



BCA Green Mark for New Buildings (Non-Residential)

2015

For Pilot

Green Mark 2015 Revision Log

Revision	Description	Date Effective
R0	Launch for Pilot	02/09/2015

For Pilot

What is Green Mark?

The Building and Construction Authority (BCA) Green Mark scheme was launched in 2005 and is an internationally recognised green building rating system tailored for the tropical climate. 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 is comprised of a number of distinct rating tools that together holistically rate the built environment for its environmental performance. These include:

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

Green Mark 2015

Green Mark for New Buildings – (Non-Residential) 2015 is the fifth edition of the Green Mark scheme for new buildings. Developed with extensive industry collaboration and 10 years of Green Mark, this version delivers:

- A streamlined criteria that ***addresses sustainability in a more balanced and holistic manner***
- ***Greater Emphasis*** – climatically contextual design, energy effectiveness, greater focus on health and wellbeing of building occupants, smart buildings, and a systematic approach to addressing embodied energy and resource use.
- Recognises the design process and encourages due processes to respond to site context which facilitates ***sustainability to be considered at the early project stages*** where there is the greatest opportunity for low cost, high reward options to be implemented.
- Green Mark itself becomes a ***design guide and accessible to professionals, students and the population at large***
- A ***collaborative framework***– with 102 external industry members involved in its setting of metrics, assessment methods and performance levels.

Why Green Mark?

Green Mark provides a consistent method to assess and verify buildings for their overall environmental performance which assists project teams to deliver a more sustainable built environment and encourages best practice and market transformation.

Green Mark 2015 provides a platform to recognise and make mainstream the leadership needed to drive creative, organisational & technical improvements to the overall environmental credentials of projects. It aims to further stretch building outcomes to substantially reduce the environmental impacts and increase the life-cycle quality of projects.

The assessment process of Green Mark is based on a face to face assessment with BCA Green Mark officers, thus the assessments are rigorous, independent from commercial interests and fair. BCA Green Mark is ISO 9001 certified for its quality assurance processes ensuring a robust system is in place for project certification.

Outcomes of Green Mark 2015

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

Climate Responsiveness

A Green Mark building demonstrates its emissions reduction and its resilience to the effects of climate change. This means that the building will have a closer connection to the climate in which it is located through considered contextual design that take advantage of climatic vernacular as well as low carbon active technology.

Resource Stewardship

As stewards of the earth's resources, a Green building will use resources in an efficient manner to reduce its environmental footprint over the building life cycle. The building will demonstrate its effective management of energy, water and waste as well as the use of physical resources including the choice of construction materials and construction methods, the material finishes, and the embodied energy of the building.

Health & Wellbeing

A Green building shall contribute positively to the health and wellbeing of the user. It should be comfortable and a healthy conducive environment that is fit for its purpose. This ensures that the built environment enhances its vibrancy and liveability which is important for human health.

Conservation of Ecological Systems

A Green Building considers its wider impact on the biosphere through the integration of nature and protection of natural systems including flora and fauna.

Assessment Process

The BCA Green Mark Certification Process is as follows:



- Submittal of application with relevant supporting documents for certification upon finalisation of building design.
- 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 documentary evidences are ready.
- Assessment process includes design and documentary reviews to verify if the building project meets (i) the intents of the criteria and certification level; and (ii) the prerequisite requirements.
- For projects with potential BCA Green Mark Gold^{Plus} and Platinum rating, there is a requirement for projects to be presented and assessed by panel members.
- Site verification to be conducted upon project completion.
- 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.
- For projects with BCA Gold^{Plus} and Platinum rating, energy savings based on the actual building operating data and parameters will be required to ascertain the energy performance of the building

Green Mark 2015 Ratings

The environmental performance of a building development shall be determined by the numerical scores (i.e Green Mark points) achieved in accordance with the applicable criteria using the scoring methodology and the prerequisite requirements on the level of building performance as specified in this Green Mark scheme document. Under this assessment framework, points are awarded for incorporating sustainable design 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 development will be eligible for certification under one of the ratings namely BCA Green Mark Gold, Gold^{PLUS} or Platinum. For Singapore projects Green Mark Certified level shall be tied to the Environmental Sustainability Regulations. The design of the building development shall also meet all the relevant mandatory requirements regulated under the Building Control Regulations.

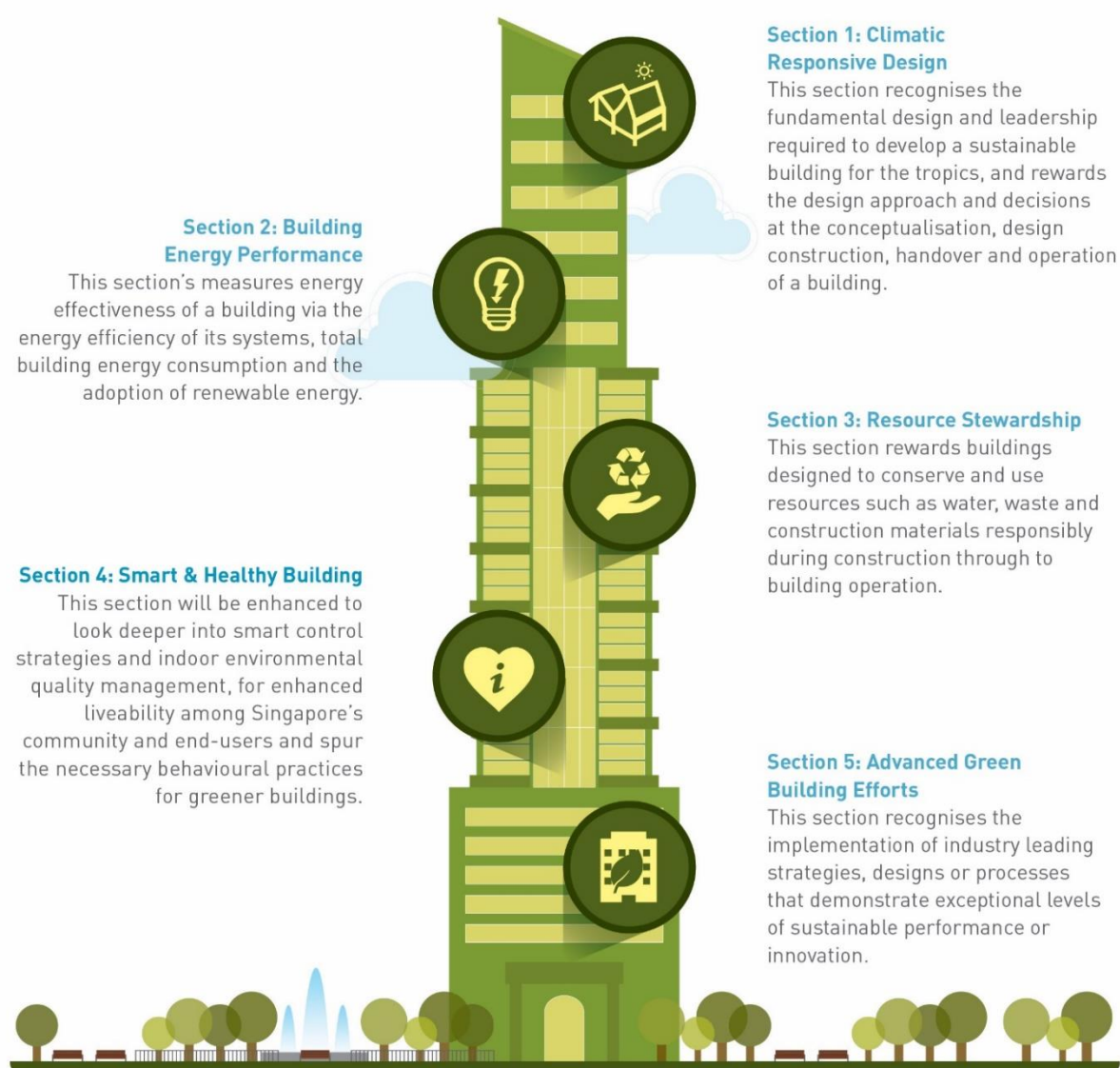
The Green Mark Score of the building design is the total of all the numerical scores (i.e. Green Mark points) assigned based on the degree of compliance with the applicable criteria. The following table states the corresponding Green Mark Score to attain the respective Green Mark rating namely BCA Green Mark Gold, Gold^{PLUS} and Platinum. Buildings must also fulfil their respective pre-requisite requirements to attain the respective Green Mark rating. The total points scored include the bonus points scored under Advanced Green Efforts

