Building and Construction Authority

BCA Green Mark Certification Standard for Existing Buildings

GM Version 3.0

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Addendums and Updates

Addendums and Updates	Page	DATE
GM Certification Standard Version 3.0		January 2016

BCA Green Mark

Certification Standard

For Existing Buildings

GM Version 3.0

January 2016

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BCA GREEN MARK CERTIFICATION STANDARD FOR EXISTING BUILDINGS

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1 INTRODUCTION

The intent of this Certification Standard for Existing Buildings (referred to as “Standards”) is to guide owners of existing buildings to improve the minimum sustainability standards of existing buildings and establish environmentally friendly practices in the operation and retrofitting of existing buildings

This Standard sets out the requirements for assessing the environmental performance of an existing building.

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

If you need clarification on any aspect of this Standard, please contact the Building and Construction Authority, Singapore (BCA).

2 SCOPE

This Standard sets out the requirement for assessing the environmental performance of a building development. It provides the assessment criteria in determining the level of environmental performance of a building development

The provision of this Standard are applicable to:

a. Existing buildings and related building systems

3 NORMATIVE REFERENCES

The following referenced codes, standards and other documents referred in this standard shall be considered part of the requirements of this Standard to the extend as prescribed.

a. Code on Envelope Thermal Performance for Buildings

b. CP 24:1999 - Code of Practice for Energy Efficiency Standard for Building Services and Equipment

c. CP 13:1999 - Code of Practice for Mechanical ventilation and Air-Conditioning in Buildings

d. CP 38:1999 - Code of Practice for Artificial Lighting in Buildings

e. SS 531:Part 1: 2006 - Code of Practice for Lighting of Work Places, Part 1 : Indoor

f. SS 554:2009 - Code of Practice for Indoor Air Quality for Air-conditioned Buildings

g. NEA's Guidelines for Good Indoor Air Quality in Office Premises

h. ASHRAE Guideline 22 – Instrumentation for Monitoring Central Chilled water Plant Efficiency by American Society of Heating, Refrigerating and Air-Conditioning Engineer (ASHRAE)

i. AHRI Standard 550/590 – Performance Rating of Water Chilling and Heat Pump Water–Heating Packages Using the Vapour Compression Cycle by Air-Conditioning, Heating and Refrigeration Institute(AHRI)

4 TERMS AND DEFINITIONS

For the purpose of this Standard, the following definitions shall apply:

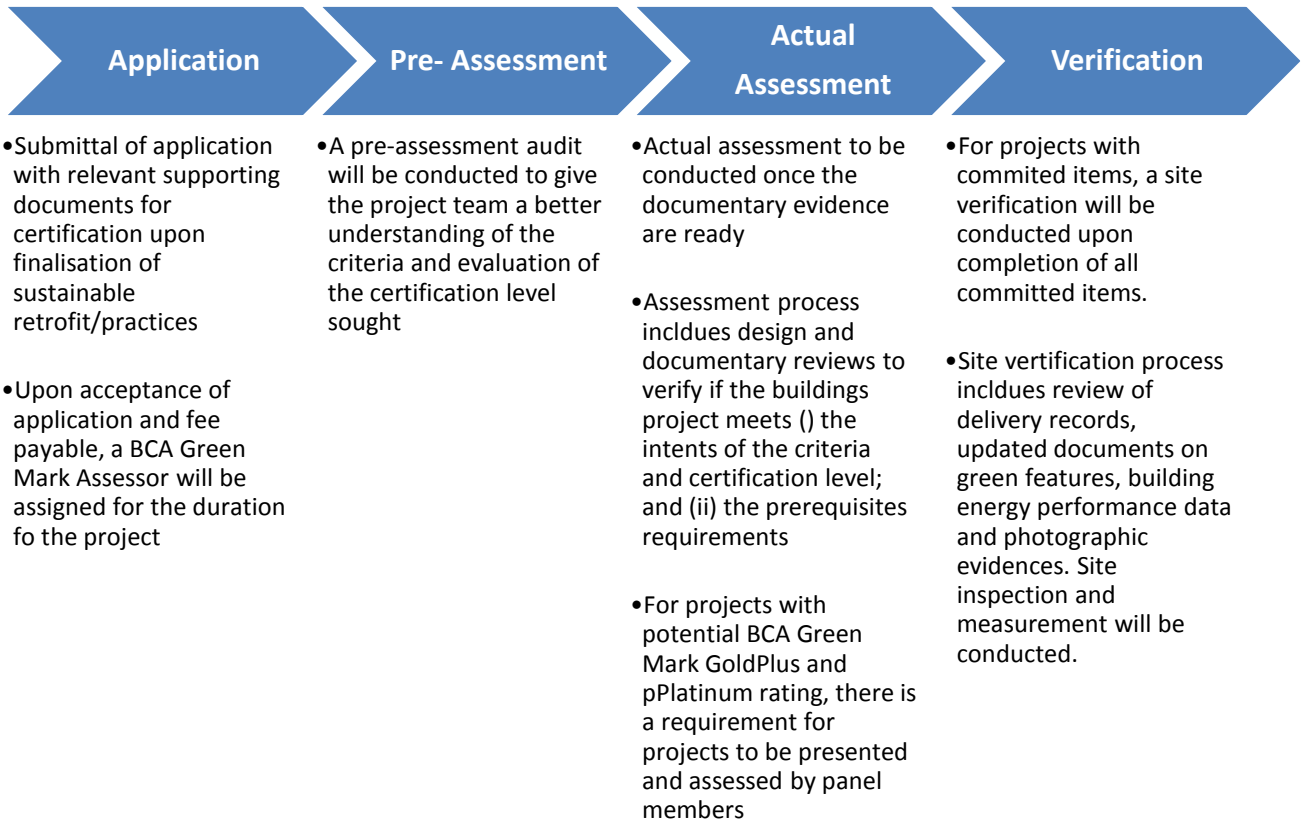
BCA	The Building and Construction Authority
Chilled Water Plant	A building's centralised air conditioning system which makes use of chilled water as the medium for removing the heat from the buildings. This includes the chillers and its ancillary equipment, including pumps and cooling towers where applicable.
Gross Floor Area (GFA)	The "gross floor area" has the same meaning as "floor area" in the Planning (Development Charges) Rules (Cap.232, R 5)
Minimum Green Mark Score	The lowest Green Mark score that would meet the minimum environmental performance required for existing buildings.

Operational System Efficiency (OSE)	The measured system efficiency of the building's chilled water plant during its normal operating hours.
Unitary Air Conditioning System	One or more factory-made assemblies that normally include an evaporator or cooling coil and a compressor combination. Units that perform a heating function area are also included.

In instances where terms are not expressly stated in this Code and are defined in other referenced documents, such terms shall have the meanings as determined in those documents.

5 CERTIFICATION PROCESS

The BCA Green Mark Certification Process is as follows:



6 ASSESSMENT FRAMEWORK

6.1 General

The environmental performance of an existing building shall be determined by the level of environmental performance and the numerical scores (i.e. Green Mark points) achieved in accordance with the degree of compliance with the applicable criteria using the scoring methodology as specified in this Standard. Under this assessment framework, points are awarded for incorporating sustainable green features and practices, which would add up to ta final Green Mark Score. Depending on the level of building's performance and Green Mark Score, the existing building will be eligible for certification under one of the four ratings namely BCA Green Mark Certified, Gold, Gold^{Plus}, or Platinum (see table 6.1). The framework and point allocations for the assessment criteria are as illustrated in Table 6.2 and 6.3.

6.2 Environmental Performance of Buildings for Certification

The Green Mark Score of an existing building is the total of all the numerical scores (i.e. Green Mark points) assigned based on the degree of compliance with the applicable criteria. The following table 6.1 states the corresponding Green Mark Score and prerequisite requirements to attain the respective Green Mark rating namely the BCA Green Mark Certified, Gold, Gold^{Plus}, or Platinum.

Table 6.1. BCA Green Mark Award Rating and Prerequisite Requirements

Green Mark Score	Green Mark Rating
90 and above	Green Mark Platinum
85 to <90	Green Mark Gold^{Plus}
75 to <85	Green Mark Gold
50 to <75	Green Mark Certified

Pre-requisite Requirements for Existing Non-residential Building Criteria

PART 1 - ENERGY EFFICIENCY

1. ENERGY EFFICIENCY

Green Mark Rating	Minimum points achievement from Part 1 – Energy Efficiency
Green Mark Certified	30 points
Green Mark Gold	35 points
Green mark Gold^{Plus}	40 points
Green Mark Platinum	45 points

2. MINIMUM SYSTEMS' EFFICIENCY

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

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

Green Mark Rating	Building Cooling Load (RT)	
	< 500	≥ 500
	Efficiency (kW/RT)	
Certified	0.85	0.75
Gold	0.80	0.70
Gold^{Plus}	0.75	0.68
Platinum	0.70	0.65

(ii) For Buildings using Air Cooled Chilled-water Plant or Unitary Air-Conditioner

Green Mark Rating	Building Cooling Load (RT)	
	< 500	≥ 500
	Efficiency (kW/RT)	
Certified	1.1	1.0
Gold	1.0	Not applicable
Gold^{Plus}	0.85	
Platinum	0.78	

For building with building cooling load of more than 500 RT, the use of air cooled central chilled-water plant or other unitary air-conditioners are not applicable for Gold and higher ratings.

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

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

3. CHILLER PLANT M&V INSTRUMENTATION

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

4. NATURAL VENTILATION AREA (only applicable to occupied areas, excluding circulation, plant rooms and transit areas):

Pre requisite requirement for Platinum - At least 75% of natural ventilated areas with effective cross ventilation with North and South facing window opening

PART 4 - INDOOR ENVIRONMENTAL QUALITY

1. IAQ Audit - to conduct an full IAQ audit three yearly that complies with NEA's Guidelines for Good Indoor Air Quality in Office Premises or SS554:2009 Code of Practice for `Indoor air quality for air-conditioned buildings' **[4 points]** [ENRB 4-1(a)]

6.3 Assessment Criteria

The environmental impact categories are broadly classified under two main groupings:

(i) Energy Efficiency consists of Part 1- Energy Efficiency where points are allocated for the various energy efficient systems, practices and features used. A minimum of 30 points must be obtained from this group to meet the minimum environmental sustainability standard.

(ii) Other Green Requirements consist of Part 2 – Water Efficiency; Part 3 – Sustainable Operation & Management; Part 4 – Indoor Environmental Quality; and, Part 5 – Other Green Features. Points are allocated for the water efficient features, use of environmental friendly practices, waste management and innovative green features used. A minimum of 20 points must be obtained from this group to comply with the minimum environmental sustainability standard.

The intent of each category is summaries as below:

(a) *Part 1 – Energy Efficiency:* This category focuses on greater use of energy efficient building system including air-conditioning, ventilation, lightings, lifts and escalators; and also monitoring of these systems. It also looks at applications of renewable energy and energy efficient features.

Important Note:

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

(b) *Part 2 – Water Efficiency:* This category focuses on the use of water efficient fittings and adoption of water efficient features, which can help to reduce the use of water for building operations.

(c) *Part 3 – Sustainable Operation & Management:* This category focuses on the building management operation and maintenance, the use of sustainable and environmental-friendly products, provision of waste management and greater use of greenery.

(d) *Part 4 – Indoor Environmental Quality*: This category focuses on promoting a healthy indoor environment which includes air quality, thermal comfort, minimizing indoor air pollutants, acceptable internal noise level and encourage good lighting quality.

(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.

Table 6.2: Framework and Point Allocation for BCA Green Mark for Existing Non-Residential Buildings Criteria (Version 3.0)

CATEGORY		POINT ALLOCATION
(I) ENERGY EFFICIENCY		
Minimum 30 points to be scored	**Part 1 – Energy Efficiency**	
	ENRB 1-1 Thermal Performance of Building Envelope	5
	ENRB 1-2 Air Conditioning System	32
	ENRB 1-3 Natural Ventilation / Mechanical Ventilation	
	ENRB 1-4 Artificial Lighting	13
	ENRB 1-5 Ventilation in Carparks	4
	ENRB 1-6 Ventilation in Common Areas	5
	ENRB 1-7 Lifts and Escalators	2
	ENRB 1-8 Energy Efficient Practices & Features	12
	ENRB 1-9 Energy Policy & Management	1
	ENRB 1-10 Renewable Energy	15
	Category Score for Part 1 – Energy Efficiency	**89**
(II) OTHER GREEN REQUIREMENTS		
Minimum 20 points to be scored	**Part 2 - Water Efficiency**	
	ENRB 2-1 Water Monitoring	4
	ENRB 2-2 Water Efficient Fittings	12
	ENRB 2-3 Alternative Water Sources	3
	ENRB 2-4 Water Efficiency Improvement Plans	1
	ENRB 2-5 Irrigation System and Landscaping	2
	ENRB 2-6 Cooling Towers	2
	Category Score for Part 2 – Water Efficiency	**24**
	Part 3 - Sustainable Operation & Management	
	ENRB 3-1 Building Operation & Maintenance	4
	ENRB 3-2 Post Occupancy Evaluation	3
	ENRB 3-3 Waste Management	7
	ENRB 3-4 Sustainable Products	8
	ENRB 3-5 Greenery	10
	ENRB 3-6 Environmental Protection	3
	ENRB 3-7 Green Transport	4
	Category Score for Part 3 – Sustainable Operation and Management	**39**
	Part 4 - Indoor Environmental Quality	
	ENRB 4-1 Indoor Air Quality Performance	8
	ENRB 4-2 Indoor Air Pollutants	2
	ENRB 4-3 Lighting Quality	5
	ENRB 4-4 Thermal Comfort	2
	ENRB 4-5 Internal Noise Level	1
	Category Score for Part 4 – Indoor environment Quality	**18**
	Part 5 – Other Green Features	
	ENRB 5-1 Green Features & Innovations	10
	Category Score for Part 5 – Other Green Features	**10**
	Category Score for Other Green Requirements	**91**
	Total Green Mark Score	**180**

Table 6.3 : Existing Non-Residential Building Criteria (energy related requirements)

<table>
<tr><th>Part 1 - Energy Efficiency</th><th>Green Mark Points</th></tr>
<tr><td>ENRB 1-1 Thermal Performance of Building Envelope

Enhance the overall thermal performance of building envelope to minimize heat gain thus reducing the overall cooling load requirement.</td><td>0.5 points for every reduction of 1 W/m2 in ETTV from the baseline of 50 W/m^2

Point scored = 0.5 x (50 – ETTV)

(Up to 5 points)</td></tr>
<tr><td>ENRB 1-2 Air-Conditioning System
Applicable to Air-conditioned Building Areas (with an aggregate air-conditioned areas > 500m^2)

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

(a) Water-Cooled Chilled-Water Plant:
a) Water-Cooled Chiller
b) Chilled water pump
c) Condenser water pump
d) Cooling tower

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

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

Air cooled Chilled-Water Plant:
▪ Air-Cooled Chiller
▪ Chilled Water Pump

Unitary Air-Conditioners:
▪ Variable Refrigerant Flow (VRF) System
▪ Water-Cooled Package Unit
▪ Single-Spilt Unit
▪ Multi-Spilt Unit</td><td>(a) Water-Cooled Chilled-Water Plant

Building cooling load ≥ 500RT

14 points for achieving plant efficiency of 0.75 kW/ton

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

Point scored = 0.35 x (% improvement)

Building cooling load < 500RT

14 points for achieving plant efficiency of 0.85 kW/ton

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

Point scored = 0.3 x (% improvement)

(Up to 20 points)

OR

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

Building cooling load ≥ 500RT

14 points for achieving plant efficiency of 1.0 kW/ton

0.25 point for every percentage improvement in the chiller plant efficiency better than 1.0 kW/ton

Point scored = 0.25 x (% improvement)</td></tr>
</table>

Part 1 - Energy Efficiency	Green Mark Points

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

Note: Where there is a combination of centralised air-con system with unitary air-conditioned system, the computation for the points scored will only be based on the air-conditioning system with a larger aggregate capacity.

Building cooling load < 500RT

14 points for achieving plant efficiency of 1.1 kW/ton

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

Point scored = 0.2 x (% improvement)

(Up to 20 points)

(c) Air Distribution system:

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

(c) Air Distribution System
0.15 point for every percentage improvement in the air distribution system efficiency over the baseline

Point scored = 0.15 x (% improvement)

(Up to 8 points)

Baseline – Fan power limitation in air conditioning system

Allowable nameplate motor power	
Constant volume	Variable volume
0.47 W/CMH	0.74 W/CMH

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

(d) *Prerequisite requirements*: Provision of permanent measuring instruments for monitoring of water-cooled chilled-water plant and air-cooled chilled-water plant efficiency. The installed instrumentation shall have the capability to calculate a resultant plant efficiency (i.e. kW/RT) within 5% of its true value and in accordance with ASHRAE Guide 22 and AHRI 550/590. The following instrumentation and installation are also required to be complied with:

- Location and installation of the measuring devices to meet the manufacturer's recommendation.
- Data acquisition system to have a minimum resolution of 16 bit.
- All data logging with capability to trend at 1 minute sampling time interval.
- Dedicated digital power meters shall be provided for the following groups of equipments: chiller(s), chilled water pump(s), condenser water pump(s) and cooling tower(s).
- Flow meters to be provided for chilled-water and condenser water loop and shall be of ultrasonic / full bore magnetic type or equivalent.
- Temperature sensors are to be provided for chilled water and condenser water loop and shall have an end-to-end measurement uncertainty not exceeding ± 0.05 °C over entire measurement or calibration range. All thermo-wells shall be installed in a manner that ensures that the sensors can be in direct contact with fluid flow. Provisions shall be made for each temperature measurement location to have two spare thermo-wells located at both side of the temperature sensor for verification of measurement accuracy.

1 point

<table>
<tr><th>Part 1 - Energy Efficiency</th><th>Green Mark Points</th></tr>
<tr><td>(e) Prerequisite requirements: Verification of central water cooled chilled-water plant instrumentation: Heat Balance – substantiating test for water cooled chilled-water plant to be computed in accordance with AHRI 550/590. The operating system efficiency and heat balance to be submitted to BCA upon commissioning.

(f) Provision of variable speed controls for chiller plant equipment such as chilled-water pumps and cooling tower fans to ensure better part-load plant efficiency.

(g) Sensors or similar automatic control devices are used to regulate outdoor air flow rate to maintain the concentration of carbon dioxide.

Carbon dioxide acceptable range ≤ 700 ppm above outdoor</td><td>1 point

1 point

1 point</td></tr>
<tr><td>ENRB 1-3 Natural Ventilation / Mechanical Ventilation
Applicable to Non Air-Conditioned Building Areas (with an aggregate non air-conditioned areas > 10% of total floor area excluding carparks and common areas)

(a) <u>Natural Ventilation</u> (only applicable to occupied areas, excluding circulation, plant rooms and transit areas)
Encourage building that facilitates good natural ventilation.
Proper design of building layout that utilises prevailing wind conditions to achieve adequate cross ventilation.

