GM ENRB: 2017

BCA GREEN MARK FOR EXISTING NON-RESIDENTIAL BUILDINGS

Technical Guide and Requirements

Updated 16 Jan 2020

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Green Mark Department

Building and Construction Authority

52 Jurong Gateway Road

#11-01, Singapore 608550

(Above JEM)

Disclaimer

Please note that all case studies that are illustrated in this technical guide are for reference only. As site conditions may vary, due diligence should be conducted to determine the suitability of the examples.

Green Mark ENRB: 2017 Revision Log

Revision	Description	Effective Date
R0	Launch for Pilot	13/09/2017
R1	For Implementation	05/09/2018
R2	Minor amendment on formatting and addition of *5.16*	1/10/2018
R3	Minor amendment	16/01/2020

Acknowledgement

The launch of the Green Mark for Existing Non-Residential Buildings, GM ENRB: 2017, is a result of an extensive industry collaboration across the building and construction value chain. We would like to extend our sincerest gratitude to all internal and external stakeholders for their invaluable support and contribution towards the development of Green Mark ENRB: 2017 that will enable us to develop a sustainable environment for our current and future generations to come.

BCA Working Group (Building and Construction Authority) Management

Mr Ang Kian Seng
Mr Toh Eng Shyan

Secretariat

Mr Thomas Pang
Ms Tracy Liu
Ms Jocelyn Chua
Mr Ang Boon Wee

Workgroup leads

Ms Tracy Liu
Mr Lee Jang Young
Ms Zhang Xiuting
Mr Md Halim Anapi
Mr Francis Tay
Mr Aloysius Aw
Mr Wee Kai Siong
Mr Koh Kwok Soon

Green Mark Advisory Committee

Er Lee Chuan Seng (Beca Asia Holdings Pte Ltd)
Mr Tang Kok Thye (ADDP Architects LLP)
Mr Neo Choon Keong (Building and Construction Authority)
Er Lam Siew Wah (Building and Construction Authority)
Mr Ang Kian Seng (Building and Construction Authority)
Mr Tan Tian Chong (Building and Construction Authority)
Mr Teo Orh Hai (Building and Construction Authority)
Mr Koh Chwee (JTC Corporation)
Mr Ang Kok Kiat (National Environment Agency)
Er Dr Johnny Wong Liang Heng (Housing and Development Board)
Er Tony Tay (WSP)
Er Koh Kin Teng (Squire Mech Pte Ltd)
Mr Tan Phay Ping (Building System and Diagnostics Pte Ltd)
Mr Tan Szue Hann (Surbana Jurong Pte Ltd)
Mr Joseph Loh Kum Hoong (G-Energy Global Pte Ltd)
Mr Lim Fatt Seng (Comfort Management Pte Ltd)
Mr Lim Tow Fok (Keppel Land International Limited)
Prof Raymond Wong Yew Wah (Nanyang Technological University)
Prof Lam Khee Poh (National University of Singapore)
Mr Anthony Goh (City Developments Limited)
Er Alfred Lim (CapitaLand Singapore Ltd)
Dr Ho Nyok Yong (Samwoh Corporation Pte Ltd)

Taskforces

Air-conditioning Taskforce

Er Koh Kin Teng, Co-Chair (Squire Mech Pte Ltd)
Prof Raymond Wong Yew Wah, Co-Chair (Nanyang Technological University)
Mr Toh Eng Shyan, Co-Chair (Building and Construction Authority)
Mr Anthony Goh (City Developments Limited)
Mr Steven Kang (Measurement & Verification Pte Ltd)
Mr Alfred Lim (CapitaLand Limited)
Mr Lim Fatt Seng (Comfort Management Pte Ltd)
Mr Terence Tan (Johnson Controls)
Mr Liu Xiao Feng (G-Energy Global Pte Ltd)
Mr Liew Kwong Chin (Trane Singapore)
Mr Raymond Tan (Daikin Air-conditioning Singapore Pte Ltd)
Mr Anatoli Kolmakov (Honeywell Building Solutions)
Mr Laurance Lee (Carrier Singapore Pte Ltd)
Mr Ke Yam Cheong (Mitsubishi Electric Asia Pte Ltd)
Mr. Carsten Ederer (Ebm-papst SEA Pte Ltd)

IEQ Taskforce

Mr Lim Fatt Seng, Co-Chair (Comfort Management Pte Ltd)
Mr Toh Eng Shyan, Co-Chair (Building and Construction Authority)
Er Leong Cheng Wee (Air-Conditioning & Refrigeration Association)
Mr Lenz Wong (Pure Science International Pte Ltd)
Mr Alan Ng Peng Yam (Keppel Land International Limited)
Mr Beh Lean Hooi (CapitaLand Singapore Limited)
Mr Lui Wing Sin (GETC Asia Pte Ltd)

Mr Raymond Tan (Daikin Air-conditioning (Singapore) Pte Ltd)
Ms Swen Tan (Daikin Air-conditioning (Singapore) Pte Ltd)
Mr Ang Chee Meng (NUS Office of Facilities Management)
Er Patrick Foong Keng Yuen (E2green Pte Ltd)
Dr Ang Keng Been (President of IAQ Society of Singapore)
Mr Lester Lam Kah Min (Setsco Services Pte Ltd)
Prof Tham Kwok Wai (National University of Singapore)
Mr Jayant Kaushal (Camfil Singapore Pte Ltd)
Ms Florence Chan (Camfil Singapore Pte Ltd)
Ms Jennifer Yap (National Environment Agency)
Dr Ron Tan (National Environment Agency)
Mr Eddy Lau (Singapore Green Building Council)

Smart Building Taskforce

Er Alfred Lim, Co-Chair (CapitaLand Singapore Ltd)
Er Tony Tay, Co-Chair (WSP)
Mr Toh Eng Shyan, Co-Chair (Building and Construction Authority)
Er Yee Peng Huey (JTC Corporation)
Mr Tony Choo (Ascendas-Singbridge Pte Ltd)
Mr Kelvin Oh Hon Chin (Johnson Controls)
Mr Lim Tow Fok (Keppeland Limited)
Dr Chia Kok Soon (Kaer Pte Ltd)
Mr Christophe Venot (ERIAN, NTU)
Mr Tan Kuan Khoon (Schneider Electric)
Mr Johnson Tan Hon Kong (Beca Carter Hollings & Ferner (S.E Asia) Pte Ltd)
Mr Yong Ping Quen (Building System and Diagnostics Pte Ltd)
Mr Jimmy Chua (Quantum Automation Pte Ltd)
Mr Leow Kok Chong (Siemens Pte Ltd)
Er Tong Kok Kwang (Office of Development & Facilities Management, NTU)

Sustainable Management Taskforce

Mr Lim Tow Fok, Co-Chair (Keppel Land International Limited)
Mr Toh Eng Shyan, Co-Chair (Building and Construction Authority)
Mr James Ng (Surbana Jurong Pte Ltd)
Mr Ho Chee Kit (Cushman & Wakefield)
Dr Lu Lu (ENGIE Services Singapore Pte Ltd)
Mr Ng Wei Siang (Asiamalls Mgt Pte Ltd)
Mr Eddy Lau (Singapore Green Building Council)
Mr Lim Fatt Seng (Comfort Management Pte Ltd)
Mr Tong Kok Kwang (Office of Development & Facilities Management, NTU)
Ms Quek Chay Hoon (Wing Tai Holding Ltd Singapore)
Mr Tan Phay Ping (Building System and Diagnostics Pte Ltd)
Er Patrick Foong Keng Yuen (E2green Pte Ltd)
Mr Challa Venu Kumar (Bharghest Building Performance Pte Ltd)
Mr Choong Chow Neng (G-Energy Global Pte Ltd)
Mr Chong Kok Yin (Office of Estate Development, NUS)

Solar PV Taskforce

Er Lee Chuan Seng, Co-Chair (Beca Asia Holdings Pte Ltd)
Mr Ang Kian Seng, Co-Chair (Building and Construction Authority)
Mr Toh Eng Shyan (Building and Construction Authority)
Mr Christophe Inglin (Energetix Pte Ltd)
Dr Thomas Reindl (Solar Energy Research Institute of Singapore)
Er Tony Tay (WSP)
Er Dr Johnny Wong Liang Heng (Housing and Development Board)
Mr Yong Ping Quen (Building System and Diagnostics Pte Ltd))
Mr Joseph Tay (Singapore Economic Development Board)
Ms Kavita Gandhi (Sustainable Energy Association of Singapore)
Mr Johnny Lim Chin Huat (Surbana Jurong Pte Ltd)
Mr Anthony Goh (City Developments Limited)

Hot Water Taskforce

Er Choong Choon Guan, Co-Chair (Alpha Consulting Engineers Pte Ltd)
Er Tay Cher Seng, Co-Chair (Natflow Pte Ltd)
Mr Toh Eng Shyan, Co-Chair (Building and Construction Authority)
Prof Raymond Wong Yew Wah (Nanyang Technological University)
Mr Steven Wong (Resorts World Sentosa)
Mr Manoj Shanker (Changi General Hospital)
Mr Nicholas Lee (Swissotel Merchant Court)
Er Mathew Ngan (Changi Airport group)
Mr Sam Lam Kwok Ho (Ngee Ann Polytechnic)
Mr Lee Chee Keong (Daiichi Jitsugyo Asia Pte Ltd)
Mr Joseph Loh (G-Energy Global Pte Ltd)
Derrick Lee (Aumada Pte Ltd)
Lisa Wei (Aircon Network Pte Ltd)

The standardised Post Occupancy Evaluation (POE) survey questionnaire was developed in collaboration with the SinBerBEST (The National University of Singapore and the Centre for the Built Environment at the University of California Berkeley).

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Elective Requirements		
Section 1 – Sustainable Management		**35 points**
1.1	Environmental Credentials of Facility Managers and Consultants	1
1.2	Sustainable Policy and Action Plan	4
1.3	Green Building Committee	2
1.4	Green Education	2
1.5	Green Fit-out Guidelines	1
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Section 2 – Building Energy Performance		**40 points**
2.1	Façade Performance	2
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Section 3 – Resource Stewardship		**30 points**
3.1	Water Efficient Fittings	7
3.2	Landscape Irrigation	1
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3.8	Recycling Facilities	3.5
3.9	Storage Area for Recyclable Waste	1
3.10	Promotion of Waste Reduction	2
3.11	Waste Monitoring	2
Section 4 – Smart and Healthy Building		**40 points**
4.1	Occupant Comfort	5.5
4.2	Outdoor Air Control	1.5
4.3	Enhanced Filtration Media	2.5
4.4	Indoor Contaminants	2.5
4.5	Lighting Quality	4
4.6	Acoustics	1
4.7	Biophilic features	2
4.8	Level I – Energy Monitoring	11
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Advanced Green Effort		20

Introduction

What is BCA Green Mark?

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

BCA Green Mark comprises a number of distinct rating tools that together holistically rate the built environment for its environmental performance:

- **New Buildings** including Non-Residential Buildings, Residential Buildings, Landed Houses, Healthcare Facilities and Data Centres
- **Existing Buildings** including Non-Residential Buildings, Residential Buildings, Schools and Data Centres
- **User Centric** including Office Interior, Retail, Supermarket, Restaurant and Laboratories
- **Beyond Buildings** including Districts, Parks, and Infrastructure

Green Mark ENRB: 2017

The BCA Green Mark for Existing Non-Residential Buildings, GM ENRB: 2017, is the fourth edition of the BCA Green Mark scheme for existing non-residential buildings. Developed with extensive industry collaboration and feedback, this version aims to:

- Streamline the criteria to *addresses sustainability in a more balanced and holistic manner*
- *Future-proof existing buildings*, *drive incremental improvements* in energy efficiency and other sustainable parameters, and *guide building owners to take practical improvement measures* towards achieving total building performance
- Recognise the constraints faced by existing buildings to ensure that the revised criteria and its pre-requisites are reasonable and achievable
- Be a *collaborative framework* with the involvement and contribution of more than 70 external industry members in its setting of metrics, assessment methods and performance baseline

Key Focus Areas in GM ENRB: 2017

Green Mark aims to drive sustainability outcomes and enable us to develop a high quality and environmentally sustainable built environment for our current and future generations to come.

<u>Tenant and Occupant Engagement</u>
Tenants and occupants play an important role in sustainable building operations. In line with the 3rd Green Building Masterplan, GM ENRB: 2017 encourages greater tenant and occupant engagement through green leases, green user and fit-out guides, as well as participation in Green Building Committees.

<u>Performance-based Procurement for Retrofit and Maintenance</u>
GM ENRB: 2017 hopes to promote sustainable building management by awarding credit points to buildings for engaging Energy Performance Contracting (EPC) firms accredited by the Singapore Green Building Council (SGBC) to implement energy improvement works with an energy performance contract or to adopt a performance-based maintenance contract to maintain the chilled water air-conditioning and air distribution systems' efficiencies.

<u>Energy Efficiency of Air Distribution Systems</u>
Air distribution systems have been identified as an area with high potential energy savings. Based on a study commissioned by BCA, the chilled water air-conditioning and air distribution systems' performance can be measured using the same performance indicator and monitored through the building management system. Hence, credit points are awarded for the efficiency of air distribution systems based on this performance indicator. This will

encourage building and facility managers to measure and understand the performance of their air distribution systems and take actions to improve or maintain the system efficiency.

Uptake of Renewable Energy

Solar energy remains the most promising renewable energy source for Singapore. To drive solar adoption, GM ENRB: 2017 awards credit points to projects that conduct a feasibility study on the building's solar energy generation potential in the structural, electrical, spatial and economic aspects. In view of limitations that can arise in installing solar PV in buildings, credit points are also awarded to other PV-related features like roof leasing for solar PV installation and purchasing of energy from renewable sources.

Enhanced Indoor Environment Quality (IEQ)

In line with 3rd Green Building Masterplan, GM ENRB: 2017 promotes good practices such as the use of high-efficiency filters in air distribution systems, the adoption of an Indoor Air Quality (IAQ) Management Plan and the use of permanent sensors to monitor indoor air pollutants such as formaldehyde, particulate matters and total volatile organic compounds.

Smart Control Technologies

Aligned with Singapore's ambition to become a Smart City, smart building controls and strategies are introduced in GM ENRB: 2017 in the areas of energy monitoring, demand control as well as integration and analytics.

Assessment Process

The BCA Green Mark Certification Process is as follows:

- Submittal of application with relevant supporting documents for certification
- Upon acceptance of application and fee payable, a BCA Green Mark Assessor will be assigned for the duration of the project

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

- Actual assessment to be conducted once the design and/or documentary evidences are ready
- Assessment process includes design and/or documentary reviews to verify if the building project meets (i) the intents of the criteria and certification level; and (ii) the pre-requisite requirements
- For buildings with potential BCA Green Mark Gold^{PLUS} and Platinum rating, there is a requirement for projects to be presented and assessed by panel members (BCA)

- Site verification to be conducted upon project completion of items committed during the actual assessment
- Site verification process includes review of delivery records, updated documents on green features, building energy performance data and photographic evidences. Site inspection and measurement will be conducted

GM ENRB: 2017 Ratings

The environmental performance of a building shall be determined by the numerical scores (i.e Green Mark credit points) achieved in accordance with the applicable criteria using the scoring methodology and the pre-requisite requirements on the level of building performance as specified in this Green Mark scheme document. Under this assessment framework, credit points are awarded for incorporating sustainable building features and practices, which would add up to a final Green Mark Score. Depending on the level of building performance and Green Mark Score, the building will be eligible for certification under one of the ratings, namely BCA Green Mark Certified, Gold, Gold^{PLUS} or Platinum.

The Green Mark Score of the building is the total of all the numerical scores assigned based on the degree of compliance with the applicable criteria. The following table states the corresponding Green Mark Score to attain the respective Green Mark award ratings. Buildings must also fulfil their respective pre-requisite requirements to be awarded Green Mark. The total points scored include the bonus points scored under Advanced Green Effort.

BCA Green Mark Award Rating Scores

Green Mark Rating	Green Mark Score
Green Mark Platinum	70 and above
Green Mark Gold^{PLUS}	60 to < 70
Green Mark Gold	>50 to < 60
Green Mark Certified	Compliance with all pre-requisite requirement

Criteria Overview

To dovetail the criteria with the sustainable outcomes of GM ENRB: 2017, the criteria will be re-structured into 5 sections, with 11 pre-requisite requirements and 42 criteria.

0. Pre-requisite Requirements

P.1 Energy Consumption Monitoring

Intent

To encourage the building owner to monitor the building's energy consumption trend in the past 3 years and review its Energy Efficiency Improvement Plan, where necessary.

Scope

Applicable to all buildings.

Assessment Criteria

The building's Energy Use Intensity (EUI) for the past 3 years shall be calculated and submitted. It shall be calculated based on actual utility bills. EUI = Annual Total Building Energy Consumption (kWh)/GFA(m^2). Any abnormal trends or significant increase in EUI should be investigated and corrective actions should be carried out to address any wastage.

Documentation Requirements

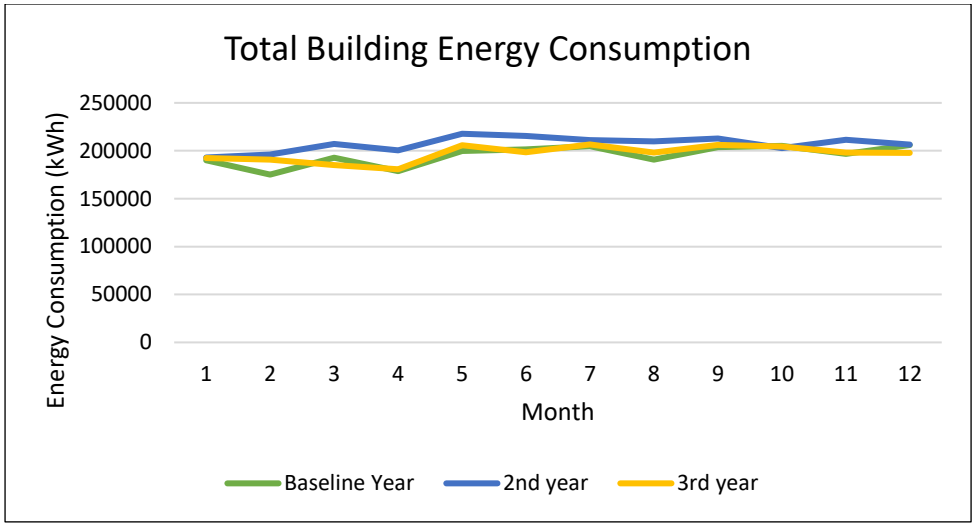
- Calculation of EUI = TBEC / GFA

  TBEC : Total building energy consumption (kWh/year)
  GFA : Gross floor area (exclude car park area) (m^2)

- The building's past 3 years' utility bill shall be submitted
- Graph showing monthly building energy consumption for the past 3 years

Worked Examples

Graph showing monthly energy consumption for the whole building.



P.2 Air-Conditioning System Minimum Operating Efficiency

Intent

To optimise a building's total system performance and reduce its overall energy consumption through the use of energy efficient and appropriately sized air-conditioning systems.

Scope

Applicable to air-conditioning systems serving the building's comfort cooling needs and where the building's aggregate air-conditioned areas exceed 500 m^2.

Assessment Criteria

The system efficiency shall not exceed the following limits indicated in the tables below. Performance of the overall air-conditioning system for the building is based on the Operating System Efficiency (OSE) of the system during standard building operating hours as defined below:

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

i) For Buildings Using Water-cooled Chilled-water Plant

Relevant equipment: *Water-cooled chillers, chilled-water pumps, condenser water pumps, cooling towers*

Green Mark Rating	Building Cooling Load (RT)	
	< 500	≥ 500
	Minimum Efficiency (kW/RT)	
Certified	0.8	0.75
Gold	0.75	0.70
GoldPLUS	0.7	0.67
Platinum	0.67	0.65

ii) For Buildings Using Air-cooled Chilled-water Plant or Unitary Air-Conditioners

Relevant equipment: *Air-cooled chillers, chilled-water pumps, variable refrigerant flow (VRF) systems, single-split units, multi-split units*

Green Mark Rating	Building Cooling Load (RT)	
	< 500	≥ 500
	Minimum Efficiency (kW/RT)	
Certified	1.1	1.0
Gold	1.0	**N.A
GoldPlus	0.85	
Platinum	0.78	

***For buildings with cooling load of more than 500 RT, the air-cooled chilled-water plant or unitary air-conditioners will be assessed on a case-by-case basis. It will only be considered when it meets the same efficiency requirement as stipulated in 2(i).*

Documentation requirement

Please refer to *2.2 Air-Conditioning System Efficiency* for the detailed requirements.

P.3 Energy Improvement on Lighting System

Intent

To reduce the energy needed to illuminate a space through the use of energy efficient lightings and control strategies.

Scope

Applicable to lighting provisions for the type of usage specified in Clause 7 of *SS 530: 2006 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment*.

