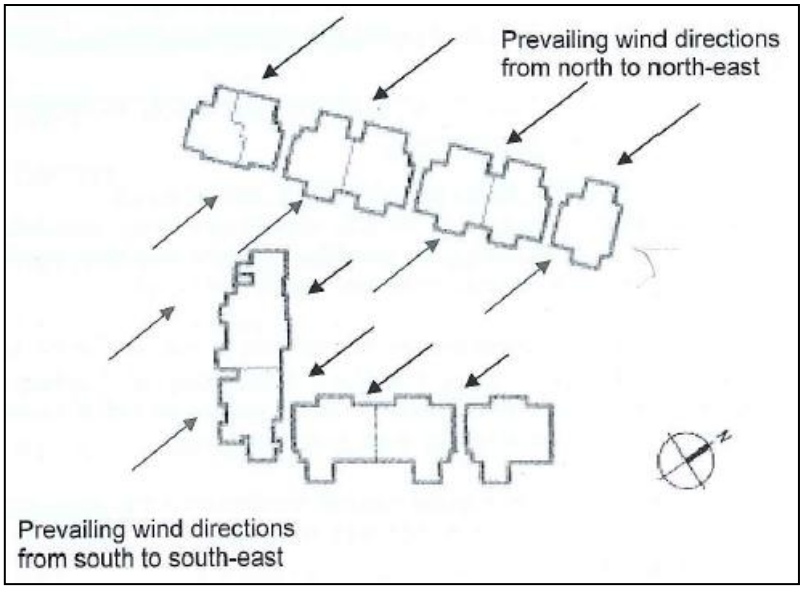
  Credits scored = 0.6 x (% of rooms/10)

Note: In Malaysia, the prevailing wind comes from two predominant directions; that is the north-east during the Northeast monsoon season and south to south-east during South-west monsoon season. Hence, buildings designed with window openings facing the north and south directions have the advantage of the prevailing wind conditions that 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.

Building Layout Design

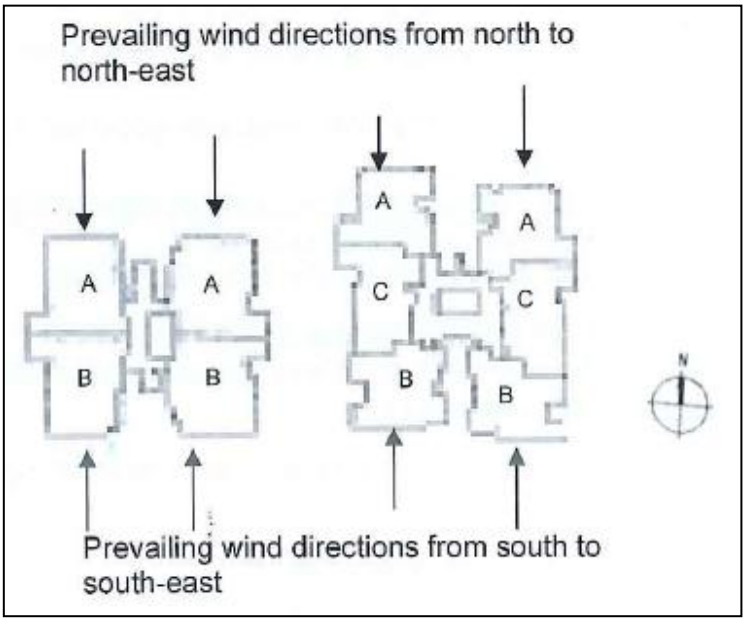
It is not necessary for the window openings to be located perpendicularly to the prevailing wind direction. An oblique angle is considered acceptable as illustrated (Refer Illustration 1-2.1 to 1-2.4).

Illustration 1-2.1:Building layout design that facilitate cross ventilation



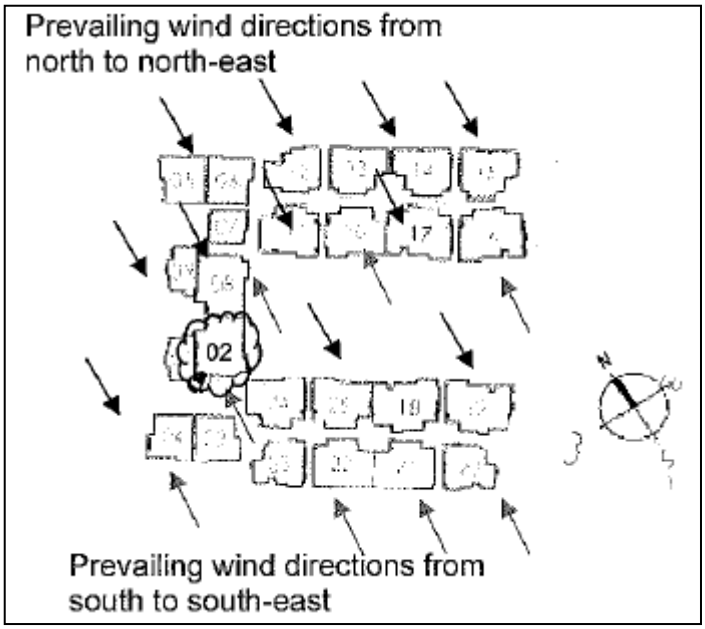
Building layout showing all dwelling units with window openings facing the north and south direction. In this instance, all units can be considered meeting the requirement 1-2(a) Option 2(i).

Illustration 1-2.2:Building layout design that facilitate cross ventilation



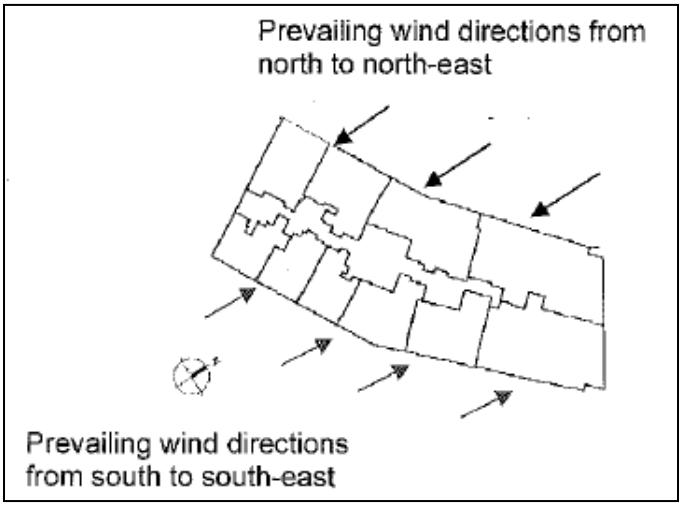
Building layout showing all dwelling unit Type A and B with window openings facing the north or south direction. The dwelling unit Types C has no window openings in the north and south directions. In this instance, no unit can be considered meeting the requirement 1-2(a) Option 2(i)