BCA Green Mark Award Rating

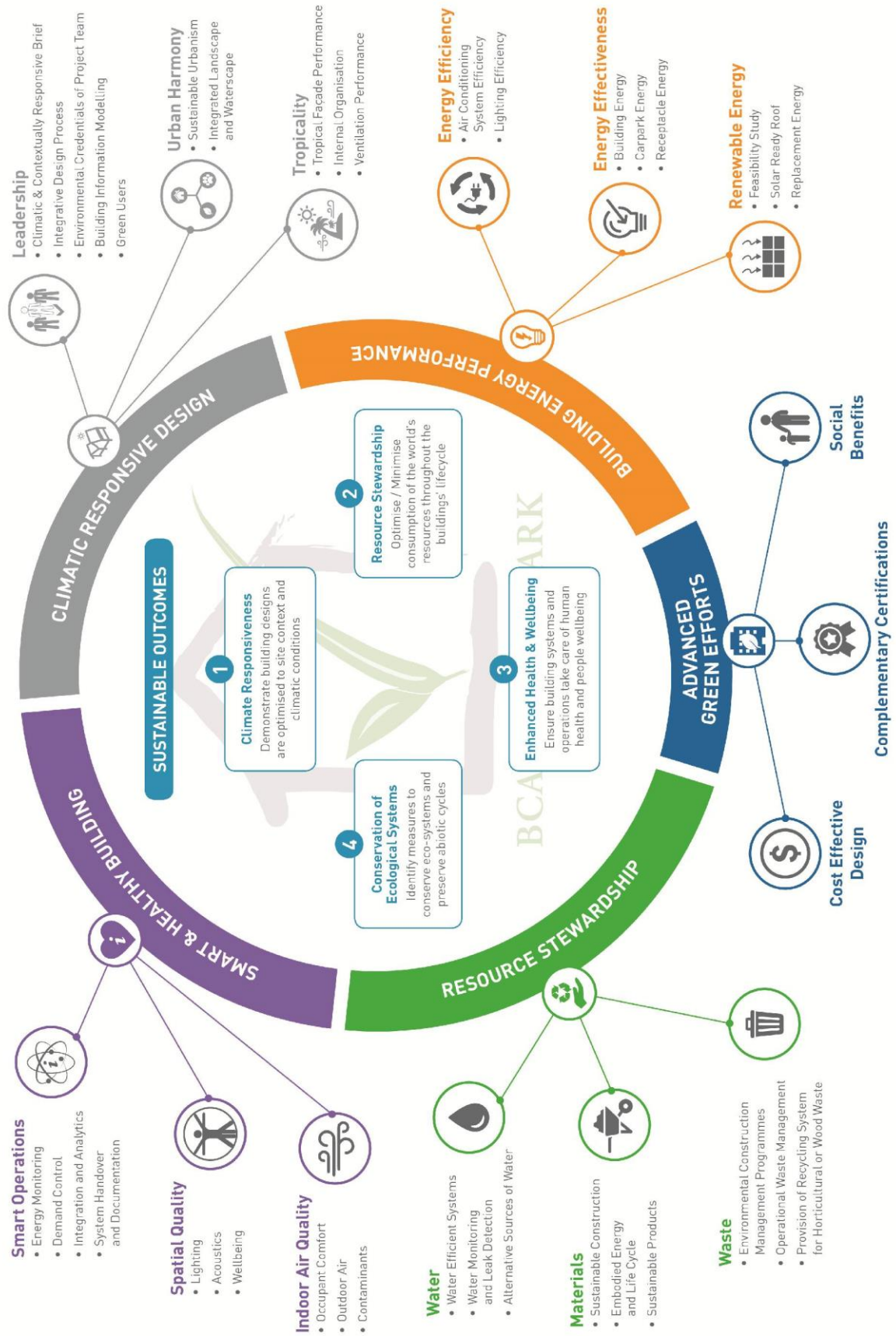
Green Mark Score	Green Mark Rating
70 and above	Green Mark Platinum
60 to < 70	Green Mark Gold ^{PLUS}
50 to < 60	Green Mark Gold
Green Mark Certified is equivalent to the BCA Regulation for Environmental Sustainability	

Criteria Overview

To dovetail the criteria with the sustainable outcomes of Green Mark 2015, the criteria will be re-structured into 5 sections, with 16 criteria and 79 sustainability indicators.



GM 2015 CRITERIA AND INDICATORS



Green Mark 2015 Indicators

S/N	Item	Points	Page
Pre Requisites			
P01 – P22	Prerequisites for All Projects	NA	9
P.23 – P38	Pre-requisite Requirements – Gold, Gold ^{PLUS} and Platinum Awards	Varies	44
1. Climatic Responsive Design		30	65
1.01	Leadership	10	66
1.01a	Climatic and Contextually Responsive Brief	1	67
1.01b	Integrative Design Process	2	68
1.01c	Environmental Credentials of Project Team	2	69
1.01d	Building Information Modelling	2	70
1.01e	User Engagement	3	73
1.02	Urban Harmony	10	76
1.02a	Sustainable Urbanism	5	77
1.02b	Integrated Landscape and Waterscape	5	84
1.03	Tropicality	10	89
1.03a	Tropical Façade Performance	4	90
1.03b	Spatial Quality and Internal Organisation	2	94
1.03c	Ventilation Performance	4	95
2. Building Energy Performance		30	99
2.01	Energy Efficiency	7	100
2.01a	Air Conditioning Total System Efficiency	4	101
2.01b	Lighting Efficiency	3	103
2.02	Energy Effectiveness	15	104
2.02a	Building Energy	11	105
2.02b	Car Park Energy	2	106
2.02c	Receptacle Energy	2	107
2.03	Renewable Energy	8	108
2.03a	Feasibility Study	0.5	109
2.03b	Solar Ready Roof	1.5	111
2.03c	Replacement Energy	6	113
3. Resource Stewardship		30	115
3.01	Water	8	116
3.01a	Water Efficient Systems	3	117
3.01b	Water Monitoring and Leak Detection	2	122
3.01c	Alternative Sources of Water	3	126
3.02	Materials	18	127
3.02a	Sustainable Construction	8	128
3.02b	Embodied Energy and Life Cycle	2	134
3.02c	Sustainable Products	8	135
3.03	Waste	4	141
3.03a	Environmental Construction Management Programmes	1	142
3.03b	Operational Waste Management	2	144
3.03c	Provision of Recycling System for Horticultural or Wood Waste	1	145

S/N	Item	Points	Page
4. Smart and Healthy Building		30	146
4.01	Indoor Air Quality	10	147
4.01a	Occupant Comfort	2	148
4.01b	Outdoor Air	3	153
4.01c	Contaminants	5	158
4.02	Spatial Quality	10	164
4.02a	Lighting	6	165
4.02b	Acoustics	2	174
4.02c	Wellbeing	2	180
4.03	Smart Building Operations	10	184
4.03a	Energy Monitoring	3	185
4.03b	Demand Control	3	188
4.03c	Integration and Analytics	3	191
4.03d	System Handover and Documentation	1	195
Green Mark Points Total		120	
5. Advanced Green Efforts		20	200
5.01	Enhanced Performance	15	201
5.02	Demonstrating Cost Effective Design	2	202
5.03	Complementary Certifications	1	203
5.04	Social Benefits	2	204

0. Pre-requisite Requirements

Pre-requisite Requirements

The pre-requisites for Green Mark 2015 sets the minimum environmental considerations that a project shall demonstrate based on industry norms. It includes provisions from other BCA's Building Control Act's Approved Document, Singapore Standards, as well as regulations by other government bodies where relevant.