Assessment Criteria

To demonstrate at least 20% improvement in the lighting power budget for common areas over the baseline stated in Annex A.

Documentation requirement

Please refer to *2.4 Lighting System Efficiency* for the detailed requirements.

P.4 Water Consumption Monitoring

Intent

To encourage the building owner to monitor the building's water consumption trend in the past 3 years and review its Water Improvement Plan, where necessary.

Scope

Applicable to all buildings.

Assessment Criteria

The building's yearly water consumption (m^3/GFA(m^2)) for the past 3 years shall be calculated and submitted. It shall be calculated based on actual utility bills.

Documentation Requirements

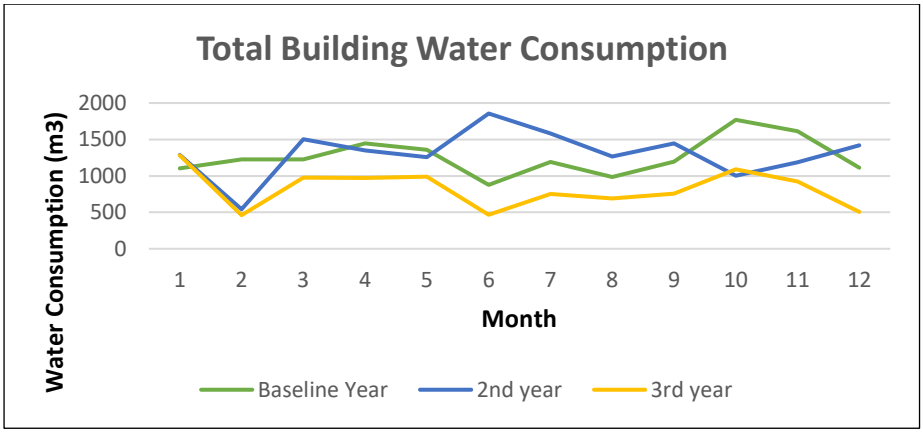
- Calculation of yearly water consumption = TBWC / GFA

  TBWC : Total building water consumption (m^3/year)
  GFA : Gross floor area (exclude car park area) (m^2)

- The building's past 3 years water bill shall be submitted
- Graph showing monthly building water consumption for the past 3 years

Worked Examples

Graph showing monthly water consumption for the whole building.



P.5 Chiller Plant Measurement and Verification (M&V) Instrumentation

Intent

To continually monitor and verify the performance of a building's chiller plant with accurate permanent measuring instruments, detect operational anomalies and realise its optimisation potential through analysis of usage patterns.

Scope

Applicable to all chilled-water air-conditioning systems.

Assessment Criteria

Permanent measuring instruments for monitoring of chilled-water system operating efficiency shall be provided. The installed instrumentation shall have the capability to calculate the resultant operating system efficiency (i.e. kW/RT) within 5% of its true value and in accordance with SS591. Each measurement system shall include the sensor(s), any signal conditioning, the data acquisition system and wiring connecting these components.

The permanent instrumentation shall comply with the following:

- Location and installation of the measuring devices to meet the manufacturer's recommendation; location of temperature sensors should be within reach to facilitate site verification

- All data logging with capability to trend at 1-minute sampling time interval, and recorded to the 3rd decimal digit

- Computation and display of water-side efficiency

- Magnetic in-line flow meter, with 1% uncertainty and capable of electronic in-situ verification to within ±2% of its original factory calibration. If installation of magnetic in-line meters is not possible, ultrasonic flow meters may be used

- 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 the entire measurement range. Provisions shall be made for each temperature measurement location to have test plugs or additional thermo-wells located before and after each temperature sensor for verification of measurement accuracy. All thermo-wells are recommended to be installed in a manner that ensures the sensors can be in direct contact with the fluid flow. There shall be valid justification if direct immersion of the temperature sensor(s) is/are not possible. Such projects will be assessed on a case-by-case basis

- Dedicated power meters of accuracy Class 1 or better and metering current transformers, where applicable, of Class 1 or better, are to be provided for each of the following groups of equipment: chillers, chilled water pumps, condenser water pumps and cooling towers fans

- A heat balance substantiating test for the water-cooled chilled-water system is to be computed in accordance to SS 591 for verification of the accuracy of the M&V instrumentation. 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 1-week period

Documentation Requirements

- Calculation of total uncertainty of resultant operating system efficiency using the following root sum square formula:

$$Error_{rms} = \sqrt{\sum (U_N)^2}$$

Where

U_N = Individual uncertainty of variable N (%)

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

In deriving the measurement errors contributed by flow meter, an additional 1% is to be included in the computation.

- Detailed schematic drawings of the instruments and test plugs locations
- Technical specifications and/or sample data sheets/ product information for instruments and meters
- Detailed drawings and schematics of the power measurement strategies for the air conditioning system
- Purchase orders and delivery orders of the instrumentation and power meters installed
- Instrumentation calibration certificates
- BMS screenshots showing the relevant calibration inputs have been entered for temperature measurement
- Site requirement: To determine the chilled-water plant efficiency using the following operation data/ installations to demonstrate compliance with design specifications:
    - From Building Management System
        - Chilled-water plant kW/RT
        - Chilled water/ Condenser water supply & return temperatures of the header to be checked for consistency against the temperatures of individual chillers and/or individual branches.
        - Chilled-water/ Condenser water header flow rate to be checked for consistency against the flow rate(s) of individual branches
        - The accuracy of the programmed formula for the computation of kW/RT of the various parameters
    - From operating chiller panel

- Chilled water/ Condenser water supply & return temperatures to be checked for consistency against the BMS data
- Evaporator approach: temperature difference between refrigerant evaporating temperature and chilled water supply temperature
- Condenser approach: temperature difference between refrigerant condensing temperature and condenser water return temperature
- Location of the chilled-water flow meter(s) installed to comply with manufacturer's recommendations

Guidance Note on Determining Heat Balance for Different Plant Configuration

- Verification of the OSE shall be conducted by computing the system heat balance of the water-cooled Chilled Water Plant in accordance with SS591 to the extent as prescribed.

  Note: For air-cooled Chilled Water Plant, heat balance requirements will not be applicable.

- The heat balance shall be computed over the entire normal operating hours as defined in clause 6.1.4 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 can be represented by,

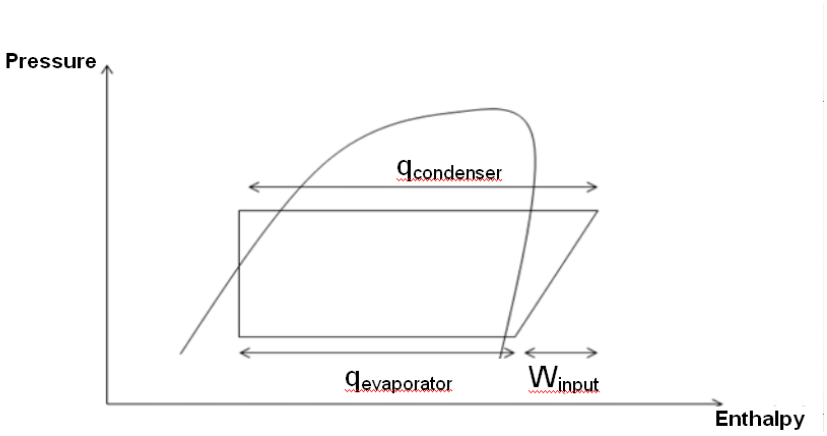
$$q_{condenser} = q_{evaporator} + W_{input.}$$

where $q_{condenser}$ = heat rejected by condenser, kW

$q_{evaporator}$ = heat gain in evaporator, kW

W_{input} = power input to compressor, kW

- The pressure enthalpy diagram below shows the concept of a 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,

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

The following example illustrates a successful heat balance where 80% of the computed heat balance falls within ± 5% as required.

	(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	**°C**	**°C**	**L/s**	**°C**	**°C**	**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 °C x [(b) – (a)] / 3.517

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

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

P.6 Indoor Temperature

Intent

To prevent overcooling of air-conditioned premises in order to save energy and provide thermal comfort to the building occupants.

Scope

Applicable to occupied air-conditioned spaces.

Assessment Criteria

The normal dry-bulb temperature for comfort air-conditioning shall be maintained at 23ºC and above.

Documentation requirement
IAQ surveillance audit report (hardcopy and softcopy in excel template) endorsed by an accredited laboratory

P.7 Indoor Air Quality (IAQ) Surveillance Audit

Intent
To ensure a comfortable and healthy indoor environment for occupants through the testing and evaluation of IAQ parameters within an occupied air-conditioned space.

Scope
Applicable to all air-conditioned premises where air-conditioning is used intermittently or continuously, with the exception of residential premises, factory production areas, hospitals, polyclinics and laboratories.

Assessment Criteria
To conduct an IAQ surveillance audit once every 3 years. The audit shall be conducted by an accredited laboratory under Singapore Accreditation Council with respect to the recommended IAQ parameters and acceptable limits stated in Table 1 of *SS 554 : 2016 Code of Practice for Indoor Air Quality for Air-Conditioned Buildings* or in Annex E of NEA's *Guidelines for Good Indoor Air Quality in Office Premises*.

Guidance note
The standardised IAQ audit report template can be found in https://www.bca.gov.sg/GreenMark/others/IAQ_report_template.xlsx.

Documentation requirement
IAQ surveillance audit report (hardcopy and softcopy in excel template) endorsed by an accredited laboratory.

P.8 Tenant and Occupant Engagement

Intent
To encourage building owners to organise more green-related activities for the building tenants and occupants so as to create awareness and drive behavioural change towards environmental sustainability. Activities may include Earth Hour, green exhibitions, seminars and talks on environmental sustainability, green practices and green products.

Scope
Applicable to all buildings targeting Green Mark Gold, Gold^{PLUS} or Platinum award ratings.

Assessment Criteria
To conduct at least one green-related activity in a year involving building tenants and occupants.

Documentation Requirement
Documentary evidences such as promotional articles including brochures, pamphlets, posters, emails and also photographs of the green- related events.

P.9 Recycling Facilities

Intent
To encourage building tenants and occupants to recycle and facilitate the segregation of recyclable consumer waste at source.

Scope
Applicable to all buildings targeting Green Mark Gold, Gold^{PLUS} or Platinum award ratings.

Assessment Criteria
Building shall provide appropriate recycling facilities for collection and storage of common recyclables such as paper, glass, metal and plastic in commingled or sorted form.

Documentation requirement

Please refer to *3.8 Recycling Facilities* for the detailed requirements.

P.10 Post Occupancy Evaluation (POE)

Intent
To seek feedback from building tenants and occupants on the indoor environment within a building and identify areas for improvement towards achieving greater occupant comfort and satisfaction.

Scope
Applicable to all buildings targeting Green Mark Gold^{PLUS} or Platinum award ratings.

Assessment Criteria
To conduct a POE survey once every 3 years and take corrective actions accordingly.

Documentation requirement
Please refer to *4.1c Post Occupancy Evaluation* for the detailed requirements.

P.11 Display of Green Mark Plaque/ Decal

Intent
To identify and distinguish exemplary buildings which are green and sustainable.

Scope
Applicable to all buildings targeting Platinum award rating.

Assessment Criteria
Building shall display the Green Mark plaque/ decal at a prominent location (eg. main lobby).

Documentation requirement
Please refer to *5.14 Display of BCA Green Mark Plaque and Decal* for the detailed requirements.

1. Sustainable Management

Introduction

This category encourages building owners to implement sustainable practices and reduce environmental impacts of their buildings over their life cycles. The criterion addresses sustainability commitment from the building management through energy and environmental policies, environmentally friendly products and practices for operating and managing the building, green procurement policy, etc.

The building management needs to engage their building occupants by educating and promoting sustainable practices and influence tenants and visitors to live, work and play sustainably. Having a Tenants' Green Building Committee can serve as a platform to involve stakeholders as well as encourage the adoption of sustainable operations and facilitate sharing of best practices.

The building management team is also encouraged to move towards measurable performance of their building systems by adopting Energy Performance Contracts for retrofitting and maintenance works.

Criteria		Points
	Leadership	
1.1	Environmental Credentials of Facility Managers and Consultants	1
1.2	Sustainable Policy and Action Plan	4
1.3	Green Building Committee	2
	User Engagement	
1.4	Green Education	2
1.5	Green Fit-out Guidelines	1
1.6	Green Lease	2
1.7	Green-related Activities for Building Occupants	3
	Greenery	
1.8	Greenery	6
	Refrigerant	
1.9	Refrigerant	4
	Green Transport	
1.10	Green Transport	4
	Sustainable Operation	
1.11	Sustainable Operation	6
	Total	**35**
Advanced Green Effort		**1**

LEADERSHIP

Intent
To recognise and promote the 'Leadership' needed to drive organisational and technical improvements to the overall environmental credentials of the building, especially during operations and retrofits.

1.1 Environmental Credentials of Facility Managers and Consultants

Scope
Applicable to in-house building and facility management team or external consultants.

Assessment Criteria
A maximum of 1 point will be awarded for the building and facility management team or external consultants with the following credentials:

- Certified Green Mark AP (FM)/GMFM (0.5 point)
- Certified Green Mark AAP (FM)/ (GMFP) (1 point)
- Singapore Certified Energy Manager (SCEM) (1 point)

Documentation Requirements
A copy of the certificate of Green Mark AP (FM) or Green Mark AAP (FM) or Singapore Certified Energy Manager (SCEM) where applicable and confirmation of their involvement and contribution in the team.

Advanced Green Effort

5.1 Accredited Green Facility Management Companies

Additional 1 point will be awarded for engagement of Green Facility Management companies, accredited by the Singapore Green Building Council (SGBC) or equivalent, in the sustainable operation and maintenance of the building.

Documentation Requirements
A copy of the certificate of Green Facility Management Companies accreditation from SGBC or equivalent

1.2 Sustainable Policy and Action Plan

Scope
Applicable to building owners and Management Corporation Strata Titles (MCSTs).

Assessment Criteria
A maximum of 4 points will be awarded for the following:

- **Energy Management Policy and Energy Improvement Plan** (1 point)
  Adoption and implementation of an Energy Management Policy, which is a written document endorsed by the top management, stating the building owner's commitment towards the way the building will use energy as well as targets on energy savings that the building endeavours to achieve. The Energy Improvement Plan thus documents the various measures and/or works that the building will undertake over the next 3 years to achieve the energy savings target

- **Water Management Policy and Water Improvement Plan** (1 point)
  Adoption and implementation of a Water Management Policy, which is a written document endorsed by the top management, stating the building owner's commitment towards the way the building will use water as well as targets on water savings that the building endeavours to achieve. The Water Improvement Plan thus documents the various measures and/or works that the building will undertake over the next 3 years to achieve the target set for water consumption reduction.

- **Waste Management Policy and Waste Recycling Plan** (1 point)
  Adoption and implementation of a Waste Management Policy, which is a written document endorsed by the top management, stating the building owner's commitment towards the way the building handles waste. The Waste Recycling Plan thus documents the various measures and/or works that the building will undertake over

the next 3 years to achieve efficient and effective waste management and promote waste recycling amongst its tenants, occupants and visitors.

- **Valid ISO 14001 or ISO 50001 Certification** (1 point)
  For having either a valid ISO 14001 (environmental management system) or ISO 50001 (energy management system) certification. The scope of activities mentioned in the certificate shall be relevant to the building and/or its facility management and operations.

Documentation Requirements

- Official Energy Management Policy with endorsement by top management and document stating the Energy Improvement Plan for next 3 years
- Official Water Management Policy with endorsement by top management and document stating the Water Improvement Plan for next 3 years
- Official Waste Management Policy with endorsement by top management and document stating the Waste Recycling Plan for next 3 years
- A copy of the ISO 14001 or ISO 50001 certificate, which is within the validity period at the time of assessment

1.3 Green Building Committee

Scope

Applicable to building owners, Management Corporation Strata Titles (MCSTs) and tenants.

Assessment Criteria

To encourage environmentally-conscious owners and tenants to come together to promote sustainability-related initiatives for the building. A maximum of 2 points will be awarded for having tenants or building occupants as members of the Green Building Committee:

- At least 3 tenants or building occupants in Green Committee (1 point)
- At least 6 tenants or building occupants; and they represent more than 30% of total lettable area (2 point)

The Committee is responsible for providing guidance and direction on all issues relating to environmental services, sustainability, waste management, etc., including the review of current policies and practices and making recommendations to the top management on energy and water conservation strategies and various environmental initiatives.

Documentation Requirements

- Documentary evidences to show the formation of the Green Committee, Minutes of meetings, Attendance, etc.
- List of tenants, lettable areas and details of tenant's involvement in the Green Committee.

USER ENGAGEMENT

Intent

This refers to the provision of relevant information and guidance to the tenants, building occupants and visitors to raise awareness on the building's green features, and on how they can contribute positively to reduce the building's environmental impact further.

1.4 Green Education

Scope

Applicable to all building types.

Assessment Criteria

A maximum of 2 points will be awarded for the provision of the following:

- **Green Building User Guide** (1 point)
  The Green Building User Guide, to be disseminated to all tenants, should provide a detailed overview of the green features and sustainable practices employed in the building and their environmental benefits. The guide should also recommend how the users could properly operate or utilise these green features as well as other sustainable practices that they can undertake within their own premises.

- **Green Corner** (1 point)
  The Green Corner should be dedicated to education and promotion of green building elements and environmental sustainability. It should be located at a prominent area, easily accessible and noticeable to all tenants, building occupants and visitors.

Documentation Requirements

- Green Building User Guide: Official green building user guide and evidence of its dissemination to the respective parties and building occupants
- Green Corner: Photographic evidence of the Green Corner

1.5 Green Fit-out Guidelines

Scope

Applicable to all buildings with occupants and tenants.

Assessment Criteria

1 point will be awarded for the provision of Green Fit-out Guidelines. The Guidelines should detail recommended minimum environmental standards to assist the tenants in making sustainable fit-out decisions. This is to be disseminated to the relevant tenant management and personnel.

Documentation Requirements

Official green fit-out guidelines and evidence of its dissemination to the building occupants/tenants

1.6 Green Lease

Scope

Applicable to all buildings with tenants.

Assessment Criteria

A maximum of 2 points will be awarded for buildings that provide and implement a Green Lease agreement with its tenants. The green lease should establish agreed levels of environmental building performance between the landlord and its tenants.

- Provision of Green lease (0.5 point) OR
- If ≥ 10% of the net lettable area are on Green lease (1 point) OR
- If ≥ 40% of the net lettable area are on Green lease (2 points)

Documentation Requirements

Official tenancy agreement with Green Lease and compliance procedures incorporated, complete with evidence of its application to the specific tenants. Other documents include list of tenants, net lettable areas and details of tenants with Green Lease.

1.7 Green-related Activities for Building Occupants

Scope

Applicable to all building types.

Assessment Criteria

A maximum of 3 points will be awarded to recognise the building owners' efforts to create awareness on environmental sustainability via green and occupant well-being related activities. The activities, targeted at the tenants and building occupants, may include Earth Hour, exhibitions, seminars and talks on environmental sustainability, green practices and products.

1 point for each green-related or occupant related activity in a year.

Documentation Requirements

Documentary evidences such as promotional articles including brochure, pamphlets, emails, photographs of the green-related events.

1.8 Greenery

Intent

This refers to the provision of greenery around the development to reduce urban heat island effect.

1.8a Greenery Provision (GnP)

Scope

Applicable to all types of greenery (trees, palms, shrubs and landscape) within the building including rooftop and sky garden and vertical greening.

Assessment Criteria

A maximum of 2.5 points will be awarded for the provision of greenery which is quantified via the Greenery Provision (GnP):

- *Greenery Provision (GnP) is calculated by considering the 3D volume covered by plants using the given Green Area Index (GAI) and total site area.*
- *Greenery Provision (GnP) = Total Green Area / Total Site Area*

Description	GAI
Trees	6
Palms	4
Shrubs	3
Landscape and grass	1

GnP	Points Allocation
0.5 to < 1.0	1
1.0 to < 2.0	1.5
2.0 to < 3.0	2
≥ 3.0	2.5

Documentation Requirements

- Plan or layout 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 shown in the Worked Example below.

Worked Examples

- Determine the number of trees, palms and the areas for shrub and turfs and other greenery areas.

- The canopy, radius and Green Area Index are pre-determined design parameters applicable for all developments.
- Compute the Green Area as shown in the Table below.

Calculation of the Greenery Provision

Description	***Qty (A)***	***Canopy area (B)***	***Radius (C)***	***Green Area Index GAI***	***Green Area (A) x (B) x (C^2) x GAI***
Trees (nos.)	*20*	*3.14*	*3.5*	*6*	*4616*
Palms (nos.)	*20*	*3.14*	*1*	*4*	*251*
Shrubs (m^2)	*20*	*NA*	*NA*	*3*	*60*
Landscape area + Roof garden + vertical greening (m^2)	*100*	*NA*	*NA*	*1*	*100*
Total Green Area :					***5027***

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 1-8(a) = **1.5 points**

1.8b Rooftop Greenery

Scope
Applicable to greenery areas at the rooftop and sky gardens.