Illustration 1-2.3:Building layout design that facilitate cross ventilation



Building layout showing the window openings of all dwelling units facing the north and south direction except dwelling unit 02. Dwelling unit 02 has window opening facing only the south direction and hence it is not considered meeting the requirements 1-2(a) Option 2(i)

Illustration 1-2.4:Building layout design that facilitate cross ventilation

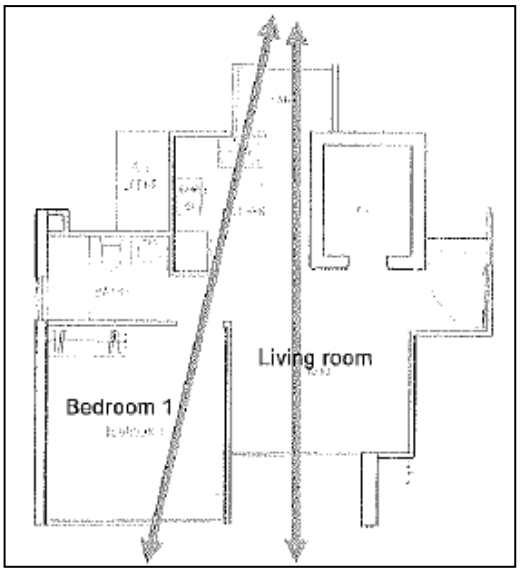


Building layout showing the window openings of all dwelling units facing either the north or south direction and hence they are not considered meeting the requirement 1-2(a) Option 2(i)

Dwelling Unit Design

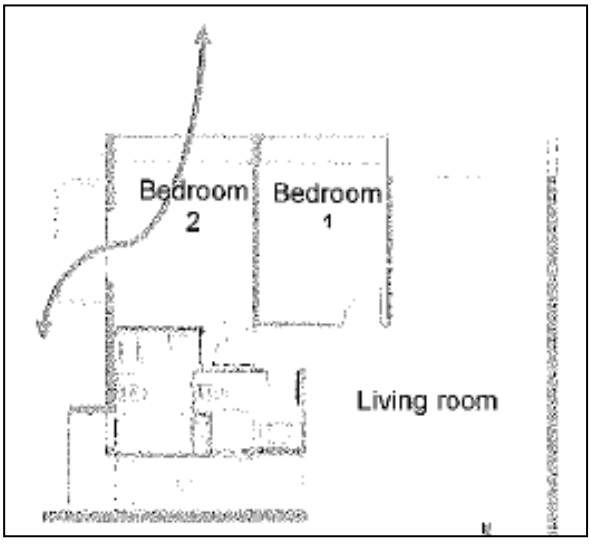
Dwelling unit design is considered to have true cross ventilation when there is a reasonably unobstructed air flow path between the windows or vents on opposite sides of the building. For this requirement, the main entrance of dwelling units is assumed to be closed and all the windows/ internal doors are assumed to be open.

Illustration 1-2.5:Dwelling unit design that facilitates true cross ventilation



Dwelling unit layout showing that both living room and bedroom 1 are considered to have true cross ventilation and meet the requirement 1-2(a) Option 2(i)

Illustration 1-2.6:Dwelling unit design that facilitates true cross ventilation



Dwelling unit layout showing only bedroom 2 is considered to have true cross ventilation. Living room and bedroom1 are not considered meeting the requirement 1-2(a) Option 2(i)

Option 2(ii) Provision of energy efficient air-conditioning system

Up to 8 credits can be scored for the use of the air-conditioners that are certified under the Energy Commission(Suruhanjaya Tenaga) or Singapore Energy Labelling Scheme based on the following rating;

Table 1-2.1: Unitary air-conditioners, electrically driven: Minimum COP-cooling

Equipment		Size	Sub-category	Minimum COP
			Non-Inverter type	Inverter type[1]
			Very Good	Excellent
Air conditioners: Air cooled with condenser	<19 kWr	Single Split/Package	2.8	3.0
		Multi-split	2.8	3.2
	≥ 19 kWr and < 35 kWr	Split or Package	2.8	3.5
	≥ 35 kWr	Split or package	2.7	2.9
Air conditioners: Water and evaporative cooled	<19 kWr	Split or package	3.6	4.0
	≥ 19 kWr and < 35 kWr	Split or package	3.7	4.4
	≥ 35 kWr	Split or package	3.8	4.4

Note:

1. The COP for the inverter unit is the weighted value, which is calculated based upon the following equation:

$$COP_{weighted} = [\ COP_{100\%} \times 0.40\ ] + [\ COP_{50\%} \times 0.60\ ]$$

Very Good	4 credits
Excellent	8 credits

Extent of coverage: All 100% of air-conditioners used in all dwelling units are energy labelled.

Note: Option 2(ii) is not applicable for developments where air-conditioners are not provided. Credits can be scored and prorated accordingly under Option 2(i).

1-2 (b) Natural Ventilation in Common Areas

1-2 (b) (i) 1 credit can be scored if at least 80% of the lift lobbies (including private lift lobbies) and corridors areas are designed to be naturally ventilated.

1-2 (b) (ii) 1 credit can be scored if at least 80% of the staircases areas are designed to be naturally ventilated.

Prerequisite Requirements	a) To be eligible for GreenRE Platinum, it is a requirement to use ventilation simulation modelling and analysis to identify the most effective building design and layout. The simulation results and the recommendations derived are to be implemented. A minimum 70% of the selected typical dwelling units must have a weighted average wind velocity of 0.60 m/s. Other than the dwelling units, common areas like staircases and lobbies (excluding those that are located in the basement areas) must also be designed as naturally ventilated spaces with provision of openable windows or other opening with aggregate area of not less than 5% of the space requires to be ventilated. b) Prescribed system efficiency of air-conditioning system for all dwelling units to be as follows: GreenRE Gold GreenRE Platinum } Air conditioners with Excellent Performance
Documentary Evidences	<u>For 1-2(a) Option 1 - Ventilation Simulation Modelling</u> • Ventilation simulation or wind tunnel testing reports summarising the analysis and modelling results for each typical space as well as the recommendations for design. • Calculation showing the percentage of units achieving good natural ventilation in the prescribed tabulated format as shown in worked example 1-2(a) Option 1. <u>For 1-2(a) Option 2(i) - Air Flow within Dwelling Units</u> • Floor plan of all the unit types with highlights if those with window openings facing the north and south directions and/or with true cross ventilation; • Schedules showing the total number of units in the development and those with window openings facing the north and south direction. • Schedules showing the total number of living rooms and bedrooms in the development and those with true cross ventilation. • Calculation showing the percentage of living rooms and bedrooms of dwelling units with true cross ventilation in the prescribed tabulated format as shown in the worked example 1-2(a) Option 2. <u>For 1-2(a) Option 2(ii) – Provision of Air-Conditioning Systems</u> • Extracts of the tender specification showing the provision of the types of air-conditioners for the dwelling units of the development; • Schedule of air-conditioners showing the numbers, types and the approved rating from the Energy Commission or Singapore Energy Labelling Scheme; • Technical product information of the air-conditioners and approved rating. <u>For 1-2(b)(i & ii) – Natural Ventilation in Common Areas</u> • Plan layouts showing the applicable common areas and confirmation that they are designed to be naturally ventilated.