The pre-requisite section has been organised to lead the project team through the various performance requirements necessary to achieve the level of rating desired.

The pre-requisites for all projects must be achieved in order to progress to score Green Mark points in the 5 main green mark sections.

Pre-requisites for All Projects:

P.01-P.22 shall be achieved by all projects in order to be eligible for Green Mark Certification.

Pre-requisites for Gold, Gold^{PLUS} and Platinum:

All pre-requisites above shall be met with the applicable additional requirements in P.23-P.38.

Pre-requisite Requirements – All Projects

P	Pre-Requisite Requirements for All Projects
P01	Envelope Thermal Transfer Value (ETTV)
P02	Maximal Thermal Transmittance for Roof
P03	Air tightness and leakage
P04	Air Conditioning Design System Efficiency
P05	Permanent Instrumentation for the Measurement and Verification of Air Conditioning Systems
P06	District Cooling System Efficiency
P07	Energy Recovery Systems
P08	Refrigerants
P09	Minimum Ventilation Rate
P10	Filtration Media for Times of Pollution
P11	Thermal Comfort
P12	Minimum Illuminance Levels
P13	Artificial Lighting Energy Performance
P14	Visible Flicker Free Lighting
P15	Vertical Transportation Efficiency
P16	Electrical Sub-Metering & BMS
P17	Energy Systems Controls
P18	Water Efficient Fittings
P19	Cycle of Concentration for Cooling Towers
P20	Low VOC Paints
P21	Sound Level
P22	Bicycle Parking

P.01 Envelope Thermal Transfer Value (ETTV)

Intent

To reduce air conditioning energy consumption to cool the indoor environment of the building due to thermal heat gain through the building façade.

Scope

Applicable to all buildings with GFA $\geq 2000\text{m}^2$ and air-conditioned areas $\geq 500\text{ m}^2$.

Assessment

As determined in accordance with the formula set out in the “*Code on Envelope Thermal Performance for Buildings*”, the ETTV shall not exceed:

Table P.01 -1 Maximum ETTV

Level of Award	Maximum ETTV
Certified	45W/m ²
Gold	45W/m ²
GoldPlus	40W/m ²
Platinum	38W/m ²

Guidance Notes

At Design Stage:

Submission of the following:

- ETTV calculation
- 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
- Extracts of the tender specification or material schedules showing the material properties of the façade and external walls

Verification (As Built):

Submission of the following:

- Purchase orders/ delivery orders of the façade and external wall system
- As-built material schedules showing the material properties of the façade and external walls
- Revised ETTV calculation in the event of any design changes that negatively affect the ETTV

References

BCA Singapore (2008) ‘Code on Envelope Thermal Performance for Buildings’; Retrieved: <http://www.bca.gov.sg/PerformanceBased/others/RETV.pdf>

P.02 Roof Thermal Transfer

Intent

To reduce thermal heat gain through the building roof.

Scope:

Applicable to all buildings with GFA $\geq 500\text{m}^2$

Where a building is partially air-conditioned and the aggregate air-conditioned area is $< 500\text{m}^2$, the U-value for the gross area of the roof shall adhere to Table P.03-2 as well.

Assessment

For buildings with aggregate air-conditioned area $\geq 500\text{m}^2$

For roofs with skylights, the Roof Thermal Transfer Value (RTTV) as determined in accordance with the formula set out in the Code on Envelope Thermal Performance for Buildings shall not exceed 50W/m^2 .

For roofs without skylights, the average thermal transmittance (U-value) for the gross area of the roof shall not exceed the limit prescribed in the table below for the corresponding weight group:

Table P.02 -1 Maximum Thermal Transmittance for roof of air-conditioned building

Weight Group	Weight Range (kg/m^2)	Maximal thermal transmittance – U-value ($\text{Wm}^{-2}\text{K}^{-1}$)
Light	< 50	0.5
Medium	50 to 230	0.8
Heavy	> 230	1.2

For non-air-conditioned buildings and buildings with aggregate air-conditioned area $< 500\text{m}^2$

For roofs of predominantly non-air conditioned buildings, the U-value for the gross area of the roof shall not exceed the limit prescribed in the table below for the corresponding weight group:

Table P.02 -2 Maximum Thermal Transmittance for roof of non-air-conditioned building

Weight Group	Weight Range (kg/m^2)	Maximal thermal transmittance – U-value ($\text{Wm}^{-2}\text{K}^{-1}$)
Light	< 50	0.8
Medium	50 to 230	1.1
Heavy	> 230	1.5

The limits stipulated in Table P.02-2 does not apply to open sided sheds, linkways, covered walkways, store rooms, utility rooms, plant rooms and equipment rooms

Guidance Notes

At Design Stage:

Submission of the following:

- RTTV calculation or U-value calculations
- The weight calculations of the various roofs and their detailed cross section
- Architectural plan layouts and elevations of the roof areas and the air-conditioned spaces
- The weight calculations of the various roofs and their detailed sectional drawings of the roof composition
- Extracts of the tender specification or material schedules showing the material properties of the roofs

Verification (As Built):

Submission of the following:

- Purchase orders/ delivery orders of the roof materials
- As-built material schedules showing the material properties of the roof
- Revised RTTV or U value calculation in the event of any design changes that negatively affect those values

Definitions

Roof Thermal Transfer Value (RTTV): A measure of the average heat gain into a building through its roof.

References

BCA Singapore (2008) 'Code on Envelope Thermal Performance for Buildings'; Retrieved: <http://www.bca.gov.sg/PerformanceBased/others/RETV.pdf>

P.03 Air tightness and leakage

Intent

To design the building envelope to prevent uncontrolled air leakage, and thus minimise any infiltration of pollutants and hot and humid air from outdoors.

Scope:

Applicable to all building envelopes bounding air-conditioned spaces.

Assessment

All windows on the building envelope shall not exceed the air leakage rates as specified in SS 212: 2007 – Specification for Aluminium Alloy Windows.

Guidance Notes

At Design Stage:

QP declaration that design of the fenestrations and the onsite construction quality will ensure air leakage rates will not be exceeded.

Verification (As Built):

Submission of air tightness & leakage verification report

References

Singapore Standard 212 (2007) 'Specification for Aluminium alloy windows'; SPRING Singapore

ISO 9972 (2006) 'Thermal performance of buildings – Determination of air permeability of buildings – Fan pressurisation method' International Standards Organisation.

P.04 Air Conditioning System Efficiency

Intent

Air conditioning systems are one of the most energy intensive components of the base building. Air-conditioning systems should be sized based on an accurate peak building cooling load as well as the cooling load profile so as to meet the operating load conditions with optimal efficiency. Various combinations of chillers should be considered and designed to match the intended building cooling load profile during operation for better energy performance.

Where the cooling capacity of any air-conditioning system exceeds 30 kW, the equipment shall comply with the relevant provisions of SS 530: 2014 - Code of Practice for Energy Efficiency Standard for Building Services and Equipment and SS 553: 2015 - Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings.

P.04 (i) – Water Cooled Chilled Water Systems

P.04 (ii) – Air Cooled Chilled Water Systems and Unitary Systems

P.04 (i) Water Cooled Chilled Water Systems

Scope

Applicable to air-conditioned building areas with an aggregate air conditioned floor area $\geq 500\text{m}^2$ using a central water cooled chilled water system. The plant efficiency includes chillers, associated pumps and cooling towers.

Assessment

The design system efficiency (DSE) of the chilled water plant shall be computed based on the simulated operational design load profile with the power inputs of the various system components selected over the operating range of the cooling load conditions.