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

Baseline: Fan power limitation I mechanical ventilation systems:
<table><tr><td colspan="2">Allowable nameplate motor power</td></tr><tr><td>Constant volume</td><td>Variable volume</td></tr><tr><td>0.47 W/CMH</td><td>0.74 W/CMH</td></tr></table>
Note : Where there is a combination of naturally ventilated and mechanical ventilated spaces, the points scored will only be based on the predominant ventilation modes of normally occupied spaces.</td><td>20 based points will be awarded for use of natural ventilation

1.6 points for every 10% of NV areas with window openings facing north and south directions and cross ventilation
(Up to 32 points)

0.6 point for every subsequent 1% improvement from the baseline
(Up to 32 points)</td></tr>
<tr><td>ENRB 1-4 Artificial Lighting

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

Please refer to the Annex 1 for the baselines of lighting power budget</td><td>0.3 point for every percentage improvement in lighting power budget

Point scored = 0.3 x (% improvement)

(Up to 13 points)

Excluding tenant lighting provision – Up to 5 points)</td></tr>
</table>

Part 1 - Energy Efficiency	Green Mark Points
ENRB 1-5 Ventilation in Carparks Encourage the use of energy efficient design and control of ventilation systems in carparks. (a) Carparks designed with natural ventilation. (b) CO sensors are used to regulate the demand for mechanical ventilation (MV) Note: Where there is a combination of different ventilation mode adopted for carpark design, the points obtained will be prorated accordingly.	Naturally ventilated carparks – 4 points Points scored based on the mode of mechanical ventilation provided Fume extract – 2.5 points MV with or without supply – 2 points (Up to 4 points)
ENRB 1-6 Ventilation in Common Areas Encourage the use of energy efficient of ventilation systems in the following common areas: (a) Toilets (b) Staircases (c) Corridors (d) Lift lobbies (e) Atrium	Extent of Coverage: At least 90% of each applicable area Point scored based on the mode of ventilation provided in the applicable areas Natural ventilation – 1.5 points for each area Mechanical ventilation – 0.5 point for each area (Up to 5 points)
ENRB 1-7 Lifts and Escalators Encourage the use of energy efficient lifts and escalators. Lifts and/or escalators with AC variable voltage and variable frequency (VVVF) motor drive and sleep mode features.	Extent of Coverage: All lifts and escalators Lifts – 1 point Escalators- 1 point
ENRB 1-8 Energy Efficient Practices & Features Encourage the use of energy efficient practices and features which are innovative and/or have positive environmental impact. (a) Computation of the energy consumption in the form of energy efficiency index (EEI) (b) Use of energy efficient products that are certified by approved local certification body (c) Use of energy efficient features Example: • Re-generative lift • Heat recovery system • Motion sensors • Sun pipes • Light shelves • Photocell sensors to maximize the use of daylight • Heat pumps, etc.	1 point 0.5 point for each equipment type (Up to 2 points) 2 points for every 1% energy saving over the total building energy consumption (Up to 9 points)

<table>
<tr><th>Part 1 - Energy Efficiency</th><th>Green Mark Points</th></tr>
<tr><td>ENRB 1-9 Energy Policy and Management

(a) Energy policy, energy targets and regular review with top management's commitment as part of an environmental strategy

(b) To show intent, measures and implementation strategies of energy efficiency improvement plans to achieve energy target set over the next three years. Committed energy savings accrued from proposed measures should be quantified.</td><td>0.5 point

0.5 point</td></tr>
<tr><td>ENRB 1-10 Renewable Energy

Encourage the application of renewable energy sources in buildings.</td><td>Point scored based on the expected energy efficiency index (EEI) and % replacement of electricity by renewable energy source

<table>
<tr><th rowspan="2">Energy Efficiency Index (EEI)</th><th colspan="2">Every 1% replacement of electricity (based on total electricity consumption) by renewable energy source</th></tr>
<tr><th>Include tenant's usage</th><th>Exclude tenant's usage</th></tr>
<tr><td>≥ 50 kWh/m²/yr</td><td>5 points</td><td>3 points</td></tr>
<tr><td>< 50 kWh/m²/yr</td><td>3 points</td><td>1.5 points</td></tr>
</table>
(Up to 15 points)</td></tr>
<tr><td>PART 1 – ENERGY EFFICIENCY CATEGORY SCORE:</td><td>(Part 1-2) X Air-conditioned Building Floor Area / Total Floor Area
+
(Part 1-3) X Non Air-Conditioned Building Floor Area / Total Floor Area
+
(Part 1-1, Part 1-4 to Part 1-10)

Where Part 1-2 = Total Green Mark Points obtained under Part 1-2

Part 1-3 = Total Green Mark Points obtained under Part 1-3

Part 1-1, Part 1-4 to Part 1-10 = Total Green Mark Points obtained under Part 1-1, Part 1-4 to Part 1-10</td></tr>
</table>

<table>
<tr><th>Part 2 - Water Efficiency</th><th colspan="3">Green Mark Points</th></tr>
<tr><td>ENRB 2-1 Water Monitoring

Provide private-metering and leak detection system for better control and monitoring.

(a) To monitor the water consumption on monthly basis

(b) Provision of private-meters for major water uses (e.g. cooling tower, water features, irrigation, swimming pools, tenants' usage)

(c) Provision of automated / smart metering for monitoring and leak detection.</td><td colspan="3">1 point

1 point

2 point</td></tr>
<tr><td rowspan="4">ENRB 2-2 Water Efficient Fittings

Encourage the use of water efficient fittings under Water Efficiency Labelling Scheme (WELS) or adopt equivalent water efficient flow-rate/flush volumes for water fittings:-
▪ Basin taps and mixers
▪ Showers
▪ Sink/Bib taps and mixers
▪ Urinals and Urinal Flush Valves
▪ Dual-Flush Low Capacity Flushing Cisterns

Or

To have PUB Water-Efficient Building Certificate.</td><td colspan="2">Rating based on Water Efficiency Labeling Scheme (WELS)</td><td rowspan="4">Points scored based on the number and water efficiency rating of the fitting type used

(up to 12 points)</td></tr>
<tr><td>Very Good</td><td>Excellent</td></tr>
<tr><td colspan="2">Weightage</td></tr>
<tr><td>9</td><td>12</td></tr>
<tr><td colspan="3">9 points</td></tr>
<tr><td>ENRB 2-3 Alternative Water Sources

Use of suitable systems that utilize alternative water sources for non-potable uses: irrigation, washing, water features, toilet flushing, etc (excluding cooling tower make up water) to reduce use of potable water. Alternative sources can include rainwater, greywater (for toilet flushing only), NEWater, AHU condensate and recycled water from approved sources.</td><td colspan="3">Points awarded based on % reduction in total potable water usage of the applicable uses

> 50 % - 3 points
≥ 10 % to 50 % - 2 points
< 10 % - 1 point

(Up to 3 points)</td></tr>
<tr><td>ENRB 2-4 Water Efficiency Improvement Plans

Targets to improve building water performance against own building water performance baseline should be set. To show intent, measures and implementation strategies of water efficiency improvement plans over the next three years. Committed water savings accrued from proposed measures should be quantified. (PUB water efficiency management plan is acceptable as evidence)</td><td colspan="3">1 point</td></tr>
</table>

Part 2 - Water Efficiency	Green Mark Points
ENRB 2-5 Irrigation System and Landscaping	
(a) Use of automatic water efficient irrigation system with rain sensor, soil moisture sensor or equivalent control system.	Extent of Coverage: At least 50% of the landscape areas are served by the system 1 point
(b) Use of drought tolerant plants that require minimal irrigation.	Extent of Coverage: At least 50% of the landscape areas 1 point
ENRB 2-6 Cooling Towers Reduce potable water use for cooling purpose.	
(a) Use of cooling tower water treatment system which can achieve 7 or better cycles of concentration at acceptable water quality.	1 point
(b) Use of NEWater or on-site recycled water from approved sources.	1 point
PART 2 – WATER EFFICIENCY CATEGORY SCORE :	Sum of Green Mark Points obtained from ENRB 2-1 to 2-6

Part 3 - Sustainable Operation & Management	Green Mark Points
ENRB 3-1 Building Operation & Maintenance	
(a) The environmental policy that reflects the sustainability goals set.	1 point
(b) A green guide for the occupants or visitors should be disseminated through various channels. Best practices to reduce energy use, water use and maintain a good indoor environment should be documented in this green guide. To demonstrate evidences of occupant involvement in environmental sustainability.	1 point
(c) In-house building management team comprises one Certified Green Mark Facilities Manager (GMFM), Singapore Certified Energy Manager (SCEM) / Green Mark Professional (GMP).	0.5 point for certified GMFM 1 point for certified SCEM / GMP (Up to 1 point)
(d) The environmental management system of the building is ISO14000 or ISO 50001 certified.	1 point
ENRB 3-2 Post Occupancy Evaluation	
(a) Conduct post occupancy survey for occupant's satisfaction on energy and environmental performance. Required number of people surveyed shall be: - 10% of total occupancy and up to 100 maximum. - minimum 5 people shall be surveyed if total occupancy is less than 50.	2 points
(b) List of corrective actions taken following the post occupancy evaluation, if any.	1 point
ENRB 3-3 Waste Management	
a) Provision of facilities or recycling bins for collection and storage of different recyclable waste such as paper, glass, plastic, food waste, etc.	2 points
b) Promote and encourage waste minimization and recycling among occupants, tenants and visitors through various avenues.	2 points
c) Provide the proper storage area for the recyclable waste.	1 point
d) To quantify and monitor the recycling programme for continuous improvement.	2 points

<table>
<tr><th>Part 3 - Sustainable Operation & Management</th><th colspan="4">Green Mark Points</th></tr>
<tr><td rowspan="3">ENRB 3-4 Sustainable Products

Promote use of environmentally friendly products that are certified by approved local certification body.</td><td colspan="3">Weightage based on the extent of environmental friendliness of products</td><td rowspan="3">Points scored based on the weightage and the extent of coverage & impact

1 point for high impact item

0.5 point for low impact item

(Up to 8 points)</td></tr>
<tr><td>Good</td><td>Very Good</td><td>Excellent</td></tr>
<tr><td>1</td><td>1.5</td><td>2</td></tr>
<tr><td>ENRB 3-5 Greenery

Encourage greater use of greenery to reduce heat island effect.

(a) Greenery Provision (GnP) is calculated by considering the 3D volume covered by plants using the following Green Area Index (GAI) :

Grass GAI = 1 ; Shrubs GAI = 3; Palms Trees GAI = 4; Trees GAI = 6

(b) Use of compost recycled from horticulture waste.

(c) Provision of roof top greenery

(d) Provision of Vertical Greenery</td><td colspan="4">GnP = 0.5 to < 1.0 - 1 point
GnP = 1.0 to < 2.0 - 2 points
GnP = 2.0 to < 3.0 - 3.5 points
GnP ≥ 3.0 - 5 points
(Up to 5 points)

1 point

<u>For roof top greenery areas</u>
≥ 20% & 50% of useable roof areas - 1 point
≥ 50% of useable roof areas - 2 points

<u>For Vertical greenery areas</u>
≥10m2 and <50m2 - 1 point
≥ 50m2 - 2 points</td></tr>
<tr><td>ENRB 3-6 Environmental Protection

(a) Green procurement policy – Adoption of sustainable and environmental-friendly procurement and purchasing policy in the operation and maintenance of the building.

(b) Reduce the potential damage to the ozone layer and the increase in global warming through the release of ozone depleting substances and greenhouse gases.

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

▪ Use of refrigerant leak detection system at critical areas of plant rooms containing chillers and other equipments with refrigerants.</td><td colspan="4">1 point

1 point

1 point</td></tr>
</table>

Part 3 - Sustainable Operation & Management	Green Mark Points
ENRB 3-7 Green Transport Promote the use of public transport or bicycles to reduce pollution from individual car use with the following provision:	
(a) Good access to nearest MRT/LRT or bus stops.	1 point
(b) Provision of covered walkway to facilitate connectivity and the use of public transport	1 point
(c) Provision of priority parking lots for hybrid/electric vehicle within the development	1 point
(d) Provision of sheltered bicycle parking lots with adequate shower and changing facilities.	Extent of Coverage : Minimum 10 number of bicycle parking lots, cap at 30 where applicable Points scored based on the number of bicycle parking lots provided (with adequate shower and changing facilities) 1 point if the number provided ≥ 1% x GFA/10 0.5 point if the number provided ≥ 0.5% x GFA/10
PART 3 – SUSTAINABLE OPERATION AND MANAGEMENT **CATEGORY SCORE :**	Sum of Green Mark Points obtained from ENRB 3-1 to 3-7

Part 4 – Indoor Environmental Quality	Green Mark Points
ENRB 4-1 Indoor Air Quality Performance To promote a healthy indoor environment. (a) *Prerequisite Requirements:* To conduct full IAQ audit once in three years that complies with NEA's Guidelines for Good Indoor Air Quality in Office Premises or SS554:2009 Code of Practice for `Indoor air quality for air-conditioned buildings' by an accredited laboratory under the Singapore Accreditation Council.	4 points
(b) Implement effective IAQ management plan to ensure building ventilation systems are frequently maintained to ensure or clean delivery of air.	1 point
(c) Use of high efficiency air filter (at least MERV 13) in AHU to reduce indoor contaminants and provide good protection for cooling coil and reducing frequency or eliminating duct cleaning	1 point
(d) Room temperature display (at least 1 unit per floor)	1 point
(e) Additional carbon dioxide sensor display (at least 1 unit per floor)	1 point
ENRB 4-2 Indoor Air Pollutants Minimise airborne contaminants, mainly from inside sources to promote a healthy indoor environment.	1 point
(a) Use of low volatile organic compounds (VOC) paints certified by an approved local certification body.	1 point
(b) Use of environmental friendly adhesives certified by an approved local certification body.	
ENRB 4-3 Lighting Quality To encourage good workplace lighting quality to promote productivity and occupant comfort	
(a) Lighting level to comply with SS531:Part 1:2006 or CP38:1999 for various uses.	1 point
(b) Controllability of lighting system	At least 90% of occupants are able to adjust lighting to suit their task needs and preference Controlled by light switches - 1 point Controlled by task lights - 2 points (Up to 2 points)

Part 4 – Indoor Environmental Quality	Green Mark Points
(c) High frequency ballast	All applicable areas in the entire building that are served by fluorescent lightings 20% to < 40% - 0.5 point 40% to < 60% - 1 point 60% to < 80% - 1.5 points 80% and above - 2 points (Up to 2 points)
ENRB 4-4 Thermal Comfort (a) Ensure the consistent indoor conditions for thermal comfort: Indoor dry-bulb temperature within 22.5 °C to 25.5 °C and relative humidity <70% (b) Controllability of temperature	1 point 1 point
ENRB 4-5 Internal Noise Level Ensure internal noise level are maintained at an appropriate levels and to comply with CP13:1999 or SS553:2009	1 point
PART 4 – INDOOR ENVIRONMENTAL QUALITY CATEGORY SCORE :	Sum of Green Mark Points obtained from ENRB 4-1 to 4-5

Part 5 – Other Green Features	Green Mark Points
ENRB 5-1 Green Features and Innovations To encourage the use of other green features which are innovative and/or have positive environmental impact. Examples : • Tenants with Green Mark for Office Interior or Restaurant • Green Lease • Ultraviolet light-C band (UV) emitters in air handling units (AHUs) to improve indoor air quality • Provision of carpark guidance system • Use of self cleaning façade system • Use of grey water recycling system • Titanium Dioxide coating to remove odour in toilets • Use of pneumatic waste collection system • Use of double refuse chutes for separating recyclable from non-recyclable wastes • Stormwater management • Power meter to monitor air side systems • Green Mark Pearl and Prestige Awards • Chiller plant performance contract with SGBC accredited EPC firms.	2 points for high impact item 1 point for medium impact item 0.5 point for low impact item (Up to 10 Points)
PART 5 – OTHER GREEN FEATURES CATEGORY SCORE :	Sum of Green Mark Points obtained from ENRB 5-1

Green Mark Score (Existing Non-Residential)

Green Mark Score = Σ Category Score [(Part 1 – Energy Efficiency) +
(Part 2 – Water Efficiency) +
(Part 3 – Sustainable Operation and Management) +
(Part 4 – Indoor Environmental Quality) +
(Part 5 – Other Green Features)]

Where Category Score for Part 1 ≥ 30 points and Σ Category score for Part 2, 3, 4 & 5 ≥ 20 points

Annex 1: Maximum lighting power budget (including ballast loss)

Type of usage	Maximum lighting power budget (W/m2)
Offices	15
Classrooms	15
Hotel guest room	15
Lecture theatres	15
Auditoriums / Concert halls	10
Shops / Supermarkets / Departmental stores (including general, accent & display lighting)	25
Restaurants	15
Lobbies / Atriums / Concourse	10
Stairs	10
Corridors	10
Car parks	5
Electronic manufacturing and fine detail / Assembly industries	20
Medium and heavy industries	15
Warehouses / Storage areas	10

7 DOCUMENTATION REQUIREMENTS

The details of the documentary evidences required can be found in the Appendix A: Scoring Methodology & Documentation for compliance. Building Owner, PE(Mech) and appropriate practitioners shall ensure that these documents and records are available as evidences to demonstrate compliance with the environmental sustainability standard and criteria.

Appendix A

SCORING METHODOLOGY & DOCUMENTATION

(I) Energy Related Requirements

Part 1 – Energy Efficiency

ENRB 1-1	Thermal Performance of Building Envelope
ENRB 1-2	Air Conditioning System
ENRB 1-3	Natural Ventilation / Mechanical Ventilation
ENRB 1-4	Artificial Lighting
ENRB 1-5	Ventilation in Car parks
ENRB 1-6	Ventilation in Common Areas
ENRB 1-7	Lifts and Escalators
ENRB 1-8	Energy Efficient Practices & Feature
ENRB 1-9	Energy Policy & Management
ENRB 1-10	Renewable Energy

ENRB 1-1 THERMAL PERFORMANCE OF BUILDING ENVELOPE

Objectives	Enhance overall thermal performance of building envelope to minimize heat gain thus reducing the overall cooling load requirement.
Applicability	Applicable to air-conditioned building spaces with aggregate areas > 500 m^2.
Baseline Standard	ETTV stands for Envelope Thermal Transfer Value. Maximum permissible ETTV = 50 W/m^2 The computation of ETTV shall be based on the methodology specified in the Code on Envelope Thermal Performance for Buildings issued by BCA.
Requirements	Up to 5 points can be scored for building envelope with better thermal performance than the baseline standard : 0.5 points for every reduction of 1 W/m^2 in ETTV from the baseline of 50W/m^2 Points scored = 0.5 x (50 – ETTV) where ETTV ≤ 50 W/m^2 For developments consisting of more than one building, the weighted average of the ETTVs based on the façade areas of these buildings shall be used as the basis for point allocation. $ETTV_{\text{Weighted Average}} = \sum (ETTV_{bldg} \times A_{bldg}) / A_{devt}$ where $ETTV_{bldg}$ = ETTV for a building (W/m^2) A_{bldg} = Summation of all facade areas that enclose all the air-conditioning areas (m^2) in a building A_{devt} = Summation of total applicable facade areas of all buildings within the development (m^2) (i.e. $\sum A_{bldg}$) *Note: For buildings that are underground, full 5 points will be given.*
Documentary Evidences	• Architectural elevation drawings showing the composition of the different façade or wall systems that are relevant for the computation of ETTV; • Architectural plan layouts and elevations showing all the air-conditioning areas; • Technical specifications of material showing the salient data of the material properties that were used for the façade or external wall system; and • ETTV calculation.
References	Code on Envelope Thermal Performance for Buildings (2008) issued by BCA.

Worked Example for 1-1

Example 1

ETTV = 45 W/m^2

Points scored = 0.5 x (50 – ETTV)= 0.5 x (50 - 45) = 2.5 points

Example 2

ETTV = 35 W/m^2

Points scored = 0.5 x (50 – ETTV) = 0.5 x (50 – 35) = 7.5 points > 5 points

Therefore, points scored should be 5 points (max)

Example 3

A proposed building development comprises three building blocks. The individual ETTV of the each building computed are as follows :

$ETTV_{bldg1}$ = 35 W/m^2 A_{bldg} = 5000 m^2

$ETTV_{bldg2}$ = 45 W/m^2 A_{bldg} = 6800 m^2

$ETTV_{bldg3}$ = 50 W/m^2 A_{bldg} = 7500 m^2

A_{devt} = 5000+6800+7500
= 19300 m^2

Therefore

$$ETTV_{Weighted\ Average} = \sum (ETTV_{bldg} \times A_{bldg}) / A_{devt}$$

$$= \frac{(ETTV_{bldg1} \times A_{bldg1}) + (ETTV_{bldg2} \times A_{bldg2}) + (ETTV_{bldg3} \times A_{bldg3})}{(A_{devt})}$$

$$= \frac{(35 \times 5000) + (45 \times 6800) + (50 \times 7500)}{19300}$$

$$= 44.35\ W/m^2$$

Points scored = 0.5 x (50 – ETTV) = 0.5 x (50 – 44.35) = 2.83 points

Note : Refer to the Code on Envelope Thermal Performance for Buildings for more detailed examples on how to compute the ETTV.

ENRB 1-2 AIR-CONDITIONING SYSTEM

Objectives

Encourage the use of better energy efficient air-conditioned equipments to minimize energy consumption.

Applicability

Applicable to air-conditioned building areas where its aggregate air-conditioned areas > 500 m^2.