References

1. MS 1525:2014 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice.

2. For air-conditioner rating, can visit Energy Commission (Suruhanjaya Tenaga) https://www.st.gov.my

Worked Example 1-2(a) Option 1

A residential development with one block of 20-storey apartments comprises 200 units and with 7 typical dwelling unit layouts or types.

1. Select the five typical dwelling unit types with the most number of units for ventilation simulation.
2. Based on the ventilation simulation results, list down the total number of units for each typical dwelling unit type and its corresponding area-weighted average wind velocity as tabulated below.

Table 1-2.2: Total number of units according to dwelling unit types.

Dwelling Units Layouts / Types		No. of Units (**A**)	Area Weighted Average Wind Velocity (**B**)
1	Typical Layout A	80	0.60
2	Typical Layout B	30	0.60
3	Typical Layout C	20	0.70
4	Typical Layout D	20	0.50
5	Typical Layout E	20	0.40
Total Number of Selected Units (**C**) : 170			
6	Typical Layout F*	15	Not included
7	Typical Layout G*	15	Not included

**Dwelling Unit Layout not selected for simulation*

Percentage of units achieving good natural ventilation is given by:

$$= \frac{\sum(A \times B)}{C \times 0.60 \text{ m/s}} \times 100\%$$

$$= \frac{(80x0.60) + (30x0.60) + (20x0.70) + (20x0.5) + (20x0.40)}{170x0.60 \text{ m/s}} \times 100\%$$

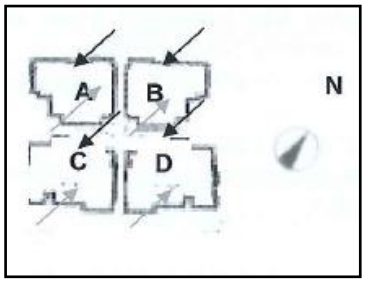
= 96%

Credits scored for 1-2(a) Option 1 = 0.2 x 96% = 19.2 credits

Worked Example 1-2(a) Option 2

For 1-2(a) Option (2)(i)

Proposed residential development with one block of 10 storey apartment comprises 40 units. Each dwelling comes with a living room and two bedrooms. There are four different unit types for this development as illustrated below.



Building Layout Design

Total no. of units in the developments = 40

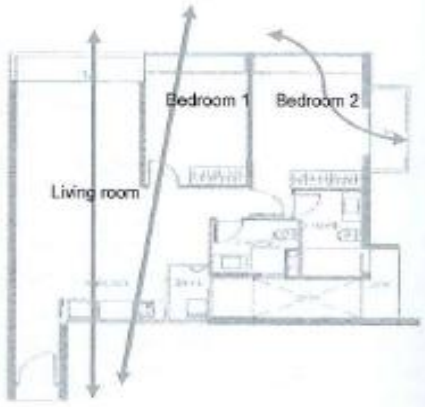
Total units with all window openings facing north and south directions = 40

% of units with window openings facing north and south directions = 40/40 x 100%

Credits scored = 0.6 x (% unit/10)
= 0.6 x (100/10)
= **6 credits**

Two-bedroom Type A

The living room, bedroom 1 and bedroom 2 are considered to have true cross ventilation.

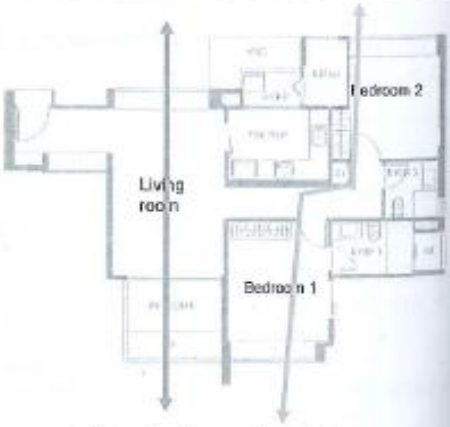


Two-bedroom Type B

The living room, bedroom 1 and bedroom 2 are considered to have true cross ventilation.

Two-bedroom Type C

Only living room is considered to have true cross ventilation. Both bedroom 1 & 2 do not meet the requirement.



Two-bedroom Type D

Only living room is considered to have true cross ventilation. Both bedroom 1 & 2 do not meet the requirement.

Dwelling Unit Design

Table 1-2.3 : Percentage of rooms with true cross ventilation

Type of dwelling unit	No. of units (a)	For each unit		Total living rooms and bedrooms with true cross ventilation (b + c) x (a)
		Living room with true cross ventilation (b)	Bedrooms with true cross ventilation (c)	
2-bedroom Type A	10	1	2	30
2-bedroom Type B	10	1	2	30
2-bedroom Type C	10	1	0	10
2-bedroom Type D	10	1	0	10
			Total :	80

Total no. of living rooms and bedrooms = 3 x 40 units = 120

Total no. of living rooms and bedrooms with true cross ventilation = 80

Percentage of living rooms and bedrooms with true cross ventilation = 80/120 x 100%
= 66.7%

Credits scored = 0.6 x (% rooms/10)
= 0.6 x (66.7/10)
= **4 credits**

For 1-2(a) Option (2)(ii)
All dwelling units are provided with" Excellent Performance" air-conditioners

Credits scored for 1-2(a) Option 2 (ii) = **8 credits**

Total credits scored for 1-2(a) Option 2 = 6 + 4 + 8
= 18 credits

Worked Example 1-2(b)

Proposed development has the following provision:

All lift lobbies and corridors are designed to be naturally ventilated except for two private lobbies of the penthouses units that are designed with air-conditioning system. All staircases are designed to be naturally ventilated.

No credit for 1-2(b)(i) if less than 80% of lift lobbies are naturally ventilated.

1 credit for 1-2(b)(ii) for staircases that are all designed to be naturally ventilated.

Therefore, credit scored for 1-2(b) = 1 credit

RES 1-3 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>1-3(a) Applicable to all normally occupied areas within the development.

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

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

Table 1-3.1: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>
1-3(b) (i) 1 credit for provision of day lighting for lift lobbies and corridors.

1-3(b) (ii) 1 credit for provision of day lighting for staircases.

1-3(b) (iii) 1 credit for provision of day lighting for car parks.</td></tr>
<tr><td>Documentary Evidences</td><td><u>For 1-3(a)</u>
• Schedules showing the total number of living and dining areas in the development and those with effective daylighting; and
• Daylight analysis (simulation/calculations) report summarizing the analysis and modelling results for each living and dining area that meets the requirement.