The following minimum design system efficiencies must be met:

Table P.04-1 Minimum Design System Efficiency of Water Cooled Chilled Water Plants

Green Mark Rating	Building Cooling Load (RT)	
	<500 RT	$\geq 500\text{RT}$
	Minimum Design System Efficiency (kW/RT)	
Certified	0.8	0.7
Gold	0.75	0.68
GoldPlus	0.7	0.65
Platinum	0.68	0.65

Building Cooling Load is determined based on the peak load on the design day. The Design System Efficiency (DSE) is based upon the Operational Design Load which is determined by the average load profile through an annual heat load simulation

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Simulated cooling load profile over the operational hours prescribed and the inputs used
- Plan layouts showing the mode of ventilation of spaces within the building as well as the location of the plant room and cooling towers.
- Technical specifications and product information of the various components of the building cooling system designed for.
- Detailed calculations of the part load power consumption of the various components over the operational design load profile
- Pump head calculations

Verification (As Built):

Submission of the following if applicable:

- Delivery orders of air conditioning system
- Completed Operational System Efficiency report of the air conditioning system detailing the total operational performance measured over a 1 week period.

Definitions

Design System Efficiency (DSE): Total kW/RT based on the calculation of the system power input (kWh) over the total building simulated operational design load (RTh).

Peak building cooling load: Determined based on design day conditions, namely where solar gains and outdoor temperatures are at their highest and there is full occupancy.

Operational design load: The simulated building cooling load profile based on the average cooling load for the building's operational hours specific to building type. The operational performance shall be based on the average RT over the time range in table P.04-2.

Table P.04-2 Operational Hours to Ascertain the Design System Efficiency

Building Type	Operational Hours
Office Buildings	9 a.m. to 6 p.m.
Retail Malls	10 a.m. to 10 p.m.
Hotels	24 Hours
Other Building Types	To be determined based on operating hours

References

Singapore Standard 530 (2014) 'Code of Practice for Energy Efficiency Standard for Building Services and Equipment'; SPRING Singapore

BCA Singapore (2013) 'Code on Periodic Energy Audit of Building Cooling System'; Retrieved: http://www.bca.gov.sg/EnvSusLegislation/others/Code_Periodic_Energy_Audit_Bldg_Cool_Sys.pdf

P.04 (ii) Air Cooled Chilled Water Plant or Unitary Conditioners

Scope

Applicable to air-conditioned building areas with an aggregate air conditioned floor area greater than 500m² using either air cooled chilled water systems or unitary systems such as variable refrigerant volume or variable refrigerant flow systems.

The air distribution system efficiency shall be excluded in this instance.

Assessment

The design system efficiency (DSE) of air-cooled chilled-water plant can be computed based on the efficiency at the expected operating part-load condition over the simulated operational design load profile as P.04(i)

The DSE for unitary systems shall be based upon the total weighted system efficiency.

The following minimum design system efficiencies must be met:

Table P.04-3 Minimum Design System Efficiency of Air Cooled Chilled Water Plants or Unitary Systems

Green Mark Rating	Building Cooling Load (RT)	
	<500 RT	≥500RT
	Minimum Design System Efficiency (kW/RT)	
Certified	0.9	0.8
Gold	0.9	DSE Must demonstrate equivalency with P.04(i) to be considered.
GoldPlus	0.85	
Platinum	0.78	

For areas with unitary system cooling, each system zone shall be simulated and the total weighted system efficiency derived over the total weighted cooling load ($RTh_{weighted} \times COP_{weighted}$).

Guidance Notes

At Design Stage:

Placement of the condensing units shall be in accordance to manufacturer's best practice recommendations.

Detailed calculations of the Design system efficiency of the air-conditioning system to be provided substantiated by the following evidence:

- Simulated cooling load profile for design day and operational (average) load including the inputs used. For VRV systems using the weighted operational load (weighted RT)
- Plan layouts showing the mode of ventilation of spaces within the building.
- Plan layouts showing the location of the air-conditioning systems demonstrating placement of the condensing units
- Technical specifications and product information of the cooling system at the rated conditions
- Detailed calculations of the part load power consumption including chilled water pumps for air cooled chilled water systems
- Weighted COP of the VRV/VRF systems
- Total Design System efficiency of the air-conditioning system.

Verification (As Built):

As built schematics, delivery orders and photographs of the air conditioning systems installed with particular emphasis on the actual installation of the condensing units in accordance with manufacturers best practice.

Definitions

Weighted COP:

The weighted COP or Coefficient of Performance is used to calculate the design system efficiency of the unitary system air conditioning based on NEA's method. The weighted COP is calculated through:

$$\text{COP}_{\text{Weighted}} = 0.4 \times \text{COP}_{100\%} + 0.6 \times \text{COP}_{50\%}$$

$\text{COP}_{100\%}$ is defined as the ratio of total cooling capacity to effective power input at full load cooling capacity.

The project team shall calculate the unitary system design system efficiency and convert the units to kW/RT.

Weighted RT

The weighted RT is based upon the operational cooling load of the unitary system. This is calculated based on the operational schedule of the systems through the following method:

$$\text{RT}_{\text{Weighted}} = 0.4 \times \text{RT}_{100\%} + 0.6 \times \text{RT}_{50\%}$$

Where $\text{RT}_{100\%}$ is the installed capacity of the zone (excluding standby units), and $\text{RT}_{50\%}$ is 50% of the installed capacity of the zone (excluding standby units)

Unitary system zones:

A system zone is the internal area that served by a singular unitary system which is determined by the condenser unit and the connected fan coil units (FCU's) or connected Air handling units (AHU's)

Air Cooled Chilled Water Systems DSE:

Calculated in the same way as water cooled chilled water systems, except that there is no condenser water loop.

References

Singapore Standard 530 (2014) 'Code of Practice for Energy Efficiency Standard for Building Services and Equipment'; SPRING Singapore

Singapore Standard 553 (2015) 'Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings'; SPRING Singapore

National Environment Agency (2013) 'Tick Rating and Air-conditioners COP'; Retrieved: <http://www.nea.gov.sg/energy-waste/energy-efficiency/household-sector/tick-rating>

P.05 Permanent Instrumentation for the Measurement and Verification of Air Conditioning Systems

Intent

To encourage the use of better energy management and monitoring of air conditioning systems including air distribution systems, to ensure optimal operational efficiency.

P.05 (i) Water Cooled Chilled Water Systems

Scope

Applicable to all water cooled chilled water systems.

Assessment

Permanent measuring instruments for monitoring of ACMV system efficiency, including the chilled water plant and air distribution subsystem shall be provided. The installed instrumentation shall have the capability to calculate resultant system efficiency (i.e. kW/RT) within 5% of its true value. Each measurement system shall include the sensor, any signal conditioning, the data acquisition system and wiring connecting them.

The permanent instrumentation shall comprise of the measurement of the following:

- All data are to be logged at 1 minute sampling time interval, and recorded to the 3rd decimal digit
- Flow meters are to be provided for chilled-water and condenser water loop and shall be full bore electromagnetic / ultrasonic type of 1% uncertainty or equivalent. Electromagnetic flowmeter shall be capable of electronic in-situ verification to within $\pm 2\%$ of its original factory calibration
- Temperature sensors are to be provided for chilled water and condenser water loop and shall have an end-to-end measurement uncertainty not exceeding $\pm 0.05^\circ\text{C}$ over the entire measurement or calibration range. All 20thermo-wells shall be installed in a manner that ensures that the sensors can be in direct contact with fluid flow. Provisions shall be made for each temperature measurement location to have two spare 20thermos-wells located at both side of the temperature sensor for verification of measurement accuracy.
- Dedicated power meters (of IEC Class 1 or equivalent) and associated current transformers (of class 0.5 or equivalent) are to be provided for each of the following groups of equipment: chillers, chilled water pumps, condenser water pumps, cooling towers and air distribution equipment.
- Minimally 1 weather station set along the cooling towers to measure dry-bulb air temperature and relative humidity.

Guidance Notes

Refer to BCA FAQ's on Instrumentation for Permanent Measurement and Verification for Water-Cooled Chilled Water Plant System.

At Design Stage:

The end to end measurement uncertainty shall be derived through the root sum square formula supported by the following documentation:

- Detailed schematic drawings of the instruments locations and locations of test plugs
- Instrumentation specifications and / or sample data sheets
- Calculation of end to end measurement uncertainty.