Scope covers all air-conditioned equipments for the buildings as listed:

- Chillers
- Chilled-Water Pumps
- Condenser Water Pumps
- Cooling Towers
- Air Handling Units (AHUs)
- Fan Coil Units (FCU)
- Direct-Expansion (DX) Unitary Air-Conditioners / Condensing Units which include single-split units, multi-spilt units and variable refrigerant flow (VRF) system

Baseline Standard

1-2(a) Water Cooled Chilled-Water Plant

Baseline	Building Cooling Load	
	< 500 RT	**≥ 500 RT**
Pre-requisite Requirements Minimum System Efficiency for Water-cooled Chilled Water Plant	0.85 kW/RT	0.75 kW/RT

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

Baseline	Building Cooling Load	
	< 500 RT	**≥ 500 RT**
Pre-requisite Requirements Minimum System Efficiency for Air Cooled Chilled-Water Plant or Unitary Air-Conditioners	1.1 kW/RT	1.0 kW/RT

1-2(c) Air Distribution System

For air distribution fan systems, the fan motor power required shall not exceed the baseline as shown in the table below.

Constant Air Volume System	Variable Air Volume System
0.47 W/cmh	0.74 W/cmh

Requirements for 1-2(a) & 1-2(b)	**1-2 (a) Water Cooled Chilled-Water Plant (Up to 20 points)** **Building cooling load ≥ 500 RT** • 14 points for achieving chiller plant efficiency of 0.75 kW/RT. • 0.35 point for every percentage improvement in the chiller plant efficiency better than 0.75 kW/RT. • Points scored = 0.35 x (% improvement) **Building cooling load < 500 RT** • 14 points for achieving chiller plant efficiency of 0.85 kW/RT. • 0.3 point for every percentage improvement in the chiller plant efficiency better than 0.85 kW/RT. • Points scored = 0.3 x (% improvement) **1-2 (b) Air Cooled Chilled-Water Plant** **Building cooling load ≥ 500 RT** • 14 points for achieving chiller plant efficiency of 1.0 kW/RT. • 0.25 points for every percentage improvement in the air-conditioning system efficiency better than 1.0 kW/RT. • Points awarded = 0.25 x (% improvement) **Building cooling load < 500 RT** • 14 points for achieving chiller plant efficiency of 1.1 kW/RT. • 0.2 point for every percentage improvement in the air-conditioning system efficiency better than 1.1 kW/RT. • Points awarded = 0.2 x (% improvement) ***Important notes :***

(i) Where there is a combination of central chilled-water plant with unitary air-conditioned system, the computation for the points scored will only be based on the air-conditioning system with a larger aggregate capacity.

(ii) The building cooling load and chiller plant system efficiency can be determined based on the measured operating conditions of the system; which shall include the chillers, pumps, cooling towers and associated equipment.

(iii) For simplicity and consistency, the expected operating efficiency will be based on the total energy consumption over total hourly cooling loads during the specified building operation hours as defined below :

Office Buildings:
- Monday to Friday : 9 am to 6 pm

Retail Malls :
- Monday to Sunday : 10 am to 9 pm

Hotels and serviced apartments :
- Monday to Sunday : 24 Hours
  (day time load: 7am to 11pm; night time load: 11pm to 7am)

Other Building Types
To be determined based on operating hours

(iv) For the design system efficiency, the expected chilled water plant efficiency shall be calculated based on the measured building cooling load profile through an Energy Audit before the retrofit. The energy audit shall be performed by an accredited Energy Services Company (ESCO) or a Professional Mechanical Engineer (Mech).

(v) For air-cooled variable refrigerant flow system and unitary air-conditioners, the efficiency shall be computed based on the efficiency of rated capacity or at the expected operating part-load condition of the outdoor condensing units.

Requirements for 1-2(c)

1-2 (c) Air Distribution System (Up to 8 points)

- 0.15 point for every percentage improvement in the air distribution system efficiency above the baseline.

Constant Air Volume System	Variable Air Volume System
0.47 W/cmh	0.74 W/cmh

Points scored = 0.15 x (% improvement)

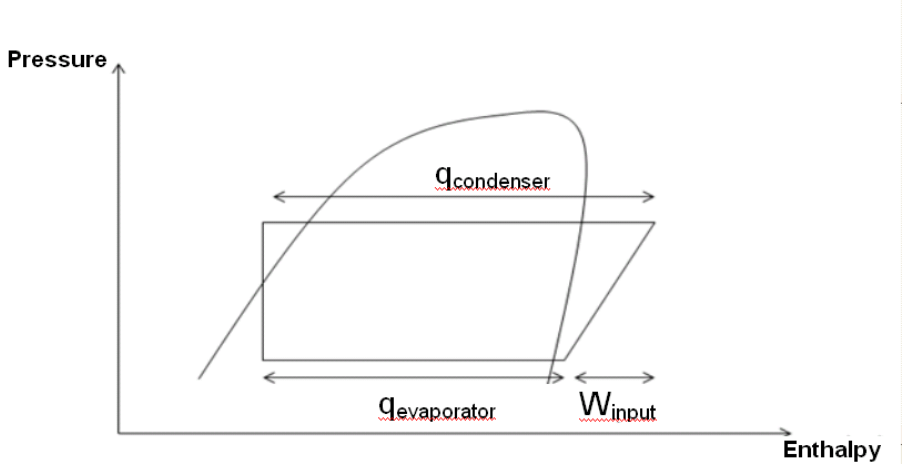
- The efficiency of the air distribution system can be determined from the rated fan power and air flowrate of the AHU and FCU or by site measurement.

Requirements for 1-2(d)

1-2 (d) Instrumentation for Monitoring Central Chilled Water Plant Efficiency

- 1 point for the provision of permanent measuring instruments for monitoring of water-cooled and air-cooled chilled-water plant efficiency. The installed instrumentation shall have the capability to calculate resultant chilled-water plant efficiency (i.e. kW/RT) within ± 5 % of the true value and in accordance with ASHRAE Guide 22 and AHRI 550/590.

Requirements for 1-2(e)	• The following instrumentation and installation are also required to be complied with : (a) Location and installation of the measuring devices to meet the manufacturer's recommendation. (b) Data Acquisition system i.e. Analog-to-digital or A/D converter used shall have a minimum resolution of 16 bit. For example, ▪ The specification for the A/D converter of the BTU meter should have a minimum resolution of 16-bit. This applies to direct data acquisition from the BTU meter. ▪ For data acquisition using Building Management System (BMS), the specification of the specific Digital Direct Controller (DDC) connecting the temperature sensors should have a minimum resolution of 16-bit. (c) All data logging with capability to trend at 1 minute sampling time interval. (d) Flow meters for chilled-water and condenser water loop shall be ultrasonic / full bore magnetic type or equivalent. (e) Temperature sensors are to be provided for chilled water and condenser water loop and the measurement system shall have an end-to-end uncertainty from the temperature sensors to the read out devices not exceeding ± 0.05 °C over the entire measurement or calibration range. All thermo-wells shall be installed in a manner that ensures that the sensors can be in direct contact with fluid flow. (f) Provisions shall be made for each temperature measurement location to have two spare thermo-wells located at both side of the temperature sensor for verification of measurement accuracy. (g) Dedicated digital power meters shall be provided for the following groups of equipment: chiller(s), chilled water pump(s), condenser water pump(s) and cooling tower fan(s). **<u>1-2 (e) Heat balance Substantiating test</u>** 1 point for submitting the verification of chilled-water plant instrument using the heat balance-substantiating test in accordance with AHRI 550/590. The heat balance shall be computed over the entire normal operating hours with more than 80% of the computed heat balance within ± 5% over a one (1) week period. For a perfectly balanced chiller system, the heat balance is represented by the following equation: $q_{condenser} = q_{evaporator} + W_{input}$ where $q_{condenser}$ = heat rejected $q_{evaporator}$ = cooling load W_{input} = power input to compressor The pressure enthalpy diagram below shows the concept of heat balance equation in a vapour compression cycle.



Pressure Enthalpy Chart

The system heat balance of the chilled water plant shall be computed using the formula stated below over the normal operating hours,

$$\text{Percent Heat Balance} = \left| \frac{(q_{evaporator} + W_{input}) - q_{condenser}}{q_{condenser}} \right| \times 100\% \leq 5\%$$

Note: For <u>open drive</u> chillers, the W_{input} shall take into account the motor efficiency provided by the manufacturer. An example is provided as follows:

Input power to motor = 100kW (measured)

Motor rated efficiency (η) = 90%

Adjusted power input to compressor W_{input} = 100kW x 90%
= 90kW

In the event where hydraulic losses of pumps constitute a substantial heat gain, these losses could be accounted for. The values shall be determined from motor efficiency and pump efficiency values provided by the manufacturer. Examples are illustrated as follows:

(a) **For chilled water pump(s) adjustment,**

Motor input power (measured)	= 30 kW	(A)
Motor rated efficiency (η)	= 90%	(B)
Pump rated efficiency (η)	= 80%	(C)

Hydraulic losses = (A) x (B) x [(100% – (C)]
= 30kW x 90% x (100% - 80%)
= 5.4 kW

Adjusted total input power W_{input} = kW_i (chillers) + 5.4kW

where kW_i (chillers) = adjusted power input to compressor, kW

Requirements for 1-2(f) **Requirements for 1-2(g)**	(b) **For condenser water pump(s) adjustment,** Motor input power (measured) = 20 kW (A) Motor rated efficiency (η) = 90% (B) Pump rated efficiency (η) = 80% (C) Hydraulic losses = (A) x (B) x [(100% – (C)] = 20kW x 90% x (100% - 80%) = 3.6 kW Adjusted $q_{condenser(adj)}$ = $q_{condenser}$ - 3.6kW **1-2 (f) Variable speed control devices for chiller plant equipment (1 point)** 1 point can be scored if there are provisions of variable speed controls for plant equipment, e.g. chilled water pumps and cooling tower fans to ensure better part-load efficiency of the plant. **1-2 (g) Sensors or similar automatic control devices (1 point)** 1 point can be scored if sensors or similar automatic control devices are used to regulate outdoor air flow rate to maintain the concentration of carbon dioxide (CO_2) in accordance with Table 1 – Recommended IAQ Parameters of SS 554. Carbon dioxide acceptable range: ≤ 700 ppm above outdoor.
Documentary Evidences for 1-2(a) & 1-2(b)	**For 1-2(a) & 1-2(b) – Water-cooled and Air-cooled chilled water plants** • Latest Energy Audit report on the chiller plant before retrofit, endorsed by a Professional Engineer (Mech) or Energy Auditor registered with BCA. • Detailed calculations of the proposed equipment efficiency of the retrofitted chiller plant as shown in the worked examples 1-2(a), • Drawings showing the proposed chilled water schematic of the retrofitted chiller plant; • Drawings showing the proposed layout of the retrofitted chiller plant equipment; • If there is addition or reduction of cooling load, cooling load simulation report shall be submitted. • Chiller plant equipment (i.e. chillers, pumps, cooling towers) technical schedule and specifications. • Chiller plant equipment schedule to be presented in following format:

ID	Description	Name plate motor (kW)	Pump Head (m)	Flow rate (L/S)	Pump / Fan efficiency	Motor Efficiency
CHWP-1	Chilled water pump 1	55 kW	30m	151.2	85%	95%
CHWP-2	Chilled water pump 2	30 kW	30m	75.6	85%	95%
CWP-1	Condenser water pump 1	45 kW	20m	189	85%	95%
CWP-2	Condenser water pump 2	22 kW	20m	94.5	85%	95%
CT-1	Cooling tower 1	45 kW	-	130	75%	92%
CT-2	Cooling tower 2	45 kW	-	130	75%	92%

ID	Description	Type	Name plate motor (kW)	Cooling Capacity (RT)	Chilled water LWT	Chilled water ∆T	Efficiency kW/RT
CH-1	Chiller 1	Centrifugal	550	1000	6.7 °C	5.5°C	0.55
CH-2	Chiller 2	VSD Screw	260	500	6.7 °C	5.5°C	0.52

Documentary Evidences for 1-2(c)

For 1-2(c) – Air Distribution System

- Detailed calculations of the overall improvement in equipment efficiency of the air distribution system in the prescribed tabulated formats as shown in the worked examples 1-2(c);
- Technical product information of the air distribution system.

Documentary Evidences for 1-2(d)

For 1-2(d) – Permanent Measuring Instrument

- Instruments' calibration certificates from accredited laboratory and factory calibration certificates from manufacturers.
- Design / As-built drawings of the chiller plant room layouts showing the details of the instruments' locations.
- Summary of instruments to be presented in the following format :-

ID	Description	Sensor Type	Measurement/ Calibration range	Measurement Uncertainty	Last Calibration Date
TT01	CHWS Temperature	10K Ω Thermistor	0°C - 40°C	± 0.05°C	10/10/2012
TT02	CHWR Temperature	10K Ω Thermistor	0°C - 40°C	± 0.05°C	10/10/2012
TT03	CWS Temperature	10K Ω Thermistor	0°C - 40°C	± 0.05°C	10/10/2012

TT04	CWR Temperature	10K Ω Thermistor	0°C - 40°C	± 0.05°C	10/10/2012
FM01	CHW Flow	Magnetic Full Bore	30 l/s- 200 l/s	± 0.5%	10/10/2012
FM02	CW Flow	Magnetic Full Bore	30 l/s- 200 l/s	± 0.5%	10/10/2012
kW01	Chiller 1 Power	True RMS, 3 phase	60 – 600 kW	± 0.5%	10/10/2012
kW02	Chiller 2 Power	True RMS, 3 phase	60 – 600 kW	± 0.5%	10/10/2012
kW03	CHW Pump 1 & 2 Power	True RMS, 3 phase	20 – 200 kW	± 0.5%	10/10/2012
kW04	CW Pump 1 & 2 Power	True RMS, 3 phase	20 – 200 kW	± 0.5%	10/10/2012
kW05	CT 1 & 2 Power	True RMS, 3 phase	15 – 150 kW	± 0.5%	10/10/2012

- Calculation of the overall uncertainty of measurement of the resultant chiller plant efficiency in kW/RT to be within ± 5 % of the true value based on instrumentation specification / calibration certificates. Refer to Worked examples 1-2(d).

Documentary Evidences for 1-2(e)

<u>For 1-2(e) – Heat Balance Substantiating Test</u>

- Heat balance substantiating test result verifying the central chilled-water plant's instrumentation shall be submitted in the format as specified in the Worked Examples for 1-2(e).

Documentary Evidences for 1-2(f)

<u>For 1-2 (f) – Variable Speed Drives</u>

- Technical specifications of the control devices and a write up/drawings on how these devices are used;
- Plan layouts showing the locations of variable speed control devices for the chiller plant equipment i.e. chilled water pump and cooling tower fans; or schematic print-out from BMS;

Documentary Evidences for 1-2(g)

<u>For 1-2(g) – Sensors for Carbon Dioxide</u>

- Technical specifications of the control devices and a write up/drawings on how these devices are used;
- Plan layouts showing the locations and the types of control devices used to regulate fresh air intake or schematic print-out from BMS.

References

CP 24:1999 - Code of Practice for Energy Efficiency Standard for Building Services and Equipment

CP 13:1999 - Code of Practice for Mechanical ventilation and Air-Conditioning in Buildings

ASHRAE Guideline 22 – Instrumentation for Monitoring Central Chilled water Plant Efficiency by American Society of Heating, Refrigerating and Air-Conditioning Engineer (ASHRAE)

	AHRI Standard 550/590 – Performance Rating of Water Chilling and Heat Pump Water–Heating Packages Using the Vapour Compression Cycle by Air-Conditioning, Heating and Refrigeration Institute(AHRI) Singapore Standard 591 (2013) – Code of Practice for long term measurement of central chilled water system energy efficiency

Worked Examples for 1-2(a)

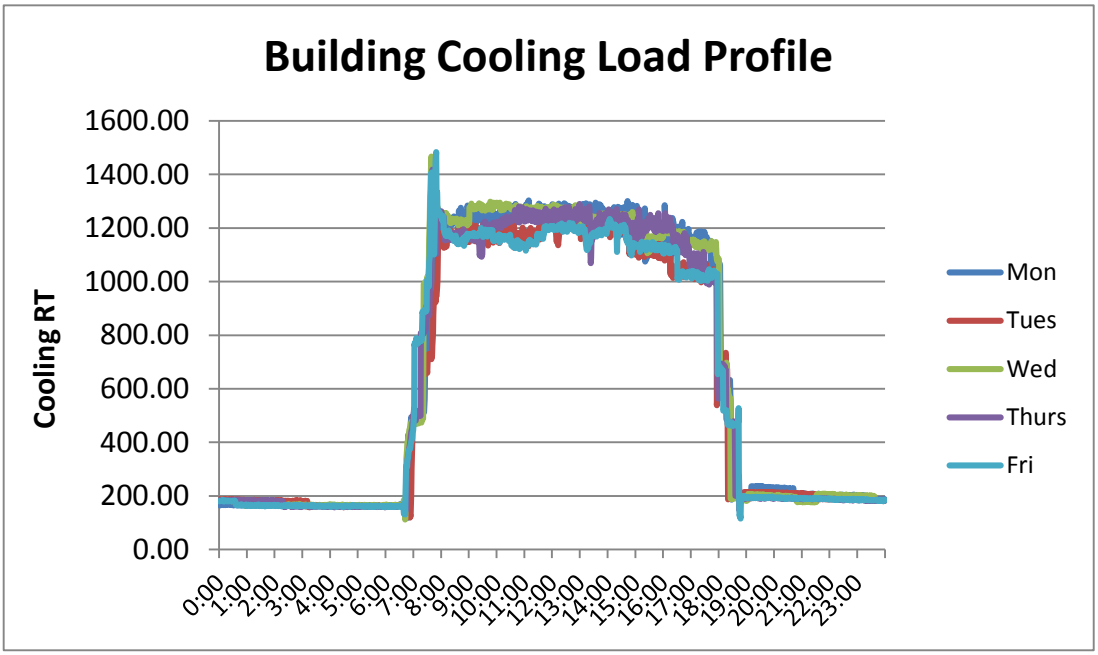
Determining the System Efficiency for Central water-cooled chiller system

Background info

- Office building air-conditioned floor area = 70,000 m^2
- Building operating hours : 8 am to 6pm
- The building cooling load profile is determined from the energy audit on the chiller plant before retrofitting; the result is shown below.

Step 1 : Building cooling load profile (from audit measurements)

Based on the measured building cooling load profile for the building operation hours from 8:00 to 18:00, the cooling load is **1200 RT**.



Worked Examples for 1-2(a)

Continued

From energy audit, the building cooling load profile is shown:-

Time	Average Cooling Load (RT)
0:00	190
1:00	190
2:00	190
3:00	190
4:00	190
5:00	190
6:00	190
7:00	1400
8:00	1200
9:00	1200
10:00	1200
11:00	1200
12:00	1200
13:00	1200
14:00	1200
15:00	1200
16:00	1150
17:00	1150
18:00	1150
19:00	190
20:00	190
21:00	190
22:00	190
23:00	190

The chiller plant system efficiency will be computed based on the following cooling loads measured during the specified operating hours i.e. 0900 to 1800 hrs (office building):

(a) 0900 to 1600 hrs : 1200 RT

(b) 1600 to 1800 hrs : 1150 RT

Worked Examples for 1-2(a)

Continued

Step 2 : Proposed Chiller Plant Equipment configuration

Proposed chiller plant equipment configuration:-

Equipment	Office hours (0900 to 1800 hrs)	After Office hours (1800 to 0900 hrs)
Chillers	3 nos. x 700 RT (2 in operation & 1 stand-by)	2 nos. x 200 RT (1 in operation & 1 stand-by)
Chilled Water Pumps	3 nos. x 45 kW (2 in operation & 1 stand-by)	2 nos. x 15 kW (1 in operation & 1 stand-by)
Condenser Water Pumps	3 nos. x 55 kW (2 in operation & 1 stand-by)	2 nos. x 18.5 kW (1 in operation & 1 stand-by)
Cooling Towers	3 nos. x 900 RT, each having 3 fans x 7.5 kW	

Important notes :

(1) It is important to design the air-conditioning plant configuration for other load conditions that are not within the building operating hours specified, although this is not required for point scoring purpose.