<u>For 1-3(b)</u>
• Extracts of the tender specification or drawings showing the use of day lighting for lift lobbies and corridors, staircases and car parks where applicable.</td></tr>
<tr><td>References</td><td>MS 1525:2014 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice</td></tr>
</table>

Worked Example 1-3(a)

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

Table 1-3.2: Daylight factor for each of the room in every type of layout

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

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

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

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

Credits scored for 1-3(a) = 1 credits

Worked Example 1-3(b)

Proposed 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.

No.	Criteria	Credit Allocated	Credit
1-3(b) (i)	Lift lobbies and corridors	1	1
1-3(b) (ii)	Staircases	1	1
1-3(b) (iii)	Day lighting for carparks.	1	0
		TOTAL	2

No credit given for carpark as it does not meet the minimum 80% of the applicable areas.

Therefore, credits scored for 1-3(b) = 2 credits

RES 1-4 ARTIFICIAL LIGHTING

<table>
<tr><td>Objectives</td><td>Encourage the use of energy efficient lighting to minimise energy consumption from lighting usage</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.

Use of suitable and effective light fitting such as LED, T5 and etc can contribute to better energy efficiency in buildings.</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 10 credits can be scored for the improvement in the lighting power budget in common areas.

0.25 credit for every percentage improvement in the lighting power budget over the baseline standard. That is:

Credits scored = 0.25 x (% improvement)

Please refer to Table 11 in MS 1525:2014 for maximum lighting power budget (intensity) according to type of usage. Below are some example:

Table 1-4.1:Lighting power budget
<table><tr><th>Type of usage</th><th>Maximum Lighting Power Budget (W/m^2)</th></tr><tr><td>Stairs</td><td>5</td></tr><tr><td>Car parks</td><td>5</td></tr><tr><td>Corridors</td><td>5</td></tr><tr><td>Lobbies</td><td>5</td></tr><tr><td>Toilets</td><td>6</td></tr><tr><td>Gymnasium (Exercise area)</td><td>5</td></tr></table>Remarks:
1. Display lighting, specialised lighting and building’s exterior lighting are to be included in the calculation of lighting power budget.
2. The lighting power budget shall not apply in individual residences and apartments but shall apply to common area such as landscape lighting, mechanical rooms, stairs, lobbies, corridors and car parks within the residential building.</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; improvement in the prescribed tabulated format as shown in the worked example 1-4;
• Technical product information of the lighting luminaries used.</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 1-4

a) Determine the total power consumption based on the lighting layout design for each areas 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 1-4.2 : Total power consumption based on each fitting type

Description	Areas (m^2) (A)	Light Fitting Type (B)	Power Consumption per fitting (W) (C)	Ballast Loss (W) (D)	No. of Fitting (E)	Total power consumption based on fitting type [(C+D)x(E)]
Corridors	580	T5	1x28	3	70	2170
Staircases	420	T5	1X28	3	35	1085
Car parks	1500	T5	1x28	3	130	4030
Exterior Lighting	200	LED bollard	4x1	1	28	140
		Floodlight CDM-TC	1x35	4	15	585
					Total:	8010

Table 1-4.3 : Total power consumption based on design and MS 1525 requirements

Description	Areas (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) (HxA)
Corridors	580	2170	3.74	5	2900
Staircases	420	1085	2.85	5	2100
Car parks	1500	4030	2.69	5	7500
Exterior Lighting	200	725	3.63	3	600
	Total:	8010			13100

% improvement in the lighting power budget

= [∑ (H x A) – ∑(F)/∑(H x A) x 100]

= (13100 – 8010)/13100 x 100)

= 38.85%

Credits scored = 0.25 x 38.85% = 9.7 credits

Therefore, credit scored for 1-4 should be 9.7 credits.

RES 1-5 VENTILATION IN CARPARKS

Objectives	Encourage the use of energy efficient design and control of ventilation systems in car parks.
Applicability	Applicable to all car park spaces in the development.
Baseline Standard	-
Requirements	1-5(a) 6 credits can be scored for car park spaces that are fully naturally ventilated. 1-5(b) For carparks that have to be mechanically ventilated, credits can be scored for the use of carbon monoxide (CO) sensors in regulating such demand based on the mode of mechanical ventilation (MV) used; 4 credits for car parks using fume extract system and 3 credits for those with MV with or without supply. Note: Where there is a combination of different ventilation modes adopted for carpark design, the credits scored under this requirement will be prorated accordingly.
Documentary Evidences	For 1-5(a) and (b) • Plan layouts showing all car park provision for the development with highlights of the car park spaces that are designed to be naturally ventilated and/or mechanical ventilated; • Plan layout indicating the location of CO sensors and the mode of ventilation adopted for the design; and • Calculation showing the credits allocation if there is a combination of different ventilation mode adopted for the car park design.
References	-
Worked Example 1-5	Proposed development has two levels of basement car parks. Level 1 basement car park (B1) is designed with more than 20% openings for natural ventilation and fume extract system. Level 2 basement car park (B2) is fully mechanically ventilated. CO sensors are installed to control the ventilation system for both car park levels. Areas of basement car park – B1 = 700m^2 Areas of basement car park – B2 = 500m^2 Total areas = 1200m^2 Credits scored for 1-5 = (700/1200) x 4 + (500/1200) x 3 = 3.58 credits

RES 1-6 LIFTS

Objectives	Encourage the use of energy efficient lifts.
Applicability	Applicable to **ALL** lift in the development.
Baseline Standard	-
Requirements	1 credit can be scored for the use of lift with energy efficient features such as AC variable voltage and variable frequency (VVVF) motor drive and energy efficient features such as sleep mode.
Documentary Evidences	• Extracts of the tender specification indicating the types of lifts and related features used; and • Technical information of the lifts.
References	-
Worked Example 1-6	Proposed development has the following provision; All lifts are VVVF motor drive with sleep mode features 1 credit for the use VVVF motor drive with sleep mode features. Therefore, credits scored for 1-6 = 1 credit

RES 1-7 ENERGY EFFICIENT FEATURES

Objectives	Encourage the use of energy efficient features that are innovative and have positive environmental impact in term of energy saving.
Applicability	Applicable to practices and features that are not listed in the requirements under Part 1 – Energy Efficiency.
Baseline Standard	-
Requirements	(a) 0.5 credit for the use of energy efficient equipment or products that are certified by approved local certification body for at least 90% of the applicable equipment type or products. (Up to 2 credits) (b) Up to 5 credits can be scored for the use of the following energy efficient features based on their potential environmental benefits and the extent of coverage. i. Use of thermal insulation or cool paints on the east and west facing external walls • 2 credits for window to wall ratio (WWR) of less than 0.5 • 1 credit for WWR that is between 0.5 – 0.75 • 0.5 credit for WWR of more than 0.75 ii. Use of occupancy sensors for private lift lobbies, staircases, common toilets • 1 credit for at least 50 occupancy sensors installed • 0.5 credit for less than 50 occupancy sensors installed iii. Provision of vertical greenery system on building façades abutting the living, dining and bedrooms areas of dwelling units and club house • 2 credits for more than 50% of building façades • 1 credit for at least 25% of building façades • 0.5 credit for clubhouse iv. Provision of clothes drying facilities and open spaces • 1 credit for more than 90% of all dwelling units • 0.5 credit for between 50% to 90% of dwelling units v. Provision of lifts with better energy efficient features (Up to 2credits) • 2 credits for the use of regenerative drive system for at least 90% of lifts installed • 1 credit for the use of gearless drive system for at least 90% of lifts installed vi. 0.5 credit for the provision of ductless fans for basement ventilation.

vii. 0.5 credit for the computation of Energy Efficient Index (EEI) for common facilities of the development.