Verification (As Built):

The performance verification may include onsite testing by BCA officers.

A heat balance-substantiating test for water cooled chilled-water plant to be computed in accordance with *BCA Code on Periodic Energy Audit of Building Cooling System* shall be submitted with the following information:

- Purchase Orders and Delivery Orders of the instrumentation installed
- Extracts of the instrumentation specifications and brochures
- Instrumentation calibration certificates
- As-built schematic drawings showing the location of each power meters, flow meters and temperature sensors.
- BMS screenshots showing the relevant calibration inputs have been entered for the temperature measurement

References

BCA Singapore (2011) 'FAQs on Instrumentation for Permanent Measurement and Verification for Water-cooled Chilled Water Plant System'; Retrieved: <https://www.bca.gov.sg/GreenMark/others/fqamv.pdf>

BCA Singapore (2013) 'BCA Code on Periodic Energy Audit of Building Cooling System'; Retrieved: http://www.bca.gov.sg/EnvSusLegislation/others/Code_Periodic_Energy_Audit_Bldg_Cool_Sys.pdf

Singapore Standard 591 (2013) 'Code of Practice for long term measurement of central chilled water system energy efficiency'; SPRING Singapore

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

AHRI Standard 550/590 (2011) 'Standard for Performance Rating Of Water-Chilling and Heat Pump Water-Heating Packages Using the Vapour Compression Cycle'; Air-Conditioning, Heating and Refrigeration Institute

P.05 (ii) Air Cooled Chilled Water Systems and Unitary Air Conditioning Systems

Scope

Applicable to all air cooled chilled water systems and unitary systems.

Assessment

Permanent measuring instruments for monitoring of ACMV power consumption, including the air distribution subsystem, shall be provided.

The permanent instrumentation shall comprise of the measurement of dedicated power meters (of IEC Class 1 or equivalent) and associated current transformers (of class 1 or equivalent) provided for: chillers, chilled water pumps, condensing units (CU's) and air distribution equipment.

Guidance Notes

At Design Stage:

Submission of the following:

- Detailed drawings and schematics of the power measurement strategies for the air conditioning system
- Technical specifications and product information for the power meters

Verification (As Built):

Submission of the following:

- Delivery orders and performance specifications of the installed power meters
- As Built schematics showing the location of the power meters

References

Singapore Standard 591 (2013) 'Code of Practice for long term measurement of central chilled water system energy efficiency'; SPRING Singapore

P.06 District Cooling System Efficiency

Intent

To ensure that district cooling systems are being operated in an efficient manner.

Scope

Applicable to air conditioned buildings that are purchasing chilled water from a District Cooling System (DCS) Supplier. A supplier of district cooling services is registered under the Energy Conservation Act (ECA) with the National Environment Agency (NEA).

Assessment

For District Cooling System (DCS), the project shall meet the following cooling system efficiency (kW/RT):

Table P.07-1 Minimum Design System Efficiency of District Cooling Systems

District Cooling System	Required District Cooling System Efficiency (kW/RT)
DCS by service provider (including gazetted by law DCS zones)	0.75 kW/RT * Note: there will be progressive tightening of the standard. <i>This is projected to be 5% improvement in energy efficiency effective between 2018 and 2020</i>

The design system efficiency of the district cooling system shall be computed based on the annual average of the overall system efficiency of the district cooling system declared and submitted by the District Cooling supplier.

Guidance Notes

Disclosure of Efficiency standard of District Cooling Plants - Disclosure is to equip building owners with relevant information (e.g. annual average of the overall DCS efficiency) necessary for the planning and costing the purchase of chilled water from District Cooling suppliers in comparison with conventional standalone chiller system. This knowledge will allow building owners and their project teams to make informed design decisions as well as identifying the strategies required to achieve the targeted Green Mark rating.

At Design Stage:

Submission of the following:

- Simulated operational cooling load profile for the proposed development as defined in P.04(i).
- Technical specification and performance data of the various components of the building cooling system designed including the chilled water pumping systems and the air distribution system efficiency (kW/RT)
- Applicable Measurement and Verification instrumentation as P.05
- Plan layouts showing the mode of ventilation of spaces within the building as well as the location of the applicable air-conditioning systems

Supplier of the District Cooling System will need to provide the following evidence:

- Reports of the annual average of the overall DCS efficiency endorsed by qualified Energy Auditor.

Verification (As Built):

Submission of the following:

- Monthly bills from DCS supplier
- As-built drawings showing DCS connection with the proposed building
- Testing and commissioning report of installed system and components on the building side
- As-built drawings showing installed equipment on the building side
- Purchase Order and Delivery Order of equipment

Supplier of the District Cooling System will need to provide the following evidence:

- Annual average of the overall energy efficiency performance of the district cooling plants by DCS supplier, endorsed by qualified Energy Auditor. Requirements and standards shall refer to BCA Code on Periodic Energy Audit of Building Cooling System

$$\text{Actual energy performance of the DCS plant (kW/RT)} = \frac{\text{Annual electricity consumption of a DCS plant (kWh)}}{[(24 \text{ hrs} * 365 \text{ days}) * \text{Annual Cooling Load(RTh)}]}. \text{ This excludes other auxiliary services (electricity consumption from lighting, mechanical ventilation, air-conditioning systems, receptacle loads etc) as well renewable energy generation}$$
- Audit report on the operating efficiency of the district cooling plant if requested by BCA

References

Singapore Standard 530 (2014) 'Code of Practice for Energy Efficiency Standard for Building Services and Equipment'; SPRING Singapore

Singapore Standard 553 (2015) 'Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings'; SPRING Singapore

International District Energy Association (2008) 'District Cooling Best Practice Guide'

BCA Code on Periodic Energy Audit of Building Cooling System.

P.07 Energy Recovery Systems

Intent

To reduce the energy to condition outdoor air through the use of energy recovery.

Scope

Applicable to projects specified to use energy recovery devices to reduce the cooling demand as per SS 553.

Assessment

For projects where exhaust air of 2.5m³/s or greater from conditioned space in a single location shall have an energy recovery system of at least 60% recovery effectiveness tested under AHRI standard 1060

For projects with no recirculation provided the air volume is < 2.5m³/s the following options are acceptable:

- Provision of run-around coil that could achieve the minimum of 45% energy transfer efficiency
- Provision of plate heat exchanger of minimum 50% energy transfer efficiency or thermal wheel of 65% energy transfer efficiency
- Any other device of minimum 50% energy transfer efficiency

Guidance Notes

At Design Stage:

Submission of the following:

- Performance specifications of the energy recovery systems that shall be used in the project
- Schematics and drawings showing their location
- Detailed design calculations on the energy recovery effectiveness

Verification (As Built):

Submission of as-built schematics and performance specifications of the energy recovery systems installed.

References

Singapore Standard 553 (2015) 'Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings'; SPRING Singapore

P.08 Refrigerants

Intent

To reduce the potential damage to the ozone layer and increase in global warming caused by the release of ozone depleting substances and greenhouse gasses as well as ensuring adequate leak detection systems are in place.

Scope

Applicable to buildings with air conditioning systems.

Assessment

All air conditioning systems in the buildings should use refrigerants with ozone depleting potential (ODP) of zero OR global warming potential (GWP) of less than 100.