(2) The estimated operating pump and motor power of the various components at part-load condition as illustrated in Step 4 & 5 are based on the affinity laws assuming that the system curve remains unchanged.

Step 3 : Water-cooled Chillers' Performance

Chillers in operation are 2 nos. x 700 RT during office hours and 1 no. x 200 RT for after office hour operation.

Performance data for selected chillers (700 RT) as given by chiller suppliers is shown below:-

% Load	Capacity (RT)	Chiller Input Power (kW)	Chiller Efficiency kW/RT	Evaporator		Condenser	
				CHWST (°C)	CHWRT (°C)	CWRT (°C)	CWST (°C)
100	700	363	0.519	6.67	12.31	34.80	29.68
90	630	329	0.522	6.67	12.31	34.29	29.68
80	560	291	0.520	6.67	12.31	33.78	29.68
70	490	260	0.533	6.67	12.31	33.28	29.68
60	420	227	0.543	6.67	12.31	32.77	29.68
50	350	195	0.563	6.67	12.31	32.27	29.68
40	280	165	0.596	6.67	12.31	31.76	29.68
30	210	135	0.652	6.67	12.04	31.25	29.68
20	140	104	0.750	6.67	10.27	30.75	29.68
15	105.3	87	0.836	6.67	9.39	30.50	29.68

Cooling load (RT)	No. of Chillers in operation	% Load	kW/RT	Total Chiller Power (kW)
A	B	C	D	E = A x D
1200 RT	2 nos. x 700RT	85.7%	0.521	625.2
1150 RT	2 nos. x 700RT	82.1%	0.520	598.0

Worked Examples for 1-2(a)

Continued

Step 4 : Chilled Water Pumps' Performance

(i) 2 nos. x 45 kW pumps will be in operation during office hours and are installed with Variable Speed Drives (VSD)

(ii) Operating pump head = 28 m (from energy audit)

(iii) Pump efficiency = 86.8 % at design operation condition

(iv) Motor efficiency = 94.2 % at design operation condition

(v) Motor absorbed power (kW) is calculated from = $\frac{(Q)(\rho)(g)(h)}{(10^6)(\eta_p)(\eta_m)}$

where

Q=water flow rate in L/s
ρ=density of water = 1000 kg/m^3
g=gravitational acceleration = 9.81 m/s^2
h=static pressure head m
η_p= pump efficiency
η_m=motor efficiency

Chilled Water Pump 1 & 2 (45 kW)					
% Load	A	B	C	D	E = (A x 1000 x 9.81 x B) / (10^6 x C x D)
	Rated Flow (l/s)	Rated Head (m)	Motor Efficiency (%)	Pump Efficiency (%)	Pump input power (kW)
100	106.1	28	94.2	86.8	35.64
90	95.49	22.68	94.2	84.2	26.76
85.7	90.9	20.56	94.2	84	23.17
82.1	87.1	18.87	94.2	83.7	20.45
80	84.88	17.92	94.2	83.3	19.00
70	74.27	13.72	94.2	79.9	13.27
60	63.66	10.08	94.2	77.3	8.64

For total cooling requirement of 1200 RT, the 2 nos. CHW pumps will operate at part-load i.e. 1200RT / 1400RT i.e. 85.7%.

Cooling load (RT)	No. of CHW pumps in operation	% Load	Pump input power (kW)	Total CHW Pump Power (kW)
A	B	C	D	E = B x D
1200	2 nos.	85.7%	23.17	46.34
1150	2 nos.	82.1%	20.45	40.9

Note: It is recommended to limit the speed of the pump to a minimum of 60% of the load.

Worked Examples for 1-2(a)

Continued

Step 5 : Condenser Water Pumps' Performance

(i) 2 nos. x 55 kW will be in operation during office hours and all pumps are installed with Variable Speed Drives (VSD)

(ii) Operating pump head = 32 m (from energy audit)

(iii) Pump efficiency = 88.5 % at design operation condition

(iv) Motor efficiency = 94.7 % at design operation condition

Condenser Water Pump 1 & 2 (55 kW)					
% Load	A	B	C	D	E = (A x 1000 x 9.81 x B) / (10^6 x C x D)
	Rated Flow (L/s)	Rated Head (m)	Motor Efficiency (%)	Pump Efficiency (%)	Pump input power (kW)
100	132.51	32	94.7	88.5	49.63
90	119.26	25.92	94.7	85.9	37.28
85.7	113.56	23.5	94.7	85.5	32.33
~~82.1~~	~~108.8~~	~~21.57~~	~~94.7~~	~~85.2~~	~~28.53~~
80	106.01	20.48	94.7	85	26.46
70	92.76	15.68	94.7	81.4	18.51
60	79.51	11.52	94.7	78.8	12.04

The 2 nos. CW pumps are designed to operate consistently at part-load condition 85.7%

Cooling load (RT)	No. of CW pumps in operation	% Load	Pump input power (kW)	Total CW Pump Power (kW)
A	B	C	D	E = B x D
1200	2 nos.	85.7%	32.33	64.66
1150	2 nos.	85.7%	32.33	64.66

Note: It is recommended to limit the speed of the pump to a minimum 60% of the rated capacity.

Worked Examples for 1-2(a)

Continued

Step 6 : Operating efficiency for Cooling Towers

(i) 2 nos. cooling towers will be in operation with Variable Speed Drives (VSD)

(ii) Heat rejection capacity per cooling tower = 900 RT

(iii) Total heat rejection for 2 nos. cooling towers = 900 RT x 2 = 1800 RT

(iv) Each tower with 3 fan cells, each fan motor = 7.5 kW

(v) Fan Motor efficiency = 92 %

(vi) Fan motor input power for each tower = (7.5 kW x 3 fans.) / 92% = 24.46 kW

(vii) Total power for 2 nos. cooling towers = 24.46 kW x 2 = 48.92 kW

Cooling load (RT)	Chiller Input Power (kW)	Required Heat Rejection (RT)
A	**B**	**C = A + (B / 3.517)**
1200	625.2	1377.77
1150	598	1320.03

Cooling load (RT)	No. of CT in operation	Total CT Heat Rejection Capacity (RT)	Percentage Loading for Required & Available Heat Rejection (RT)
A	**B**	**D**	**E = C / D**
1200	2	1800	76.5 %
1150	2	1800	73.3 %

At full speed (100%), total cooling tower (2 nos.) power consumption = 24.46 x 2 = 48.92 kW

Based on the fan law,

$$\frac{\text{Fans Power}_{@\ 76.6\%}}{\text{Fans Power}_{@\ 100\%}} = \left(\frac{\text{Fans Speed}_{@\ 76.6\%}}{\text{Fans Speed}_{@\ 100\%}}\right)^3$$

At 76.6% speed (via VSD), total cooling towers' fans power = 48.92 x $(0.765)^3$ = **21.90 kW**

Similarly, at 73.4% speed, total cooling towers' fans power = 48.92 x $(0.733)^3$ = **19.27 kW**

Cooling Load (RT)	Required Part load % for CT	Total Fan Motor Power at required part load (kW)
1200 RT	76.5%	21.90
1150 RT	73.3%	19.27

Note: It is recommended to limit the speed of the cooling tower fans to a minimum of 50% of the rated capacity.

Step 7 : System Efficiency

The chiller plant system efficiency at various cooling loads is tabulated below.

Worked Examples for 1-2(a)

Continued

Time	Average Cooling Load	Chillers Power Input	CHW Pumps Power	CW Pumps Power	CT power	Total Power Input
	(RT)	(kW)	(kW)	(kW)	(kW)	(kW)
9:00	1200	625.2	46.34	64.66	21.90	758.1
10:00	1200	625.2	46.34	64.66	21.90	758.1
11:00	1200	625.2	46.34	64.66	21.90	758.1
12:00	1200	625.2	46.34	64.66	21.90	758.1
13:00	1200	625.2	46.34	64.66	21.90	758.1
14:00	1200	625.2	46.34	64.66	21.90	758.1
15:00	1200	625.2	46.34	64.66	21.90	758.1
16:00	1150	598	40.9	64.66	19.27	722.83
17:00	1150	598	40.9	64.66	19.27	722.83
18:00	1150	598	40.9	64.66	19.27	722.83
Total (0900 to 1800)	$\sum CL_i$ = 11850	6170.4	447.08	646.6	211.11	$\sum TPL_i$ = 7475.19
Efficiency kW/RT		0.521	0.038	0.055	0.018	**0.631**

To summarize, the chiller plant system efficiency for this office building is :

Equipment	Efficiency (kW/RT)
Chillers	0.521
Chilled water pumps	0.038
Condenser water pumps	0.055
Cooling towers	0.018
Total	0.631

< 0.75 kW/RT

14 points for meeting the prescribed chilled-water plant efficiency of 0.75 kW/RT

0.35 point for every percentage improvement in the chilled-water plant efficiency over the baseline

Therefore, points scored = 14 + 0.35 x (% improvement)

= 14 + 0.35 x [(0.75 – 0.631)/0.75] x100

= 14 + 0.35 (15.89)

= 19.56 points

Worked Examples for 1-2(b)

VRF System

Determining the System Efficiency for Unitary Air-Conditioners/ Condensing Units - VRF System For total cooling load < 500RT

Method (A): Computation of system efficiency based on the rated capacity
Determine the overall efficiency of the VRF system at full load conditions:

Floor	Location Served	Specification of VRF Outdoor Condensing Unit		
		Total Cooling Capacity (kW)	Rated Power Input (kW)	COP
1	FCC Room	3.5	1.25	2.8
	Lift Lobby + Corridor	22.4	5.24	4.27
	Reception			
2	Office	44.8	10.5	4.27
	Office	44.8	10.5	4.27
	Lift lobby + Corridor	22.4	5.24	4.27
3	Office	44.8	10.5	4.27
	Office	44.8	10.5	4.27
	Lift lobby + Corridor	22.4	5.24	4.27
4	Office	44.8	10.5	4.27
	Office	44.8	10.5	4.27
	Lift lobby + Corridor	22.4	5.24	4.27
5	Office	63.3	18.4	3.44
	Lift lobby + Corridor	22.4	5.24	4.27
	Total	**447.6 kW**	**108.85**	

The total installed capacity of the VRF system = 447.6 kW

Assume building cooling load = **127.3 RT**

Overall efficiency for the VRF system at full load condition = 108.85 / 127.3

= **0.86 kW/RT**

For Building cooling load < 500 RT, 14 points for achieving chiller plant efficiency of 1.1 kW/RT.

0.2 point for every percentage improvement in the air-conditioning system efficiency better than 1.1 kW/RT.

Therefore, points scored = 14 + 0.2 x (% improvement)

= 14 + 0.2 x [(1.1 - 0.86) / 1.1] x 100

= 14 + 0.2 x (21.82)

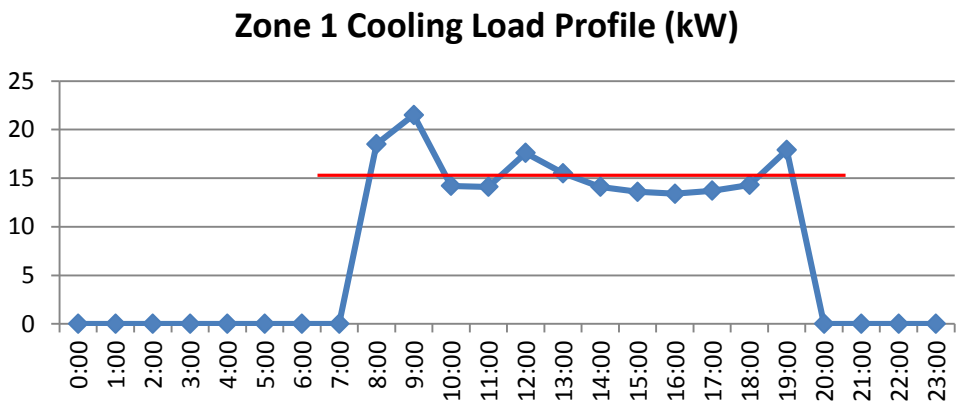
= 18.36 points

Method(B): Computation of the system efficiency based on the expected operating part load condition

Step B-1 Determine the most frequent occurring operating part load condition of the installed outdoor condensing unit capacity for all zones

(Most frequent occurring operating part-load conditions can be determined by the operating load points that form a horizontal straight line; the points can either fall on the line or very close to the line)

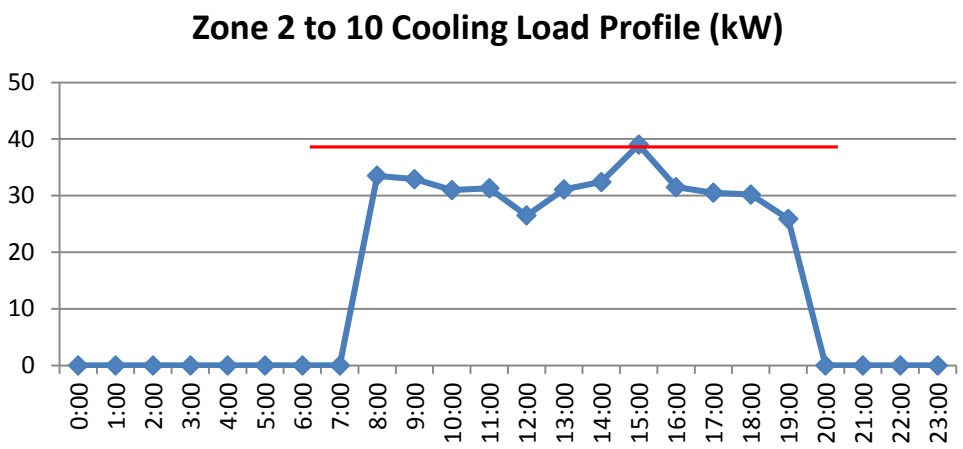
B-1(a) Zone 1 design day cooling load profile:



Time	Cooling Load (kW)
0:00 – 7.00	0
8:00	18.5
9:00	21.5
10:00	14.2
11:00	14.1
12:00	17.6
13:00	15.5
14:00	14.1
15:00	13.6
16:00	13.4
17:00	13.7
18:00	14.3
19:00	17.9
20:00–23:00	0

Based on the simulated building cooling load profile for the building operation hours from 8:00 to 19:00, the estimated most frequent occurring part-load condition of the installed capacity is 60% i.e. 13.4 kW for Zone 1

B-1 (b) Zone 2 to 10 design day cooling load profile.



Based on the simulated building cooling load profile for the building operation hours from 8:00 to 19:00, the estimated most frequent occurring part-load condition of the installed capacity is 70%
i.e. 31.4 kW for Zone 2 to 9

Time	Cooling Load (kW)
0:00 – 7:00	0
8:00	33.5
9:00	32.9
10:00	31.0
11:00	31.3
12:00	26.5
13:00	31.1
14:00	32.4
15:00	39.0
16:00	31.5
17:00	30.5
18:00	30.2
19:00	25.9
20:00–23:00	0

Step B-2 Proposed VRF System Schedule

System	Floor	Location Served	Specification of VRF Outdoor Condensing Unit						
			Total Cooling Capacity (kW)		Power Input (kW)		COP		KW/RT
			Full Installed Capacity	60% Part load	Full Installed Capacity	60% Part load	Full Installed Capacity	60% Part load	60% Part load
1	1	FCC Room	22.4	13.4	5.24	2.55	4.2	5.25	0.67
	1	Lift Lobby + Internal Corridor							
	1	Reception							
System	**Floor**	**Location Served**	Full Installed Capacity	70% Part Load	Full Installed Capacity	70% Part Load	Full Installed Capacity	70% Part Load	70% Part Load
2 to 9	2 to 9	Office	44.8	31.4	10.5	6.28	4.29	5.02	0.70
		Office							
		Office							
		Office							
		Office							
		Lift Lobby							
		Lobby 2							

Step B-3 Determine the system efficiency of the VRF systems at the expected operating part-load condition

The system efficiency of VRF systems serving the building is:

System	Floor	Total Power Input (kW)	Total Required Cooling (kW)	Total Required Cooling (RT)
1	1	2.55	13.4	3.81
2 to 9	2 to 9	50.24	251.2	71.42
Total:		**52.79**		**75.23**

System efficiency for the VRF system = 52.79 / 75.23

= **0.70 kW/RT**

14 points for meeting the prescribed system efficiency of 1.1 kW/RT

0.6 points for every percentage improvement in the air-conditioning system efficiency over the baseline

Points scored = 14 + 0.2 x (% improvement)

= 14 + 0.2 [(1.1 – 0.70)/1.1x 100%] = 21.27 points > 20 points

Therefore, points scored is 20 points (max)

Worked Examples for 1-2(c)

For 1-2(c) - Determining the Efficiency for Air Distribution Equipment from Technical Specification / Nameplates

1. AHUs (VAV system):
   a. Total fan power consumption = 245.527 kW = 245527 W
   b. Total air volume flow rate = 409212 CMH
   Air-side system efficiency = 245527/409212 = 0.6 W/CMH

2. AHUs (CAV system):
   a. Total fan power consumption = 275.2 kW = 275200 W
   b. Total air volume flow rate = 678520 CMH
   Air-side system efficiency = 275200/678520 = 0.406 W/CMH

3. FCUs
   a. Total fan power consumption = 411.52 kW = 411520 W
   b. Total air volume flow rate = 979805 CMH
   Air-side system efficiency = 411520/979805 = 0.420 W/CMH

4. Overall required air distribution system efficiency specified under CP 13:1999

$$= \frac{(0.74)(409212) + (0.47)(678520) + (0.47)(979805)}{(409212 + 678520 + 979805)} = 0.523 \text{ W/CMH}$$

5. Overall required air distribution system efficiency based on suppliers' specs / contract specs = (245527 + 275200 + 411520) / (409212 + 678520 + 979805)

   = 932247/2067537 W/CMH

   = 0.451 W/CMH

Table 1-2(c) : Equipment Efficiency (Air-Distribution System)

Equipment Type	From Specs		Allowable nameplate motor power CP 13 (W/CMH)	Power Required by the motor at design condition (W/CMH)
	Total air flow (CMH)	Nameplate motor power (W)		
1. AHUs (VAV)	409212	245527	0.74	0.60
2. AHUs (CAV)	678520	275200	0.47	0.406
3. FCUs	979805	411520	0.47	0.420
Total	**2067537**	**932247**	**0.523**	**0.451**

See working (4) above

See working (5) above

% Improvement in Efficiency for Air Distribution Equipment = (0.523 -0.451) / 0.523

= 0.1377 x 100%

= 13.77%

Points scored = 0.2 x (% improvement) = 0.2 x (13.77) = 2.75 points

Worked Examples For 1-2(d)

Computation of overall uncertainty in the resulting chilled-water plant efficiency

For 1-2(d) - Computation of overall uncertainty in the resulting chilled-water plant efficiency

As instrumentation measurement uncertainties stated in calibration certificates and technical specifications are based on controlled conditions in a laboratory, it is necessary to allow for on-site deviations and measurements. The overall measurement system comprising the temperature, flow and power measurement shall be capable of calculating resultant chiller-water plant efficiency with the uncertainty within ±5% for on-site measurement. Each measurement shall include the sensor, any signal conditioning (if available), the data acquisition system and the wiring connecting them. The following example illustrates the computation of the uncertainty of the overall measurement system installed.

Item	Measurement System	End-to-End Measurement Uncertainty (% of reading)
1	Temperature	$\frac{\sqrt{0.05^2 + 0.05^2}}{5.5} = 1.3\%$ see note (1)
2	Flow	1% see note (2) + 1% (i.e. 2%)
3	Power	1% see note (3)

Note:

(1) Temperature measurement system shall have an end-to-end measurement uncertainty of ± 0.05°C over the entire measurement range. The combined uncertainty for ΔT is computed based on the root-sum square formula with ΔT assumed to be 5.5 °C as illustrated above.

(2) An additional 1% to be included in the computation of measurement errors for flow meter.

(3) Uncertainty of power measurement system shall include that of the current transformer where applicable. It is recommended that 3rd party verified power meter be specified to ensure accuracy.

The overall uncertainty of the measurement system shall be the combination of the individual uncertainty of each measurement system. Based on the above information, the overall uncertainty of measurement is as shown in the following :

$$\text{Error}_{rms} = \sqrt{(\sum (U_N)^2)}$$

$$= \sqrt{(1.3^2 + 2^2 + 1^2)}$$

$$= 2.6\ \%$$

where U_N = individual uncertainty of variable N (%)

N = mass flow rate, electrical power input or delta T

Therefore, the total uncertainty for the calculated chilled-water plant efficiency (kW/RT) is 2.6 %, which falls within the 5% of the true value.