Calculation of EEI for Common Facilities:

EEI = (TEC / GFA) x 365 days

Where:

(a) TEC : Total electricity consumption for common facilities (kWh/day)
(b) GFA : Gross floor area of development (m^2)

The common facilities and the daily usage hours of these facilities are pre-determined for consistency as shown in Table 1-7.1. They are to be used in the computation for EEI. Other common facilities that are not listed should be included under 'Others' and the operation hours can be estimated based on the likely usage pattern.

Table 1-7.1: Common Facilities and Daily Usage Pattern

	Description	**Daily Usage (hr)**
	A) Mechanical Load	
	MV fan (plant room)	9
	Car park fan	4
	A/C for club house	12
	A/C for lobbies	12
	A/C for guard house	24
	Domestic pump	2
	Ejector pump	2
	Booster pump	3
	Sump pump	0.5
	B) Lift Load	
	Passenger lifts	2
	Service lift	2
	C) General lighting	
	Car park lighting – 24 hours operation	24
	Car park lighting – 5 hours operation	5
	Guard house lighting	12
	Façade lighting	5
	Landscape lighting – 12 hours operation	12
	Landscape lighting – 5 hours operation	5
	Lift lobbies, corridors & staircase lighting – 12 hours operation	12
	Lift lobbies, corridor & staircase lighting – 5 hours operation	5
	D) Club Facilities	
	Club house interior lighting	12
	Power to Gym equipment, SPA, etc	6
	Swimming pool filtration	12
	Water features	8
	E) Others	
	Facilities A	To estimate
	Facilities B	To estimate

Notes: For features that are not listed in RES 1-7 (i) to (vii) above, the QP is required to submit the details showing the positive environmental impacts and potential energy savings of the proposed features to GreenRE for assessment

<table>
<tr><td>Documentary Evidences</td><td>

Extracts of the tender specification showing the provision of the proposed energy efficient features and the extent of implementation where applicable;
Technical product information on the energy efficient features used; and
Calculation of the potential energy saving that could be reaped from the use of these features.
Calculation of the Energy Efficiency Index (EEI) using the pre-determined daily usage pattern as in Table 1-7.1 and in the prescribed tabulated format as shown in the worked example 1-7(vii).

</td></tr>
<tr><td>References</td><td>-</td></tr>
<tr><td>Worked Example 1-7(vii)</td><td>
<u>Background info:</u>
Proposed residential development with the following estimated electricity consumption for common facilities.

Table 1-7.2: Estimated electricity consumption for common facilities
<table>
<tr><th></th><th>Description</th><th>Estimated Load (KW)</th><th>Daily usage (hr)</th><th>Load per day (KWh)</th></tr>
<tr><td></td><td colspan="4">A) Mechanical Load</td></tr>
<tr><td></td><td>MV fan (plant room)</td><td>9</td><td>9</td><td>81</td></tr>
<tr><td></td><td>Car park fan</td><td>320</td><td>4</td><td>1280</td></tr>
<tr><td></td><td>A/C for club house</td><td>8</td><td>12</td><td>96</td></tr>
<tr><td></td><td>A/C for lobbies (1st sty & Basement)</td><td>0</td><td>12</td><td>0</td></tr>
<tr><td></td><td>A/C for guard house</td><td>2</td><td>24</td><td>48</td></tr>
<tr><td></td><td>Domestic pump</td><td>70</td><td>2</td><td>140</td></tr>
<tr><td></td><td>Ejector pump</td><td>13</td><td>2</td><td>26</td></tr>
<tr><td></td><td>Booster pump</td><td>28</td><td>3</td><td>84</td></tr>
<tr><td></td><td>Sump pump</td><td>12</td><td>0.5</td><td>6</td></tr>
<tr><td></td><td colspan="4">B) Lift Load</td></tr>
<tr><td></td><td>Passenger Lifts</td><td>470</td><td>2</td><td>940</td></tr>
<tr><td></td><td>Service lifts</td><td>0</td><td>2</td><td>0</td></tr>
<tr><td></td><td colspan="4">C) General lighting</td></tr>
<tr><td></td><td>Car park lighting – 24 hours operation</td><td>23</td><td>24</td><td>552</td></tr>
<tr><td></td><td>Car park lighting – 5 hours operation</td><td>23</td><td>5</td><td>115</td></tr>
<tr><td></td><td>Guard house lighting</td><td>0.3</td><td>12</td><td>3.6</td></tr>
<tr><td></td><td>Façade lighting</td><td>0</td><td>5</td><td>0</td></tr>
<tr><td></td><td>Landscape lighting – 12 hours operation</td><td>30</td><td>12</td><td>360</td></tr>
<tr><td></td><td>Landscape lighting – 5 hours operation</td><td>28</td><td>5</td><td>140</td></tr>
<tr><td></td><td>Lift lobbies, corridor & staircase Lighting – 12 hours operation</td><td>20</td><td>12</td><td>240</td></tr>
<tr><td></td><td>Lift lobbies, corridor & staircase Lighting – 5 hours operation</td><td>19</td><td>5</td><td>95</td></tr>
<tr><td></td><td colspan="4">D) Club Facilities</td></tr>
<tr><td></td><td>Club house interior lighting</td><td>12</td><td>12</td><td>144</td></tr>
<tr><td></td><td>Power Gym equipment, SPA, etc</td><td>85</td><td>6</td><td>510</td></tr>
<tr><td></td><td>Swimming Pool Filtration</td><td>50</td><td>12</td><td>600</td></tr>
<tr><td></td><td>Water Feature</td><td>25</td><td>8</td><td>200</td></tr>
<tr><td></td><td colspan="3">Total KWh per day</td><td>5660.60</td></tr>
</table>
</td></tr>
</table>

	<u>Calculation of EEI for Common facilities:</u> Total electricity consumption per day = 5660.60 kWh/day EEI = (TEC / GFA) x 365 days = (5660.60 / 40 000) x 365 = 51.65 kWh/m^2/yr Credits scored for 1-7(vii) = 0.5 credit