A refrigerant leak detection system shall also be installed in critical areas of plant rooms containing chillers and / or other equipment using refrigerants

Guidance Notes

At Design Stage:

Submission of the following:

- Extracts from the tender specification stating the list of refrigerants that are permitted in the project based on their GWP and or ODP
- Extracts from the specification indicating the leak detection system to be installed

Verification (As Built):

Submission of the following:

- List of the refrigerants used in the air conditioning system(s) and the applicable cooling systems
- Details of the installed leak detection system

Definitions

Global Warming Potential (GWP) – the global warming potential of a chemical relative to 1 unit of carbon dioxide, the higher the GWP the higher the global warming potential. The GWP shall be determined through the Intergovernmental Panel on Climate Change (IPCC) methodology using a 100-year Integrated Time Horizon (or ITH)

Ozone Depleting Potential (ODP) - ODP is the ratio of the relative amount of degradation to the ozone layer caused by a particular substance relative to the calculated depletion for the reference gas CFC 11 (ODP = 1.0)

Montreal Protocol has addressed the use and the phase out of the use of CFC's and HCFC's. Currently industry replacement is based on HFC's which are potent global warming contributors. Points under additional green efforts can be awarded to projects that use alternatives to HFC's providing all health and safety issues are fully addressed and relevant approval from authorities is granted

References

Intergovernmental Panel on Climate Change (IPCC) (2001) 'Global Warming Potential of Refrigerants'; Retrieved: <http://www.ipcc.ch/ipccreports/tar/wg3/index.php?idp=144>

United Nations Environment Programme (UNEP) (2007) 'Information about the management and phase out of hydrochlorofluorocarbons (HCFCs)'; Retrieved: <http://www.unep.org/ozonaction/topics/hcfc.asp>

P.09 Minimum Ventilation Rate

Intent

To ensure adequate ventilation of buildings for the health and comfort of the occupants.

Scope

Applicable to regularly occupied spaces which are air-conditioned or mechanically ventilated.

Assessment

The project team shall design the air-conditioning system to provide appropriate quantum of outdoor air rates as stated in SS 553: 2015 Table 1– *Outdoor Air Supply Requirement for Comfort Air-Conditioning* or SS 553: 2015 Table 5 – *Outdoor Air Supply For Mechanical Ventilation In Non-Air-Conditioned Buildings or Parts of Buildings with No Natural Ventilation*. The ventilation systems shall be designed to ensure that the minimum outdoor air intake equals or exceeds the maximum exhaust airflow.

Guidance Notes

At Design Stage:

Submission of the following:

- Minimum outdoor air interpretation and computation by zones according to SS 553: 2015 Table 1 or Table 5
- The maximum exhaust airflow interpretation and computation by zones
- Extracts of tender specification showing the requirement to design the system to meet the requirement of Table 1 or Table 5 in SS 553: 2015
- Mechanical design drawings and schematics reflecting the minimum outdoor supply air to individual zones

Verification (As Built):

Submission of the following:

- As built drawings showing the outdoor air supply to the air distribution systems
- Onsite photographic evidence of the outdoor air duct opening to the air distribution systems

References

Singapore Standard 553 (2015) 'Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings'; SPRING Singapore

ASHRAE Standard 62.1 (2013) 'Ventilation for Acceptable Indoor Air Quality'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

P.10 Filtration Media for times of Pollution

Intent

To adequately remove harmful pollutants from outdoor air taken in ventilation in the event of poor outdoor air quality for the health and well-being of the occupants.

Scope:

Applicable to all air conditioned buildings.

Assessment

The air distribution system shall be designed in accordance with SS553: 2015. The code specifies the minimum filter requirements, namely the use of fine dust filters of at least a rating of Minimum Efficiency Reporting Value (MERV) 14 (ASHRAE 52.2: 2012) or F8 (EN779: 2012), in the event of poor outdoor air quality, such as that during haze events, or presence of indoor source of fine particles.

Guidance Notes

At Design Stage:

Submission of relevant design drawings and specifications depicting outdoor air filtration strategy and the design provision that MERV 14 filters can be installed during events of poor air quality. This would include fan sizing for the increased potential pressure drop, and the space for the filtration media to be placed.

Verification (As Built):

Submission of as built drawings and onsite photographs proving ability to install MERV 14 or equivalent filter during events of poor air quality.

References

Singapore Standard 553 (2015) 'Code of Practice for Air-conditioning and mechanical ventilation in buildings'; SPRING Singapore

Singapore Standard 554 (2015) 'Code of Practice for Indoor air quality for air-conditioned buildings'; SPRING Singapore

P.11 Thermal Comfort

Intent

Air-conditioning is a major consumer of energy in a building. As it is used primarily to provide a thermally comfortable space for the building occupants, a fundamental requirement is that the air-conditioning system is designed to achieve thermal comfort.

Scope

Generally applicable to all occupied building areas with air conditioning systems

Assessment

The air-conditioning system shall be designed to allow for cooling load variations due to fluctuations in ambient air temperature, internal loads and occupancy whilst maintaining a consistent indoor condition for thermal comfort based on SS553: 2015 Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings.

The dry bulb temperature of the conditioned spaces should be between 23°C and 25°C, and relative humidity less than 65%.

Guidance Notes

At Design Stage:

Submission of design details showing how the air conditioning system shall provide consistent indoor conditions for thermal comfort.

Verification (As Built):

Submission of on-site measurements verifying indoor air temperature (wet bulb and dry bulb) and the relative humidity with measurement locations highlighted on a plan.

References

Singapore Standard 553 (2015) 'Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings'; SPRING Singapore

P.12 Minimum illuminance levels

Intent

Lighting shall be adequately provided in a building for its intended purpose. For the purposes of promoting energy efficiency in buildings, the use of artificial lighting as the sole means of lighting during daylight hours is to be discouraged.

Scope:

Applicable to all buildings.

Assessment

The lux level and uniformity of lighting within the building spaces shall be designed to comply with the recommended illuminance in SS 531 – Code of Practice for Lighting of Workspaces.

This shall be demonstrated through lux level simulations or other approved methods.

Where daylighting is available, lighting control strategies should be considered to reduce the energy consumption of the lighting whilst maintaining the adequate illuminance.

Guidance Notes

At Design Stage:

Submission of the following documents:

- Lighting layout plans
- Lighting schedules showing the number, location, and type of luminaries used
- Luminaries data sheets
- Lighting level simulation showing the resultant lux level and uniformity of the lighting design at the relevant heights (such as work planes) that meets or surpasses prevailing code requirements

Verification (As Built):

Submission of the following documents:

- As built lighting layout, lighting schedule and luminaries data sheets
- Purchase orders and delivery orders of the luminaries used in the project
- On-site measurements of the as built lux level achieved

References

Singapore Standard 531: Part 1 (2006) 'Code of Practice for Lighting of work places Part 1: Indoor'; SPRING Singapore

P.13 Artificial Lighting Energy Performance

Intent

To ensure that the lighting provisions in the building adhere to minimum performance levels for energy efficiency.

Scope:

Applicable to building lighting including car park lighting, external and landscape lighting as well as façade lighting.

Assessment

The lighting power density shall be calculated for the building and shall meet the lighting power budget in SS 530: 2014 whilst adhering to requirements under P.13 *Minimum Illuminance levels*

Guidance Notes

Indicator 2.01b *Lighting System Efficiency* shall be used to check this pre-requisite requirement

At Design Stage:

Submission of the following documents:

- Lighting layout plans
- Lighting schedules showing the number, location, and type of luminaries used
- Luminaries data sheets

Verification (As Built):

Submission of the following documents:

- As built lighting layout, lighting schedule and luminaries data sheets
- Purchase orders and delivery orders of the luminaries used in the project

References

Singapore Standard 530 (2014) 'Code of Practice for Energy Efficiency Standard for Building Services and Equipment'; SPRING Singapore

P.14 Visible Flicker Free Lighting

Intent

To use visible flicker free luminaires in regularly occupied spaces to minimise physiological discomfort for building occupants.

Scope

Applicable to all lighting using ballasts and drivers within regularly occupied areas of the building.

Assessment

High frequency electronic ballasts or equivalent drivers where LED lighting is being used to at least shall be used for at least 90% of all regularly occupied areas of the building. There shall be no visible flickering when dimmed.

Guidance Notes

At Design Stage:

Submission of specifications of high frequency ballasts with frequency > 20 kHz and equivalent performance characteristics from LED drivers that demonstrate that visible flicker has been addressed.

Verification (As Built):

Submission of purchase orders and delivery orders of the high frequency ballasts and drivers used.

References

<http://www.ledbenchmark.com/faq/LED-Flicker-Measurement.html>

<http://www.lrc.rpi.edu/programs/solidstate/assist/recommends/flicker.asp>

P.15 Vertical Transportation Efficiency

Intent

To adopt energy efficient vertical transportation systems to reduce their energy consumption

Scope

Applicable to all lifts and escalators in the development.