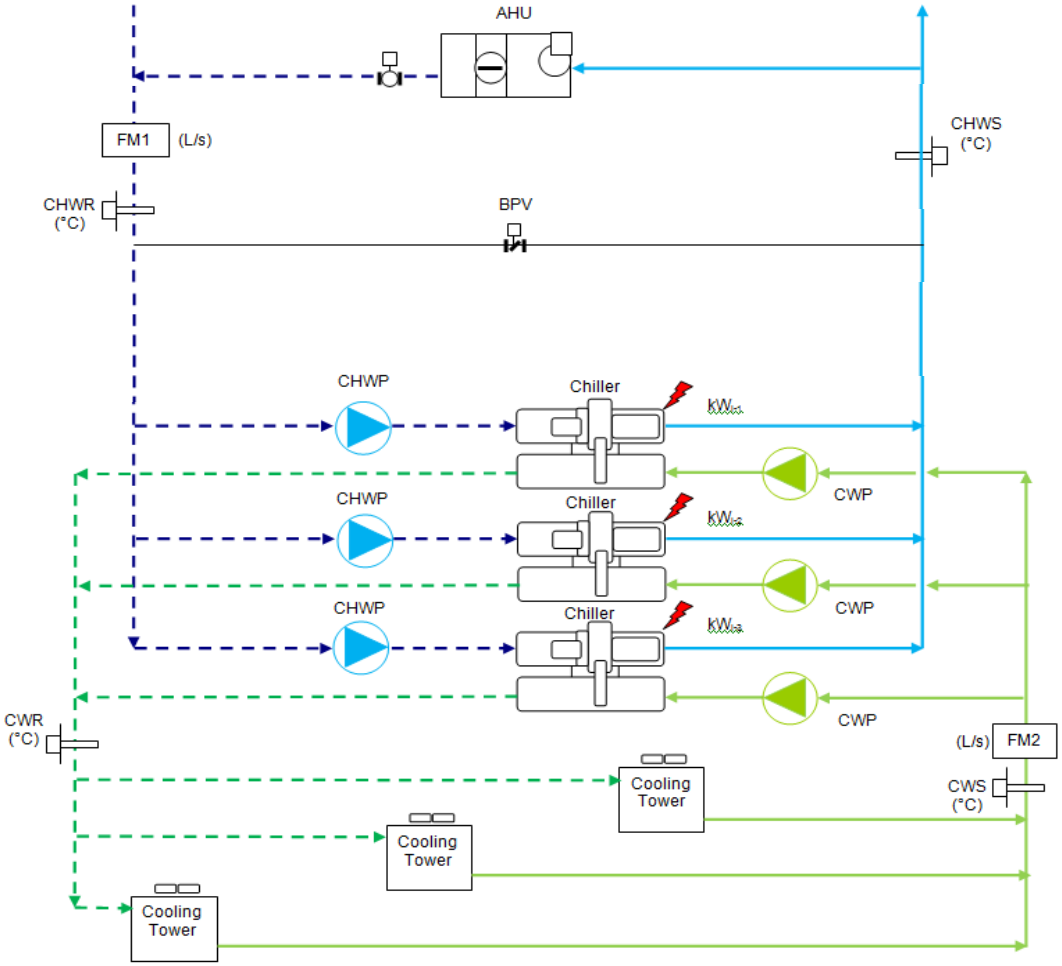
Worked Example 1-2(e)

Determining Heat Balance for Different Plant Configuration

Constant Primary Chilled Water System

Determining Heat Balance for Different Plant Configurations

Plant A – Constant Primary Chilled-Water System



A: $q_{evaporator}$ = m x Cp x ΔT = FM1 x Cp x (CHWR - CHWS)

B: $q_{condenser}$ = m x Cp x ΔT = FM2 x Cp x (CWR - CWS)

C: W_{input} = kW_{i-1} + kWi_{-2} + kWi_{-3}

where Cp = 4.19 kJ/kg.ºC & density of chilled water is assumed to be 1kg/l

Percent heat balance = [(A + C) – B] / B x 100%

Note : In the event where hydraulic losses of pumps constitute substantial heat gain, W_{input}/ $q_{condenser}$ may be adjusted to account for these additional heat gain. The value shall be determined from variable speed drive losses, motor efficiency and pump efficiency values certified by the manufacturer.

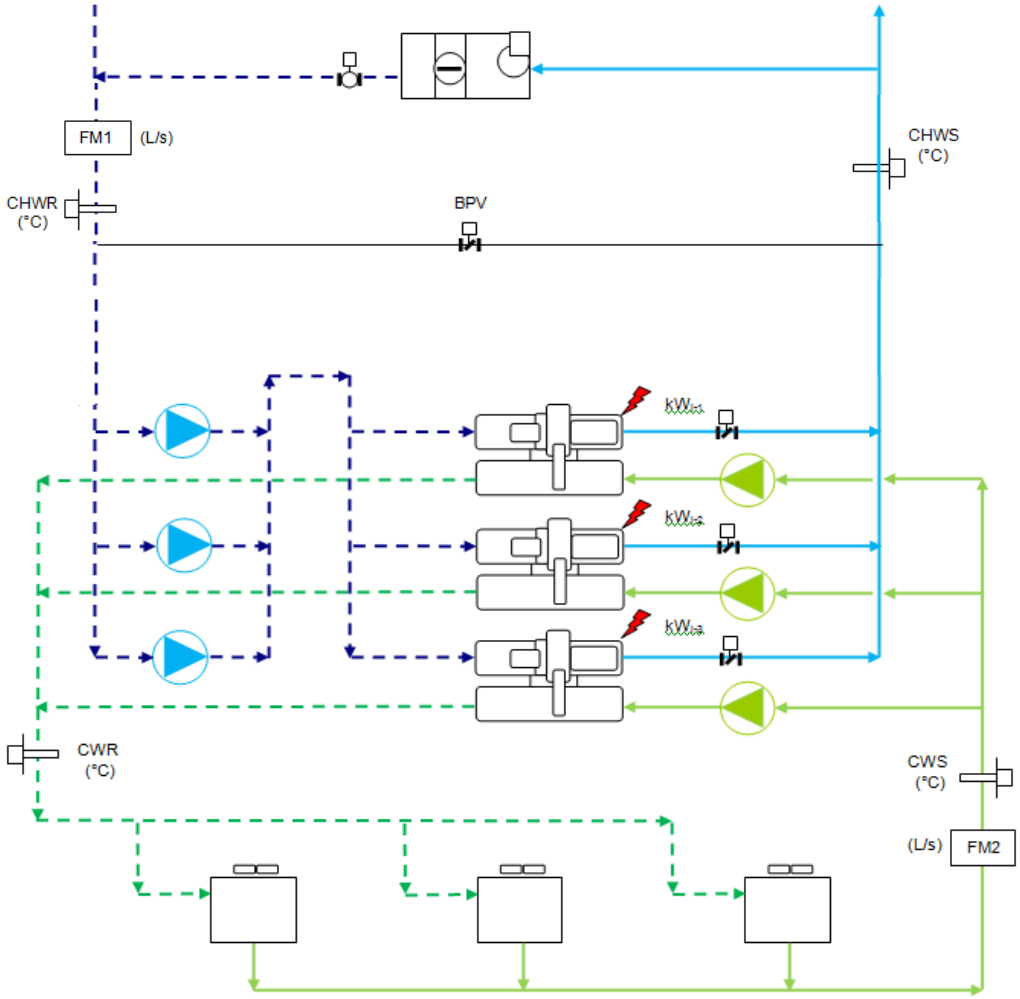
Worked Example 1-2(e)

Determining Heat Balance for Different Plant Configuration

Variable Primary Chilled Water System

Determining Heat Balance for Different Plant Configuration

Plant B – Variable Primary Chilled-Water System



A: $q_{evaporator}$ = FM1 x Cp x (CHWR - CHWS)

B: $q_{condenser}$ = FM2 x Cp x (CWR - CWS)

C: W_{input} = kW_{i-1} + kWi_{-2} + kWi_{-3}

where Cp = 4.19 kJ/kg.ºC & density of chilled water is assumed to be 1kg/l

Percent heat balance = [(A + C) – B] / B x 100%

Note: In the event where ~~h~~hydraulic losses of pumps constitute substantial heat gain, W_{input}/ $q_{condenser}$ may be adjusted to account for these additional heat gain. The value shall be determined from variable speed drive losses, motor efficiency and pump efficiency values certified by the manufacturer.

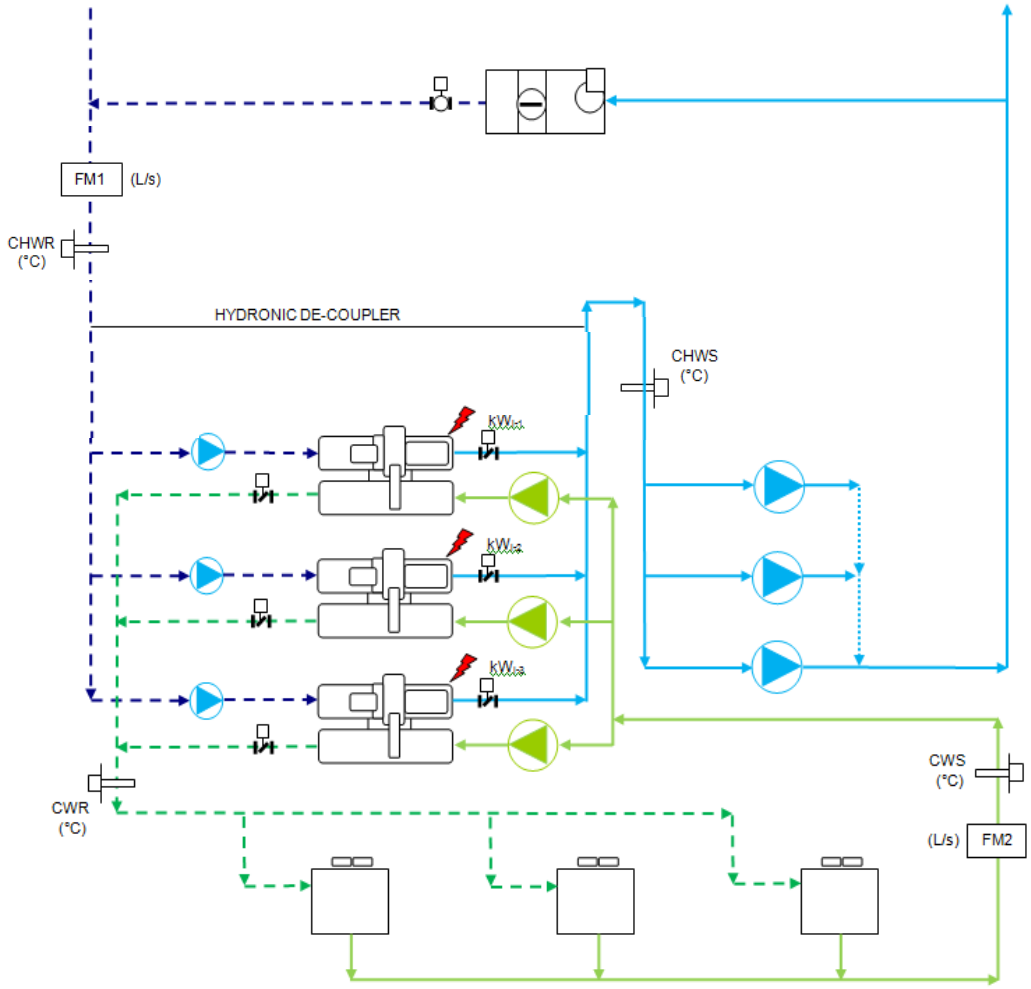
Worked Example 1-2(e)

Determining Heat Balance for Different Plant Configuration

Constant Primary & Variable Secondary Chilled Water System

Determining Heat Balance for Different Plant Configuration

Plant C – Constant Primary & Variable Secondary Chilled-Water System



A: $q_{evaporator}$ = FM1 x Cp x (CHWR – CHWS)

B: $q_{condenser}$ = FM2 x Cp x (CWR - CWS)

C: W_{input} = kW_{i-1} + kW_{i-2} + kW_{i-3}

where Cp = 4.19 kJ/kg.ºC & density of chilled water is assumed to be 1kg/l

Percent heat balance = [(A + C) – B] / B x 100%

Note: In the event where hydraulic losses of pumps constitute a substantial heat gain, W_{input}/ $q_{condenser}$ may be adjusted to account for these additional heat gain. The value shall be determined from variable speed drive losses, motor efficiency and pump efficiency values certified by the manufacturer.

Worked Example 1-2(e)

Heat Balance Calculation

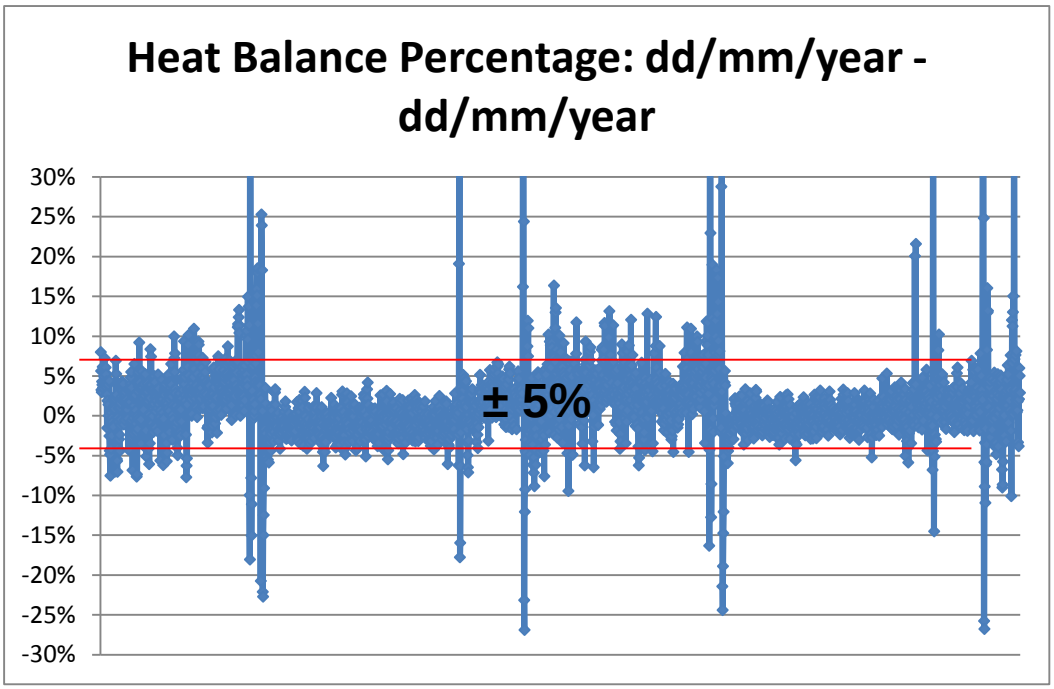
	(a) Chilled water supply temperature	(b) Chilled water return temperature	(c) Chilled water flow rate	(d) Condenser water supply temperature	(e) Condenser water return temperature	(f) Condenser water flow rate	(g) Chiller kWe	(h) Heat Gain	(i) Heat Rejected	(j) Percent Heat Balance
dd/mm/yyyy hh:mm	℃	℃	L/s	℃	℃	L/s	kW	RT	RT	%
16/6/2012 15:00	6.70	12.60	84.10	29.4	35.5	97.65	308	591.14	709.65	-4.36
16/6/2012 15:01	6.71	12.50	84.20	29.5	35.4	97.60	309	580.81	686.03	-2.53
16/6/2012 15:02	6.72	12.30	84.30	29.6	35.3	97.55	310	560.41	662.44	-2.10
16/6/2012 15:03	6.73	12.10	84.20	29.7	35.2	97.50	311	538.68	638.86	-1.84
16/6/2012 15:04	6.74	12.20	84.10	29.8	35.1	97.55	312	547.05	615.95	3.22
16/6/2012 15:05	6.75	12.00	84.00	29.9	35	97.60	311	525.39	593.01	3.51
16/6/2012 15:06	6.74	12.30	84.10	29.8	35.1	97.65	310	557.07	616.58	4.64
16/6/2012 15:07	6.73	12.10	84.20	29.7	35.2	97.60	309	538.68	639.52	-2.03
16/6/2012 15:08	6.72	12.10	84.30	29.6	35.3	97.55	308	540.32	662.44	-5.21
16/6/2012 15:09	6.71	12.20	84.20	29.5	35.4	97.50	309	550.71	685.33	-6.82
16/6/2012 15:10	6.70	12.40	84.10	29.4	35.2	97.55	310	571.10	674.06	-2.20
16/6/2012 15:11	6.70	12.60	84.10	29.4	35.5	97.65	308	591.14	709.65	-4.36
16/6/2012 15:12	6.71	12.50	84.20	29.5	35.4	97.60	309	580.81	686.03	-2.53
16/6/2012 15:13	6.72	12.30	84.30	29.6	35.3	97.55	310	560.41	662.44	-2.10
16/6/2012 15:14	6.73	12.10	84.20	29.7	35.2	97.50	311	538.68	638.86	-1.84
16/6/2012 15:15	6.74	12.20	84.10	29.8	35.1	97.55	312	547.05	615.95	3.22
16/6/2012 15:16	6.75	12.00	84.00	29.9	35	97.60	311	525.39	593.01	3.51
16/6/2012 15:17	6.74	12.30	84.10	29.8	35.1	97.65	310	557.07	616.58	4.64
16/6/2012 15:18	6.73	12.10	84.20	29.7	35.2	97.60	309	538.68	639.52	-2.03
16/6/2012 15:19	6.72	12.10	84.30	29.6	35.3	97.55	308	540.32	662.44	-5.21
16/6/2012 15:20	6.71	12.20	84.20	29.5	35.4	97.50	309	550.71	685.33	-6.82
16/6/2012 15:21	6.70	12.40	84.10	29.4	35.2	97.55	310	571.10	674.06	-2.20
Total							**6814**	**12,202.71**	**14,367.72**	**32.36**
									Total data count	**22**
									Data Count > +5% error	**0**
									Data Count < -5% error	**4**
									Percentage of heat balance within ± 5%	**82%**

Heat Gain (h) = m x Cp x ΔT = (c) x 4.19kJ/kg.ºC x [(b) – (a)] / 3.517

Heat Rejected (i) = (f) x 4.19 kJ/kg ºC x [(e) – (d)] / 3.517

Percent Heat Balance (j) = [(g) / 3.517 + (h) – (i)] / (i) x 100%

System level heat balance plot (example)



Summary of Heat Balance (example)

	Quantity	Unit	Formula
Sum of total electrical energy used	6814	kWh	(A)
Sum of total cooling produced	12,202	RTh	(B)
Sum of total heat rejected	14,367	RTh	(C)
Chiller Plant Efficiency	0.56	kW/RT	(A) / (B)
Total Heat Balance Data Count	22	-	(D)
Data Count > 5% error	0	-	(E)
Data Count < 5% error	4	-	(F)
Data Count within ±5% error	18	-	(G) = (D) – (E) – (F)
% Heat Balance within ±5% error	82	%	(G) / (D) x 100%

Based on the above example, 82% of the heat balance calculation falls within ± 5% which fulfills the criterion of 80%.

Note : Actual heat balance shall be conducted over the entire normal operating hours with more than 80% of the computed heat balance within ±5% over one (1) week period.