RES 1-8 RENEWABLE ENERGY

Objectives	Encourage the use of renewable energy sources in buildings.
Applicability	Includes all renewable energy sources
Baseline Standard	-
Requirements	Up to 16 credits can be scored based on the percentage replacement of electricity by the renewable energy source 3 credits for every 1% replacement of electricity (based on annual electricity consumption exclude household's usage) by renewable energy Condition: The credits scored for renewable energy provision shall not result in a double grade jump in GreenRE rating (i.e. from GreenRE Bronze to Silver to Gold to Platinum).
Documentary Evidences	• Extract of the tender specification and plans showing the location of the renewable energy system and the extent of implementation; • Technical product information on the salient features if the renewable energy system and the expected renewable energy generated; and • Calculation of the percentage replacement of electricity and the total annual electricity consumption of the development.
References	-
Worked Example 1-8	A residential development with GFA of 15,000m^2. The Energy Efficiency Index for its common facilities is 50 kWh/m^2/year The installation of solar array on the roof of its open car park was estimated to generate 7,500 kWh annually Total electricity consumption of the development's common areas = 50 x 15,000 = 750, 000 kWh/year Percentage of replacement of electricity by renewable energy = 7,500 / 750,000 x 100% = 1% Credits scored for 1-8 for 1% replacement of electricity = 3 credits

Part 2- Water Efficiency	**RES 2-1 Water Efficient Fittings** **RES 2-2 Water Usage Monitoring** **RES 2-3 Irrigation System and Landscaping**

RES 2-1 WATER EFFICIENT FITTINGS

<table>
<tr><td>Objectives</td><td>Reduce the use of potable water by using water efficient fittings covered under the Water Efficiency Product Labelling Scheme (WEPLS) or Water Efficiency Labelling Scheme (WELS).</td></tr>
<tr><td>Applicability</td><td>Applicable to the water fittings covered by the WEPLS or WELS as follows:
Basin taps and mixers
Flushing cistern
Sink/bib taps and mixers
Shower taps and mixers or showerheads
Urinals and urinals flush valve</td></tr>
<tr><td>Baseline Standard</td><td>As specified under Water Efficiency Product Labelling Scheme (WEPLS) or Water Efficiency Labelling Scheme (WELS).</td></tr>
<tr><td>Requirements</td><td>Up to 10 credits can be scored based on the number and water efficiency rating of the fitting type used (at least 90% of the fitting 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>0.5 credit</td><td>1 credit</td><td>2 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 worked example; and
Calculation showing the percentage of proposed water fittings that are approved under any international recognized water efficiency labelling scheme e.g. WEPLS or WELS.</td></tr>
<tr><td>References</td><td>1. For more information on WEPLS, please refer to: (http://www.span.gov.my/index.php?option=com_content&view)

2. For more information of WELS, please refer to: http://www.pub.gov.sg/wels/Pages/default.aspx</td></tr>
</table>

Worked Example 2-1

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

Table 2-1.1: Computation of credits for water fittings

Ref.	Water Fitting Type	WEPLS rating				Total	Credits Allocated
		Efficient	Highly Efficient	Most Efficient	Not Rated		
1	Shower taps and mixers	0	45	0	0	45	1
2	Basin taps and mixers	0	0	55	0	55	2
3	Sink/bib taps and mixers	0	70	0	0	70	1
4	Flushing cisterns	0	0	50	0	50	2
5	Others - Urinals for club house	0	0	0	5	5	0
	Total	0	115	105	5	225	6

Credits scored = 6 credits

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

RES 2-2 WATER USAGE MONITORING

Objectives	Promote the use of sub meters for better control and monitoring of major water usage.
Applicability	Applicable to sub-metering provisions for major water uses of the building developments.
Baseline Standard	-
Requirements	1 credit can be scored if sub meters are provided for **ALL** major water uses i.e. irrigation system, cooling tower and tenant's usage.
Documentary Evidences	• Extracts from the tender specification stating the locations and provision of private meters for all major water uses. • Schematic drawings of cold water distribution system showing the location of the sub meters provided.
References	-

RES 2-3 IRRIGATION SYSTEM AND LANDSCAPING

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

Part 3- Environmental Protection

RES 3-1 Sustainable Construction
RES 3-2 Sustainable Products
RES 3-3 Greenery Provision
RES 3-4 Environmental Management Practice
RES 3-5 Green Transport
RES 3-6 Stormwater Management
RES 3-7 Community Connectivity

RES 3-1 SUSTAINABLE CONSTRUCTION

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

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

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

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

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

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

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

Therefore, credits scored = 4 credits

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

Worked Example 3-1(b) – Cont'd

Table 3-1.4 – Concrete Usage Index

COMPUTATION OF CONCRETE USAGE INDEX RESIDENTIAL BLDG

Project Reference No.: AXXXX-00001-2015 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

Worked Example 3-1(b) Cont'd

COMPUTATION OF CONCRETE USAGE INDEX				RESIDENTIAL BLDG
Project Reference No. : AXXXX-00001-2015 Total no. of storey for the project: 15				
Block No : A				
Structural System		Thickness (mm) or size (mm x mm)	Volume of concrete (m^3)	Remark *
2	2^{nd} storey to 30^{th} storey (Typical floor layout)			
	2.9 Internal walls – load bearing walls	200	40	RC
	2.10 Internal walls – non-load bearing walls	Nil	0	-
	2.11 Others (kerbs, ramps, services risers etc)	Nil	0	-
	Volume of concrete for one storey (m^3)		360	
	Constructed floor area for one storey		933.3	
	Total volume of concrete for 2^{nd} to 15^{th} storey		360x15=5400	
	Total constructed floor area for 2^{nd} to 15^{th} storey (m^2) (including roof level)		933.3x15=14000	
Total volume of concrete for this project (m^3)			5987	
Total constructed floor area for this project (m^2)			15000	
Concrete Usage Index (CUI in m^3/m^2)			0.4	

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

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

RES 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 appropriate environmentally friendly products that are certified by approved local/international certification body. The products used should have considerably contributions in the overall environmental sustainability standard of the development. Credits scored will be based on the weightage, extent of coverage and impact.

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

Table 3-2.1 : Weightage for credits allocation
<table><tr><th>Extent of Environmental Friendliness of Product</th><th>Weightage for Credits Allocation</th></tr><tr><td>Good</td><td>1</td></tr><tr><td>Very Good</td><td>1.5</td></tr><tr><td>Excellent</td><td>2</td></tr></table>
The use of environmental friendly products or recycled materials used for all dwelling units of the development will be considered as <u>high impact</u> (1 credit). Items that are used for all common areas, external works and communal facilities are considered as <u>low impact</u> (0.5 credits).

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

References

For more info on product certification, please refer to:

http://www.sirim-qas.com.my/index.php/zh/our-services/product-certification/eco-labelling-scheme

http://www.sec.org.sg/sgls or http://www.sgbc.sg/green-certifications

Worked Example 3-2

1. Determine if the environmental friendly products selected are certified with approved local/international certification body.