Assessment Criteria
A maximum of 1 point will be awarded for greenery areas on the rooftop or high grounds within the building:

- For green area ≥ 20% to 50% of useable roof area (0.5 point)
- For green area ≥ 50% of useable roof area (1 point)

Note: Areas occupied by mechanical equipment shall be excluded from the computation of useable roof area.

Documentation Requirements
Plan or layout showing the greenery area on the roof top and calculation showing the percentage area compared to total useable roof area.

1.8c Vertical Greenery

Scope
Applicable to greenery areas on the building facade.

Assessment Criteria
A maximum of 1 point will be awarded for vertical greenery areas:

- For vertical green area ≥ 10m^2 and <50m^2 (0.5 point)
- For vertical green area ≥ 50m^2 (1 point)

Documentation Requirements
Plan or layout and calculation of the vertical greenery area

1.8d Sustainable Landscape Management

Scope
Applicable to all buildings with greenery.

Assessment Criteria
1.5 points will be awarded if the building landscape is certified under NParks' Landscape Excellence Assessment Framework (LEAF). The LEAF certification scheme recognises buildings with outstanding provision and management of greenery.

OR

If the landscape is not certified under LEAF, points can be scored if there is a landscape management plan in place, covering the following items (0.5 point for each item and up to a maximum of 1.5 points):

- Use of organic composts from horticultural wastes (0.5 point)
- Provision for onsite composting (0.5 point)
- Provision of general landscape maintenance and management plan (0.5 point)

Documentation Requirements
- LEAF certification: A copy of the LEAF certificate or Letter of Award from NParks
- Landscape Management Plan: The official Landscape Management Plan and implementation records supported by photographic evidence, delivery orders of composts with reports of soil / compost mixes as well as landscape maintenance manual
- PO/ DO on the purchase of organic composts
- Photographic evidence of onsite composting

1.9 Refrigerant

Intent
This refers to the responsible use and management of refrigerants and to minimise the impact of refrigerants on the environment.

1.9a Green Refrigerant

Scope
Applicable to air-conditioning systems within the building.

Assessment Criteria
A maximum of 1.5 points is available for the use of environment-friendly refrigerants with Ozone Depleting Potential (ODP) = 0 and/or Global Warming Potential (GWP) < 100 to minimise the impact on the environment.

ODP & GWP	Points Allocation
ODP = 0 OR GWP<100	0.5
ODP = 0 AND GWP<750	1
ODP = 0 AND GWP<10	1.5

Documentation Requirements
Chiller technical specification or photographs of chiller's or condensing unit's name plates that shows the type of refrigerant used

1.9b Refrigerant Leak Detection System

Scope
Applicable to air-conditioning systems within the building.

Assessment Criteria
1 point will be awarded if an automated refrigerant leak detection system is installed in the plant room(s) housing the chillers and/or other equipment that contain refrigerants.

Documentation Requirements
Drawings or technical specification or photographs of installed refrigerant leak detection system.

1.9c Refrigerant Management System

Scope
Applicable to air-conditioning systems within the building.

Assessment Criteria
1.5 points will be awarded if there is a refrigerant management procedure or strategies in place on proper handling of refrigerants during storage and top-up, maintaining of the log sheets, tracking and reducing the refrigerant consumption as well as avoiding leakages.

Documentation Requirements
Official document stating the comprehensive details on refrigerant management and handling including the procedures on proper handling of refrigerant, maintaining the log sheets, tracking, proper safety procedures and preventing refrigerant leaks.

1.10 Green Transport

Intent
The choice of transportation modes for commuting has a significant environmental impact in terms of emissions and pollution. Although buildings are not directly responsible for traffic, they can influence commuting habits based on their location and accessibility. This section rewards strategies and actions that discourage single-occupant vehicle use and encourage the use of alternative transportation modes such as public transport or cycling.

1.10a Good Access to Public Transport Networks

Scope
Applicable to all buildings.

Assessment Criteria
0.5 point will be awarded if the building has good access (< 500m walking distance) to public transport networks such as MRT/ LRT stations and bus stops.

Documentation Requirements
Site layout plan showing the location of the building and the location of the MRT/LRT stations or bus stops.

1.10b Provision of Covered Walkway

Scope
Applicable to all buildings.

Assessment Criteria
0.5 point will be awarded for the provision of covered walkway(s) to the nearest public transport networks.

Documentation Requirements
Site layout plan or photograph showing the connection of covered walkway from the development to the MRT/LRT stations or bus stops

1.10c Priority Parking Lots for Hybrid and Electric Vehicles

Scope
Applicable to all buildings.

Assessment Criteria
A maximum of 1.5 points will be awarded for the provision of priority parking lots for hybrid or electric vehicles within the building:

- At least 1 priority parking lot per 100 lots or at least 10 priority parking lots (1 point)
- At least 1 no. of electric vehicle charging point near the priority parking lots (0.5 point)
- Provision of electrical vehicle charging and parking infrastructure for vehicles or to facilitate electric car-sharing service (0.5 point)

Documentation Requirements
Site layout plan or photograph showing the overall parking lots, parking lots for hybrid and electric vehicles and vehicle charging point.

1.10d Bicycle Parking Lots

Scope
Applicable to all buildings.

Assessment Criteria
A maximum of 1.5 points will be awarded for the provision of bicycle parking lots, shower and changing facilities as follows:

- Provision of at least 2 bicycle parking lots per 1,500m^2 GFA (0.5 point); or
  Provision of at least 3 bicycle parking lots per 1,500m^2 GFA (1 point); or
  Provision of at least 50 bicycle parking lots (1 point)
- Provision of shower and changing facilities (0.5 point)

Documentation Requirements
Site layout plan or photograph showing the bicycle parking lots.

Worked Example
An Office Building has a Gross Floor Area of 20,000 m^2 and provides 30 bicycle parking lots.

To score 0.5 points, the minimum no. of bicycle parking lots (based on 2 lots per 1,500m^2) = (20,000 ÷ 1,500) x 2 = 26.7 or 27 lots

To score 1 point, the minimum no. of bicycle parking lots (based on 3 lots per 1,500m^2) = (20,000 ÷ 1,500) x 3 = 40 lots

Since 30 lots are provided, then 0.5 points will be scored

If shower and changing facilities are provided, additional 0.5 point can be scored.

1.11 Sustainable Operation

Intent
This refers to the implementation of various policies and measures to promote sustainable operations and maintenance within the building.

1.11a Green Procurement Policy

Scope
Applicable to all buildings.

Assessment Criteria
1 point will be awarded for the adoption and implementation of a Green Procurement Policy, which is a written document endorsed by the top management, stating the building owner's commitment towards procuring green products, materials, goods and services from contractors and vendors committed to environmental sustainability.

Documentation Requirements
Official Green Procurement Policy and evidence of purchase or quotation for environmental friendly products. Products which are certified by local certification body shall be specified in the Green Procurement Policy.

1.11b Performance-based Procurement for Retrofitting

Scope
Applicable to all buildings with a centralised air-conditioning system.

Assessment Criteria
A maximum of 2 points is available for the adoption of an Energy Performance Contract (EPC) of at least 12 months by EPC firms accredited by Singapore Green Building Council (SGBC) or equivalent for replacement of the following systems to achieve measurable performance outcomes:

- Centralised chilled-water system with guaranteed efficiency of 0.65 kW/RT or better (1 point)
- Air distribution system with guaranteed efficiency of 0.25 kW/RT or better (1 point)

Documentation Requirements
- Extracts of the EPC signed between building owner and an EPC firm including details of the guaranteed performances and duration of the performance contract
- A copy of the certificate of EPC accreditation by SGBC or equivalent
- Verification report showing the operating efficiencies of the chilled water system and air distribution system

1.11c Performance-based Procurement for Maintenance

Scope
Applicable to all buildings with a centralised air-conditioning system.

Assessment Criteria
A maximum of 2 points is available for the adoption of a performance-based maintenance contract of at least 3 years by EPC firms accredited by Singapore Green Building Council (SGBC) or equivalent for the following systems to maintain its operational system efficiency:
- Centralised chilled-water system with guaranteed efficiency of 0.65kW/RT or better (1 point)
- Air distribution system with guaranteed efficiency of 0.25 kW/RT or better (1 point)

Documentation Requirements
- Extracts of the EPC signed between building owner and an EPC firm including details of the guaranteed performances and duration of the performance contract.
- Verification report showing the operating efficiencies of the chilled water system and air distribution system.

1.11d System Handover and Documentation

Scope
Applicable to all buildings.

Assessment Criteria
1 point will be awarded for maintaining proper and updated system verification and handover documents of retrofitted building systems. When a building system (e.g. air-conditioning system, Building Automation System (BAS)) is retrofitted, it shall be properly tested and verified to ensure compliance with the desired efficiency and performance levels. The documents shall include description of systems' operation and controls, testing and commissioning reports, as-built drawings, technical and training manuals and user guides.

Documentation Requirements
- Handover document containing written description of the retrofitted building systems, its operation and control strategy, testing and commissioning reports, technical and training manuals, user guides and as-built drawings
- Letter of completion issued by building owner/consultants
- Integration test results of air and hydronic systems
- Network schematic of the BMS network, showing device locations and network addresses
- Description of BMS point list including user adjustable points, hard and derived points, and their respective controller and register addresses

2. Building Energy Performance

Introduction

This category encourages good passive building design with the use of energy efficient equipment and systems to reduce energy consumption of the building.

Air-conditioning system typically accounts for about 30-50% of a typical commercial building's energy consumption in Singapore's tropical climate. The appropriate use of natural ventilation and building envelope with good orientation and thermal performance helps to reduce air-conditioning load. Apart from these passive designs, the use of energy efficient equipment and systems helps to reduce the total building energy consumption.

In addition, the use of renewable energy can further reduce the building's overall carbon emission and grid energy consumption.

Criteria	Points
2.1 Façade Performance	2
2.2 Air-conditioning System Efficiency	Up to 17
2.3 Natural/Mechanical Ventilation Performance	
2.4 Lighting System Efficiency	6
2.5 Vertical Transportation System	1.5
2.6 Ventilation in Carpark	2
2.7 Ventilation in Common Areas	3
2.8 Energy Efficiency Practices and Features	2
2.9 Adoption of Renewable Energy	6.5
TOTAL	40
Advanced Green Effort	11.5

2.1 Façade Performance

Scope
Applicable to all air-conditioned buildings.

Assessment Criteria

Envelope Thermal Transfer Value (ETTV) (W/m^2)	Points
45 ≤ ETTV< 50	1
40 ≤ ETTV< 45	2

Advanced Green Effort

5.2 ETTV < 40W/m^2

Additional 1 point will be awarded if the ETTV is less than 40W/m^2

Documentation Requirements
- Endorsed ETTV calculation document previously done during new building's BP submission for buildings without façade changes
- For buildings with façade changes to provide:
  - 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 and external wall system; and
  - ETTV calculation

2.2 Air-conditioning System Efficiency

Scope
Applicable to all air-conditioning system serving the building's comfort cooling needs and where the building's aggregate air-conditioned areas exceed 500m^2.

2.2a) Water-cooled Chilled-water Plant

Assessment Criteria
A maximum of 12 points is available for the percentage improvement in the operating system efficiency of a water-cooled chilled-water plant comprising of the following components:

- Water-Cooled Chiller
- Chilled water pump
- Condenser water pump
- Cooling tower

The percentage improvement shall be calculated based on the baselines stated in the table below.

<table>
<tr><td rowspan="2">Baseline</td><td colspan="2">Building Cooling Load</td><td rowspan="2">Maximum points</td></tr>
<tr><td>< 500 RT</td><td>≥500 RT</td></tr>
<tr><td></td><td>0.8 kW/RT</td><td>0.75 kW/RT</td><td rowspan="2">12</td></tr>
<tr><td>Points scored</td><td colspan="2">0.6 x (% improvement from baseline)</td></tr>
</table>

* 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 prorated based on their respective areas.

Documentation Requirements
- Latest Energy Audit report on the chiller plant before retrofit
- Detailed calculations of the proposed equipment efficiency of the chiller plant as shown in the worked examples below
- Drawings showing the proposed chilled water schematic of the chiller plant

- Drawings showing the proposed layout of the 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
- After retrofit to provide completed OSE Audit Report endorsed by PE(Mechanical) or Energy Auditor, measured over one-week period. (The report template can be found at https://www.bca.gov.sg/EnvSusLegislation/others/AnnexB_Energy_Audit_Report.doc)
- 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	30m	151.2	85%	95%
CHWP-2	Chilled water pump 2	30	30m	75.6	85%	95%
CWP-1	Condenser water pump 1	45	20m	189	85%	95%
CWP-2	Condenser water pump 2	22	20m	94.5	85%	95%
CT-1	Cooling tower 1	45	-	130	75%	92%
CT-2	Cooling tower 2	45	-	130	75%	92%

ID	Description	Type	Name plate motor (kW)	Cooling Capacity (RT)	Chilled water LWT	Chilled water ΔT	Efficiency kW/RT
CH-1	Chiller 1	Centrifugal	150	1000	6.7 °C	5.5°C	0.55
CH-2	Chiller 2	VSD Screw	90	500	6.7 °C	5.5°C	0.52

Worked Example 2.2a

An Office Building has air-conditioned floor area of 70,000 m^2, building operation hours from 9am to 6pm.

The building cooling load profile is determined from the energy audit on the chiller plant, the result is shown below

Hrs	Water Cooled Chiller Plant							
	Daily Avg. Cooling Load (RT)	P_{CH} (kW)	P_{CHWP} (kW)	P_{CWP} (kW)	P_{CT} (kW)	Chiller Plant Total Power (kW)	Chiller Plant (kW/RT)	Chiller configuration
9:00:00 AM	1,444	722	45.7	57.8	43.3	868.8	0.60	700 RT x 3 nos.
10:00:00 AM	1,395	698	42.6	55.8	41.9	837.9	0.60	700 RT x 3 nos.
11:00:00 AM	1,801	901	71.1	72.0	54.0	1097.7	0.61	700 RT x 3 nos.
12:00:00 PM	1,790	895	70.2	71.6	53.7	1090.4	0.61	700 RT x 3 nos.
1:00:00 PM	1,749	874	67.0	69.9	52.5	1063.7	0.61	700 RT x 3 nos.
2:00:00 PM	1,836	918	73.8	73.4	55.1	1120.1	0.61	700 RT x 3 nos.
3:00:00 PM	1,816	908	72.3	72.7	54.5	1107.7	0.61	700 RT x 3 nos.
4:00:00 PM	1,654	827	59.9	66.2	49.6	1002.6	0.61	700 RT x 3 nos.
5:00:00 PM	1,493	747	48.8	59.7	44.8	900.0	0.60	700 RT x 3 nos.
6:00:00 PM	1,237	618	33.5	49.5	37.1	738.3	0.60	700 RT x 2 nos.
Daily Consumption (9:00AM - 6.00PM)	ΣCL_i =16,215 RTh	8,107 kWh	585 kWh	648.6 kWh	486 kWh	9,827 kWh	kWh/RTh = 0.61 kW/RT	

Water-cooled Chiller Plant efficiency (kW/RT)	0.61

Percentage improvement = (0.75 – 0.61) / 0.75 = 18.66%

Therefore, point scored = 0.6 x 18.66 = 11.2

2.2b) Air-cooled Chilled-water Plant / Unitary Air-Conditioners

Assessment Criteria

A maximum of 12 points will be awarded for the percentage improvement in the operating system efficiency of an air-cooled chilled-water plant or unitary air-conditioner comprising of the following components:

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

The percentage improvement shall be calculated based the baseline stated in the table below.

Baseline	Building Cooling Load		Maximum points
	< 500 RT	≥500 RT	
	1.1 kW/RT	1.0 kW/RT	12 Capped at 8 points for VRF air-conditioning systems without permanent M&V
Points scored	= 0.3 x (% improvement from baseline)		

Documentation Requirements

- For air-cooled chilled-water plant, the documentation requirements are the same with 2.2a) other than cooling towers and condenser pumps
- For Unitary Air-Conditioners, to provide Technical specifications and product information of the various components of the cooling system
- The unitary Air-Conditioners' cooling efficiency is computed based on the total weighted system efficiency. The formula used is 3.517/ $COP_{weighted}$. For variable refrigerant flow (VRF) system, the efficiency can be computed based on the following formula from NEA: $COP_{weighted} = 0.4 \times COP_{100\%} + 0.6 \times COP_{50\%}$

$COP_{100\%}$ is defined as the ratio of the cooling capacity to effective power input at full load cooling capacity
$COP_{50\%}$ is defined as the ratio of the cooling capacity to effective power input at 50% cooling capacity

The design outdoor conditions can be taken at 32°C dry-buld and 26°C web-buld with a daily range of 8°C (*based on clause 7.1.6 in SS553 : 2016)*

Important Notes:

Note 1: For building with different air-conditioning systems, the point scored will be pro-rated based on the cooling load of each system.

Score = load factor $_{water\text{-}cooled}$ x score $_{water\text{-}cooled}$ + load factor $_{air\text{-}cooled/unitary}$ x score $_{air\text{-}cooled/unitary}$
Where load factor $_{water\text{-}cooled}$ = average cooling load $_{water\text{-}cooled}$/(average total cooling load)
load factor $_{Air\text{-}cooled}$ = average cooling load $_{Air\text{-}cooled}$/(average total cooling load)

Note 2: For building using VRF air-conditioning system, up to 12 points can be scored if permanent M&V is provided. Otherwise, it is capped at 8 points.

Note 3: For buildings using district cooling system, the points scored will be based on the weighted percentage of the points scored under 2.2c) Air Distribution System.

Worked Example 2.2b

Based on the same building in worked example 2.2a) but with additional unitary air conditioners provided (without permanent M&V) for some shops.

- Average Hourly Cooling Load ($RT_{weighted}$)
- Hourly weighted COP ($COP_{weighted}$)

Hours	Average Hourly Cooling Load (RT)	Hourly weighted COP	Total Condensing Units Power Input (kW)	Unitary/ Split System Efficiency (kW/RT)
9:00AM	200	4.9	144	0.72
10:00AM	350	4.82	255	0.73
11:00AM	350	4.82	255	0.73
12:00PM	350	4.82	255	0.73
1:00PM	350	4.82	255	0.73
2:00PM	350	4.82	255	0.73
3:00PM	350	4.82	255	0.73
4:00PM	350	4.82	255	0.73
5:00PM	350	4.82	255	0.73
6:00PM	350	4.82	255	0.73
7:00PM	150	4.71	112	0.75
8:00PM	150	4.71	112	0.75
9:00PM	150	4.71	112	0.75
10:00PM	150	4.71	112	0.75
Daily Consumption (9:00AM - 6.00PM)	3950 RTH		2887 kWh	kWH/RTH = 0.73 kW/RT

Point scored for unitary system = 0.3 x (1.1 – 0.73)/1.1 x 100 = 10 (Capped at 8 for VRF without permanent M&V)

Summary for the entire building:

System	Total RTh	Chiller Plant System/ Unitary System Efficiency (kW/RT)	Load Percentage
Water Cooled Chilled Water Plant	16,215	0.61	80.41%
Unitary System	3950	0.73	19.59%
TOTAL	20,165	0.63	100%

Therefore, the point awarded = 11.2 x (16,215/20,165) + 8 x (3950/20,165) = 10

2.2 c) Air Distribution System

Assessment Criteria

A maximum of 4 points is available for the percentage improvement in the operating system efficiency of the air distribution system comprising of the following components:

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

Air distribution operating system efficiency baseline	0.28 (kW/RT)	Max Credit Points
Points scored	= 0.14 x (% improvement)	4 *(Please refer to Note 4 below.)*

Note 4: In order to score for this criteria, the building's air-conditioning system Energy Use Intensity (EUI) for the past one year shall be calculated and submitted. It shall be calculated based on the following formulae:

(i) EUI_{AC} = Annual building energy consumption of air-conditioning system (kWh) / GFA (m^2).
(ii) $EUI_{AC\#}$= Annual building energy consumption of air-conditioning system (kWh) within standard building operating hours defined in the table below / GFA(m^2).

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

Advanced Green Effort
5.3 Demonstration of Better Air-side Efficiency

A maximum of 2 additional points is available if the air-side efficiency is better than 0.2kW/RT with baseline of 0.28kW/RT. The efficiency should be demonstrated via an energy audit.