Abbreviations used in Worked Example 1-2(e)

CH	Chiller	--
CHWP	Chilled Water Pump	-
CWP	Condenser Water Pump	-
CT	Cooling Tower	-
CHWS	Chilled Water Supply Temperature	^oC
CHWR	Chilled Water Return Temperature	^oC
CWS	Condenser Water Supply Temperature	^oC
CWR	Condenser Water Return Temperature	^oC
KW	Electrical Power Consumption	kW
$q_{evaporator}$	Cooling Load	kW or RT
$q_{condenser}$	Heat Rejection	kW or RT
W_{input}	Energy Input	kW
AHU	Air Handling Unit	
BP	Bypass Line	
BPV	Bypass Valve (2-Way Modulating)	
Cp	Specific Heat Capacity of Water	4.19 kJ/kg.^oC

ENRB 1-3 NATURAL VENTILATION / MECHANICAL VENTILATION

<table>
<tr><td>Objectives</td><td>Encourage building that facilitates good natural ventilation or with provision for ventilation by efficient mechanical ventilation system.</td></tr>
<tr><td>Applicability</td><td>Applicable to non air-conditioned building spaces with aggregate areas > 10% of the total floor areas <u>excluding carparks, plant rooms and common areas</u>.

<u>Important notes</u>: Where there is a combination of naturally ventilated and mechanical ventilated spaces, the points scored will only be based on the predominant ventilation modes of normally occupied spaces.</td></tr>
<tr><td>Baseline Standard</td><td><u>1-3(a) Natural Ventilation</u>
• Natural ventilation with window openings facing North and South directions and building design that utilizes prevailing wind conditions to achieve adequate cross ventilation.

<u>1-3(b) Mechanical Ventilation</u>
• Reference to fan system design criteria in CP 13: 1999 – Code of Practice for Mechanical Ventilation and Air-conditioning in buildings.

<table><tr><td colspan="2">Fan motor shall not exceed</td></tr><tr><td>Constant volume</td><td>Variable volume</td></tr><tr><td>0.47 W/cmh</td><td>0.74 W/cmh</td></tr></table></td></tr>
<tr><td>Requirements</td><td><u>1-3(a) Natural Ventilation</u>
• Up to 32 points can be scored under natural ventilation.

• 20 points can be scored for the use of natural ventilation.

• Additional 1.6 points can be scored for every 10% of NV areas with window openings facing north and south directions and cross ventilation.

Points scored = 1.6 x (% of NV areas / 10)

Note: In Singapore, the prevailing wind comes from two predominant directions; that is the north to North-East during the Northeast monsoon season and South to South-East during the South-West monsoon season. Hence, buildings with window openings facing the North and South directions have the advantage of the prevailing wind conditions which would enhance indoor thermal comfort.

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

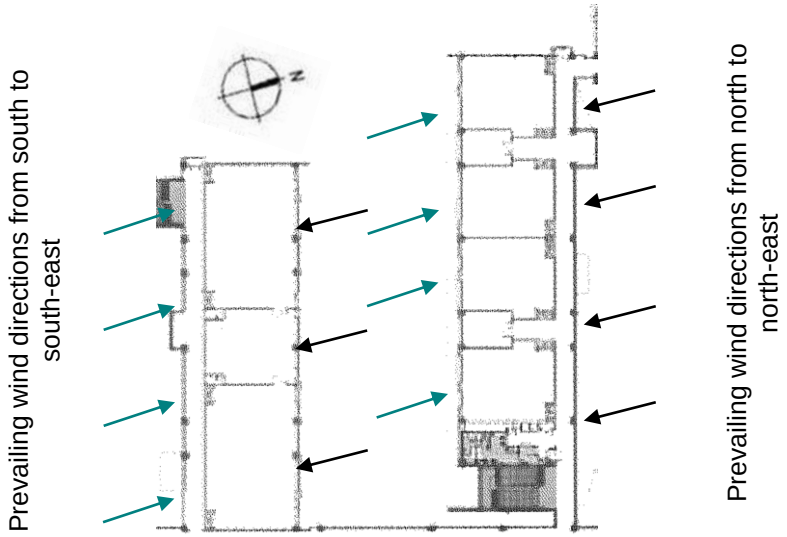


Illustration - Building layout shows all rooms with window openings facing the north and south directions.

1-3(b) Mechanical Ventilation

- Up to 32 points can be scored for the use of energy efficient MV system.
- 0.6 points can be scored for every subsequent 1% improvement from baseline.

Documentary Evidences

For 1-3(a) Natural Ventilation

- Architectural plan layouts showing the rooms with highlights of those with window openings in the N-S direction and/or with air-conditioned systems;
- Calculation showing the percentage of rooms with window openings facing north and south directions in the prescribed tabulated format as shown in the worked example 1-3(a)(i).

For 1-3(b) Mechanical Ventilation

- Architectural plan layouts showing the mode of ventilation for areas / rooms that are mechanically ventilated
- MV fan equipment schedule and technical specifications.

References

CP 13: 1999 – Code of Practice for Mechanical Ventilation and Air-conditioning in Buildings.

Worked Example

1-3(a)(i)

Background information for Natural Ventilation example

An institutional building comprises two 3-storey classroom block A and B with majority of the window openings facing the N-S direction and cross ventilation, a 4 storey classroom Block C with window opening in the E-W direction and three blocks of office, meeting rooms and computer rooms which are air-conditioned.

Ref	Description	Rooms with window openings in the N-S direction (a)	Total no. of naturally ventilated rooms (b)	% of rooms with window openings in N-S direction

1	Classroom Blk A & B	40	60	$\sum$ (a)/ $\sum$ (b) x100%
2	Classroom Blk C	0	40	
3	Offices, meeting rooms and computer rooms with air-conditioning	NA	NA	
	Total :	40	100	

Points scored for window openings = 1.6 x (% of units / 10%)

facing N-S directions = 1.6 x [($\sum$ (a)/ $\sum$ (b) x100%) /10%]

= 1.6 x [(40/100 x 100%) / 10]

= 6.4 points

Total points scored for Natural Ventilation = 20 + 6.4

= 26.4 points < 32 points (max)

Worked Example

1-3(a)(i)

Background information for Mechanical Ventilation example

A small industrial factory development comprises of 4-storey block with 6 workshop spaces that are mechanically ventilated.

MV fan schedule:

Workshop	Fan	Fan Type	Air Flow Rate (CMH)	Fan Input Power (kW)	Fan Efficiency (W/CMH)
1	FAF 1-1	Axial	39000	8.28	0.21
2	FAF 1-2		39000	8.28	0.21
3	FAF 1-3		39000	8.28	0.21
4	FAF 2-1		24000	3.92	0.16
5	FAF 2-2		24000	3.92	0.16
6	FAF 2-3		24000	3.92	0.16
1	EAF 1-1		39000	8.28	0.21
2	EAF 1-2		39000	8.28	0.21
3	EAF 1-3		39000	8.28	0.21
4	EAF 2-1		24000	3.92	0.16
5	EAF 2-2		24000	3.92	0.16
6	EAF 2-3		24000	3.92	0.16
		TOTAL	378,000	73.24	

Total fan input power = **73.24 kW**

Total air flow rate = **378,000 CMH**

Baseline: Total fan power = 378,000 CMH x 0.47 W/CMH

= 177.66 kW

Points scored = 0.6 x (% improvement)

= 0.6 x [(177.66 – 73.24)/177.66 x 100

= 0.6 x 58.8

= 35 points > 32 (max)

Therefore, point scored should be 32 points.

ENRB 1-4 ARTIFICIAL LIGHTING

Objectives	Encourage the use of better efficient lighting to minimize energy consumption from lighting usage while maintaining proper lighting level.
Applicability	Applicable to lighting provisions for the type of usage specified in the CP 24:1999 Clause 7 – Lighting power budget.
Baseline Standard	Maximum lighting power budget stated in Annex 1 of the GM ENRB Version 3.
Requirements	• Up to 13 points if includes tenants' lighting provision OR up to 5 points if tenants' lighting provision is excluded for the improvement in the lighting power consumption. • 0.3 point for every percentage improvement in the lighting provisions over the baseline standard. That is Points scored = 0.3 x (% improvement) • Display and specialized lightings are to be included in the calculation of lighting power budget. For hotels and offices, task lightings are to be included in the lighting power budget computation.
Documentary Evidences	• Lighting layout plan; • Calculation of the lighting power budget showing individual locations with area in m^2, fittings type, power consumption in watt, ballast loss, no. of lamps, total power consumption in watt, power density watt/m^2, reference power density watt/m^2, reference total power consumption 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.
References	• CP 24: 1999 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment. • SS 531: Part 1: 2006 – Code of Practice for Lighting of Work Places – Indoor • Annex 1 of Green Mark for Existing Non-Residential Buildings (Version 3.0) : Maximum lighting power budget (including ballast loss)
Worked Example 1-4	▪ Determine the total power consumption based on the lighting layout design for each area and light fitting types used. ▪ Calculate the total power consumption based on the maximum lighting power budget stated in the References. ▪ Calculate the percentage improvement in the total power consumption.

Worked Example 1-4 – Cont'd

Table 1-4-1: 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 Fittings (E)	Total power consumption based on fitting type [(C+D) x (E)]
Office Type 1	1500	T5	28	3	490	15190
Office Type 2	1250	T5	28	3	420	13020
Meeting Room	75	T8	36	6	15	630
		Surface downlight	26	3	16	464
Corridors Type 1	150	T5	28	3	40	1240
Corridors Type 2	205	T5	28	3	40	1240
		Surface downlight	70	3	10	730
Atrium	850	T8	28	6	174	5916
		Surface downlight	150	3	10	1530
Carparks	7500	T5	28	3	870	26970
Staircase	300	T5	28	3	40	1240
Male toilets	45	PLC	13	3	15	240
Female toilets	45	PLC	13	3	15	240
					Total	**68650**

Table 1-4-2 : Total power consumption based on design and SS 530 requirements

Description	Areas (m^2)	Design Data		SS 530 Requirements	
		Total Power Consumption (by area)(W)	Design Lighting Power Budget (W/m^2)	Reference Lighting Power Budget (W/m^2)	Reference Total Power Consumption (by area) (W)
	(A)	(F)	(F/A)	(H)	(H x A)
Office Type 1	1500	15190	10.13	15	22,500
Office Type 2	1250	13020	10.42	15	18,750
Meeting Room	75	1094	14.59	15	1,125
Corridors Type 1	150	1240	8.27	10	1,500
Corridors Type 2	205	1970	9.61	10	2,050
Atrium	850	7446	8.76	10	8,500
Carparks	7500	26970	3.60	5	37,500
Staircase	300	1240	4.13	6	1,800
Male toilets	45	240	5.33	5.33	240
Female toilets	45	240	5.33	5.33	240
Total		**68650**			**94,205**

	% improvement in the lighting power consumption = [Σ(HxA) - Σ(F)] / Σ(HxA) x 100% = (94205-68650)/94205 x 100% = 27.13% Points scored = 0.3 x 27.13 = 8.14 points Therefore, points scored should be 8.1 points if tenant's lighting is included ; and points scored should be 5 points (max) if tenant's lighting is excluded.

ENRB 1-5 VENTILATION IN CARPARKS

Objectives	Encourage the use of energy efficient design and control of ventilation systems in carparks.
Applicability	Applicable to all carpark spaces in the development.
Baseline Standard	Nil
Requirements	1-5(a) • 4 points can be scored if the carparks spaces are fully naturally ventilated. 1-5(b) • Up to 4 points can be scored for carparks that are mechanically ventilated. Points can only be scored for the use of carbon monoxide (CO) sensors in regulating the demand for the mechanical ventilation (MV) used; 2.5 points for carparks using fume extract system and 2 points for those with MV with or without supply. Note: Where there is a combination of different ventilation mode adopted for carpark design, the points scored under this requirement will be prorated accordingly.
Documentary Evidences	For 1-5(a) and (b) • Plan layouts showing all carpark provisions with highlights of the carpark spaces that are designed to be naturally ventilated and/or mechanical ventilated; • Plan layouts indicating the locations of CO sensors and the mode of ventilation adopted for the design; and • Calculation showing the points allocation if there is a combination of different ventilation modes adopted for the carpark design.
References	CP 13:1999 – Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings.
Worked Example 1-5	A building has a 6-storey naturally ventilated carparks and one level of mechanically ventilated basement carparks with CO sensors installed to regulate MV. Areas of naturally ventilated carparks = 6 x 600 = 3600 m^2 Areas of basement carparks = 600 m^2 Total areas = 4200 m^2 Points scored for ENRB 1-5 = (3600/4200) x 4 + (600/4200) x 2 = 3.71 points < 4 points (max)

ENRB 1-6 VENTILATION IN COMMON AREAS

Objectives	Encourage the use of energy efficient ventilation systems in common areas.
Applicability	Applicable to the following common areas:- ▪ Toilets ▪ Staircases ▪ Corridors ▪ Lift Lobbies ▪ Atriums
Baseline Standard	Nil
Requirements	• Up to 5 points can be scored for the use of natural ventilation as an effective passive cooling design strategy to reduce the energy used by air-conditioning systems in these common areas. • Extent of coverage: At least 90% of each applicable area (by numbers). • Points are scored based on the mode of ventilation provided in these applicable areas. • Natural ventilation – 1.5 points for each common area • Mechanical ventilation – 0.5 point for each common area
Documentary Evidences	• Plan layouts showing the applicable areas and the respective modes of ventilation; and • Schedules showing the numbers, locations of the applicable areas and the modes of ventilation used.
References	CP 13:1999 – Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings.
Worked Example 1-6	An existing building has the following details : • No. of toilets = 45 ; where 10 units are mechanical ventilated and 35 units are natural ventilated. % of toilet units with natural ventilation = (35)/45 = 77.8 % < 90% and hence only 0.5 points shall be awarded for this item • No. of staircases = 100 ; all are mechanical ventilated. Points scored is 0.5 point • No. of lift lobbies = 22 ; all are naturally ventilated. Points scored is 1.5 points Total points scored for ENRB 1-6 = 0.5 + 0.5 +1.5 = 2.5 points < 5 points(max)

ENRB 1-7 LIFTS AND ESCALATORS

Objectives	Encourage the use of energy efficient lifts and escalators.
Applicability	Applicable to <u>all</u> lifts and escalators in the building.
Baseline Standard	Nil.
Requirements	• 1 point can be scored for the use of lifts with energy efficient features such as AC variable voltage and variable frequency (VVVF) motor drive or equivalent, and sleep mode features. • 1 point can be scored for the use of escalators with motion sensors to regulate usage.
Documentary Evidences	• Technical specification indicating the types of lifts, escalators and related features used; and
References	-
Worked Example 1-7	An existing building has the following provision : Two lift types : (a) Type L1 with VVVF motor drive and sleep mode features **(ii)** Type L2 with VVVF motor drive and sleep mode features Two escalator types : (a) Type E1 with VVVF motor drive and motion sensors **(ii)** Type E2 without VVVF motor drive and motion sensors 1 points for the use of lifts with VVVF and sleep mode features. No point for escalators as not all escalators are designed with motion sensors. Points scored for ENRB 1-7 = 1 point

ENRB 1-8 ENERGY EFFICIENT PRACTICES & FEATURES

Objectives	Encourage the use of energy efficient practices and features which are innovative and have positive environmental impact in terms of energy saving.
Applicability	Applicable to practices and features that are not listed in the requirements under Part 1 – Energy Efficiency.
Baseline Standard	-
Requirements	1-8 (a) • 1 point can be scored for the computation of using Energy Efficiency Index (EEI) as a building performance indicator to measure the building's unit area energy consumption for monitoring and improvements. Calculation of EEI : **EEI = [(TBEC – DCEC) / (GFA – DCA)] x (NF/OH)** *where:* (a) TBEC : Total building energy consumption (kWh/year) (b) DCEC : Data centre energy consumption (kWh/year) © GFA : Gross floor area (exclude car park area) (m^2) (d) DCA : Data centre area (m^2) (e) NF : Normalising factor based on a typical weekly operating hours that is 55 hrs/week (g) OH : Weighted weekly operating hours (hrs/week) Note : (1) EEI is based on 100% occupancy rate for consistency. (2) All major energy consumption equipments are to be included in the estimation of total building energy consumption. (3) For industrial buildings, process load should be excluded. 1-8(b) • Up to 2 points can be scored for the use of energy efficiency products that are certified by approved local certification body. 0.5 point for each energy efficient type. 1-8(c) • Up to 9 points can be scored for the use of the following approved energy efficient features depending on the potential energy saving. 2 points for every 1% energy saving over total building energy consumption. ▪ Re-generative lift ▪ Light shelves ▪ Photo sensors ▪ Motion sensors ▪ Heat recovery devices ▪ Sun pipes for natural lighting ▪ Heat pumps ***Important notes:*** *For features that are not listed ENRB 1-8© above, it is required to submit the details showing the positive environmental impacts and potential energy savings of the proposed features to BCA for assessment before submittal of Green Mark Score.*

<table>
<tr><td>Documentary Evidences</td><td>For 1-8(a)
• Calculation of the Energy Efficiency Index (EEI) in the prescribed tabulated format as shown in the worked example 1-8(a).
• Twelve(12) months energy bills

For 1-8(b)
• Certification from approved local certification body (such as SGLS and SGBC) which spelt out the material certification standards, rating and details.
• Technical product information.

For 1-8(c)
• Write-up and drawings showing the provision of the proposed energy efficient features and the extent of implementation where applicable;
• Technical product information on the energy efficient features used; and
• Calculation of the potential energy savings that could be reaped from the use of these features.</td></tr>
<tr><td>References</td><td>• Singapore Green Building Council (SGBC)
Certified products : http://www.sgbc.sg/index.php/certification/assess/C109/

• Singapore Environmental Council at http://www.greenlabel.sg/sgls</td></tr>
<tr><td>Worked Example 1-8(a)</td><td>For 1-8(a)
• Tabulate the total annual building electricity consumption (TBEC) based on 12 months energy bills.
• Compute the Energy Efficiency Index of the building .

Background info :

Assume an existing building with GFA of 21,835 m^2, operatiing hours per week is 60 hours at 100% occupancy rate. No data centre in the building.

<table>
<tr><th>Month</th><th>Total Electricity Bill</th></tr>
<tr><td>Mar-11</td><td>756,730</td></tr>
<tr><td>Apr-11</td><td>819,278</td></tr>
<tr><td>May-11</td><td>819,538</td></tr>
<tr><td>Jun-11</td><td>742,540</td></tr>
<tr><td>Jul-11</td><td>806,854</td></tr>
<tr><td>Aug-11</td><td>847,571</td></tr>
<tr><td>Sep-11</td><td>865,244</td></tr>
<tr><td>Oct-11</td><td>834,212</td></tr>
<tr><td>Nov-11</td><td>872,959</td></tr>
<tr><td>Dec-11</td><td>847,652</td></tr>
<tr><td>Jan-12</td><td>935,965</td></tr>
<tr><td>Feb-12</td><td>767,112</td></tr>
<tr><td>TOTAL (kWH/yr)</td><td>9,915,655</td></tr>
</table>

EEI = [(TBEC – DCEC) / (GFA – DCA)] x (NF / OH)
= [(9,915,655 – 0) / (21,836 – 0)] x (55 / 60)</td></tr>
</table>

	= (9,915,655 / 21,836) x 0.917 = 454.12 x 0.917 = 416.41 kWh/m^2/yr Points scored for ENRB 1-8(a) = 1 point
Worked Example 1-8©	An existing building uses motion sensors to control the lightings in all staircases and toilets. (i) <u>Toilets</u> Total light fittings to be controlled by motion sensors = 2 x 350 nos. Power consumption by light fitting = 2 x 350 x 42 W = 29,400 W Assume 5 hours per day that the light fittings are off when it is not occupied. Electricity saving = 29,400 W x 5 hours = 147 kWh/day Annual electricity saving = 147 x 365 = 53,655 kWh/yr <u>(ii) Staircases</u> Total light fittings to be controlled by motion sensors = 2 x 180 nos. Power consumption by light fitting = 2 x 180 x 21 W = 7,560 W Assume 10 hours per day that the light fittings are off when it is not used Electricity saving = 7,560 W x 10 hours = 75.6 kWh/day Annual electricity saving = 75.6 x 365 = 27,594 kWh/yr Total annual electricity saving using motion sensors = 53,655 +27,594 = 81,249 kWh/yr **% energy savings = Energy savings / Total building energy consumption** % energy savings = 81,249 / 9,915,655 = 0.819 % Points scored for 1-8© = 2 points for every 1 % energy saving = 2 x 0.819 = 1.64 points

ENRB 1-9 ENERGY POLICY AND MANAGEMENT

Objectives	To establish energy policy and targets for the better building energy efficiency
Applicability	Generally applicable to all buildings.
Baseline Standard	Nil.
Requirements	(a) 0.5 point can be scored for establishing Energy Policy, energy targets and regular review with top management. (b) 0.5 point can be scored for having measures or strategies for energy improvement plans to achieve the energy target set over the next 3 years. Committed energy savings accrued from the proposed measures should be quantified.
Documentary Evidences	(a) Energy Policy with senior management's endorsement and energy targets for next 3 years. (b) List of energy efficiency improvement plans for the next 3 years and the computation of energy savings for each measure to arrive at the energy targets.
References	An energy policy is a written document stating the way the building management will use energy and what targets it hopes to achieve. It should show how the building management intends to achieve the targets and plans for how energy efficiency will continually be improved in the future. The policy should be developed in consultation with the senior management so as to secure commitment from the management.
Worked Example 1-9	**<u>Sample of Energy Policy</u>** **<u>Goals</u>**: ABC Pte Ltd is committed to the responsible management of energy and water and by using these resources in the most efficient and environmentally responsible manner possible. Towards this end, ABC Pte Ltd shall: (a) improve energy efficiency continuously by implementing effective energy management (b) 71inimize environmental impact (c) have programs that support all operations and customer satisfaction while providing a safe and comfortable work environment.