2. Check if the products used are meant for all dwelling units of the development and can be considered as high impact. Products that are meant for common areas and external works such as toilets, lobbies and landscaping areas are considered as low impact.

3. Check on the extent of environmental friendliness of the products and the rating granted by the approved certification body.

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 certified wooden doors for all dwelling units. Product is rated as 'Very Good' by approved local/international certification body.
(b) Use of certified bamboo flooring for all units' bedrooms. Product is rated as 'Excellent' by approved local/international certification body.
(c) Use of certified roof waterproofing coating. Product is rated as 'Excellent' rating by approved local/international certification body.

Table 3-2.3 : Detail calculation for credits scoring

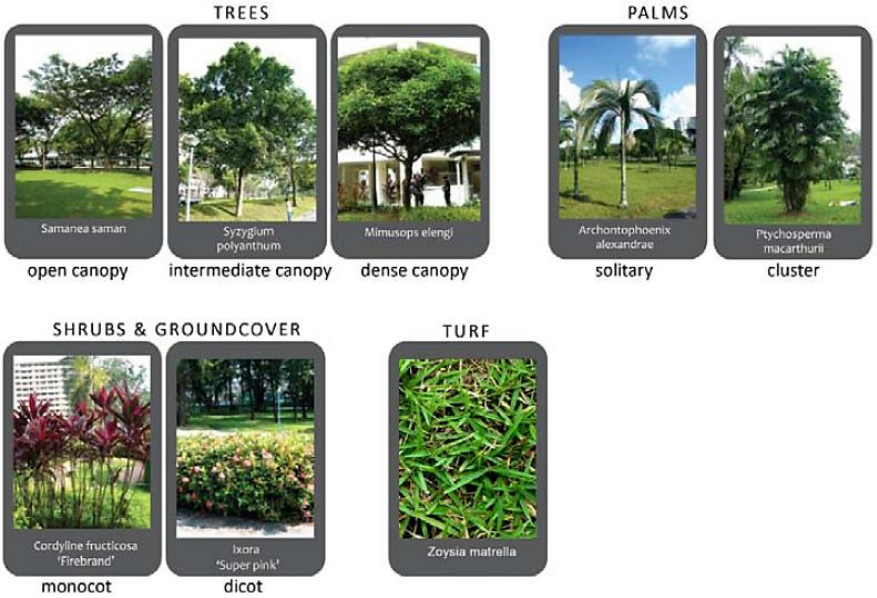
Products and Extent of coverage		With approved certification	Credits allocated based on impact (A)	Weightage based on rating (B)	Credits scored (AxB)
(a)	Wooden doors for all dwelling units	Yes	1	1.5	1.5
(b)	Bamboo flooring for all units' bedrooms	Yes	1	2	2
(c)	Roof waterproofing	Yes	0.5	2	1

Therefore, credits scored for 3-2 = 1.5 + 2 +1 = 4.5 credits

RES 3-3 GREENERY PROVISION

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

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

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

Green Plot Ratio (GnPR) = Total Leaf Area / Site Area

Table 3-3.2 : Credits Allocation according to GnPR

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

3-3 (b) 1 credit for restoration of trees on-site, conservation or relocation of existing trees on site.

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

Documentary Evidences

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; and
- Calculation showing the extent of the greenery provision in the prescribed tabulated formats as in worked example 3-3(a).

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.

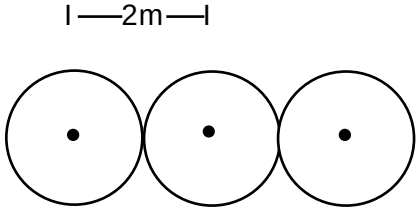
For 3-3 (c)

- Extracts of the tender specification showing the requirements to use compost recycled from horticulture waste.

Exceptions

TREES AND PALMS SPACING (CENTRE-TO-CENTRE)

(a) If the selected trees and palms are to be planted at ≤ 2m from trunk-to-trunk as illustrated below, the leaf area shall be calculated as the product of LAI value and planted area (in m^2).



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

National Parks Board, Singapore - 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 2000 m^2

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

= 5790 / 4000 = 2.9 < 3.0

Where GnPR = 2.0 to < 3.0

Therefore, credits scored for 3-3(a) = 2 credits

RES 3-4 ENVIRONMENTAL MANAGEMENT PRACTICE

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

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

RES 3-5 GREEN TRANSPORT

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

RES 3-6 STORMWATER MANAGEMENT

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

RES 3-7 COMMUNITY CONNECTIVITY

Objectives	Encourage development in urban area with existing infrastructure to minimise the use of private mode of transportation.
Applicability	Generally applicable to building developments.
Baseline Standard	-
Requirements	1 credit can be scored for project located within walking distance of 1km to at least 10 Basic Services. Basic Services include, but are not limited to: • Bank • Beauty • Convenience/Grocery • Day care • Fire Station • Hardware • Laundry • Library • Police station • Park • Pharmacy • Post Office • Restaurant • School • Supermarket • Clinic
Documentary Evidences	• Site layout plan showing the location of the development site and the location of Basic Services mentioned above.
References	-

Part 4 – Indoor Environmental Quality	**RES 4-1 Noise Level** **RES 4-2 Indoor Air Pollutants** **RES 4-3 Waste Disposal** **RES 4-4 Indoor Air Quality in Wet Areas**

RES 4-1 NOISE LEVEL

Objectives	Recognise buildings that are designed to consider the potential noise levels within the dwelling units are maintained at an appropriate level.
Applicability	Generally applicable to building developments.
Baseline Standard	"The Planning Guidelines for Environmental Noise Limits and Control " Department of Environmental Malaysia, Ministry of Natural Resource and Environmental Malaysia
Requirements	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} 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.
Documentary Evidences	• Extracts of the tender specification showing the requirement to design the occupied space with the ambient sound levels; and • A report of the detailed analysis and recommendations from acoustic consultant on how the designed ambient sound levels can be met where applicable.
References	-

RES 4-2 INDOOR AIR POLLUTANTS

Objectives	Minimise airborne contaminants, mainly from inside sources to promote a healthy indoor environment.
Applicability	Generally applicable to building developments.
Baseline Standard	-
Requirements	4-2(a) 1 credit can be scored for the use of low volatile organic compounds (VOC) paints certified by approved local/ international certification body for at least 90% of the internal wall areas. 4-2(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 4-2(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. • Technical product information <u>For 4-2(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 or equivalent for all composite wood products used. • Technical product information
References	-

RES 4-3 WASTE DISPOSAL

Objectives	Minimise airborne contaminants from waste.
Applicability	Generally applicable to building developments.
Baseline Standard	-
Requirements	1 credit can be scored if the refuse chutes or waste disposal are located at open ventilation areas such as service balconies or common corridors
Documentary Evidences	• Plan layouts showing the location of the refuse chutes for all typical dwelling units.
References	-