Points awarded = 0.14 x (% improvement) – 4 (Capped at 2 points)

Documentation Requirements

- Detailed calculations of the overall improvement in equipment efficiency of the air distribution system in kW/RT, the energy consumption for air distribution system should be measured or from technical specifications. For AHUs, the energy consumption should be measured, such as from power meter readings, VSD readings or EC motor readings
- The cooling consumption is based on the Chiller plant cooling load in OSE report
- Technical product information of the air distribution system

Worked Example 2.2c

Based on the same building in worked example 2.2a

Hrs	Cooling load	Air-Distribution System		
		Total Air Distribution Power (kW)	Air Distribution Efficiency (kW/RT)	Air Distribution Configuration
9:00:00 AM	1,444	353	0.24	AHU-VAV
10:00:00 AM	1,395	341	0.24	AHU-VAV
11:00:00 AM	1,801	401	0.22	AHU-VAV
12:00:00 PM	1,790	406	0.23	AHU-VAV
1:00:00 PM	1,749	397	0.23	AHU-VAV
2:00:00 PM	1,836	400	0.22	AHU-VAV
3:00:00 PM	1,816	396	0.22	AHU-VAV
4:00:00 PM	1,654	389	0.24	AHU-VAV
5:00:00 PM	1,493	365	0.24	AHU-VAV
6:00:00 PM	1,237	302	0.24	AHU-VAV
Daily Consumption (9:00AM - 6.00PM)	16,215 RTh	3,750 kWh	0.23	

The point awarded = 0.14 x (0.28 -0.23) / 0.28 x 100 = 2.5

Worked Example 2.2d

An office building with GFA of 29,568m^2 has the following energy consumption for air-conditioning system (including air distribution system).

Time	Annual Energy Consumption of Air-Conditioning System (kWh/yr)
0000 to 0900	83,861.6
0900 to 1800	1,677,255.2
1800 to 0000	335,451.2
Total	2,285,258.8

EUI_{AC} = 2,285,258.8 / 29,568 = 77.24 kWh/m^2 •yr

$EUI_{AC\#}$ = 1,677,255.2 / 29,568 = 56.73 kWh/m^2 •yr

2.3 Natural /Mechanical Ventilation Performance

Scope

Applicable to occupied areas (excluding circulation, plant rooms and transit areas), with an aggregate non air-conditioned building area > 10% of the total floor area excluding car parks and common areas.

a) Natural Ventilation

Assessment Criteria

A maximum of 17 points is available for the use of natural ventilation (NV). This is to encourage building that facilities good natural ventilation. Naturally ventilated areas should be properly designed to utilise prevailing wind condition to achieve adequate cross ventilation, and effectively designed to be thermally comfortable and healthy for the building occupants.

10 points will be awarded for the use of natural ventilation. In addition, 1 point awarded for every 10% of NV areas with window openings facing north and south directions and cross ventilation demonstrated.

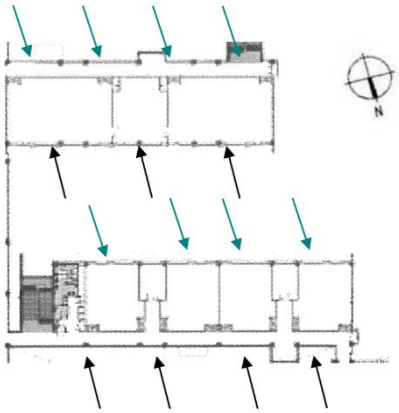
Documentation Requirements

- Natural ventilation with window openings facing North and South directions and building design that utilizes prevailing wind conditions to achieve adequate cross ventilation
- Points scored = 10 + 1 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).

Prevailing wind directions from south to south-east



Prevailing wind directions from north to north-east

Worked Example

<u>Background information for Natural Ventilation example</u>

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	∑ (a)/ ∑ (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 x (% of units / 10%)

facing N-S directions = 1 x [(∑ (a)/ ∑ (b) x100%) /10%]

= 1 x [(40/100 x 100%) / 10]

= 4 points

Total points scored for Natural Ventilation = 10 + 4

= 14 points < 17 points (max)

b) Mechanical Ventilation

Assessment Criteria

A maximum of 16 points is available for the use of mechanical ventilation (MV). This is to encourage the use of energy efficient mechanical ventilation system as the preferred ventilation mode to reduce the use of air-conditioning in buildings.

0.3 point will be awarded for every 1% improvement in the mechanical ventilation system from the baseline stated in the table below:

Allowable Nameplate Motor Power	
Constant Volume	Variable Volume
0.47W/CMH	0.74W/CMH

Note: Where there is a combination of naturally ventilated and mechanically ventilated spaces, the points scored will only be based on the predominant ventilation modes of normally occupied spaces.

Documentation Requirements

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

Worked Example

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:

Area	Fan	Fan Type	Air Flow Rate (CMH)	Fan Nameplate Power (kW)	Fan Efficiency (W/CMH)
Workshop 1	FAF 1-1	Axial (CAV)	39000	8.28	0.21
Workshop 2	FAF 1-2		39000	8.28	0.21
Workshop 3	FAF 1-3		39000	8.28	0.21
Workshop 4	FAF 2-1		24000	3.92	0.16
Workshop 5	FAF 2-2		24000	3.92	0.16
Workshop 6	FAF 2-3		24000	3.92	0.16
Workshop 1	EAF 1-1		39000	8.28	0.21
Workshop 2	EAF 1-2		39000	8.28	0.21
Workshop 3	EAF 1-3		39000	8.28	0.21
Workshop 4	EAF 2-1		24000	3.92	0.16
Workshop 5	EAF 2-2		24000	3.92	0.16
Workshop 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 = 0.3 x (% improvement)

= 0.3 x [(177.66 – 73.24)/177.66 x 100]

= 0.3 x 58.8

= 17.64 points > 16 (max)

Therefore, point scored should be 16 points.

2.4 Lighting System Efficiency

Scope

Applicable to all buildings' interior lighting provision.

Assessment Criteria

The points awarded shall be based on the percentage improvement from the lighting power budget in *the annex table A.* A maximum of 6 points, 3 points for common areas and 3 points for lettable/non-common area, is available as follows:

- Points scored = 0.1 x (% improvement from baseline)

The lighting should be designed in accordance to the recommended lux levels in *SS 531 – 1 : 2006 – Code of Practice for Lighting of Workplaces Part 1 – Indoor Lighting or CP 38 : 1999 Code of Practice for Artificial Lighting in Buildings.* Please refer to Annex A for the baseline of lighting power budget.

Documentation Requirements

- As-built lighting layout, lighting schedule and luminaries' data sheets
- Lighting power budget calculation

Worked Example

This is an example of an office with both lettable and building owner occupied area.

Description	**Areas (m^2)**	**Light Fitting Type**	**Power Consumption per fitting (W)**	**Ballast Loss (W)**	**No. of Fittings**	**Total power consumption based on fitting type (C+D) x (E)**	**Reference Total Power consumption (J x A)**	**Design Lighting Power Budget (W/m^2) (F/A)**	**Reference Lighting power Budget (Annex A)**
	(A)	**(B)**	**(C)**	**(D)**	**(E)**	**(F)**	**(H)**	**(I)**	**(J)**
Office Type 1 (tenant)	1500	T5	28	3	490	15190	22500	10.13	15
Office Type 2 (tenant)	1250	T5	28	3	420	13020	18750	10.42	15
Meeting Room (tenant)	75	T8	36	6	15	630	1125	14.59	15
		Surface downlight	26	3	16	464			
Corridors Type 1	150	T5	28	3	40	1240	1500	8.27	10
Corridors Type 2	205	T5	28	3	40	1240	2050	9.61	10
		Surface downlight	70	3	10	730			
Atrium	850	T8	28	6	174	5916	8500	8.76	10

		Surface downlight	150	3	10	1530			
Carparks	7500	T5	28	3	870	26970	37500	3.60	5
Staircase	300	T5	28	3	40	1240	1800	4.13	6
Male toilets	45	PLC	13	3	15	240	675	5.33	15
Female toilets	45	PLC	13	3	15	240	675	5.33	15
Total for lettable/non-common area						**29304**	**42375**		
Total for common area						**39346**	**52700**		

(i) % improvement in the lighting power consumption for lettable/ non common area
= (42375 – 29304)/ 42375
= 30.85%

Points scored = 0.1 x 30.85 = 3.09 points > 3 (max)
Therefore, points scored for lettable/ non-common areas should be 3points

(ii) % improvement in the lighting power consumption for common area
= (52700 – 39346)/ 52700
= 25.34%

Points scored = 0.1 x 25.34 = 2.53 points < 3 (max)
Therefore, points scored for common areas should be 2.53 points

(iii) Hence, the total points scored for Lighting System Efficiency is 2.53 + 3 = 5.53 points.

2.5 Vertical Transportation System

Scope
Applicable to all lifts, escalators and travellators in the buildings.

Assessment Criteria
1 point will be awarded for the provision of all lifts, escalators and travellators which are equipped with AC variable voltage and variable frequency (VVVF) motor drive and sleep mode features.

Lifts with regenerative drive will be awarded an additional 0.5 point.

Documentation Requirements
- Technical specification indicating the types of lifts, escalators, travellators and related features used

2.6 Ventilation in Carpark

Scope
Applicable to buildings with carparks.

Assessment Criteria
A maximum of 2 points is available for the following provisions:

a) Mechanically ventilated carparks with carbon monoxide (CO) sensor control (1.5 points)
b) Carparks with natural ventilation (2 points)

Note 1: Full points can be awarded in this criteria for buildings with no carpark.

Note 2: Where there is a combination of different ventilation mode adopted for carpark, the points awarded will be pro-rated accordingly based on area.

Documentation Requirements
- 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

Worked Example

Background information for Ventilation in Carpark example

An existing 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 Section 2.6	= (3600/4200) x 2 + (600/4200) x 1.5
	= 1.93 points < 2 points (max)

Points scored for Section 2.6 is 1.93 points.

2.7 Ventilation in Common Areas

Scope

Applicable to all common areas in a building.

Assessment Criteria

A maximum of 3 points will be awarded to encourage the use of energy efficient ventilation systems in the following areas. 1 point is awarded for each area with natural ventilation; and 0.5 point for each area with mechanical ventilation.

a) Toilet
b) Staircases
c) Corridors
d) Lift lobbies
e) Atrium

The extent of coverage should be at least 90% of each applicable area.

Documentation Requirements

- 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

Worked Example

Background information for Ventilation in Common Areas example

An existing building with 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 points

Total points scored for Section 2.7 is = 0.5 + 0.5 + 1 = 2 < 3 points (max)

2.8 Energy Efficient Practices and Features

Scope

Applicable to all buildings.

Assessment Criteria

A maximum of 2 points is available to encourage the use of energy efficient practices and features which are innovative and/or have positive environmental impact.

1 point is awarded for every 1% energy saving over the annual total building energy consumption.

Documentation Requirements

- 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 from the use of these features

Worked Example

Background information for Energy Efficient Practices and Features example

An existing building uses motion sensors to control the lightings in all staircases and toilets. Its total annual building energy consumption before installation of motion sensor is 9,915,655 kWh/m^2.

(i) Toilets

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

(ii) Staircases

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 Section 2.8 = 1 point for every 1 % energy saving
= 1 x 0.819 = 0.82 point < 2 points (max)

2.9 Renewable Energy

Criteria	Points
2.9a Solar Energy Feasibility Study	1
2.9b Solar Ready Roof	1.5
2.9c Adoption of Renewable Energy	4
TOTAL	6.5
Advanced Green Effort	8.5

2.9a Solar Energy Feasibility Study

Scope

Applicable to all buildings.

Assessment Criteria

1 point will be awarded for buildings that conduct a solar energy feasibility study and submit a report as outlined below.

Documentation Requirements

The report shall consist of the following details:

- **Executive Summary** – A non-technical summary of the building's potential for solar adoption, including the building owner's decision on whether solar PV would be installed for the building, accompanied with appropriate justifications.

- **Roof Characteristics and Shading Considerations** – Description of the roof's characteristics (i.e. number of roofs, roof area, and height variation of various roofs) to be provided with drawings. Any potential shading from external sources (e.g. adjacent buildings, trees, etc) as well as internal sources from within the building (e.g. M&E services, lamp posts, etc) are to be considered and quantified. Any considerations for shading due to external factors beyond the building's boundaries are to be supplemented with site drawings (or future development plans) that depict the estimated height of shading source.

- **Technical Solar Energy Generation Potential** – Based on the shading consideration and any building specific constraints, the following information are to be provided using the prescribed list of assumptions stated below. Any unique assumptions are to be clearly stated.
    - Expected solar capacity potential on the roof (in kWp) based on shading consideration and layout
    - Expected annual electricity generation (in kWh) based on the solar capacity potential

  Guiding assumptions
    - *Solar PV technologies (unshaded) with area efficiency of 0.1 kWp/m^2 and annual generation yield of 1,100 – 1,300 kWh/kWp can be assumed if the building has not decided on the specific PV technology to use.*
    - *Tariff at $0.20 per kWh for low tension rate and $0.15 per kWh for high tension rate can be assumed if the building does not have information on the potential electricity tariff (more information may be found at http://www.solar-repository.sg/future-electricity-price-scenarios).*

- **Economics of Solar Installation** – Using the electricity generation potential, the economics of the solar installations are to be quantified with the following considerations:
    - Upfront costs of installation
    - Expected maintenance costs
    - Expected annual electricity bills based on the actual energy consumption of the building
    - Expected cost savings for generation of electricity to be consumed on site
    - Expected revenue from solar electricity sold to grid (if applicable)
    - Payback period/ Discount rate

- **Roof Access and Safety Requirements** – Identify the access and safety measures that would have to be installed.

- **Recommendations on Roof Spatial Optimisation** – Recommendations to maximise the usable roof space are to be provided.

- **Acknowledgement** – The report shall be acknowledged and signed off by the QP/ PE(Electrical) or PV specialist consultant and (ii) the building owner.

2.9b Solar Ready Roof

Scope

Applicable to projects that have been awarded points under *2.9a Solar Energy Feasibility Study*.

Assessment Criteria

The building should demonstrate solar readiness for at least 50% of the feasible roof area determined through the solar energy feasibility study. 0.5 point will be awarded for each of the following:

- **Structural readiness**: Provisions to accommodate optimised structural installation of solar panels on rooftop spaces (0.5 point)
- **Electrical readiness**: Provisions to accommodate optimised electrical installation of solar panels on rooftop spaces (0.5 point)
- **Spatial readiness**: Provisions to optimise the available non-shaded rooftop area for photovoltaic and/or adoption of the recommendations for roof spatial optimisation outlined in the solar energy feasibility study (0.5 point)

Note: Where solar panels are installed under *2.9c Adoption of Renewable Energy*, the area coverage of the feasible roof area by the panels can be counted towards meeting this criterion.

Documentation Requirements

- Detailed drawings and/or technical specifications showing the relevant design features and provisions for roof readiness.
- After retrofit, to provide as-built drawings and on-site photographs of relevant design features and provisions for roof readiness.
- Note: To score for structural readiness, a structural QP/ PE(Civil) shall certify that the building and roof can support any additional static and wind loads imposed by the future PV system prior to installation.

Worked Examples

Structural Readiness

The building and roof shall be able to support any additional static and wind loads imposed by the PV system. Depending on the type of roof and components of the PV installation, the static load differs. For wind load, it depends on the installation angle. Examples of roofs designed to accommodate easy structural installation of solar panels include, but not limited to, the following:

- **Metal roofs:** Use of roof profiles with suitable seams that allow easy application of roof clamps; and avoidance of trapezoidal or corrugated profiles.
- **RC roofs:** Design feature or solution that does not require heavy ballast to prevent solar modules from lifting off in strong wind conditions. For example, provision of anchor points for solar support systems prior to application of waterproofing.
- **Trellis:** Use of trellis with 10-15° slope, instead of horizontal top surface, to facilitate optimal solar module tilt angle.

Electrical Readiness

- Provision of room or sheltered space at roof level or maximum one level below to accommodate inverters, circuit breakers and PV feed-in switchboards.
- Correct dimensioning of sufficient/ adequate circuit breakers for PV feed-in.
- Pre-connecting PV feed-in switchboards to main AC switchboard.

Spatial Readiness

- Shifting of shade-casting structures such as staircase doghouses, lift motor rooms, water tanks and M&E equipment away from the east-west sun path, where possible.

2.9c Adoption of Renewable Energy

Scope

Applicable to buildings with on-site generation and consumption of renewable energy.

Assessment Criteria

A maximum of 4 points is available based on the building's Energy Use Intensity (EUI) and percentage replacement of electricity by the renewable energy source.

All energy replacement by renewable energy systems has to be verified with actual energy production and consumption.

EUI = Annual Total Building Energy Consumption (kWh) / GFA (m^2)

Energy Use Intensity (EUI) [kWh/m^2.yr]	Credit Points Awarded for % Replacement of Total Building Electricity Consumption by Renewable Energy (max. 4 points)
≥ 120	1 point for every 0.5%
80 ≤ EUI < 120	1 point for every 1.0%
50 ≤ EUI < 80	1 point for every 1.5%
< 50	1 point for every 2.5%

Documentation Requirements

Before installation:

- Technical product information on the salient features of the renewable energy systems and the expected renewable energy generated
- Detailed drawings showing the location and renewable energy provisions
- Calculation of the percentage replacement of electricity compared with the total annual electricity consumption of the building

After installation:

- As-built drawings and on-site photographs of the renewable energy systems
- Technical specifications and integration reports of the installed systems including total capacity installed
- Testing and commissioning report
- Purchase/ delivery orders of the total capacity installed
- Logging of the energy production and calculate the annual energy replacement rate (please refer to table below)
- Updated details of the renewable energy systems installed as per table below:

Description on type of renewable energy system installed and location of installation	**Area of renewable energy system installed (m^2) (where applicable)**	**kWp installed (kWp)**	**Energy produced per year, i.e. annual yield (kWh), verified with actual energy production and consumption**	**Notes/ Remarks (if any)**
e.g. Monocrystalline solar panels at upper roof of Block A				
e.g. Thin film solar modules at roof of Block B				
Total				
Total energy produced per year (A)				
GFA of building (m^2) (B)				
Total building energy consumption (kWh/yr) (C)				
Annual energy replacement rate (%) (A/C)				
EUI (kWh/m^2•yr) (C/B)				

Worked Example

For buildings with on-site generation and consumption of renewable energy

Based on contractor/ supplier's specifications and/or as-built details, fill up details of the renewable energy systems installed in the table below:

Description on type of renewable energy system installed and location of installation	**Area of renewable energy system installed (m^2) (where applicable)**	**kWp installed (kWp)**	**Energy produced per year, i.e. annual yield (kWh), verified with actual energy production and consumption**	**Notes/ Remarks (if any)**
Monocrystalline solar panels at upper roof of Block A	1,000	100	120,000	
Thin film solar modules at roof of Block B	1,000	100	120,000	
Total		**200**	**240,000**	
Total energy produced per year (A)			**240,000**	
GFA of building (m^2) (B)			**65,298**	
Total building energy consumption (kWh/yr) (C)			**7,868,852**	

Annual energy replacement rate (%) (A/C)	**3.05%**
EUI (kWh/m^2•yr) (C/B)	**120.51**

Therefore,

GM credit points awarded under *2.9c Adoption of Renewable Energy* (based on EUI > 120) = 3.05/0.5 = 6.1 (capped at 4 points)

GM credit points awarded under *5.4a Further Electricity Replacement by Renewable Energy* (under Advanced Green Effort – see below) = 2.1 points

Advanced Green Effort

5.4a) Further Electricity Replacement by Renewable Energy
A maximum of 6 additional points is available based on the building's EUI for further percentage electricity replacement by renewable energy, beyond the points capped in the table under *2.9c Adoption of Renewable Energy*.

Refer to documentation requirements and worked examples given under *2.9c Adoption of Renewable Energy*.

5.4b) Purchase of Renewable Energy from Licenced Electricity Retailers
Additional 1 point will be awarded if a building purchases renewable energy from licensed electricity retailer(s), (i.e. power purchase agreement on offsite generation of renewable energy), with a minimum of 5% of the total building energy to be purchased from renewable energy sources and a minimum contract period of 3 years.

Documentation Requirements
The Power Purchase Agreement (PPA) between the building owner and licensed electricity retailer(s) on off-site generation of renewable energy shall be furnished^ and comprise of the following:

- Minimum of 5% of total building energy to be purchased from renewable energy sources, and
- Minimum contract period of 3 years.

^Key confidential information and/or figures e.g. tariff rates can be omitted accordingly.

Worked Examples
Refer to scenario-based examples given under *2.9c Adoption of Renewable Energy*.

5.4c) Rooftop Leasing/ Licensing for Photovoltaic Installation
Additional 1.5 points will be awarded if a building leases its feasible roof area for photovoltaic installation.

Documentation Requirements
The Rooftop Leasing/ Licensing Agreement between the building owner and solar developer on the usage of the building's rooftop for the generation of renewable energy shall be furnished^.

^Key confidential information and/or figures e.g. leasing rates can be omitted accordingly.

Additional Guidance Notes
To encourage on-site deployment and use of renewable energy, credit points can only be awarded for rooftop leasing/ licensing if the building does not do on-site generation and consumption (i.e. did not attain credit points under sections 2.9c and 5.4a).

Worked Examples
Refer to scenario-based examples given under *2.9c Adoption of Renewable Energy*.