(d) maintain an acceptable level of comfort level for staff, tenants and other building users.

Strategy:

(a) Benchmark energy use of all facilities by January 2012.

(b) Compared with 2011 baseline, reduce energy consumption by 3 percent per square metres by 2012 and 5 percent per square metres by 2014.

(c) Each year realistic energy reduction targets will be set and monitored regularly.

(d) To regularly monitor and assess the energy, gas and water consumption.

(e) Any unusually high usage will be investigated and corrected.

(f) Educate employees about how to save energy at work and at home.

(g) Our target for energy and water performance are:

	Current yearly performance	Target yearly performance	% target reduction per year
Electricity $kWh/m^2/yr$	9,915,000	9,615,000	3%

Applicability:
This policy shall apply to all facilities, business units and employees.

Approved by:
[Company CEO]

ENRB 1-10 RENEWABLE ENERGY

<table>
<tr><td>Objectives</td><td>Encourage the use of renewable energy sources in buildings.</td></tr>
<tr><td>Applicability</td><td>Includes all renewable energy sources (e.g. solar panels, wind turbine)</td></tr>
<tr><td>Baseline Standard</td><td>Nil.</td></tr>
<tr><td>Requirements</td><td>Up to 15 points can be scored based on the building energy efficiency index and percentage replacement of electricity by the renewable energy source :
<table>
<tr><th rowspan="2">Expected Energy Efficiency Index (EEI)</th><td colspan="2">Every 1 % replacement of electricity (based on total electricity consumption) by renewable energy source (Up to 15 points)</td></tr>
<tr><th>Include tenants' usage</th><th>Exclude tenants' usage</th></tr>
<tr><td>≥ 50 kWh/m^2/yr</td><td>5 points</td><td>3 points</td></tr>
<tr><td>< 50 kWh/m^2/yr</td><td>3 points</td><td>1.5 points</td></tr>
</table>
Note : For computation of EEI, refer to worked example 1-8(a) under ENRB 1-8 – Energy Efficient Features</td></tr>
<tr><td>Documentary Evidences</td><td>• Description and drawings on the renewable energy system and the extent of implementation;
• Technical product information on the salient features of the renewable energy system and the expected renewable energy generated; and
• Calculation of the percentage replacement of electricity compared with the total annual electricity consumption of the building.</td></tr>
<tr><td>References</td><td>Nil.</td></tr>
</table>

(I) Other Green Requirements

Part 2 – Water Efficiency

ENRB 2-1 Water Monitoring

ENRB 2-2 Water Efficient Fittings

ENRB 2-3 Alternative Water Sources

ENRB 2-4 Water Efficiency Improvement Plans

ENRB 2-5 Irrigation System and Landscaping

ENRB 2-6 Cooling Towers

ENRB 2-1 WATER MONITORING

Objectives	Promote the use of private meters and leak detection system for better control and monitoring of water usage.
Applicability	Applicable to sub-metering provisions for major water uses of the building developments.
Baseline Standard	Nil.
Requirements	2-1 (a) • 1 point can be scored if the building's water consumption is monitored on monthly basis. 2-1 (b) • 1 point can be scored if private water meters are provided for major water uses e.g. cooling tower, water features, irrigation system, swimming pools, tenants' usage where applicable. 2-1 (c) • 1 point can be scored if there is provision of automated and/or smart metering for the monitoring and leak detection.
Documentary Evidences	2-1 (a) • Tabulation of the monthly water usage for the last 12 months and a graph showing the consumption trend from PUB monthly bills and each private meter's recording. 2-1 (b) • Documentary evidences and/or photographs of each private water sub-meters and records of recording and monitoring; or • Schematic drawings of cold water distribution system showing the location of the sub-meters provided. 2-1 (c) • Documentary evidences and trend logging records to show the provision of the automated metering and leak detection system.
References	Nil.

ENRB 2-2 WATER EFFICIENT FITTINGS

<table>
<tr><td>Objectives</td><td>Reduce the use of potable water by encouraging the use of water efficient fittings under the PUB Water Efficiency Labeling Scheme (WELS) or adopt equivalent water efficient flowrate/flush volumes for the water fittings.</td></tr>
<tr><td>Applicability</td><td>Applicable to all water fittings covered by the WELS as follows:
Basin taps and mixers
Shower taps and mixers or showerheads
Sink/bib taps and mixers
Urinals and Urinal Flush Valves
Dual-Flush Low Capacity Flushing Cisterns
Note: Water closets in public toilets fitted with flush valve and automatic flush devices can be excluded in computation.</td></tr>
<tr><td>Baseline Standard</td><td>As specified under PUB Water Efficiency Labelling Scheme (WELS).</td></tr>
<tr><td>Requirements</td><td>• Up to 12 points can be scored based on the number and water efficiency rating of the fitting type used.
<table><tr><th>WELS Rating</th><th>Water Efficiency</th><th>Weightage for Point Allocation</th></tr><tr><td>✓✓</td><td>Very Good</td><td>9</td></tr><tr><td>✓✓✓</td><td>Excellent</td><td>12</td></tr></table>Or
• 9 points can be scored if the building is certified with PUB Water Efficient Building.</td></tr>
<tr><td>Documentary Evidences</td><td>• Water fitting schedules showing the numbers, types and the approved rating of the water fittings in the prescribed tabulated format shown in the worked example.
• Documentary evidences such as WELS water efficiency label, catalogues, etc.
• A copy of PUB Water Efficient Building certificate.</td></tr>
<tr><td>References</td><td>PUB WELS - http://www.pub.gov.sg/wels/rating/Pages/Requirements.aspx</td></tr>
</table>

Worked Example 2-2

Example of a water fitting schedule showing the numbers, types and the approved rating of the proposed fittings.

Table 2-2 –Computation of the percentage of water fittings under WELS

Ref	Water Fitting Type	WELS rating		Mandatory Requirement MWELS	Total no. based on fitting type
		Excellent	Very Good	Good	
1	Shower taps and mixers	0	30	30	60
2	Basin taps and mixers	200	0	10	210
3	Sink/bib taps and mixers	0	0	0	0
4	Dual-flush low capacity flushing cisterns	0	80	0	80
5	Urinals and urinal flush valves	50	0	0	50
Total no. based on rating (A)		250	110	40	$\sum A = 400$
Weightage (B)		12	9	0	-
Total (AxB)		3000	990	0	$\sum(AxB) = 3990$

Points scored = $\sum(AxB) / \sum A$

= 3990 / 400

= 9.98

Points scored for ENRB 2-2(a) = 9.98 points

ENRB 2-3 ALTERNATIVE WATER SOURCES

<table>
<tr><td>Objectives</td><td>Use of suitable systems that utilize alternative water sources for non-potable uses such as irrigation, washing, water features, toilet flushing, etc (excluding cooling tower make-up water) to reduce use of potable water. Alternative sources can be referred to rainwater, greywater, NEWater, AHU condensate and recycled water from approved sources.</td></tr>
<tr><td>Applicability</td><td>Applicable to all buildings.</td></tr>
<tr><td>Baseline Standard</td><td>Nil.</td></tr>
<tr><td>Requirements</td><td>Up to 3 points can be scored based on percentage reduction in potable water usage of the applicable uses.
<table>
<tr><td>Percentage reduction</td><td>Points</td></tr>
<tr><td>> 50 %</td><td>3 points</td></tr>
<tr><td>< 10 % to 50 %</td><td>2 points</td></tr>
<tr><td>< 10 %</td><td>1 point</td></tr>
</table></td></tr>
<tr><td>Documentary Evidences</td><td>• Relevant schematics showing the location and design of the non-potable water source.
• Calculation showing the percentage reduction of potable water using the alternative water sources.
• PUB water bills showing monthly water consumption.</td></tr>
<tr><td>References</td><td>Nil.</td></tr>
<tr><td>Worked Example</td><td>Assuming rainwater is used for irrigation and the consumptions from PUB bills are as shown:-
<table>
<tr><th>Months</th><th>PUB Water (m^3)</th><th>NEWater (m^3)</th><th>Total (m3)</th></tr>
<tr><td>January</td><td>1,774</td><td>149</td><td>1,923</td></tr>
<tr><td>February</td><td>2,018</td><td>106</td><td>2,124</td></tr>
<tr><td>March</td><td>2,744</td><td>183</td><td>2,927</td></tr>
<tr><td>April</td><td>2,227</td><td>185</td><td>2,412</td></tr>
<tr><td>May</td><td>2,575</td><td>101</td><td>2,676</td></tr>
<tr><td>June</td><td>2,650</td><td>168</td><td>2,818</td></tr>
<tr><td>July</td><td>2,324</td><td>195</td><td>2,519</td></tr>
<tr><td>August</td><td>2,567</td><td>181</td><td>2,748</td></tr>
<tr><td>September</td><td>2,657</td><td>146</td><td>2,803</td></tr>
<tr><td>October</td><td>2,612</td><td>113</td><td>2,725</td></tr>
<tr><td>November</td><td>938</td><td>122</td><td>1,060</td></tr>
<tr><td>December</td><td>1,986</td><td>177</td><td>2,163</td></tr>
<tr><td>Total (m3/yr)</td><td>27,072</td><td>1,826</td><td>28,898</td></tr>
</table></td></tr>
</table>

	Rainwater consumption = 1,826 m^3/yr Total water consumption = 28,898 m^3/yr Percentage reduction in potable water = 1,826 / 28,898 = 6.32% Points scored for ENRB 2-3 = 1 point

ENRB 2-4 WATER EFFICIENCY IMPROVEMENT PLANS

Objectives	Establish plans and strategies to reduce the dependency of potable water usage.
Applicability	Applicable to all buildings.
Baseline Standard	Nil
Requirements	• 1 point can be scored if there are intent, measures and implementation strategies for water efficiency improvement plans over the next 3 years. • Committed water savings accrued from the proposed measures should be quantified.
Documentary Evidences	• Water improvement plan and proposed measures to achieve these targets for the next three years. • Calculation showing the estimated water savings for each proposed measure.
References	Nil.

ENRB 2-5 IRRIGATION SYSTEM AND LANDSCAPING

Objectives	Provision of suitable control systems for irrigation system and use of plants that require minimal irrigation to reduce potable water consumption.
Applicability	Applicable to buildings with landscaping provision.
Baseline Standard	-
Requirements	2-5(a) 1 point can be scored if more than 50% of the landscape areas are served by water efficient irrigation system with features such as rain sensor, soil moisture sensor or equivalent control system. 2-5(b) 1 point can be scored if at least 50% of the landscape areas consist of drought tolerant plants that require minimal irrigation.
Documentary Evidences	2-5(a) • Write up and details for the water efficient irrigation system; • Relevant layout plans showing the overall landscape areas and the areas that are using the system; and • Calculation to determine the percentage of the landscape areas that are using the system. 2-5(b) • Relevant layout plans showing the overall landscape areas and the areas that use drought tolerant plants or plants that require minimal irrigation; and • Calculation showing the percentage of the landscape areas that use drought tolerant plants or plants that require minimal irrigation.
References	The list of drought tolerant / resistant plant species may be obtained from the online website: http://florafaunaweb.nparks.gov.sg/; go to "Browse Plants" > "Plant Characteristics & Use" > "Green Roof".

ENRB 2-6 COOLING TOWERS

Objectives	Reduce potable water consumption for cooling purpose.
Applicability	Applicable to building developments with water-cooled central chillers systems, and water-cooled package units.
Baseline Standard	Nil.
Requirements	2-6 (a) 1 point can be scored for the use of cooling tower water treatment system which can achieve 7 or better cycles of concentration at acceptable water quality. 2-6(b) 1 point can be scored for the use of NEWater or on-site recycled water from approved sources to meet the water demand for cooling tower purpose.
Documentary Evidences	2-6(a) Lab test showing cooling tower water treatment system can achieve 7 or better cycles of concentration at acceptable water quality. 2-6(b) Relevant drawings and details showing how the NEWater or other recycled water source is used for the cooling tower water demand.
References	Nil.

(II) Other Green Requirements

Part 3 – Sustainable Operation & Management

ENRB 3-1 Building Operation & Maintenance

ENRB 3-2 Post Occupancy Evaluation

ENRB 3-3 Waste Management

ENRB 3-4 Sustainable Products

ENRB 3-5 Greenery

ENRB 3-6 Environmental Protection

ENRB 3-7 Green Transport

ENRB 3-1 BUILDING OPERATION & MAINTENANCE

Objectives	To encourage the adoption of green practices that is environmentally friendly and sustainable in the operation and maintenance of a building.
Applicability	Generally applicable to all types of buildings.
Baseline Standard	Nil.
Requirements	3-1(a) • 1 point can be scored if the building management has an Environmental Policy that reflects sustainability goals set for the building and its systems. 3-1(b) • 1 point can be scored if the building management has a green guide which is disseminated to the building occupants and visitors to inculcate 'green' mindset. Best practices to reduce energy use, water use and maintain a good indoor environment should be documented in this green guide. • Building management is also required to demonstrate evidences of occupant involvement in environmental sustainability. 3-1(c) • Up to 1 point can be scored if the in-house building management team comprises:- – one Certified Green Mark Facilities Manager (GMFM) (0.5 point) or – one Certified Green Mark Professional (GMP) (1 point) or – one Singapore Certified Energy Manager (SCEM) (1 point). 3-1(d) • Up to 1 point can be scored if the environmental management system of the building is ISO 14000 or ISO 50001 certified.
Documentary Evidences	3-1(a) • A copy of the Environmental Policy with endorsement or mandate by top management. 3-1(b) • A copy of the building green guide containing best practices for energy and water conservation and good indoor environment; and also the details of the environmental friendly facilities and features within the building and their uses in achieving the intended environment performance during building operation. • Supporting documents on efforts/various avenues to disseminate the green guide to occupants and to inculcate 'green' mindset in occupants. 3-1(c) • Certified true copies of the certificate of GMFM or GMP or SCEM of in-house building management team and confirmation of their involvement and contribution in the Green Mark assessment.

	3-1 (d) • A certified true copy of the ISO 14000 or ISO 50001 certificates, which are within the validity period at the time of assessment. The scope of activities mentioned in the certificate shall be relevant to the building and/or building management/operations.
References	• The Environment Policy is a written commitment of the management's stance towards the building environment in which it operates. The policy shall outline management's intent to reduce its carbon footprint, improve recycling, minimizing waste, improve efficiencies of its building systems, etc. • It must be signed by top management to demonstrate that it is a company policy and reviewed at regular intervals. • The policy must be communicated to employees and others working on behalf of the management. • The policy shall also include a framework for continual improvement to environmental performance and pollution prevention and regulatory compliances.

ENRB 3-2 POST OCCUPANCY EVALUATION

Objectives	A post-occupancy evaluation is a survey which includes questions for building occupants about the building operations. These include thermal comfort, lighting quality, cleanliness, work environment, furniture and more. The objective is to gauge occupants' satisfaction on indoor environmental quality and identify corrective actions that will enhance comfort.
Applicability	Applicable to all buildings.
Baseline Standard	Satisfactory level of more than 80% to be achieved.
Requirements	3-2(a) • 2 points can be scored if building management conduct post occupancy survey to evaluate occupants' satisfaction on indoor environmental performance. • Required number of people surveyed shall be 10% of total occupancy and up to 100 maximum. A minimum 5 people shall be surveyed if total occupancy is less than 50. 3-2(b) • 1 point can be scored for corrective actions taken following the post occupancy evaluation.
Documentary Evidences	3-2(a) • A written confirmation on the total no. of building occupancy. • Summary of the complete analysis of the survey forms. • Survey forms submitted by the respondents. 3-2(b) • List of the corrective actions based on the respondents' comments. • Acknowledgement from the complainant on the action taken by the building management.
References	Nil.

ENRB 3-3 WASTE MANAGEMENT

Objectives	To reduce waste consumption by recycling, monitoring and educating the building occupants.
Applicability	Applicable to all buildings.
Baseline Standard	Nil.
Requirements	3-3(a) • 2 points can be scored for the provision of facilities or recycling bins for collection and storage of different recyclable waste such as paper, glass, plastic etc. 3-3(b) • 2 points can be scored for the promotion of waste minimization and recycling among occupants, tenants and visitors. 3-3(c) • 1 point can be scored for the provision of a proper storage area for the recyclable waste. 3-3(d) • 2 points can be scored for quantifying the recyclables and monitoring the recycling program for continuous improvement. Recyclables include glass, paper, metal (including drinking cans), plastic and other wastes such as printer cartridges, food waste, etc.
Documentary Evidences	3-3(a) • Plan layout showing the location of the recycling bins for collection and storage of different recyclable wastes. 3-3(b) • Supporting documents on efforts and avenues to educate occupants, tenants and visitors on waste reduction and recycling. 3-3(c) • Plan layout showing the location of the storage area for the recyclable waste and the recycle bins for the different recyclables. 3-3(d) • Details of monthly data collections and amount of recyclables generated in-house.
References	• Waste management at http://app2.nea.gov.sg/topics_waste.aspx • Waste minimization and recycling at http://app2.nea.gov.sg/topics_wasteminimisation.aspx

ENRB 3-4 SUSTAINABLE PRODUCTS

<table>
<tr><td>Objectives</td><td>Encourage the use of materials that are environmentally friendly and sustainable which are certified by approved local certification body.</td></tr>
<tr><td>Applicability</td><td>Applicable to all buildings</td></tr>
<tr><td>Baseline Standard</td><td>Nil.</td></tr>
<tr><td>Requirements</td><td>Up to 8 points are allocated for the use of environmentally friendly products that are certified by approved local certification body. Points awarded will be based on the weightage, extent of coverage and impact.

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

<table>
<tr><th>Extent of Environmental Friendliness of products</th><th>Weightage for Point 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 used for the main building elements or functional spaces will be considered as high impact if the quantities used by percentage are more than 50% (i.e. extent of coverage) as compared to the total quantities used for the same intended purpose. Items that do not meet the minimum coverage or are used in other common areas, external works etc will be considered as low impact.

Note: The point allocated for low volatile organic compound (VOC) paints and adhesives certified by approved local certification body can be found in ENRB 4-2 and hence shall not be included in the scoring for ENRB 3-4.</td></tr>
<tr><td>Documentary Evidences</td><td>• Certification from approved local certification body (such as SGLS and SGBC) which should spell out the material certification standards, rating and details.
• Technical product information.</td></tr>
<tr><td>References</td><td>• Singapore Green Building Product certification
Certified products : http://www.sgbc.sg/index.php/certification/assess/C109/

Scoring method : http://www.sgbc.sg/index.php/certification/cert_faqs/

• Singapore Environmental Council at http://www.greenlabel.sg/sgls</td></tr>
</table>

Worked Example 3-4(i)

1. Determine if the environmental friendly products selected are certified with approved certification body and the product rating.

2. Check if the products used are meant for main building elements or functional spaces and can be considered as high impact. Examples are internal drywall partitions in every functional space unit, carpets for office spaces, etc. Products that are meant for common areas and external works such as toilets, lobbies and landscaping areas are considered as low impact.

3. If the selected products are potential high impact items, then determine the quantities used for these products as compared to the total quantities required for the same intended purpose. If the quantities of the products are more than 50% of the total requirement, it is considered as high impact. If it is less than 50% of the total requirement then it should be considered as low impact.