Assessment

Use of Variable Voltage Variable Frequency (VVVF) drives and sleep mode features all lifts and escalators (except for typologies – such as hydraulic lifts where such technology is not available).

Guidance Notes

At Design Stage:

Submission of extracts of specifications that indicate the types of lifts, escalators and related features used.

Verification (As Built):

Submission of purchase orders and delivery orders of the installed lifts and escalators with the technical product specifications indicating the VVVF motor drive, sleep mode and occupancy sensors

P.16 Electrical Sub-Metering & BMS

Intent

To enable audit and continuous improvement by identifying major energy use thereby optimising energy use or avoiding wastage.

Scope

Applicable to all buildings of 5000m² GFA or more.

Assessment

Subsystem measurement devices with remote capability (including power meters or flow meters) shall be provided, linked to a BMS/EMS and shall measure and trend energy consumption data of:

- (i) Each of the following energy sub systems:

Table P.17-1 Applicable Energy Sub Systems

Use (total of all loads)	Sub-systems thresholds
Lift & Escalator	Sum of all feeders > 50 kVA
Heater, including heat pump	> 50 kW _{th}
Process loads	Connected loads > 50 kVA Connected gas or district services load > 75 kW
Unitary air-conditioning system (including VRF systems)	No threshold
Mechanical ventilation	The subsystem's load > 15kW

- (ii) Each floor, tenancy and high energy load (> 50kVA) areas such as car park, office, retail shops, data centres, IT closets and process areas (e.g. kitchens, laundries).

Guidance Notes

At Design Stage:

Submission of the following:

- Sub-system equipment specifications
- Power meter and current transducer specifications
- The remote capability and link to a BMS/EMS system
- Single line diagram showing the location of the power meters
- Design of the main switchboards (MSBs) and power distribution boxes (DBs)

Verification (As Built):

Submission of the following:

- Purchase Order and Delivery Order of the sub-system, equipment, power meter and current transducers
- As-built electrical single line diagrams showing the location of each power meters
- As-built MSBs, DBs design
- BMS or supervisory control and data acquisition (SCADA) display of meter readings and trends
- Commissioning report of the sub-metering system

References

Singapore Standard 553 (2015) 'Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings'; SPRING Singapore

Singapore Standard CP5 (1998) 'Code of Practice for electrical installations'; SPRING Singapore

P.17 Energy Systems Controls

Intent

To facilitate energy efficient operations and controllability of the mechanical and electrical systems within the building.

Scope:

Applicable to all building types and includes controls for air-conditioning systems, lighting systems and hotel guestroom controls.

Assessment

Air conditioning systems shall be equipped with manual switches, timers or automatic controls for shutting off part of the air-conditioning system during periods of non-use, or reduced heat load.

Lighting controls shall be provided in accordance with SS 530: 2014 Code of Practice for Energy Efficiency Standard for Building Services and Equipment.

In hotel buildings, a control device shall be installed in every guestroom for the purpose of automatically switching off the lighting and reducing the air-conditioning when a guestroom is not occupied.

Guidance Notes

At Design Stage:

Submission of Specifications, detailed drawings and descriptions of the various control strategies that will be employed within the building and how they will provide the relevant controls to reduce energy consumption.

Verification (As Built):

Submission of As-built drawings and on site evidence of the installed controls for the energy systems.

References

Singapore Standard 530 (2014) 'Code of Practice for Energy Efficiency Standard for Building Services and Equipment'; SPRING Singapore

P.18 Water Efficient Fittings

Intent

To reduce potable water consumption through the use of water efficient fittings

Scope

Applicable to all buildings with water fittings installed.

Assessment

The project shall demonstrate the use of water efficient fittings that meet minimum requirements under PUB's Water Efficient Building (Basic) as detailed in the following table

Table P.18-1 Water Efficient Fittings Requirements

Type of Water Fittings	Prescribed Minimum WELS ratings	Applicable Areas
Basin Taps & Mixers	Excellent WELS rating	Public/Staff/School Toilets
	Very Good WELS rating	Other Areas <i>Exception : Hospital Wards & Operating Theatre</i>
Sink Taps & Mixers	Very Good WELS rating	All Areas <i>Exception : Hospital Wards & Operating Theatre</i>
Shower Taps, Mixers or Showerheads	Very Good WELS rating	Public/Staff/School Shower facilities
Dual Flush Flushing Cisterns	Very Good WELS rating	All areas

All other water fittings such as urinal flush valves, bib taps that are not listed in the above table shall comply with the mandatory standards stipulated in the Singapore Standard CP 48 – Code of Practice for Water Services

Guidance Notes

At Design Stage:

Submission of the following:

- Extracts of the tender design specification showing all the water fitting provisions for the development;
- Water fitting schedules showing the numbers, types and the approved rating of the proposed fittings in the prescribed tabulated format shown below:

Ref.	Water Fitting Type	Quantity			Total No. based on fitting type	State Applicable Areas
		WELs Excellent	WELs Very Good	Mandatory MWELS		
1	Basin Taps and Mixers					
2	Sink Taps & Mixers					
3	Shower Taps & Mixers					
4	Dual-Flush Flushing Cisterns					
5	Total No. of fittings					

Verification (As Built):

Submission of water fitting schedules showing the number, brand/model no, types, delivery orders and approved WELS rating of the installed fittings in the prescribed tabulated format shown below.

Ref.	Water Fitting Type	Quantity			Total No.	State Applicable Areas	Delivery Order Ref No
		WELs Excellent	WELs Very Good	Mandatory MWELS			
1	Basin Taps and Mixers						
2	Sink Taps & Mixers						
3	Shower Taps & Mixers						
4	Dual Flush Flushing Cisterns						
5	Total No. of fittings						

References

Singapore Standard CP 48 (2005) 'Code of Practice for water services'; SPRING Singapore

Public Utilities Board, Singapore (2013) 'Guidebook on Water Efficiency Labelling Scheme'; Retrieved: http://www.pub.gov.sg/wels/rating/Documents/WELS_Guidebook.pdf

P.19 Cycle of Concentration for Cooling Towers

Intent

To reduce water consumption for cooling purposes

Scope

Applicable to building developments with cooling towers.

Assessment

The Project shall demonstrate the use of a water treatment system for cooling towers that can achieve 7 cycles of concentration (CoC) at an acceptable water quality and operational performance

Guidance Notes

At Design Stage:

Submission of the following:

- Technical specification showing the requirements to be incorporate with the cooling tower design to achieve at least seven cycles of concentration.
- Relevant drawings and details showing how the cooling towers have been designed, the location of the cooling towers and other supporting systems that are required to achieve the proposed cycle of concentration.
- Technical specification of the non-chemical water treatment methods adopted and the methodology to enable the desired cycle of concentration without compromising on the water quality and operational performance
- Maintenance regime of the non-chemical water treatment methods adopted

Verification (As Built):

Submission of onsite testing reports showing the cycles of concentration achieved and maintained most of the time.

P.20 Low Volatile Organic Compound (VOC) Paints

Intent

To limit the use of high-emitting building and furnishing materials to improve indoor air quality for the health and well-being of occupants.

Scope:

Applicable to all indoor paints.

Assessment

The internal paints shall be certified by an approved local certification body.

All coats of paint shall be considered, including primers, sealers, base coats and top coats.

The paints shall comply with the following VOC content:

VOC content (water-based) shall be $\leq 25 \text{ gL}^{-1}$ for matt, $\leq 30 \text{ gL}^{-1}$ for low sheen, $\leq 75 \text{ gL}^{-1}$ for semi-gloss

Test methods for paint VOC content shall comply with ISO 17895 or ISO 11890.