Scenario-based Examples

With reference to section 5.4 (Advanced Green Effort), the following examples are given to aid understanding of how credit points are awarded for certain scenarios.

Example 1: Building consumes only 50% of the renewable energy generated on-site to replace a certain percentage of its total building energy consumption. The remaining 50% of the renewable energy generated on-site is exported out into the grid through a licensed electricity retailer.

- Up to 12.5 points can be awarded under section 2.9a, b and c (up to 6.5 points)
- To note:
    - The above applies whether or not renewable energy systems (e.g. solar panels) installed on the building is owned by the building owner or solar developer.

Example 2: Building consumes the renewable energy generated on-site to replace a certain percentage of its total building energy consumption. The building also undertakes an off-site power purchase agreement or arrangement with a licensed electricity retailer for renewable energy to further replace its total building energy consumption.

- Up to 13.5 points for:
    - *On-site generation and consumption of renewable energy:* Up to 12.5 points can be awarded under section 2.9a, b and c (up to 6.5 points) and section 5.4a (up to 6 points)
    - *Off-site power purchase agreement:* 1 point can be awarded under *5.4b Purchase of Renewable Energy From Licensed Electricity Retailers*, if the amount of renewable energy purchased can replace at least 5% of the building's total building energy consumption and the contract is signed for a minimum of 3 consecutive years.

Example 3: Building undertakes a rooftop leasing/ licensing agreement with a solar developer on the usage of its rooftop for the generation of renewable energy. The building does not consume any of the renewable energy generated from the solar PV system that is installed on its roof.

- Up to 2.5 points can be awarded under 2.9a Solar Energy Feasibility Study and 2.9b Solar Ready Roof
- 1.5 points can be awarded under *5.4c Roof Leasing for Photovoltaic Installation*

3. Resource Stewardship

Introduction

With the global use of resources increasing in the backdrop of limited carrying capacity of the Earth, it is imperative that we work towards conserving the Earth's resources for future generations to come. "Resource Stewardship" refers to the responsible use and protection of the environment through conservation and sustainable practices. This section rewards projects for the responsible use and conservation of resources in building operations and occupancy. Resources covered include water, green products and operational waste.

Criteria	Points
Water	14.5
Materials	7
Waste	8.5
TOTAL	30
Advanced Green Effort	2

Water

With increasing occurrences of droughts and dry spells attributed to varying weather phenomenon and global warming, bouts of water shortage globally are an ever imminent threat. As Singapore has limited water catchment resources, it is crucial to implement good water management in order to ensure the long term sustainability of Singapore's water system. Considering water efficient fittings, monitoring consumption and potable water replacement strategies can reduce potable water consumption and raise awareness on responsible use of water during building operations.

Criteria	Points
3.1 Water Efficient Fittings	7
3.2 Landscape Irrigation System	1
3.3 Reduction in Water Consumption of Cooling Towers	2.5
3.4 Water Monitoring and Leak Detection	1
3.5 Water Usage Portal and Dashboard	1
3.6 Use of Alternative Water Sources	2
TOTAL	14.5
Advanced Green Effort	2

3.1 Water Efficient Fittings

Scope

Applicable to all buildings with water fittings installed.

Assessment Criteria

A maximum of 7 points is available for the use of water efficient fittings under PUB's Water Efficiency Labelling Scheme (WELS) or adoption of water efficient flow-rate/ flush volume for the following:

- Basin taps and mixers
- Showers
- Sink/ Bib taps and mixers
- Urinals and urinal flush valves
- Dual flushing cistern for WC

Rating based on PUB's Water Efficiency Labelling Scheme (WELS)	
Very Good	Excellent
Weightage	
5	7

Alternatively, 5 points will be awarded for buildings which have attained a PUB Water Efficient Building (WEB) (Basic) certification.

Documentation Requirements

- A valid PUB Water Efficient Building (WEB) Certification, or;
- Water fitting schedules showing the numbers, types and the WELS rating of the proposed fittings in the prescribed tabulated format shown below:

Water Fitting Type	Quantity			Applicable Areas	Total No
	Excellent	Very Good	Other rating		
Basin Taps & Mixers					
Sink Taps & Mixers					
Shower Taps & Mixers					
Dual-Flush Flushing Cisterns					
Total No. of fittings					

Worked Example

Example of point computation for the water fitting provisions of a hotel development:

Water Fitting Type	Quantity			Applicable Areas	Delivery Order Ref No/ Brand	Total No
	Excellent	Very Good	Other rating			
Basin Taps & Mixers	50			Public Toilets	T1234/ Xbrand	480
	30			Staff Toilets	T3456/ Ybrand	
		400		Other Areas including hotel guestrooms	T2222/ Zbrand	
Sink Taps & Mixers		50		All areas	T4321/ Abrand	50
Shower Taps & Mixers	20			Shower facilities at common areas (Public use)	T2343/AXbrand	30
			10	Hotel guestrooms	T6524/ ABbrand	
Showerheads		20		Public use	T7648/ YZbrand	30
			10	Hotel guestrooms	T2676/ XZbrand	
Dual-Flush Flushing Cisterns		420		All areas	T2454/ FVbrand	420
Total No. of fittings	100	890	20			1010

Total points scored = (100 x 7 + 890 x 5) / 1010 = 5.10

3.2 Landscape Irrigation System

Scope
Applicable to all buildings with landscape irrigation.

Assessment Criteria
A maximum of 1 point is available for buildings with:

- At least 50% of the landscape areas are served by water efficient irrigation systems with features such as automatic sub-soil drip irrigation and moisture or rain sensor control (0.5 point)
- At least 50% of the landscape areas comprise of drought tolerant plants (0.5 point)

Documentation Requirements:

- Relevant layout plans showing the overall landscape areas and the areas that would be served using the irrigation system or planted with drought tolerant plant
- Calculation showing the percentage of the landscape areas that would be served using the system or planted with drought tolerant plants

Worked Example

Project A	Coverage of Overall Landscape Area (%)	Points
Water efficient irrigation systems	45	0
Drought tolerant plant	60	0.5
Total		0.5

Project B	Coverage of Overall Landscape Area (%)	Points
Water efficient irrigation systems	75	0.5
Drought tolerant plant	50	0.5
Total		1

3.3 Reduction in Water Consumption of Cooling Towers

Scope
Applicable to all buildings with cooling towers.

Assessment Criteria
A maximum of 2.5 points is available for buildings which undertake the following measures to reduce the consumption of potable water for its cooling towers:

- Use of a cooling tower water treatment system which can achieve 7 or better cycles of concentration with acceptable water quality (1 point)
- Use of NEWater or alternative approved sources of water such as on-site recycled water, rainwater, Air Handling Unit (AHU) condensate, etc. (1 point)
- Use of a heat recovery system or equivalent device that helps to reduce heat rejection required through the cooling towers (0.5 point)

Documentation Requirements

- Cooling tower water treatment system
  - A valid water analysis report of the cooling tower with 7 or better cycles of concentration and acceptable water quality
- Alternative approved sources of water
  - Relevant layout plan or photos showing the provision of an alternative approved source of water
- Heat recovery system or equivalent device
  - Technical and design specification of devices such as heat pumps
  - Calculation of the water savings

Worked Example

Water saving potential of heat pump in a mixed development - The heat pump has a heating capacity of 430.6kW at the condenser water loop as the heat source. The manufacturer's technical data sheet is as follows:

DESIGN PERFORMANCE												
Capacity (kW)	Input Power (kW)	Performance (COP)	Heating (kW)	Cooling (kW)	Evaporator				Condenser			
					P.D. (kPA)	T in (°C)	T out (°C)	Flow (l/s)	P.D. (kPA)	T in (°C)	T out (°C)	Flow (l/s)
430.6	86.1	5.0	430.6	344.2	28.6	35.0	29.0	13.7	37.4	55.0	65.0	10.3

Based on the fundamental principle = Q = m x h

Where

Q: Evaporation heat (kJ/kg)
h: Evaporation heat (kJ/kg) 2257 @ atmospheric pressure
M: Mass of water (kg)
Water saving in Volume V = Mass/ Density

Assuming the estimated total heat load requirement of this particular development for one whole day to be 2.580 kWh, we can then derive it to be equivalent to about 6 hours of operation of the heat pump by dividing it over the heat capacity of 430.6 kW.

Based on the technical data sheet, the heat pump has a cooling capacity of 344.2 kW which is the heat source that can be harvested from the condenser water loop. In other words, this will be the reduction in heat rejection by cooling towers or the amount of heat that is diverted from cooling towers.

Total heat source harvested per day = 344 kW x 6 hours = 2,064 kWh = 7,430,400 kJ

Mass of water m = Q/h = 7,430,400 / 2,257 = 3,293 kg

Volume of water = Mass/ Density = 3,293 kg/ 995.7kg/m^2 = 3.3 m^3 which is 3,300 L of water per day

(Note: The heat source of heat pumps can typically be harvested from the chilled water loop or condenser water loop. Please also note that the density of water is different for different temperatures. For example, for chilled water loop, water temperature is approximately 10 – 15°C, thus the water density value between 998.2 – 999.7 kg/m3 should be used in the computation. Similarly, for condenser water loop where water temperature is approximately 30-35°C, the water density value between 992.2 – 995.7 kg/m^3 should be used.)

From the calculation, the project can save 3,300 L/day of water if a heat pump is used to harvest the heat source from condenser water loop. With this calculation, 0.5 point is awarded.

3.4 Water Monitoring and Leak Detection

Scope

Applicable to all buildings with potable and non-potable water usage.

Assessment Criteria

A maximum of 1 point is available for the following provisions to monitor the water consumption of the building:

- Private meters for all major water uses in the building (0.5 point)
- Smart remote metering system with alert features for leak detection and monitoring purposes (0.5 point)

Guidance Notes

Common major water uses for building type where private meters should be installed to monitor the amount of water used are as listed.

Building Type	Major Water Uses
Hotels	• Guestrooms • Cooling towers* • Food and beverage outlets • Production kitchen • Laundry • Cold water supply inlet to hot water supply or boiler • Swimming pool • Spa & gym
Institutional Buildings (IHL, prison, military or defence installations)	• Cooling towers* • Toilets for each block • Washing areas • Swimming pool • Food and beverage outlets/ kitchens
Hospitals	• Cooling towers* • Toilets, wards and operating theatres for each block • Kitchen • Cold water supply inlet to hot water supply or boiler
Sports and Recreational Facilities and Tourist Attractions	• Cooling towers* • Exhibits or enclosures • Washing areas • Toilets • Food and beverage outlets • Irrigation • Swimming pools
Office or Retail Buildings (or any other building types that are not specifically stated)	• Cooling towers* • Toilets • Pantries • Food and beverage outlets • Production and processes

**Note: For cooling towers, make-up water meters are to be provided to monitor water loss due to evaporation, drift and blow down during cooling tower operation.*

Documentation Requirements

- Private meters:
  - Schematic drawings of the water distribution system showing the location of the private water metering provided, or;
  - Photographs of the private water metering provided
- Remote metering system:
  - Screenshots of the BMS system integration and the water leak detection alert settings

3.5 Water Usage Portal and Dashboard

Scope

Applicable to all buildings with potable and non-potable water usage.

Assessment Criteria

A maximum of 1 point is available for water usage portal(s), dashboard(s) or other equivalent forms with the following provisions:

- Display metered data, trending of water consumption and relevant parameters which facilitate better management of water consumption during building operation (0.5 point)
- Allow individual tenants to monitor their own water usages and consumption (0.5 point)

Documentation Requirements

Screenshots of the installed water usage portal, dashboard or equivalent form showing display of the metered water data by area or use and other relevant parameters as well as trending and computed benchmark

3.6 Use of Alternative Water Sources

Scope

Applicable to all buildings with potable water usage.

Assessment Criteria

A maximum of 2 points is available based on the percentage reduction in the building's total annual potable water usage through the use of alternative water sources for applicable non-potable uses, such as irrigation, washing, water features, toilet flushing, etc. (excluding cooling tower make up water).

% reduction of potable water	Points
< 10 %	1
≥10 % to 50 %	1.5
> 50 %	2

Documentation Requirements

- Calculation of percentage reduction of potable water or documentation such as water bill that shows the actual water reduction after use of alternative water sources
- Schematic diagram or photograph of the alternative water system

Worked Example

Example of a mixed-used development with the following water consumption in 2016.

Months of 2016	Domestic Water (m^3)	NEWater (m^3)		Rainwater (m^3)	Total (m^3)
		Toilet flushing	Cooling Tower Make Up	Irrigation	
January	20,000	2,000	10,000	500	32,500
February	25,000	2,000	10,000	500	37,500
March	20,000	2,000	10,000	500	32,500
April	20,000	2,000	10,000	500	32,500
May	20,000	2,000	15,000	500	37,500
June	20,000	2,000	10,000	500	32,500
July	25,000	2,000	10,000	500	32,500
August	20,000	2,000	10,000	500	32,500
September	20,000	2,000	10,000	500	32,500
October	20,000	2,000	10,000	500	32,500
November	20,000	2,000	10,000	500	32,500
December	20,000	2,000	10,000	500	32,500
Total	**250,000**	**24,000**	**125,000**	**6,000**	**405,000**

Total water consumption from alternative sources

= NEWater (Toilet flushing) + Rainwater (Irrigation)

= 24,000 + 6,000 = 30,000 m^3 (exclude make up water for cooling tower)

Therefore, percentage reduction of potable water = 30,000 / 405,000 = 7.4% (1 point)

Materials

Intent

To encourage effort to reduce the environmental impact of the building through sustainable practices and use of sustainable fit-out systems. Green fit-outs are considered to encourage the adoption of more sustainable materials and approaches within the building.

Criteria	Points
3.7 Green Material and Products	
a) Green Products	2
b) Green Materials	5
TOTAL	7

3.7 Green Material and Products

3.7a Green Products

Scope

Applicable to all buildings.

Assessment Criteria

A maximum of 2 points is available for building services and mechanical and electrical (M&E) products certified by an approved local certification body. Structural components are excluded.

SGBC or equivalent Certification Rating	Points
Good (1 tick)	0.25
Very Good (2 ticks)	0.5
Excellent (3 ticks)	0.75
Leader (4 ticks)	1

Examples of green products include:

- Chillers
- Auto-tube cleansing system
- Pumps
- Transformers

Documentation Requirements

- A valid green product certification by an approved local certification body
- Catalogue of the green product
- Photograph of the product provided where available

3.7b Green Materials

Scope

Applicable to all buildings.

Assessment Criteria

A maximum of 5 points is available for non-structural building component products certified by approved local certification body. Structural and M&E components are excluded.

Points will be awarded based on the certification rating and the impact (i.e. certification rating x impact).

SGBC or equivalent Certification Rating	Points
Good (1 tick)	0.25
Very Good (2 ticks)	0.5
Excellent (3 ticks)	0.75
Leader (4 ticks)	1

Credit Point Based on Impact of the Products	
High Impact	1 point
Low Impact	0.5 point

Guidance Notes

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.

Products that are meant for common areas and external works such as toilets, lobbies and landscaping areas and are adopted in more than 50% of the applicable areas would be considered as low impact. Non-building products, such as cleaning agent and paper, that are essential for the operation of the building, would also be considered as low impact.

Impact and Coverage	Type of Products
High Impact*	• Carpet • Ceiling board • Flooring • Doors
Low Impact	• Precast concrete road kerbs • Cleaning products • Paper • Toilet paper • Detergent • Hand soap

* Items that do not meet the minimum coverage or are used in other common areas will be considered as low impact.

Documentation Requirements

- A valid green product certification by an approved local certification body
- Catalogue of the green product
- Relevant layout plan or photos showing the extent of coverage of the green products

Worked Example

Example of a proposed development with the following provisions:

Products and Extent of coverage		Local Certification rating	Points allocated based on impact (A)	Points allocated based on rating (B)	Points Scored (A x B)
(a)	Carpets for 30% of all office spaces	SGBC Excellent	0.5	0.75	0.375
(b)	Wooden doors for all areas	SGBC Leader	1	1	1
(c)	Cleaning detergent	SGLS	0.5	0.25	0.125
(d)	Printing paper for all offices		0.5	0.25	0.125

Therefore, points scored = 0.375 + 1 + 0.125 + 0.125 = 1.625 points

Waste

It is estimated that 2.2 billion tonnes of waste will be generated globally in 2025 (Source: World Bank). Singapore's output of solid waste has increased significantly over the years, from 1,260 tonnes per day in 1970, to a high of 8,559 tonnes per day in 2016 (Source: NEA). Waste is an indicator of excess as it means we are using more than we need and depleting precious raw materials. The disposal of waste via landfills and incineration places a strain on land resources, as well as generates pollutants harmful to human health and the environment. To minimise waste generation, it is crucial to provide adequate facilities and systems to manage operational waste.

Criteria	Points
3.8 Recycling Facilities	3.5
3.9 Storage Area for Recyclable Wastes	1
3.10 Promotion of Waste Reduction	2
3.11 Waste Monitoring	2
TOTAL	8.5

3.8 Recycling Facilities

Scope
Applicable to all buildings.

Assessment Criteria
A maximum of 3.5 points is available for the provision of facilities or systems to carry out the following:

- Collection and storage of common recyclables such as paper, glass, metal and plastic in commingled or sorted form (1 point)
- Recycling of specialised waste stream such as electronic waste, light bulbs/fluorescent tubes, and food waste (1 point for each specialised waste stream; up to 2 points)
- Consolidation of horticultural waste for recycling (0.5 point)

The recycling facilities or systems provided should be applicable to the building type and level of occupancy. It should also be placed in a location convenient for building users, or close to the source of waste generation.

Documentation Requirements
Relevant layout plan or photos showing the provision of the recycling facilities for collection of the relevant recyclables where applicable.

3.9 Storage Area for Recyclable Wastes

Scope
Applicable to all buildings.

Assessment Criteria
1 point will be awarded for the provision of proper dedicated storage area at a central location for recyclable wastes.

Documentation Requirements
Relevant layout plan or photos showing the provision of the recycling facilities for storage of the relevant recyclables where applicable.

3.10 Promotion of Waste Reduction

Scope
Applicable to all buildings.

Assessment Criteria
A maximum of 2 points is available to recognise the effort of the building owner to promote and encourage waste reduction and recycling among its tenants, building occupants and visitors. (1 point per avenue of promotion)

Documentation Requirements
- Relevant documentation such as the printouts of email and poster that promote and encourage waste reduction and recycling among its tenants, building occupants and visitors.
- Photos showing the location and provision of promotional materials where applicable.

3.11 Waste Monitoring

Scope
Applicable to all buildings.

Assessment Criteria
A maximum of 2 points is available for quantifying and monitoring the waste collected within the building for continuous improvement on waste reduction:

- Quantifying and monitoring of the waste disposed (1 point)
- Quantifying and monitoring of the waste recycled (1 point)

Documentation Requirements
- Waste disposed
  - Valid documentation of records on waste disposal
- Waste recycled
  - A valid waste recycling report from the waste collection vendor. The waste recycling report should quantify the recyclables collected according to its type such as paper, glass and metal

4. Smart and Healthy Building

Introduction

Most of us spend a substantial proportion of our time within buildings. Good indoor environmental quality is therefore essential to ensure the health and well-being of building occupants. In addition to periodic maintenance and inspection of the indoor premises, building owners and facility managers can increase occupant satisfaction within the indoor environment by engaging its occupants through regular surveys and feedback for improvement.

At the same time, managing a building's indoor environmental quality well necessitates operating the building smartly. Smart controls, direct access and visualisation to building data as well as early fault detection allows the facility management team to gain a good understanding of the building's performance and condition. This enables necessary intervention and optimisation measures to be carried out in a timely manner.

Criteria	Points
4.1 Occupant Comfort	5.5
4.2 Outdoor Air Control	1.5
4.3 Enhanced Filtration Media	2.5
4.4 Indoor Contaminants	2.5
4.5 Lighting Quality	4
4.6 Acoustics	1
4.7 Biophilic Features	2
4.8 Energy Monitoring	11
4.9 Demand Control	5
4.10 Integration and Analytics	5
TOTAL	40
Advanced Green Effort	15

Healthy Building

Aspects of a healthy indoor environment include better air quality, pleasant acoustics, quality lighting, as well as biophilic design features that evoke the experience of nature. A healing, positive environment nurtures healthier and more productive occupants.

Criteria	Points
4.1 Occupant Comfort	5.5
4.2 Outdoor Air Control	1.5
4.3 Enhanced Filtration Media	2.5
4.4 Indoor Contaminants	2.5
4.5 Lighting Quality	4
4.6 Acoustics	1
4.7 Biophilic Features	2
TOTAL	19
Advanced Green Effort	12

4.1 Occupant Comfort

Scope
Applicable for all buildings with air-conditioning for comfort cooling.

Assessment Criteria
A maximum of 5.5 points will be awarded for the followings which contribute towards ensuring occupant comfort:

4.1a Thermal Comfort

1 point will be awarded if the indoor dry-bulb temperature is maintained between 23ºC to 25ºC and relative humidity not exceeding 70% for consistent indoor conditions and comfort air-conditioning.