RES 4-4 INDOOR AIR QUALITY IN WET AREAS

Objectives	Encourage provision of adequate natural ventilation and day lighting in wet areas.
Applicability	Generally applicable to all wet areas such as kitchens, bathroom and toilets of the development.
Baseline Standard	-
Requirements	Up to 2 credits can be scored if there is provision for adequate natural ventilation and day lighting in wet areas i.e. kitchens, bathroom and toilets. • 2 credits for more than 90% of all applicable areas. • 1 credit for at least 50% to 90% of all applicable areas.
Documentary Evidences	• Plan layouts showing the location of the window openings of the kitchens, bathrooms and toilets for all typical dwelling units.
References	-

Part 5 – Other Green Features

RES 5-1 GREEN FEATURES & INNOVATIONS

Objectives	Encourage the use of green features that are innovative and have positive environment impact on water efficiency, environment protection and indoor environment quality of the buildings.
Applicability	Generally applicable to all building development.
Baseline Standard	-
Requirements	Up to 7 credits can be scored for the use of the following green features depending on their potential environmental benefits and the extent of coverage. <u>Water efficiency</u> i. Use of self-cleaning façade system • 2 credits for more than 75% of the applicable facades areas • 1 credit for more than 50% of the applicable facades areas • 0.5 credit for at least 25% of the applicable facades areas ii. Use of integrated basin/cistern pedestal system • 2 credit s for more than 50% of all dwelling units' flushing cisterns • 1 credit for more than 25% of all dwelling units' flushing cisterns • 0.5 credit for at least 10% of all dwelling units' flushing cisterns iii. Use of grey water recycling system • 2 credits for all blocks of the development. • 1 credit for at least one block of the development. iv. Provision of system to recycle surface runoff from the vertical green wall and sky garden • 1 credit for at least 25% of the green areas • 0.5 credit for less than 25% of the green areas v. Use of water efficient washing machine with WEPLS "Efficient" rating and above • 1 credit for more than 90% of all dwelling units. • 0.5 credit for at least 50% of all dwelling units. <u>Environmental Protection</u> i. Use of precast toilet • 2 credits for more than 75% of all toilets • 1 credit for more than 50% of all toilets • 0.5 credit for at least 25% of all toilets ii. Provision of green roof and roof top garden • 1 credit for more than 50% of the roof areas • 0.5 credit or at least 25% of the roof areas

	iii. 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 iv. 1 credit for the provision of double refuse chutes for separating recyclable from non-recyclable waste. v. 0.5 credit for the use of non-chemical termite treatment system. vi. 0.5 credit for the provision of at least 5 nos. of compost bins to recycle organic waste. vii. 0.5 credit for the use of non-chemical water treatment system for swimming pools. viii. Conservation of existing building structure or building envelope (by areas). • 2 credits for conserving more than 50% of the existing structure or building envelope • 1 credit for conserving at least 25% of the existing structure or building envelope ix. 1 credit for the computation of Concrete Usage Index (CUI) of the building development. x. Adoption of demolition protocol to maximise resource recovery of demolition materials for reuse or recycling. • 2 credits for recovery rate of more than 35% crushed concrete waste to be sent to the approved recycles with proper facilities • 1 credit for recovery rate at least 20% crushed concrete waste to be sent to the approved recyclers with proper facilities <u>Indoor Air Quality</u> 1 credit for the use of pneumatic waste collection system. <u>Others</u> 0.5 credit for the use of siphonic rainwater discharge system at roof. **Notes:** For features that are not listed above, the QP is required to submit the details showing the positive environmental impacts, possible saving 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 drawing and supporting documents) of the green features;

	• A summary sheet listing the breakdown and the extent of implementation as well as the total requirements for the same intended purpose for the specific green features used; and • Quantified evidences on the potential environmental benefits that the features can bring to the development. • Computation of Concrete Usage Index (CUI) and supporting documents as stated under RES 3-1(b) • Demolition audit from showing the summary of the total and actual quantity of concrete waste and delivery records or receipts from approved recycling firm.
References	-

Part 6 – Carbon Emission of Development

RES 6-1 CARBON EMISSION OF DEVELOPMENT

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

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

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

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

4. Documentation Requirements

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

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

Table: Summary Checklist and the Corresponding Signatories for GreenRE Residential & Landed Home Criteria

GreenRE Criteria	Required Signatories
Part 1 – Energy Efficiency	
RES 1-1 Thermal Performance of Building Envelope- RETV	PA
RES 1-2 Naturally Ventilated Design and Air-Conditioning System • Dwelling Unit Comfort - Ventilation Simulation/ Design - Use of energy efficient air conditioners • Natural Ventilation in Common Areas	 PA PE PA
RES 1-3 Daylighting	PA
RES 1-4 Artificial Lighting	PE
RES 1-5 Ventilation in Carparks	PE
RES 1-6 Lifts	PE
RES 1-7 Energy Efficient Features • Heat Recovery Devices • Motion Sensors/ Photo Sensors • Others	 PE PE S
RES 1-8 Renewable Energy	S
Part 2 – Water Efficiency	
RES 2-1 Water Efficient Fittings	PA
RES 2-2 Water Usage Monitoring	PE
RES 2-3 Irrigation System and Landscaping	PE
Part 3 – Environmental Protection	
RES 3-1 Sustainable Construction	PE
RES 3-2 Sustainable Products	PA
RES 3-3 Greenery Provision	PE
RES 3-4 Environmental Management Practice	PE
RES 3-5 Green Transport	PA
RES 3-6 Stormwater Management	PE
RES 3-7 Community Connectivity	PA
Part4 – Indoor Environmental Quality	
RES 4-1 Noise Level	S
RES 4-2 Indoor Air Pollutants	PA
RES 4-3 Waste Disposal	PA
RES 4-4 Indoor Air Quality in Wet Areas	PA
Part 5 – Other Green Features	
RES 5-1 Green Features & Innovations	S
Part 6 – Carbon Emission of Development	
RES 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

VENTILATION SIMULATION METHODOLOGY AND REQUIREMENTS

A1 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.

A2 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.

A3 Ventilation Simulation Methodology

A3.1 All simulation shall be carried out under isothermal condition of 33.0°C air temperature at steady state condition.

A3.2 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.

A3.3 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.

A3.4 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 A3.4 below. The inbound vertical wind profile shall assume to be given by the Logarithmic Law reference height at 15.0m

Table A3.4: 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

A3.5 There shall have two large scale simulation models using the specified computational domain and grid stated in paragraph A3.2 and A3.3, 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 A3.5 (iv) from each typical unit design layout as determined in A3.5 (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. For residential buildings, the applicable areas refer to living room, open kitchen (that is connected to the living room), study rooms and all bedrooms. The area-weighted average wind velocities of these areas are to be computed at horizontal-plane 1.2m above the floor level. The same applies to naturally ventilate functional spaces for non-residential buildings.

A3.6 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:

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

A4 Documentation Requirements

A4.1 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