   Example of products that are rated as 'Good' by the approved local certification body.

Products and Extent of coverage		With approved certification	Points allocated based on impact	Weightage based on rating	Points scored
(a)	Carpets for all office spaces	Yes	1	1	1
(b)	Panel boards as internal partition for more than 50% of office spaces	Yes	1	1	1

Points scored for 3-4 (i) = 1+1 = 2 points

Worked Example 3-4(ii)

Note: Certain products have more environmentally friendly features than others. Other than recycled materials, they may have added features like low VOC assembly or manufactured with resource efficient processes, durability etc which will render the products more environmental superior than others. If the certified products selected are more environmental superior products and are rated by the approved local certification body as of better rating, higher weightage will be given in term of point scoring.

Example of a proposed development with the following provisions:

(a) Use of carpets for all office spaces. Product is not certified.

(b) Use of panel boards as internal partitions for more than 50% of the office spaces and the product is rated to be 'Very Good' by the approved certification body.

(c) Precast concrete road kerbs. Product is rated as 'Good' by approved local certification body.

(d) Use of roof waterproofing coating. Product is rated as 'Very Good' by approved local certification body.

(e) Use of wooden doors for all areas. Product is rated as 'Excellent' by approved local certification body.

Worked Example 3-4(ii)

Products and Extent of coverage		With approved certification	Points allocated based on impact (A)	Weightage based on rating (B)	Points scored (AxB)
(a)	Carpets for all office spaces	No	NA	NA	0
(b)	Panel boards as internal partition for more than 50% of office spaces	Yes	1	1.5	1.5
(c)	Precast road kerbs	Yes	0.5	1	0.5
(d)	Roof waterproofing	Yes	0.5	1.5	0.75
(e)	Wooden doors for all areas	Yes	1	2	2

Therefore, points scored for 3-2 (ii) = 1.5 +0.5+0.75+2 = 4.75 points

ENRB 3-5 GREENERY PROVISION

<table>
<tr><td>Objectives</td><td>Encourage greater use of greenery to reduce heat island effect.</td></tr>
<tr><td>Applicability</td><td>Applicable to buildings with landscaping areas.</td></tr>
<tr><td>Baseline Standard</td><td>Nil.</td></tr>
<tr><td>Requirements</td><td><u>3-5(a)</u>
• Up to 5 points can be scored for the provision of greenery within the developments including roof top/ sky garden and green roof and vertical greening.

• Greenery Provision (GnP) is calculated by considering the 3D volume covered by plants using the following Green Area Index (GAI) : Grass GAI = 1 ; Shrubs GAI = 3; Palms Trees GAI = 4; Trees GAI = 6

Greenery Provision (GnP) = Total Green Area / Total Site Area

<table>
<tr><th>GnP</th><th>Points Allocation</th></tr>
<tr><td>0.5 to < 1.0</td><td>1</td></tr>
<tr><td>1.0 to < 2.0</td><td>2</td></tr>
<tr><td>2.0 to < 3.0</td><td>3.5</td></tr>
<tr><td>≥ 3.0</td><td>5</td></tr>
</table>

<u>3-5(b)</u>
• 1 point for the use of compost recycled from horticulture waste and/or organic compost.

<u>3-5(c)</u>
• Provision of roof top greenery: 1 point for ≥20% to 50% of useable roof areas and 2 points for ≥ 50% of useable roof areas.

<u>3-5(d)</u>
• Provision of vertical greenery: 1 point for ≥10m^2 to <50m^2 greenery areas and 2 points for ≥ 50m^2 greenery areas.</td></tr>
<tr><td>Documentary Evidences</td><td><u>For 3-5(a)</u>
• Plan layouts showing the site area as well as the greenery that is provided within the development;

• Calculation showing the extent of the greenery provision in the prescribed tabulated format as in worked example 3-5(a).

<u>For 3-5(b)</u>
• Documentary evidences stating the compost used is made from recycled horticulture waste and/or organic compost with certification from approved local certification body. Horticulture waste is manufactured from grass, leaves and tree clippings.</td></tr>
</table>

<table>
<tr><td></td><td>For 3-5(c)
• Plan layouts showing the greenery area on the roof top and the calculation of the percentage area compared to useable total roof area.

For 3-5(d)
• Plan layouts showing the vertical greenery area and the calculation of this area.</td></tr>
<tr><td>References</td><td>Nil.</td></tr>
<tr><td>Examples</td><td>1) Determine the number of trees, palms and the areas for shrub and turfs and other greenery area

2) The canopy, radius and Green Area Index are pre-determined design parameters applicable for all developments.

3) Compute the green areas as shown in the Table 3-5(a) below.

Table 3-5(a) – Calculation of the Greenery Provision
<table>
<tr><th>Description</th><th>Qty (A)</th><th>Canopy area (B)</th><th>Radius (C)</th><th>Green Area Index GAI</th><th>Green Area (A)x(B)x(C^2)xGAI</th></tr>
<tr><td>Trees (Nos)</td><td>20</td><td>3.14</td><td>3.5</td><td>6</td><td>4615.8</td></tr>
<tr><td>Palms (Nos)</td><td>20</td><td>3.14</td><td>1</td><td>4</td><td>251.2</td></tr>
<tr><td>Shrubs (m^2)</td><td>20</td><td>NA</td><td>NA</td><td>3</td><td>60</td></tr>
<tr><td>Landscape area + Roof garden + vertical greening (m^2)</td><td>100</td><td>NA</td><td>NA</td><td>1</td><td>100</td></tr>
<tr><td colspan="5">Total Green Area :</td><td>5027</td></tr>
</table>
Assume site area is 4000m^2
Greenery Provision (GnP) = Total Green Area / Total Site Area
= 5027 / 4000
= 1.26 (1.0 to <2.0)

Therefore, points scored for 3-5(a) = 2 points</td></tr>
</table>

ENRB 3-6 ENVIRONMENTAL PROTECTION

Objectives	To encourage the adoption of sustainable and environmental friendly procurement and purchasing policy in the operation and maintenance of the building and the use of environmentally friendly refrigerant in the air-conditioning system.
Applicability	Generally applicable to all buildings.
Baseline Standard	Nil.
Requirements	3-6(a) • 1 point can be scored for the adoption of sustainable and environmental friendly procurement and purchasing policy in the operation and maintenance of the building. 3-6(b)(i) • 1 point can be scored for using refrigerants with ozone depletion potential (ODP) of zero and with global warming potential (GWP) of less than 100. 3-6(b)(ii) • 1 point can be scored for installing a refrigerant leak detection system at critical areas of the plant rooms with chillers and other equipment with refrigerants.
Documentary Evidences	For 3-6(a) • Documentary evidences stating management's green procurement policy and extracts of tender specification or quotation for environmental friendly products. For 3-6(b) • Extracts of technical specification or photographs of chiller's or condensing unit's name plate that shows refrigerant used for the chillers. • Technical specification and/or drawings/photographs showing the refrigerant leak detection system.
References	Green Procurement Policy The goal of this policy is to reduce the adverse environmental impact of building owners' purchasing decisions by buying goods and services from contractors and vendors who are committed to environmental sustainability. The following are some strategies for this Policy:- a) Purchase only most up-to-date energy efficient equipment, where applicable. This includes, but not limited to air-conditioning system, lightings and office appliances. b) Purchase only readily biodegradable and phosphate free cleaning detergents and products that meet approved certification standards and have eco-labels such as Singapore Green Label Scheme (SGLS). c) Purchase only bio-based plastic products that are biodegradable and compostable, such as bags, food and beverage containers, and cutlery.

	d) For building maintenance, purchase products/materials such as paint, carpeting, adhesives and furniture, with the lowest amount of volatile organic compounds (VOCs), highest recycled content, and low or no formaldehyde. e) For landscape maintenance, to employ landscape contractors who are familiar with sustainable landscape management techniques such as, drip irrigation, composting and use of mulch and compost produced from regionally generated plant debris and/or food waste.

ENRB 3-7 GREEN TRANSPORT

Objectives	Promote the use of public transport and environmental friendly transport options to reduce pollution from individual car use.
Applicability	Generally applicable to all buildings.
Baseline Standard	Nil.
Requirements	3-7(a) • 1 point can be scored if building has good access (< 500m walking distance) to public transport networks such as MRT/LRT stations and bus stops. 3-7(b) • 1 point can be scored for provision of covered walkway to facilitate connectivity and use of public transport. 3-7(c) • 1 point can be scored for provision of adequate priority parking lots for hybrid/electric vehicle within the development. 3-7(d) • Up to 1 point can be scored for the provision of covered/sheltered bicycles parking lots with adequate shower facilities. *(Minimum provision of 10 bicycle parking lots; cap at* 30 *bicycle parking lots where applicable)* : – 1 point if the number of bicycles parking lots is ≥ 1% x (GFA/10) – 0.5 point if the number of bicycles parking lots is ≥ 0.5% x (GFA/10)
Documentary Evidences	For 3-7(a) • Site layout plan in the context of the surrounding area showing the location of the building and the location of the MRT/LRT stations and bus stops. For 3-7(b) • Site layout plan showing the connection of covered walkway from the development to the MRT/LRT stations or bus stops; and • Documentary evidences or letter of commitment stating the requirement to provide covered walkway. For 3-7(c) • Documentary evidences or letter of commitment stating the requirement to provide priority parking lots for hybrid/electric vehicle. For 3-7(d) • Documentary evidences or letter of commitment stating the requirement to provide covered/sheltered bicycles parking lots, shower and changing facilities for the development and the quantity and location of bicycle lots provided. The shower and changing facilities shall be accessible to the cyclists.
References	Nil.

Worked Example **3-7(d)**	Example 1 An existing building has a Gross Floor Areas (GFA) of 12,000 square metres. Minimum number of bicycle parking lots = 1% x (12000/10) = 12 lots (with adequate shower facilities) Minimum number of bicycle parking lots = 0.5% x (12000/10) = 6 lots (with adequate shower facilities) 1 point will be scored if the number of bicycles parking lots provided ≥ 12 lots. 0.5 point will be scored if the number of bicycles parking lots provided ≥ 10 lots with adequate shower facilities. Since the minimum provision of 10 bicycles parking lots is required, no points given if the number of bicycles parking lots provided is < 10 lots. Example 2 An existing building has a Gross Floor Areas (GFA) of 70,000 square metres. Minimum number of bicycle parking lots = 1% x (70000/10) = 70 lots (with adequate shower facilities) (1 point) Minimum number of bicycle parking lots = 0.5% x (70000/10) = 35 lots (with adequate shower facilities) (0.5 point) 1 point will be scored if the number of bicycles parking lots provided is 30 lots with adequate shower facilities. Note : Cap at 30 bicycles parking lots

(II) Other Green Requirements

Part 4 – Indoor Environmental Quality

ENRB 4-1 Indoor Air Quality (IAQ)
ENRB 4-2 Indoor Air Pollutants
ENRB 4-3 Lighting Quality
ENRB 4-4 Thermal Comfort
ENRB 4-5 Internal Noise Level

ENRB 4-1 INDOOR AIR QUALITY PERFORMANCE

Objectives	Ensure building ventilation systems are designed and installed to provide acceptable IAQ under normal operating conditions.
Applicability	Applicable to all air-conditioned buildings.
Baseline Standard	-
Requirements	4-1(a) Pre-requisite Requirement 4 points can be scored for performing full IAQ audit by an accredited laboratory under Singapore Accreditation Council. Results of audit shall comply with NEA's Guidelines for Good Indoor Air Quality in Office Premises or SS554:2009 Code of Practice for Indoor Air Quality for Air-conditioned Buildings. 4-1(b) 1 point can be scored for implementing effective IAQ management plan to ensure that building ventilation systems are frequently maintained to ensure clean delivery of air. 4-1(c) 1 point can be scored for the provision of high efficiency air filter (at least MERV 13) in Air Handling Units. 4-1(d) 1 point can be scored for providing Room Temperature display (at least 1 unit per floor). 4-1(e) 1 point can be scored for providing Carbon Dioxide sensor display (at least 1 unit per floor).
Documentary Evidences	For 4-1(a) • IAQ audit results/report by an accredited laboratory. For 4-1(b) • Document or report on the implementation of the IAQ management plan. For 4-1(c) • Technical product information which should include the minimum efficiency reporting value (MERV) parameters of the filters; For 4-1(d) • Layout plan showing the location of Room Temperature display. For 4-1(d) • Layout plan showing the location of Carbon Dioxide sensor display.

References	• NEA's Guidelines for Good Indoor Air Quality in Office Premises • SS 554:2009 - Code of Practice for Indoor Air Quality for Air-conditioned Buildings • IAQ management programme, refer to guidelines given in Annex G of SS554:2009 Code of Practice for Indoor Air Quality for Air-conditioned Buildings. • Air filter classification can be found in Annex E of SS554:2009 Code of Practice for Indoor Air Quality for Air-conditioned Buildings.

ENRB 4-2 INDOOR AIR POLLUTANTS

Objectives	Minimise airborne contaminants, mainly from inside sources to promote a healthy indoor environment.
Applicability	Generally applicable to all building developments.
Baseline Standard	Nil
Requirements	4-2(a) 1 point can be scored for the use of low volatile organic compounds (VOC) paints certified under approved local certification body. 4-2(b) 1 point can be scored for the use of adhesives certified by approved local certification body.
Documentary Evidences	For 4-2(a) • Layout plans and/or documentary evidences showing areas using the low VOC paints. • Certification by approved local certification body. • Technical specification of the low VOC paints. For 4-2(b) • Documentary evidences on the use of the adhesives. • Certification by approved local certification body. • Technical specification of the adhesives.
References	Nil.

ENRB 4-3 LIGHTING QUALITY

Objectives	To encourage good workplace lighting quality to promote productivity and occupant comfort.
Applicability	Generally applicable to all internal areas.
Baseline Standard	Schedule of lighting requirements stated in SS531:Part 1:2006 or CP 38:1999.
Requirements	4-3(a) • 1 point can be scored if the lighting levels comply with SS531 or CP38:1999 for various uses. 4-3(b) • 1 point can be scored if at least 90% of occupants are able to control lightings by light switches. • 2 point can be scored if at least 90% of occupants are able to control lightings by task lightings. 4-3(c) • Up to 2 points can be scored for the use of high frequency ballasts in the fluorescent lightings if it is adopted in all applicable areas that are served by fluorescent lightings. 20% to < 40% - 0.5 point 40% to < 60% - 1 point 60% to < 80% - 1.5 points 80% and above - 2 points
Documentary Evidences	For 4-3(a) • Tabulation of lux level measurements and plan layout showing the location of the measurements taken. For 4-3(b) • Tabulation of areas where task lights or light switches are used. For 4-3(c) • A summary sheet listing all fluorescent lightings used for the developments and those with high frequency ballasts. • Technical specification for the high frequency ballasts used in all fluorescent luminaries.
References	CP 38:1999 : Code of Practice for Artificial Lighting in Buildings SS 531:Part 1:2006 : Code of Practice for Lighting of Work Places Part 1 – Indoor Lighting

ENRB 4-4 THERMAL COMFORT

Objectives	To encourage buildings to maintain good indoor conditions for thermal comfort.
Applicability	Generally applicable to all indoor air-conditioned environment.
Baseline Standard	Indoor conditions for comfort air-conditioning as stated in CP 13:1999.
Requirements	4-4(a) • 1 point can be scored if the indoor dry-bulb temperature is within 22.5 °C to 25.5 °C and relative humidity <70%. 4-4(b) • 1 point can be scored if occupants are able to control the indoor temperature.
Documentary Evidences	• Tabulation of temperature and relative humidity measurements and plan drawings indicating locations of sampled points taken. • Tabulation of areas where temperature can be controlled by thermostats.
References	CP 13:1999 – Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings.

ENRB 4-5 INTERNAL NOISE LEVEL

Objectives	To control and keep the background noise in occupied spaces at levels appropriate to the intended use of the spaces.
Applicability	Generally applicable to all building developments.
Baseline Standard	Recommended ambient sound level in CP 13:1999 or SS 553:2009.
Requirements	1 point can be scored if the occupied spaces in buildings are maintained at the recommended ambient sound levels stated in CP 13:1999 or SS 553:2009.
Documentary Evidences	• Tabulation of sound levels measurements and comparison with the recommended sound levels in CP 13”1999 or SS 553:2009. • Plan drawings indicating locations of sampled points taken.
References	CP 13:1999 – Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings. SS 553:2009 - Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings.

(II) Other Green Requirements

Part 5 – Other Green Features

ENRB 5-1 Green Features and Innovations

ENRB 5-1 OTHER GREEN FEATURES

Objectives	Encourage the use of green features which are innovative and have positive environmental impact on water efficiency, environmental protection and indoor environmental quality of the buildings.
Applicability	Generally applicable to all building developments.
Baseline Standard	Nil.
Requirements	Up to 10 points can be scored for the use of the non-energy related green features depending on their potential environmental benefits or reduced environmental impacts. Examples of the green features are:- <u>Water Efficiency</u> (i) Use of self cleaning façade system • 2 points for more than 75% of the applicable facade areas • 1 point for more than 50% of the applicable facade areas • 0.5 point for at least 25% of the applicable facade areas (ii) Use of grey water recycling system • 2 points for all blocks of the development • 1 point for at least one block of the development (iii) Recycling of AHU condensate • 1 point for more than 75% of the AHU condensate • 0.5 point for at least 50% of the AHU condensate <u>Environmental Protection</u> (i) 0.5 point for the use of non-chemical termite treatment system such as termite baiting system, anti-termite mesh. (ii) 0.5 point for the provision of at least 5 nos. of compost bins to recycle organic waste. (iii) 0.5 point for the use of non-chemical water treatment system for swimming pools. (iv) 1 point for the provision of double refuse chutes for separating recyclable from non-recyclable waste. (v) Treatment of storm water runoff before discharge to public drains. • 2 points for treatment of run-off for more than 10% of total site area • 1 point for treatment of run-off for up to 10% of total site area Note: The treatment of storm water runoff shall be through provision of infiltration features or design features as recommended in PUB's ABC Water design Guidelines.

	(vi) 0.5 point for use of new generation of refrigerants with ODP =0 **<u>and</u>** GWP <150. <u>Indoor Air Quality</u> (i) 1 point for the use of pneumatic waste collection system. (ii) Use of Ultraviolet light-C band (UV) emitters in air handling units to improve indoor air quality. • 1 point for more than 75% of the AHU have this emitter • 0.5 point for at least 50% of the AHU have this emitter (iii) Use of at least MERV 14 or equivalent – 0.5 point <u>Others</u> (i) 0.5 point for the use of siphonic rainwater discharge system at roof. (ii) 0.5 point for the provision of carpark guidance system. (iii) 1 point for having Green Lease arrangement for building tenants. (iv) 0.5 points for the use of Titanium Dioxide coating to remove odour in toilets. (v) 0.5 points for the use of automatic condenser tube cleaning system for the chillers. (vi) Encourage tenants to take up Green Mark Occupant Centric Schemes (cap at 2 points). • 0.5 point for having at least 3 tenant certified under Green Mark Occupant-Centric Schemes • 1 point for achieving Green Mark Pearl Award • 2 points for achieving Green Mark Pearl Prestige Award (vii) Provision of Green Corner, which is an area dedicated to education and promotion on green and environmental sustainability. It must be located at prominent location/s, where occupants have easy access to it. • 0.5 point for having posters and displays on green and sustainability. • 1 point for having screen showing the building's real time energy performance. (viii) Install power meters for monitoring of air side system (cap at 2 points). • 0.5 point for installing power meters to all air side system and link up to BMS for ease of monitoring and calculating total system kw/ton. • 1 point for achieving 0.28 kw/ton (Total air side system kWh / total cooling load Rtonh) • 2 points for achieving 0.25 kw/ton (Total air side system kWh / total cooling load Rtonh) (ix) 1 point for having an energy performance contract with a SGBC accredited Energy Performance Contracting Firm that guarantees the operational system efficiency of a chiller plant. The contract should at least be valid for the next 3 years.
Documentary Evidences	• Write-up describing the provision of the green features and the extent of implementation.

	• Technical product information (including drawings and supporting documents) of the green features; • Details showing the positive environmental impact and benefits that the features can bring to the building.
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