Documentation requirement
IAQ surveillance audit report by an accredited laboratory indicating temperature measurement readings

4.1b Temperature Control

0.5 point will be awarded if occupants are able to control the indoor temperature by zones according to their preference. The thermostat set point should not go below 23ºC.

Documentation requirement
Picture evidence indicating the type and location of the thermostats

4.1c Post Occupancy Evaluation

2 points will be awarded if a Post Occupancy Evaluation (POE) survey is conducted and the corrective actions are taken accordingly to promote occupant satisfaction. The POE sample size should be at least 10% of the occupant population in the building, or at least 100 if there are more than 1,000 occupants or 10 if there are less than 100 occupants in the building.

Documentation requirement
- A written confirmation on the total number of building occupancy
- Completed survey forms and emails submitted by the respondents
- The spreadsheet in softcopy of the standardised POE survey results showing the summary of the survey analysis and the list of corrective actions taken

Additional guidance notes
- The spreadsheet of the standardised POE survey questionnaire is available at https://www.bca.gov.sg/GreenMark/others/POE_survey_template.xlsx
- The spreadsheet of the standardised POE survey results is available at https://www.bca.gov.sg/GreenMark/others/POE_results_template.xlsx

4.1d Indoor Air Quality Management

2 points will be awarded for following IAQ management practices stated in *Workplace Safety and Health Guidelines – Management of Indoor Air Quality in Air-Conditioned Workplaces*. The appointed in-house IAQ manager should attend relevant IAQ courses and educate the facility management staff accordingly. The IAQ management framework flowchart in the Guidelines should also be used.

Additional guidance notes
- Workplace Safety and Health Guidelines: Management of Indoor Air Quality in Air-Conditioned Workplace can be downloaded at https://www.wshc.sg/files/wshc/upload/infostop/attachments/2016/IS20160322000000396/WSH_Guidelines_on_Management_of_IAQ.pdf

Documentation requirement
- An IAQ management policy indicating the commitment to adhere to the IAQ management practices stated in WSH guidelines
- Documentary evidences for the followings;
  i. Appointment of in-house IAQ manager
  ii. IAQ manager's relevant IAQ course records and certificates
  iii. IAQ manager conducts in-house briefing/training to educate the facility management staff

iv. Implementation of IAQ management practices

Advanced Green Effort

5.6 Thermal Comfort with Elevated Air Speed

2 points will be awarded for the use of innovative solutions, such as high temperature cooling with increased air speed, to achieve the following thermal comfort conditions while reducing energy consumption:

- Demonstrate compliance with thermal comfort criteria (-0.5 < PMV < 0.5 and/or PPD <10%) through ASHRAE 55, ISO 7730 or EN 15251 methodologies
- Indoor temperature maintained at 26ºC and above

Additional guidance notes

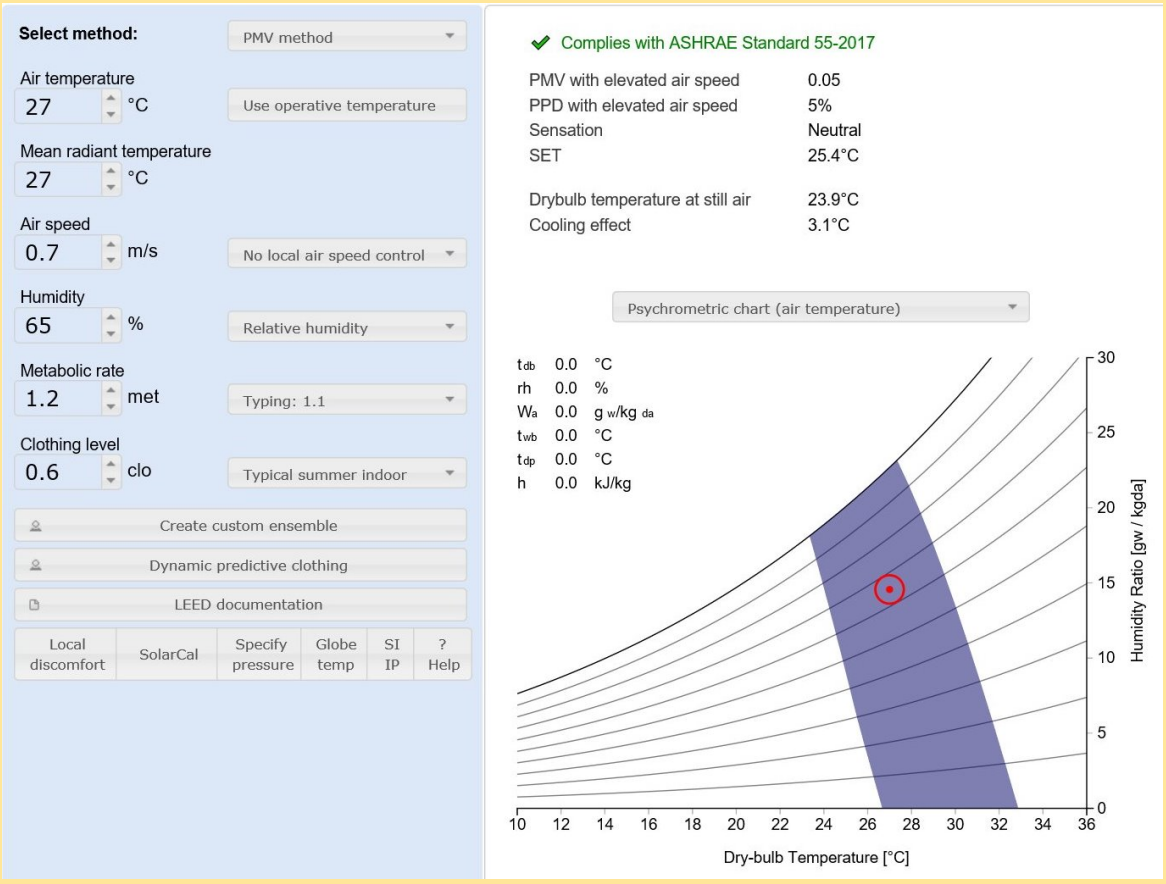
- Projects scoring this criterion are also considered to have met the pre-requisite requirement of *P6 Indoor Temperature* and the elective requirement of *4.1 Occupant Comfort - Thermal Comfort*.

Documentation requirement

- A documentary evidence demonstrating the compliance with the abovementioned thermal comfort criteria
- IAQ surveillance audit report by an accredited laboratory, indicating the indoor temperature being maintained at 26ºC and above as well as relative humidity and air speed measured

Worked Example

CBE Thermal Comfort Tool can be used to demonstrate project's compliance to thermal comfort.



Source: http://comfort.cbe.berkeley.edu

Advanced Green Effort

5.7 IAQ Surveillance Audit

2 points will be awarded if an IAQ surveillance audit is conducted once every 3 years by an accredited laboratory under Singapore Accreditation Council with respect to the recommended IAQ parameters and acceptable limits stated in Table 1 of SS554: 2016, based on the reference methods.

Additional guidance notes

- The spreadsheet for the standardised IAQ audit report is available at https://www.bca.gov.sg/GreenMark/others/IAQ_report_template.xlsx

Documentation requirement

- IAQ surveillance audit report (hardcopy and softcopy in spreadsheet) endorsed by an accredited laboratory indicating that the methods which are used are based on the reference methods described in table 1 of SS 554 : 2016.

4.2 Outdoor Air Control

Scope

Applicable to all building supplying outdoor air to normally occupied spaces.

Assessment Criteria

A maximum of 1.5 points is available for the following to ensure sufficient and effective ventilation to a building's air-conditioned spaces and prevent contaminant build-up.

4.2a Dedicated Outdoor Air System

1 point will be awarded for the provision of a dedicated outdoor air system, such as pre-cooled units, to encourage effective treatment of the outdoor air for cooling and dehumidification.

Documentation requirement

- Schematics of the air distribution system that are connected to the dedicated outdoor air system (Precool AHU/FCU system)
- Pictures showing the location of the dedicated outdoor air system

4.2b Demand Control Ventilation

0.5 point will be awarded for the use of demand control ventilation strategies, such as provision of carbon dioxide (CO_2) sensors or equivalent devices, to regulate the quantity of fresh air supplied to the building's air-conditioned spaces.

Documentation requirement

- Schematics of the air distribution system showing the control mechanism and strategy of demand control ventilation
- A method statement on how the devices control and regulate the outdoor air volume to maintain indoor air quality
- IAQ surveillance audit report by an accredited laboratory
- Pictures showing the location of the sensing devices such as CO_2 sensor or occupancy counter

Advanced Green Effort

5.8 Outdoor Airflow Monitoring System

A maximum of 2 points will be awarded for measuring and monitoring the outdoor airflow volume of the following units to ensure provision of sufficient ventilation for various spaces, in accordance with desired ventilation rates

- All precool units (e.g. PAHU) (1 point)
- > 90% coverage (by nos.) of a building's AHUs and/or Fan Coil Units (FCUs) (1 point)

Documentation requirement

- Schematics, specifications and method statement for the provision of direct outdoor airflow measurement devices with capabilities to measure the outdoor air intake volume with an accuracy of +/- 10% of the minimum outdoor airflow
- A method statement for programming alerts when the outdoor air volume drops below the minimum set points and varies by more than 15% above the airflow set point
- Pictures showing the location of the airflow measurement devices
- BMS or standalone system logged data (minimum of a 2-week period) of the outdoor air volume and

4.3 Enhanced Filtration Media

Scope

Applicable to all buildings with AHUs or systems for dedicated treatment of outdoor air.

Assessment Criteria

A maximum of 2.5 points will be awarded for the following to remove harmful pollutants from the building's ventilation system:

- 0.5 point will be awarded if at least Minimum Efficiency Rating Value (MERV) 6 or equivalent filters for outdoor air filtration all the time; and at least MERV 14 or equivalent filters when the outdoor pollution level is in the unhealthy range in accordance with Ministry of Health's guidelines. (0.5 point)

OR

- 1 point will be awarded for the permanent provision of MERV 14 or equivalent filters to all precool units (e.g. PAHUs) (1 point)
- 1.5 points will be awarded for the permanent provision of MERV 14 or equivalent filters to all PAHUs and > 90% coverage of AHUs (by nos.) (1.5 points)

Documentation requirement

- Air filtration classification testing report for the actual filters which are used on site
- Pictures showing filters which are being used on site

Advanced Green Effort

5.9 SGBC or equivalent Certified Air Filters

A maximum of 1 point can be scored for the use of SGBC or equivalent certified air filters at all AHUs (>90% coverage) including Precool AHU.

SGBC or equivalent Certification Rating	Points
Good (1 tick)	0.25
Very Good (2 ticks)	0.5
Excellent (3 ticks)	0.75
Leader (4 ticks)	1

Guidance notes

The list of SGBC certified air filters can be downloaded at https://sgbc.online/certification-directory/products/50/

Documentation requirements

- SGBC or equivalent product certificate for the actual filters used on site
- Pictures showing filters which are being used on site

4.4 Indoor Contaminants

Scope

Applicable to all buildings with normally occupied air-conditioned spaces.

Assessment Criteria

A maximum of 2.5 points is available for the following which contribute towards indoor contaminant pollution control:

4.4a Ultraviolet Germicidal Irradiation (UVGI) System or Equivalent Airborne Disinfection Technologies

The provision of a UVGI system or equivalent in AHUs to control airborne infective microorganisms. The UV wavelength should be of 254nm and a safety interlock for maintenance access should be provided.

- 30 to 50% coverage (by nos.) of a building's AHUs (0.5 point)
- > 50% coverage (by nos.) of a building's AHUs (1 point)

Documentation requirement

- Technical specifications of the UVGI system showing UV wavelength of 254nm and safety interlock provision
- Manufacturer's guideline on the intensity, location (near the cooling coil), reflector design and number of lights according to the AHU design
- Schedule of AHUs indicating UVGI provision

4.4b Indoor Air Quality Display

A maximum of 1.5 points is available for the provision of display panels at each floor or tenancy indicating the following information to raise awareness amongst the tenants, building occupants and visitors on the building's indoor air quality. Recommended locations include regularly occupied areas for offices, function rooms for hotels, and centralised locations for retail malls.

- Temperature (0.5 point)
- Relative humidity (0.5 point)
- CO_2 concentration (0.5 point)

Documentation requirement

- Technical specifications of the sensors
- Photographs showing location of the sensors for display
- Plan layouts showing the display location and the type of sensors used for display

Advanced Green Effort

5.10 Indoor Air Quality Trending & Monitoring

A maximum of 4 points is available for permanent trend logging and monitoring of the following parameters, with at least 1 measuring point per floor and linked to a centralised system:

- Temperature and relative humidity (1 point)
- At least 1 common indoor air pollutant such as formaldehyde, Total Volatile Organic Compounds (TVOC) or particulate matters (1 point each, up to 3 points)

Documentation requirement

- Technical specifications of the sensors
- Pictures showing location of the sensors for monitoring
- Plan layouts showing the monitoring location and the type of sensors used for monitoring
- Two-week trend logging data from the centralised monitoring system

Advanced Green Effort

5.11 Local Exhaust and Air Purging System

Scope

Applicable to all relevant spaces, e.g. photocopier rooms

A maximum of 1 point will be awarded for the provision of the following systems:

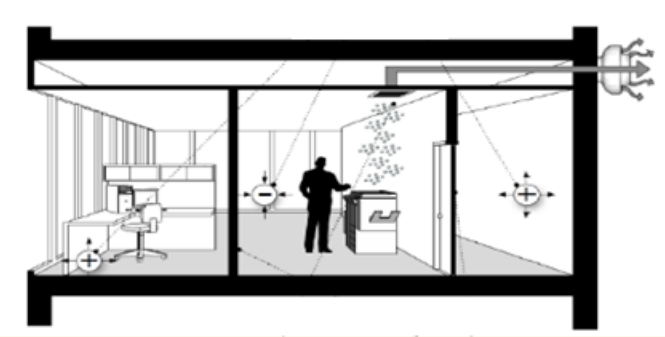
- Local isolation and exhaust system to remove the pollutants at source, e.g. photocopier room with exhaust system (0.5 point)
- Air purging system to replace contaminated indoor air with outdoor fresh air (0.5 point)

Documentation requirement

Schematics, pictures and method statement for the local exhaust and/or air purging system

Worked Example

This is a schematic drawing showing the location and working principle of local exhaust system.



Source: Indoor Air Quality Guide, ASHRAE

4.5 Lighting Quality

Scope
Applicable to all occupied spaces of buildings.

Assessment Criteria
A maximum of 4 points is available for the following which contribute towards ensuring well-lit and comfortable spaces and minimising physiological discomfort for the building occupants and users. Extent of coverage: at least 90% of the occupied areas.

4.5a Lighting Level

1 point will be awarded if the measured indoor lighting levels comply with the recommended illuminance (average lux) stated in *SS 531 : 2006 Code of Practice for Lighting of Work Places Part 1 – Indoor Lighting* or *CP 38 : 1999 Code of Practice for Artificial Lighting in Buildings.*

Documentation requirement
- Tabulation of lux level measurements and plan layout showing the location of the measurements taken
- The measured levels should be compared against the relevant code requirement

Worked Example
A table showing the type of interior space, measured Lux and minimum Lux in SS531:2006

Type of interior, task or activity	Measured Lux	Reference Lux (as specified in SS531: 2006)
Office Space Type 1	500	500
Atrium	200	100
Corridor type 1	150	100
Toilet	150	100
Mechanical & Electrical Rooms	250	200
Carpark	100	75
Stairs, escalators	200	150

4.5b Task Light

1 point will be awarded for the provision of task lights for the building occupants and users at workstations to achieve task-appropriate illumination and flexibility for user adjustment and control.

Documentation requirement
- Tabulation of the areas with provision of task light

4.5c Flicker-Free Fittings

1 point will be awarded if lightings can avoid flicker and stroboscopic effects by using the following:
- High frequency ballasts (frequency >20kHz) for fluorescent luminaries
- LED lighting with <30% flicker

Documentation requirement
- Technical specifications to demonstrate compliance to the abovementioned high frequency ballasts and LED driver output frequency requirements
- Tabulation of the areas with provision of flicker free fittings

4.5d Colour Rendering Index

1 point will be awarded if lightings can meet the minimum colour rendering index (R_a or CRI) stated in *Clause 5 of SS 531 : 2006 Code of Practice for Lighting of Workplaces.*

Documentation requirement
- Technical specifications indicating the colour rendering index of the lightings
- Tabulation of specified R_a or CRI in respective areas

Worked Example

A table showing the type of interior space, Lighting R_a and minimum R_a in SS531:2006

Type of interior, task or activity	Type of light fitting	No. of light fitting	Specified Ra or CRI	Minimum R_a or CRI (as specified in SS531: 2006)
Office Space Type 1	T5	108	80	80
Atrium	LED	24	60	60
Corridor type 1	LED	12	40	40
Toilet	LED	12	80	80
Mechanical & Electrical Room 1	T5	16	60	60
Carpark	T5	420	40	40
Stairs, escalators	T5	36	40	40

4.6 Acoustics

Scope

Applicable to all occupied spaces of buildings.

Assessment Criteria

1 point will be awarded if the measured indoor sound levels comply with the recommended ambient sound levels in *SS 553 : 2009 Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings* or *CP 13 : 1999 Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings.*

Documentation requirements

- Tabulation of sound level measurements and plan layout showing the location of the measurements taken
- The measured levels should be compared against the relevant code requirement

4.7 Biophilic Features

Scope

Applicable to all buildings.

Assessment Criteria

A maximum of 2 points is available for the provision of biophilic features in the common areas that improves the building occupants and users' physical and mental well-being through direct and indirect experiences of nature such as:

- Access to indoor plants – 0.5 point
- Sky garden and/or sky terrace – 0.5 point
- Aquarium – 0.5 point
- Images and/or shapes of nature – 0.5 point
- Use of natural materials, texture and geometry – 0.5 point
- Any others that enhance human connection to nature – 0.5 point each

Documentation requirements

Plan drawings and pictures showing location and extent of biophilic features

Smart Building Operations

To encourage the use of automation and data analytics that enable building operators and professionals to enhance productivity and maintain energy efficiency by optimising equipment and related processes for energy reduction and comfort requirements.

Criteria	Points
4.8 Energy Monitoring	
4.8a Electrical Sub-metering	6
4.8b Energy Portal and Dashboard	3
4.8c Building Management System (BMS) and Controller with Open Protocol	1
4.8d Connection to BCA Smart Chiller Portal	1
4.9 Demand Control	
4.9a Common Areas	2
4.9b Occupied/Tenanted Areas	3
4.10 Integration and Analytics	
4.10a Basic Integration and Analytics	5
4.10b Advanced Integration and Analytics	
TOTAL	21
Advanced Green Effort	3

4.8 Energy Monitoring

4.8a Electrical Sub-Metering

Scope

Applicable to all buildings.

Assessment Criteria

A maximum of 6 points is available for the provision of electrical sub-meters to the following so as to enable audit and continuous improvement towards the optimisation of energy use:

- Air distribution equipment, such as Air Handling Units (AHUs) and/or Fan Coil Units (FCUs) (2 points)
  The sub-meters shall have remote capability and shall be linked to a monitoring system to measure, trend, compute and display the air-side, water-side and total system efficiencies in kW/RT where the cooling load for computation can be derived from P.2 Air-Conditioning System Minimum Operating Efficiency.

- Other major energy sub-systems (up to 4 points)
  The sub-meters shall have remote capability and shall be linked to a monitoring system to measure, trend and display the energy consumption of each sub-system listed below, but not limited to:
  - Lighting for common areas (1 point)
  - Lighting for non-common areas (1 point)
  - Lift system (1 point)
  - Escalator system (1 point)
  - Carpark mechanical ventilation system (1 point)
  - Any other major energy sub-system (1 point)

For water-cooled chilled-water plant systems, appropriate permanent measurement devices have been stipulated in *P.5 Permanent Instrumentation for the Measurement and Verification of Air Conditioning Systems*.

Documentation Requirements (Airside equipment)

- Sub-system equipment specifications
- Power meter and current transformer specifications
- The remote capability and link to a BMS/EMS
- Single line diagram showing the location of the power meters
- Main switch board and power distribution boxes design
- BMS or supervisory control and data acquisition (SCADA) display of meter readings and trends

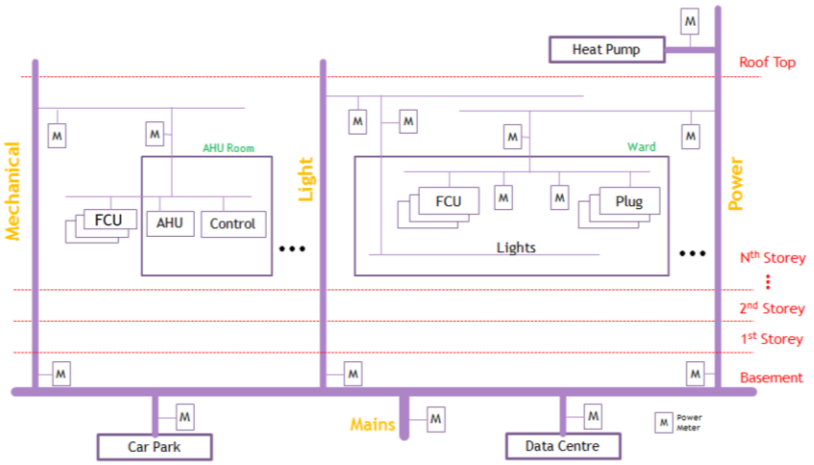
- If FCU's power consumption could not be metered due to valid constraints, nameplate power could be used

Documentation Requirements (Other major energy sub-systems)

- Specifications of the portal and/or dashboard. The data acquisition system must be able to store measured data for at least 36 months.
- The system shall be able to create reports showing hourly, monthly and annual energy consumption associated with each meter, with option to export the data in .csv or .xls format.
- Photographic evidence of the installed energy portal and/ or dashboard, displaying metered energy data, by area or by system. Trend and cost of energy used, together with energy benchmark should be displayed.

Worked Example

A hospital installed sub-meters for its building in accordance to the following diagram:



- Sub meters used to monitor AHU and FCU usage which are linked to a monitoring system to measure, trend, compute and display the air-side, water-side and total system efficiencies in kW/RT. (2 points);

- Sub meters are also installed and linked to a monitoring system to measure, trend and display other sub-systems such as:

Item	Points
Lighting system for common (eg. corridors, staircases) and non-common (eg. wards) areas.	1 + 1=2
Carpark mechanical ventilation system	1
Heat pump system	1
Data centre	1
Total for other sub systems	5 (capped at 4)

Total points scored for this section= 2 + 4 = 6

4.8b Energy Portal and Dashboard

Scope

Applicable to all buildings.

Assessment Criteria

A maximum of 3 points is available for the provision of an energy portal and/or dashboard, which presents a building's energy use data in a relevant manner, to the following groups:

- Internal building and facility management team, in the form of digital display or web-based and mobile applications. (1 point)
- Building occupants and visitors, in the form of digital displays in common area. (1 point)
- Tenants, showing the total energy consumption of the building and the individual tenant consumption. (1 point)

Documentation Requirements

- Specifications of the portal and/or dashboard. The data acquisition system must be able to store measured data for at least 36 months.
- The system shall be able to create reports showing hourly, monthly and annual energy consumption associated with each meter, with option to export the data in .csv or .xls format.
- Photographic evidence of the installed energy portal and/ or dashboard, displaying metered energy data, by area or by system. Trend and cost of energy used, together with energy benchmark should be displayed.

4.8c Building Management System (BMS) and Controllers with Open Protocol

Scope

Applicable to all buildings.

Assessment Criteria

1 point will be awarded for the use of BACnet, Modbus or any other non-proprietary protocols as the network backbone for the building management system (BMS). The BMS shall be able to provide scheduled export of a set of any chosen data points with time stamp to commonly used file formats such as .csv or .xls.

Documentation Requirements

Write-up on the BMS or other equivalent building management, control and monitoring system which describes the protocol used.

4.8d Connection to BCA Smart Chiller Portal

Scope

Applicable to all buildings with central chilled-water system.

Assessment Criteria

1 point will be awarded for the provision of chiller plant performance data to the BCA Smart Chiller Portal.

The sampled data of 1-minute interval shall be grouped and transmitted automatically, at least once a day, to the portal using the REST API interface defined in Annex B.

Advanced Green Effort

5.12 Permanent Measurement and Verification (M&V) for Variable Refrigerant Flow (VRF) Systems

A maximum of 3 additional points will be awarded for the provision of the following:

- Power meters for all condensing units of the VRF system (1 point)
- Permanent measuring instruments for monitoring of the energy efficiency performance of the VRF condenser units and air distribution sub-system (2 points)
  The installed instrumentation shall have the capability to calculate the resultant system efficiency (i.e. kW/RT or Coefficient of Performance (COP)) within ±10% uncertainty. Each measurement system shall include the sensor, any signal conditioning, the data acquisition system and wiring connecting them. All data are to be logged at 5-minutes sampling time interval, recorded to at least 1 decimal place, and available for extraction for verification purposes.

Documentation Requirements

- Detailed schematic drawings of the instruments and sensor locations
- Technical specifications and/or sample data sheets/ product information for instruments and meters
- Detailed drawings and schematics of the measurement strategies for the VRF system
- Purchase orders and delivery orders of the instrumentation installed

4.9 Demand Control

Scope
Applicable to all buildings.

Assessment Criteria
A maximum of 5 points is available for the use of occupancy-based controls to monitor and regulate the temperature, airflow, or lighting brightness of the following spaces in the building to optimise the building's energy consumption for air-conditioning, mechanical ventilation (ACMV) and lighting:

4.9a Common Area

A maximum of 2 points is available for each of the following areas (0.5 point for every 50% coverage by area):

- Toilets
- Staircases
- Corridors
- Lift lobbies
- Atriums

4.9b Lettable/Non-Common Area

A maximum of 3 points is available for occupied/ tenanted area, such as offices, retail shops or hotel guest rooms (1 point for every 25% coverage by area).

Documentation Requirements

- Location plan of relevant sensors to show at least 50% of common areas or 25% of occupied/ tenanted areas are covered
- Specification of the sensors and associated controllers

Control system screens showing sensor input and corresponding controller output

Worked Example
A 200-room hotel building installed motion sensors for all common areas' toilets and staircases.

A key card system is also installed for all hotel rooms to automatically detect occupancy once the guest insert his room card in the control switch. In the "Occupied" mode, the guest will be able to control the lighting system and adjust his room temperature according to his preference.

When the room card is removed, all lightings and ventilation will reduce to minimal set point to reduce energy consumption.

Lux sensors were also installed to control perimeter lights within its back of house areas. On days with bright daylight, perimeter lights would be dimmed or switched off automatically to reduce energy consumption.

The points scored is as follows:

Item	Points
Motion sensors for all (100%) of toilets.	0.5 x 100%/50% = 1
Motion sensors for all (100%) of staircases.	0.5 x 100%/50% = 1
Occupancy key card system for all (100%) hotel rooms	0 as it is mandated in SS553:2016 Para 8.16 for hotel with more than 50 guest rooms
Photocell sensor for perimeter lighting covering 30% of occupied areas with external windows	1 x 30%/25% = 1.2 (cap at 3)
Total for this section	3.2

4.10 Integration and Analytics

Scope
Applicable to all buildings.

Assessment Criteria
A maximum of 5 points is available for the integrative use of data to optimise workflow or sustain high performance and energy efficiency in a building.

4.10a Basic Integration and Analytics

A maximum of 2 points will be awarded for basic integration and analytics. 0.5 point will be awarded for each basic integration and analytics feature put in place, such as, but not limited to, the following:

Basic Features	Example
Use adaptive control algorithms	• Adjust cooling tower approach based on wet bulb temperature
Exception handling by Identifying systems that deviates from expected performance	• When efficiency of chiller plant system (in kW/RT) deviates >10% • When a space setpoint is set below a typical value • When a space operates significantly below its setpoint
Detect equipment that run outside intended hours or settings	• AHUs/ FCUs that run past regular office hours
Monitor equipment condition for preventive maintenance	• Use embedded sensors to predict mechanical wear and failure • Priorities equipment maintenance using machine condition monitoring
Basic fault detection and diagnostics (FDD) of sensors by finding failed or improperly operating sensors or actuators	• Compare set points to actual to find leaking valves or stuck dampers • Set algorithms to counter-check between sensors

4.10b Advanced Integration and Analytics

A maximum of 3 points will be awarded for advanced integration and analytics. 1 point will be awarded for each advanced integration and analytics feature put in place, such as, but not limited to, the following:

Advanced Feature	Example
Whole system optimisation using a network of HVAC equipment	• Drive pumps minimally to satisfy the most demanding valve.
Integration of sub-systems to optimise resource use or improve user experience	• Integration of ID card access system to a hot-desk scheme
Use of Building Information Modelling (BIM) or similar applications that provide location-based visualisation of multiple sensors	• BIM for facilities and asset management such as energy and water use or temperature and relative humidity monitoring.
Participate in a Demand Response programme with electricity retailer	• Reduce energy consumption of specific electrical items for short periods Refer to *Demand Response Programme by EMA.

*EMA webpage link: https://www.ema.gov.sg/Demand_Response_Program.aspx

Documentation Requirements
- Delivery orders, user manuals and system integration test and commissioning reports
- Method statements for the system integration, sensors and control strategies

Worked Example
An institutional building implemented the following control strategies in its building:

1. Cooling tower approach temperature reset

The wet bulb temperature and cooling tower approach temperature is consistently monitored through the BMS. These parameters are used to control the fan speed of the cooling towers.

2. Pump energy optimisation

Traditionally, differential pressure sensor (DP) across the branch serving the most remote AHU is used to control the VSD of the chilled water pump. The set point of the differential pressure is usually fixed. To minimise pump energy, the positions of the network of AHU valves are iteratively scanned to reset the DP set point such that it just meet the need of the most demanding valve.

3. Timer control

The facilities manager set the operating hours of the chiller plant system based on the operating hours of the building.

The points scored for the institution building is as follows:

Item	Points
Cooling tower approach temperature reset (Basic)	0.5
Pump energy optimisation (Advanced)	1
Timer control	0 Standard control practices such as timer on-off and feedback loop to attain a set-point do not qualify for credit in this section.
Total for this section	1.5

5. Advanced Green Effort

Introduction

This section on Advanced Green Effort recognises the implementation of innovative strategies and demonstration of exceptional levels of sustainability and performance in building retrofit, operation and maintenance.

The Enhanced Performance criteria have indicators (5.1 to 5.12) placed within the 4 main sections of Sustainable Management, Building Energy Performance, Resource Stewardship, and Smart and Healthy Building. These are pioneering initiatives and practices that have been identified to drive the sustainable management and operation of a building.

The remaining criteria within this section will recognise buildings with broader aspects of sustainability, beyond what is specified in the criteria.

This Section will be capped at 20 points.

5.1-5.11 Enhanced Performance

Intent

Points can be awarded based on the Advanced Green Effort indicators that are highlighted within the Green Mark ENRB: 2017 criteria. Alternatively, where projects can demonstrate substantial performance to a specific sustainability indicator or outcome beyond what is specified in the criteria, points can be reviewed on a case-by-case basis.

Assessment Criteria

Submission requirements for assessment shall follow the guidance for each enhanced performance indicator within the main Green Mark sections.

Criterion	Description of criterion	Points
5.1	Accredited Green Facility Management Companies	1
5.2	ETTV < 40W/m^2	1
5.3	Demonstration of Better Air-side Efficiency	2
5.4	Renewable Energy	
	a) Replacement of electricity by on-site renewable energy	6
	b) Purchase of renewable energy from licenced electricity retailers	1
	c) Roof leasing for photovoltaic installation	1.5
5.5	Thermal Comfort with Elevated Air Speed	2
5.6	IAQ Surveillance Audit	2
5.7	Outdoor Airflow Monitoring System	
	a) All precool units (e.g. PAHUs)	1
	b) All AHUs	1
5.8	SGBC or equivalent Certified Air Filters	1
5.9	Indoor Air Quality Trending and Monitoring	
	a) Temperature and relative humidity	1
	b) At least one common indoor air pollutant such as formaldehyde, Total Volatile Organic Compounds (TVOC) or particulate matters	3
5.10	Local Exhaust and Air Purging System	
	a) Local isolation and exhaust systems to remove the pollutants at source such as photocopier room with exhaust system	0.5
	b) Air purging system to replace contaminated indoor air with outdoor fresh air	0.5
5.11	Permanent Measurement and Verification (M&V) for Variable Refrigerant Flow (VRF) Systems	
	a) Power meters installed for VRF system at least for all Condensing Units	1
	b) Provision of permanent measuring instruments for monitoring of energy efficiency performance of VRF condensing units	2

5.12 Complementary Certifications

Intent

Green Mark is an assessment tool that assesses the environmental sustainability of a building. However, in line with the 3rd Green Building Master Plan towards greater tenant/occupant engagement, additional points can be scored to encourage tenants to take up Green Mark Occupant Centric Schemes.

Assessment Criteria

A maximum of 2 additional points is available for the following to encourage the tenants in a building to take up certification of their tenanted areas or premises under the BCA Green Mark occupant-centric schemes:

- At least 1 tenant certified under a Green Mark Occupant-Centric scheme (0.5 point)
- The building achieves the BCA Green Mark Pearl Award (1 point)
- The building achieves the BCA Green Mark Pearl Prestige Award (2 points)

5.13 Display of BCA Green Mark Plaque or Decal

Intent

The BCA Green Mark Plaque and Decal is a recognition of the building owner's achievement in building and operating a sustainable property. Display of the plaque or decal will help to create awareness on green buildings to the building tenants and occupants.

Assessment Criteria

An additional 1 point will be awarded for buildings that display the BCA Green Mark Plaque or Decal at a prominent location in the building, such as the foyer or main lobby. This serves as a recognition of the building owner's achievement in building and operating a sustainable property; and also to create awareness on green buildings among the tenants, building occupants and visitors. Photos evidence of the display to be submitted to BCA.

5.14 Efficient Hot Water System

Intent

To encourage best practices in hot water system operation, points will be awarded to buildings with efficient hot water system. In addition, to drive the industry forward in monitoring the hot water system performance, points will also be awarded for hot water system M&V.

Assessment Criteria

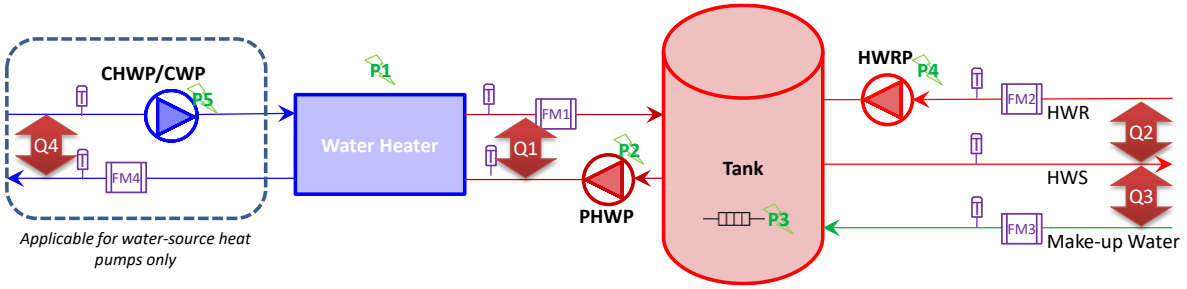
A maximum of 2 points is available for Hot Water System Ratio (HWSR) with baseline better than 1.45; another 0.5 point will be awarded for the provision of Hot Water System M&V and 0.5 point for measuring heat loss.

5.15	Description of criterion	Points
a)	Hot Water System Ratio (HWSR) baseline is 1.45 1 Point for achieving HWSR of 1.45; 0.02 point for every percentage improvement in the HWSR better than 1.45 Point scored = 0.02 x (HWSR – 1.45)/1.45 X 100	1 1
b)	Provision of permanent measuring instruments for monitoring of Hot Water System Ratio	0.5
c)	Measure Heat loss from Hot Water system, can be from third party energy audit or permanent M&V	0.5

Definitions

Hot Water System: Refers to the hot water machine and ancillary equipment such as circulation pumps, booster pumps and water storage tanks supporting the operations of the hot water plant.

Make-up Water Pumps (MWP): Pumps to supply water to hot water system to make up water being used by the users; they are also used to pressurize the system depending on the system design.



Typical Hot Water System

Water Heater Output, Q1: Heat output from water heater(s)

$$Q1(kW_t) = FM1 \times Cp \times (T1_{out} - T1_{in})$$

in which,

FM1: Primary hot water flow rate (L/s);

$T1_{out}$, $T1_{in}$: Temperature at water heater outlet and inlet respectively (°C).

Cp: Specific heat capacity of water (varies with water temperature and pressure). It is generally accepted that Cp is 4.18 J/(kg.K) within the temperature range of 45°C to 60°C.

Total Hot Water Plant Output, Q_{tot}: Total heat output by water heaters (boilers, heat pumps, solar hot water panels) and built-in electrical heaters inside calorifier tanks

$$Q_{tot}(kW_t) = Q1 + P3$$

P3 is the electrical input to the electrical heaters in the calorifier tanks. It is assumed that all electrical input to the calorifiers is converted into heat, e.g 1kW electrical input = 1kW thermal output.

Hot Water Circulation Heat Loss, Q2 : The heat loss through hot water distribution piping network

$$Q2(kW_t) = FM2 \times Cp \times (T_S - T_R)$$

in which,

FM2: Hot water return flow rate (L/s);

TS, TR Hot water Temperature at point of leaving and returning back to hot water storage tank respectively (°C)

Effective Hot Water Consumption, Q3

The heat required to heat up water from make-up water temperature to the hot water supply temperature from the hot water storage tank.

$$Q3(kW_t) = FM3 \times Cp \times (T_S - T_M)$$

in which,

FM3: Make-up water flow rate (L/s);

T_M : Make-up water Temperature (°C).

Heat recovered from Heat Source, Q4: It could be the heat recovered from chilled/condenser water of water-source heat pump or ambient air from air-source heat pump. It is generally accepted that Cp is 4.18 J/(kg.K) for condenser side and 4.19 J/(kg.K) for chilled water side.

If it's from chilled water or condenser water,

$$Q4(kW_t) = FM4 \times Cp \times (T_{Cin} - T_{Cout})$$

in which,

FM4: Chilled water or condenser water flow rate (L/s);

T_{Cin} Entering chilled water (or condenser water) to the heat source (°C)

T_{Cout} Leaving chilled water (or condenser water) from the heat source (°C)

Electrical power recovered, E_R : The electricity consumed by the chiller plant or cooling tower plant to produce same amount of cooling as heat recovered from Heat Source (Q4).

$$E_R(kW_e) = Q4 \times \eta$$

in which,

η: Measured chiller plant or cooling tower efficiency;

a) Hot Water System Ratio (HWSR): A ratio of effective hot water consumption to the total power consumed by entire hot water system, after considering Electrical power recovered (E_R).

$$HWSR = \frac{Q3}{(P_{tot} - E_R)}$$

in which,

P_{tot}: Total Power Consumption of entire hot water system, excluding make-up water pumps, if any.

$$P_{tot}(kW_e) = P1 + P2 + P3 + P4 + P5$$

P1: Input power to Water Heater

P2: Input power to Primary Hot Water Circulation Pumps.

P3: Input power to built-in electrical heaters inside the calorifier tanks, if any.

P4: Input power to Hot Water Return Pumps.

P5: Input power to dedicated Chilled Water Pumps / Condenser Water Pumps for hot water system.

Plant Room Heat Loss (Q_{L1}): The heat loss through the surface of calorifier tanks and primary loop piping work.

$$Q_{L1}(kW_t) = Q_{tot} - (Q2 + Q3)$$

Total Heat Loss in Hot Water System (Q_{Ltot}): The sum of Plant Room Heat Loss and Circulation Heat Loss.

$$Q_{Ltot}(kW_t) = Q_{L1} + Q2$$

Total Heat Loss Ratio (TLR): The ratio of Total Heat Loss in Hot Water System to the Total Hot Water Plant Output, it's the sum of Plant Room Heat Loss Rate and Circulation Heat Loss Rate.

$$TLR = \frac{Q_{Ltot}}{Q_{tot}} = PRLR + CLR$$

b) M&V requirement

Instrumentation accuracy requirement for hot water system is similar with chilled water system. Close loop thermos-well is acceptable for hot water system.

c) Heat loss of hot water system

The calculation can be done either using data from permanent M&V, or third party instrumentation

Instrument	Accuracy	Location	Remarks
Flow Meters	1% + 1%	• HWSR: Make-up water pipe • Heat Loss computation: Chilled water / condenser water, primary hot water and return water pipes	With totalizer function for make-up water
Digital Temperature sensors c/w Thermowell	0.05 °C	• HWSR: Make-up water pipe • Heat Loss computation: Chilled water / condenser water, primary hot water and return water pipes	Immersion type with closed end thermowell
Logger / Energy Meter	-	Hot water plant room	• Display not less than 2 decimals • Per minute interval logging • Consistent with Chilled water plant trend logging
Digital Power meters	1%	At main incoming if possible, else at individual equipment	With totalizer function to log kWh
Overall Error	**< 5%**		

Guidance Notes

Only hot water systems with supply temperature up to 60°C are assessed. Systems which require higher temperature supply i.e. steam for lab and hot water for kitchen are excluded. If the make-up water to these higher temperature supplies are pre-heated to 60°C using heat pump system, the pre-heating heat pump system would be assessed.

For buildings with different heating systems, only the system with the larger aggregated capacity will be considered. For example, if a hotel has both electrical heaters and heat pump system with electrical heaters having a larger aggregated capacity than heat pump system, only electrical heaters will be considered.

Documentation Requirement

- As-built drawing showing the schematic and layout of the proposed building hot water system
- Delivery orders of the hot water plant equipment, including heat pumps, circulation pumps, M&V instruments (if applicable)
- Operation hours of the hot water system and spaces served by the hot water plant
- Compliance with verification requirements under Permanent Instrumentation for the Measurement and Verification of Hot Water Plant where applicable
- Submission of energy audit report endorsed by PE (Mechanical) or Energy Auditor detailing the hot water plant performance and heat loss measured over 1-week period (if applicable)

Worked example

The calculation can be done either using data from permanent M&V, or third party instrumentation.

A hotel with 400 guestrooms is served by a hot water plant with 2 nos of water-to-water heat pumps and targeting Green Mark Gold.

Step 1 - Determine the hot water usage profile

Consultant calculated the hot water consumption, estimated to be at the range of 20 to 160 kW with the average at 80 kW.

Step 2 - Propose hot water plant configuration and derive the respective power input of various components

The proposed hot water plant configuration for the building operating hours specified are as follows:

- **Heat Pumps**: 2 nos 180 kW with multiple compressors (1 duty and 1 standby).
  Hot water Inlet / Outlet temperature: 50/55°C, Chilled water Inlet / Outlet temperature: 12/7°C, rated COP 3.3.
- **Calorifier tanks**: 2 nos of 5.0 m^3, with 100kW built-in electrical heater
- **PHWP**: 2 nos, 8.4 L/s @ 15m, rated power 1.74 kW (1 duty and 1 standby).
- **CHWP:** 5.9 L/s @ 10m rated power 0.82 kW (1 duty and 1 standby).

- **HWRP:** 2 nos each at High Zone & Low Zone : 1 L/s@ 5m, rated power 0.11kW
  (1 duty and 1 standby).
- **MWP**: No dedicated Make-up Water Pump for hot water system.

The hot water plant is located at basement 1, just beside chiller plant.

A	Effective Hot Water Energy Consumption, Q3	80.0 kW	
B	Total Energy Loss Rate (TELR)	40%	(Assumed)
C	Heat Pump Output, Q1	133.3 kW	=A / (1-B)
D	Heat Pump COP	3.3	
E	Heat Pump average operating Power, P1	40.40 kW	=C / D
F	PHWP Operating Power, P2	1.74 kW	
G	CHWP Operating Power, P5	0.82 kW	
H	HWRP Operating Power (2nos), P4	0.22 kW	
I	**Total Power , Ptot**	**43.18 kW**	=E+F+G+H
J	Heat removed from Heat Source, Q4	92.9 kW	=(D-1)/D * C, or = C-E
K	Chiller Plant efficiency	0.65 kW/RT	
L	Electricity power recovered, E_R	17.2 kW	=J *(K /3.517)
M	**HWSR**	**3.1**	=A/(I-L)

The project achieves HWSP of 3.1, better than baseline of 1.45 baseline, so score 1 points.

For improvement 0.02 x (3.1 -1.45) /1.45 x100

= 2.28 points (capped at 1point)

Hence, total point for hot water efficiency = 1 + 1 = 2 points

No heat loss is calculated (but assumed), no point scored.

No provision for permanent M&V Instrument, no point scored.

So total Green Mark point achieved is 2.

5.15 Use of Persistent Bio-Cumulative and Toxic (PBT) Free Lighting

Intent

Indoor contaminant pollution control at source can safeguard the health of building occupants.

Assessment Criteria

A maximum of 0.5 points can be scored for the use of PBT-reduced or free luminaries for ≥ 90% of light fittings in the project. PBT-reduced luminaries can be considered if the details of the mercury content and/or other PBT elements of the luminaries can be established. Such fittings should have mercury content of ≥50% lower than permissible limit, as per Environmental Protection and Management Act (Chapter 94A).

Documentation Requirements

Delivery orders and data sheets of the luminaries that demonstrate that they are PBT-reduced or free luminaries.

5.16 Adoption of Smart Facilities Management (FM)

Intent

To encourage the adoption of smart technology solutions that can improve workflow processes, increase productivity, enhance maintenance capabilities and service quality of the building's FM team.

Assessment Criteria

A maximum of 3 points will be awarded for the following:

- Conduct a feasibility study using the 5-step SMART process template including a cost benefit analysis [refer to Guidance Notes below on extracts from the "Guide to Smart FM"] (0.5 point)
- Implementation of smart technology solutions based on level of impact, with extent of adoption more than 50% as compared to the overall application or total quantities used for the same intended purpose:

Points Based on Impact of Smart Solutions (Up to 2.5 points)	
High Impact	1 point
Low Impact	0.5 point

Examples such as, but not limited to, the following:

- Usage of robotics for feedback and optimisation of processes (e.g. cleaning, security)
- Usage of video monitoring coupled with facial recognition for incident detection in security function
- Workflow automation to streamline FM services with feedback loop
- Use of digital twin to monitor assets and enable predictive maintenance

* The technology solutions shall be procured under an outcome-based performance contract. Outcome KPIs shall be tracked and reviewed for continuous improvement upon implementation. Training shall also be provided for the FM team on the use of these technology solutions.

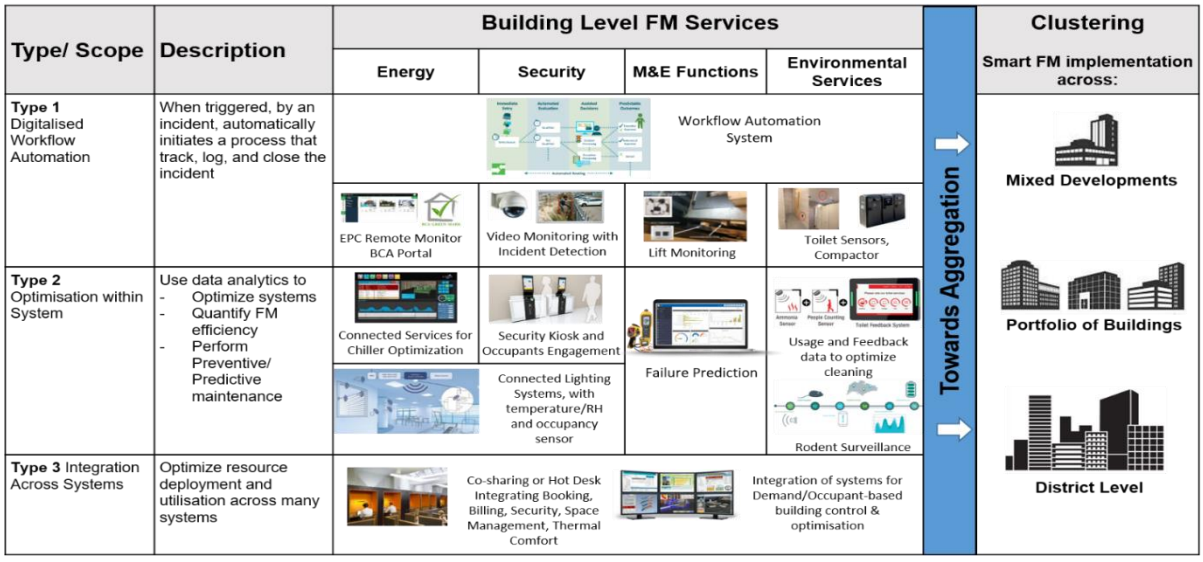
Documentation Requirements

- Completed 5-Step SMART Process Template and cost-benefit analysis
- Delivery orders, user manuals, test and commissioning reports for procured smart technology solutions
- Contract procured with clause showing outcome-based performance indicator
- Training slides including attendance sheet for FM personnel

Guidance Notes

Guide to Smart FM: www.bca.gov.sg/greenmark/others/guide_to_smart_fm.pdf

Smart FM Framework



5-Step SMART Process Template

S

SET BUSINESS OBJECTIVES & OUTCOMES

Choose 3 only

Business Objective	Desired FM Outcome and Corresponding KPI
☐ Cost	*e.g. To reduce operating cost by 10% by 2021*
☐ Manpower (Internal/External)	
☐ System Reliability	
☐ Productivity	
☐ Customer satisfaction	
☐ Security requirements	
☐ Others, please specify:	

M

MAP OUT FM SOLUTIONS AS ENABLERS

Identify FM solutions (e.g. Company A Solution - video analytics) to meet business objective and outcome
Classify FM solutions into Category 1/2/3 (type not in order of merit)

	FM Services				Towards Aggregation	Implementation across cluster of buildings
	e.g. M&E Functions	*e.g. Security*	*e.g. Cleaning Services*	Others, please specify :		
Type 1: Digitalised workflow automation	*e.g. BCA Smart Chiller Portal*	*e.g. Company A Solution*				☐ Yes ☐ No
Type 2: Optimisation within system only			*e.g. Company B Solution*			
Type 3: Integration/ Synergy across system						

A

ADOPT SUITABLE IMPLEMENTATION MODEL

Classify FM solutions into Model A/B

Implementation Model to Adopt	FM Solutions
Model A: Integrated Smart FM Solutions *(Each smart FM solution feeds data into one centralised system)* ☐ Solution as a Service via FMC ☐ Acquired & Operated by Building Owner	*e.g. BCA Smart Chiller Portal, Company A Solution*
Model B: Single Smart FM Solutions *(Multiple smart FM solutions with multiple platforms to use)*	

R

REVIEW PROCUREMENT CONTRACT

Integrated FM contract for all chosen FM services:
☐ Yes ☐ No, please specify FM services excluded: _____

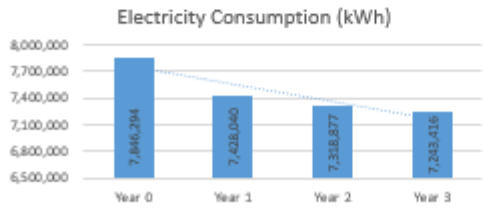
Adopt outcome/performance based contract(recommended)
☐ Yes ☐ No

FM Services Contract Term (recommended 5 to 10 years):
☐ 3+3 ☐ 5+5 ☐ 8 ☐ Others: _____

T

TRACK OUTCOMES AND REVIEW FOR CONTINUOUS IMPROVEMENT

Sample chart to track outcome KPI
Repeat this step for remaining business objectives and outcomes



Status: ☐ Behind ☐ On Track ☐ Ahead

Areas for further improvement/ Proposed recommendation: _____

Any new/emerging smart FM technology: ☐ Yes ☐ No
If yes, please specify: ____

Cost Benefit Analysis Table

Business Objectives and Desired FM Outcomes	Smart FM Solutions Adopted	Upfront Developmental Costs (A)	Recurring or Yearly Maintenance Costs (B)				Total Cost of Ownership/ Life Cycle Cost (A+B)	Annual Benefit	Total Benefit Over Entire Life Cycle	Feasibility Study Recommendation
		Year 0	Year 1	Year 2	Year 3	Remaining Years				
#1: *e.g. To reduce electricity cost by 20%*	*e.g. Chiller plant optimisation*									
	e.g. Smart lighting with occupancy sensors									
#2: *Please specify*										
#3: *Please specify*										

5.17 Other Advanced Green Effort

Intent

This criterion rewards buildings which demonstrate substantial performance beyond what is specified in criteria.

Assessment Criteria

Additional points can be awarded, on a case-by-case basis, to buildings which demonstrate substantial and exemplary performance beyond what is specified in the criteria:

Coverage	Impact	Points
≥10% and < 30% of the project	Low	0.5 point per item
≥30% and <60% of the project	Medium	1 point per item
≥60% of the project	High	2 points per item

References

P2 Air-Conditioning System Minimum Operating Efficiency

SS530:2006 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment; SPRING Singapore

SS553:2009 – Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings; SPRING Singapore

P3 Energy Improvement on Lighting System

SS530:2006 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment; SPRING Singapore

CP38:1999 – Code of Practice for Artificial Lighting in Buildings

SS531-1 2006 (2013) – Code of Practice for Lighting of Workplaces – Indoor; SPRING Singapore

P5 Permanent Instrumentation for the Measurement and Verification of Chilled Water Air Conditioning Systems

ASHRAE Guideline 22 (2012 – Instrumentation for Monitoring Central Chilled-Water Plant Efficiency; American Society of Heating, Refrigerating and Air-Conditioning Engineers

BCA (2011) – FAQs on Instrumentation for Permanent Measurement and Verification for Water-Cooled Chilled Water Plant System.

SS591: 2013 – Code of Practice for Long Term Measurement of Central Chilled Water System Energy Efficiency; SPRING Singapore

P6 Indoor Temperature

SS553:2016 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment; SPRING Singapore; SPRING Singapore

P7 IAQ Surveillance Audit

SS554:2016 – Code of Practice for Indoor Air Quality for Air-Conditioned Buildings; SPRING Singapore

Guidelines for Good Indoor Air Quality in Office Premises; NEA

1.1 Environmental Credential of Facility Managers and Consultants

Certification requirements for Certified GMFM / GMFP: https://www.bca.gov.sg/greenmark/gm_manager.html

BCA Certified GMFM: https://www.bca.gov.sg/greenmark/others/GMFM-List.pdf

BCA Certified GMFP: https://www.bca.gov.sg/greenmark/others/GMFP-List.pdf

1.6 Green Lease

BCA Green lease Toolkit: https://www.bca.gov.sg/sustain/sustain.html

1.8d Sustainable Landscape Management

Landscape Excellence Assessment Framework (LEAF); Nparks

https:www.nparkks.gov.sg/partner-us/landscape-industry/leaf

1.9b Refrigerant Leak Detection System

ANSI/ASHRAE Standard 15-2016 – Safety Standard for Refrigeration System

ANSI/ASHRAE Standard 34-2016 – Designation and Safety Classification of Refrigerants

1.9c Refrigerant Management System

Chapter 3: Refrigerants Management, from UNEP's Manual for Refrigeration Servicing Technicians:

http://www.unep.fr/ozonaction/information.mmcfiles/7443-e-Ref_manual_servicing_technicians.pdf

1.11b and 1.11c Performance-based Procurement for Retrofitting and Maintenance

Energy Performance Contracting; SGBC: http://www.sgbc.sg/sgbc-certifications/2-uncategorised/479-epc-certification

Certified Energy Performance Contracting firms: https://sgbc.online/certification-directory/services/2/

1.11d System Handover and Documentation

ASHRAE Guideline 1.1 – HVAC & R Technical Requirements for the Commissioning Process;

ASHRAE Guideline 1.4 – Procedures for Preparing Facility Systems Manuals;

ASHRAE Guideline 11 – Field Testing of HVAC Controls Components

2.1 Façade Performance

Code on Envelope Thermal Performance for Buildings (2008); BCA

2.2 Air-conditioning System Efficiency

SS530:2006 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment; SPRING Singapore

SS553:2009 – Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings; SPRING Singapore

2.3 Natural / Mechanical Ventilation Performance

SS553:2009 – Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings; SPRING Singapore

2.4 Lighting System Efficiency

SS530:2006 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment; SPRING Singapore

CP38:1999 – Code of Practice for Artificial Lighting in Buildings

SS531-1 2006 (2013) – Code of Practice for Lighting of Workplaces – Indoor; SPRING Singapore

Annex A of Green Mark for Existing Non-Residential Buildings (GM ENRB: 2017): Maximum lighting power budget (including ballast loss)

2.5 Ventilation in Carpark

SS553:2009 – Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings; SPRING Singapore

2.7 Ventilation in Common Areas

SS553:2009 – Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings; SPRING Singapore

3.1 Water Efficient Fittings

PUB Water Efficiency Labelling Scheme

3.2 Landscape Irrigation System

Fora & Fauna Web; Nparks

3.7a – b Green Products and Materials

Singapore Green Building Product Certification Directory; SGBC

Singapore Green Labelling Scheme Directory; SEC

3.8 Recycling Facilities

Waste minimization and recycling; NEA

4.1 Occupant Comfort - Thermal Comfort

SS553:2016 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment; SPRING Singapore

SS554:2016 – Code of Practice for Indoor Air Quality for Air-Conditioned Buildings; SPRING Singapore

4.1 Occupant Comfort - IAQ Management

Workplace Safety and Health Guidelines

4.2 Outdoor Air Control

SS553:2016 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment; SPRING Singapore

SS554:2016 – Code of Practice for Indoor Air Quality for Air-Conditioned Buildings

4.3 Enhanced Filtration Media

SS553:2016 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment; SPRING Singapore

SS554:2016 – Code of Practice for Indoor Air Quality for Air-Conditioned Buildings; SPRING Singapore

4.5 Lighting Quality

CP38:1999 – Code of Practice for Artificial Lighting in Buildings

SS531-1 2006 (2013) – Code of Practice for Lighting of Workplaces – Indoor; SPRING Singapore

4.6 Acoustics

SS553:2016 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment; SPRING Singapore

CP13:1999 – Code of Practice for Mechanical Ventilation and Air-Conditioning in Buildings

4.8 Energy Monitoring

ANSI/ASHRAE Standard 135: BACnet – A Data Communication Protocol for Building Automation and Control Networks

Modbus Organization, Inc (2016). The Modbus Organisation and Specifications

SS553:2016 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment; SPRING Singapore

4.8c BAS and Controllers with Open Protocol

BS EN 15232:2012 'Energy Performance of Buildings – Impact of Building Automation, Controls, and Building Management'; British Standards Institution

5.6 Enhanced Performance: High Temperature Cooling

ASHRAE Standard 55 – Thermal Comfort Conditions for Human Occupancy

ISO 7730 – Ergonomics of the Thermal Environment, analytical determination and interpretation of thermal comfort using calculation of the PMV and PPD indices and local thermal comfort criteria

CEN Standard EN 15251 – Indoor Environmental Input Parameters for Design and Assessment of Energy Performance of Buildings addressing indoor air quality, thermal environment, lighting, and acoustics

5.7 Enhanced Performance: IAQ Surveillance Audit

SS554:2016 – Code of Practice for Indoor Air Quality for Air-Conditioned Buildings; SPRING Singapore

5.8 Enhanced Performance: Outdoor Airflow Monitoring System

SS553:2016 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment; SPRING Singapore

5.11 Enhanced Performance: Local Exhaust and Air Purging System

SS553:2016 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment; SPRING Singapore

Appendix

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

Type of usage	Maximum lighting power budget (W/m^2)
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	6
Corridors	10
Toilets	15
Car parks	5
Electronic manufacturing and fine detail / Assembly industries	20
Medium and heavy industries	15
Warehouses / Storage areas	10

Annex B - REST API to Import Chiller Data

Title	*REST API to insert chiller plant raw data*
URL	*e.g. https://bca_cesp.portal.com/api/ImportRawData*
Method	*The request type* **POST**
URL Params	*Not Required*
Data Params	*[* *{* *"BuildingId": "buildinga",* *"ObjectId": "CH",* *"ObjectNo": "1",* *"DataFieldId": "KW",* *"Value": "110",* *"Timestamp": "2016-01-16 02:15:01",* *"Key": "secretkey"* *},* *{* *"BuildingId": "uwctamp",* *"ObjectId": "* CHWP*",* *"ObjectNo": "1",* *"DataFieldId": "* CWST*",* *"Value": "11.40",* *"Timestamp": "2016-01-16 02:15:01",* *"Key": "secretkey* *"},* *]*
Success Response	**Example:** **Code:** 200
Error Response	***Code:** 400, if buildingId not valid* ***Code:** 402, if building object datafield mapping not valid* ***Code:** 403, if secrectkey for that building is not correct* ***Code:** 404, Other problem*
Notes	

Building Object Naming Dictionary

Item	Type	Input	Remarks	Constraints
BuildingId	String	BuildingA	Building ID	1 to 50 character
ObjectId	string	CH	Chiller	1 to 50 character
		CHWP	Chiller Water Pump	1 to 50 character
		CWP	Condenser Water Pump	1 to 50 character
		CHWH	Chilled Water Header	1 to 50 character
		CWH	Condenser Water Header	1 to 50 character
		CT	Cooling Tower	1 to 50 character
		AIR	Air Distribution System	1 to 50 character
ObjectNo	numeric	1..10	Instance number	1 to 10
DataFieldId	String	CHWST	Chilled Water Supply Temperature	1 to 50 character
		CHWRT	Chilled Water Return Temperature	1 to 50 character
		CWST	Condenser Water Supply Temperature	
		CWRT	Condenser Water Return Temperature	
		CWF	Condenser Water Flow	
		CHWF	Chilled Water Flow	1 to 50 character
		KW	Power	1 to 50 character
Value	numeric	1..999999	Value of that point	decimal value
Timestamp	Cal + time	2016-01-16 02:15:01	Datetime format	yyyy-mm-dd hh:mm:ss
Unit	String			
Remarks	String			
Key	String	Secret key	Building secret key provided by Vendor	1 to 10 character