Guidance Notes

At Design Stage:

Submission of the following:

- Extracts of the tender specification showing the requirement to use low VOC paints that are certified by an approved local certification body.
- Certification details from approved local certification body
- Technical product information and delivery records

Verification (As Built):

Submission of purchase orders and delivery orders of the indoor paints used

References

Singapore Standard 554 (2015) 'Code of Practice for Indoor air quality for air-conditioned buildings'; SPRING Singapore

Singapore Green Building Product Certification - Singapore Green Building Council

P.21 Sound Level

Intent

To achieve a basic level of acoustic comfort in a building of its occupants' health and wellbeing.

Scope

Applicable to all occupied spaces in a building.

Assessment

Spaces to be designed for the following ambient sound levels:

Table P.21-1 Ambient Sound Levels

Area	Average dBA
Cinema's , Theatres	25
Private Offices	35
Open Offices	45
Conference Rooms	35
Classrooms	35
Hotel Guestrooms	35
Places of Public Resort (e.g. shops)	45

Guidance Notes

At Design Stage:

Detailed analysis, calculations and/or measurements to demonstrate that the ambient sound levels shall be met by the design.

Verification (As Built):

Submission of onsite measurement information of sound levels, complete with a method statement and plan drawings showing the testing locations.

References

Singapore Standard 553 (2015) 'Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings'; SPRING Singapore

P.22 Bicycle Parking

Intent

To provide the necessary infrastructure to encourage cycling as an alternative mode of transport.

Scope

Applicable to all buildings.

Assessment

The following minimum quantity of bicycle parking lots shall be provided for the development: Lots are to be installed and located in line with *LTA regulations*

Table P.01 -1 Minimum Bicycle Parking Provisions required

Building Category	Requirements
Community, Sports and Recreational facilities	<p>For Gross Floor Area (GFA) of >1,000m² to 3,000m² – 20 bicycle lots shall be provided</p> <p>For GFA >3,000m²</p> <ul style="list-style-type: none"> • First 15,00m² - 1 lot per 150m² • Subsequent GFA: 1 lot per 500m²
All Other Building Types	<p>For GFA of >1,000m² to 3,000m² – 10 bicycle lots shall be provided</p> <p>For GFA >3,000m²</p> <ul style="list-style-type: none"> • First 15,00m² - 1 lot per 300m² <p>Subsequent GFA: 1 lot per 1,000m²</p>

Guidance Notes

At Design Stage:

Submission of the extracts of the tender specifications showing the requirement to provide the required quantity of bicycle parking lots as well as drawings showing the quantity and location of the bicycle parking lots.

Verification (As Built):

Submission of photographs and as-built drawings of the bicycle parking lots

References

LTA regulation [to be advised upon implementation]

Pre-requisite Requirements – Gold, Gold^{PLUS} and Platinum Awards

P	Referenced Indicator	Pre-Requisite Requirement	Gold	Gold ^{PLUS}	Platinum
-	-	Comply with pre-requisites P.01 - P.22	✓	✓	✓
P23	1.01a	Climatic & Contextually Responsive Brief		✓ (1)	✓ (1)
P24	1.01b	Integrative Design Process			✓ (2)
P25	1.01e	Green Fit Out Guidelines		✓ (1)	✓ (1)
P26	1.02c	Greenery		✓	✓
P27	1.03c	Ventilation Performance		✓ (4)	✓ (4)
P28	2.01a	Air Conditioning Total System Efficiency		✓	✓
P29	2.03a	Renewable Energy Feasibility Study	✓ (0.5)	✓ (0.5)	✓ (0.5)
P30	3.02a	Sustainable Construction	✓ (0.5)	✓ (1.5)	✓ (3)
P31	3.02b	Embodied Energy		✓ (1)	✓ (1)
P32	3.02c	Sustainable Products	✓ (2)	✓ (3)	✓ (4)
P33	4.01a (i)	Indoor Air Quality Audit	✓ (0.5)	✓ (0.5)	✓ (0.5)
P34	4.01a (ii)	Post Occupancy Evaluation		✓ (0.5)	✓ (0.5)
P35	4.01b (ii)	Enhanced Filtration Media		✓ (0.5)	✓ (0.5)
P36	4.03d	System Handover and Documentation		✓ (1)	✓ (1)
P37	-	Energy Modelling		✓	✓
P38	-	Energy Efficiency Benchmarking		✓	✓

The points are shown in brackets are representative for a commercial building complying with the pre-requisites

P.23 Create the Climatic & Contextually Responsive Brief

Intent

To demonstrate the environmental considerations of the project at the briefing stage

Scope:

Applicable to all buildings.

Applicable for the following Award Levels:	Points
Gold^{PLUS}	1
Platinum	1

Assessment

Written statements and documents that demonstrate the sustainable briefing process of the project endorsed by the client or client's representative and the Architect Assessed under 1.01a *Climatic & Contextually Responsive Brief*.

Guidance Notes

At Design Stage:

As per Indicator 1.01a *Climatic & Contextually Responsive Brief*.

References

The Singapore Institute of Architects (2013) 'Attributes of a Sustainable Built Environment'; SIA Publishing

Sinclair, D. (2013) 'Guide to Using the RIBA Plan of Work 2013'; RIBA Publishing

P.24 Integrative Design Process

Intent

To encourage a collaborative framework for the project team to set the building performance benchmarks and targets collectively at the drawing board. This results in a more balanced and sustainable design outcome that also sets the right tone for sustainable operations and maintenance.

Scope:

Applicable to all buildings.

Applicable for the following Award levels:	Points
Platinum	2

Assessment

As per Indicator 1.01b *Integrative Design Process*.

Guidance Notes

A cross-disciplinary design team is to be formed minimally at the concept design phase. The team includes the Architect, Mechanical and Electrical Engineers, Building Owner's Representative(s), Building or Quantity Surveyor, Environmental Sustainable Design (ESD) Consultant (if applicable) and any other specialists or professionals applicable to the project including but not limited to structural engineers, facilities managers, project managers, landscape architects, community groups, specialist contractors et al.

At Design Stage:

As per Indicator 1.01b *Integrative Design Process*.

Verification (As Built):

As per Indicator 1.01b *Integrative Design Process*.

References

ASHRAE Standard 189.1 (2010) 'Standard for the Design of High-Performance Green Buildings – Informative Appendix H – Integrated Design'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

Sinclair, D. (2013) 'Assembling a Collaborative Project Team, Practical Tools including Multidisciplinary Schedules of Services'; RIBA Publishing

Integrative Process (IP) - ANSI Consensus National Standard Guide (2012) 'Design and Construction of Sustainable Buildings and Communities'; American National Standards Institute

P.25 Green Fit Out Guidelines

Intent

To ensure that the building tenants contribute positively to the environmental sustainability of the project through the enforcement of occupant / tenant fit out guidelines

Scope:

Applicable to all buildings that have tenanted areas

Applicable for the following Award levels:	Points
Gold^{PLUS}	1
Platinum	1

Assessment

The fit out guidelines that detail energy efficiency standards, water efficiency standards, environmental protection standards and indoor air quality standards for $\geq 70\%$ of the NLA.

Guidance Notes

At Design Stage:

As per **Green Fit Out Guidelines** under Indicator 1.01e *User Engagement*

Verification (As Built):

As per **Green Fit Out Guidelines** under Indicator 1.01e *User Engagement*

P.26 Greenery

Intent

To integrate a verdant landscape and waterscape that is accessible for all to enjoy into their building design, and to provide greenery within the development to enhance the biodiversity around the development and provide visual relief to building occupants and neighbours.

Scope:

Applicable to all buildings

Applicable for the following Award levels:

Gold^{PLUS}

Platinum

Assessment

Minimum Green Plot Ratio:

Table P.26-1 Minimum Green Plot Ratio

	Commercial	Industrial
Gold^{PLUS}	2.5	1.5
Platinum	3	2

OR

For projects with high site coverage and limited scope for green spaces, projects can opt to score 2 points under Indicator 1.02c *Integrated Landscape and Waterscape* for Gold^{PLUS} or 2.5 Points for Platinum

Guidance Notes

At Design Stage:

GnPr calculation as sub-indicator 1.02c (i) *Greenery Provision*

Indicator 1.02c *Integrated Landscape and Waterscape*

Verification (As Built):

GnPr calculation as sub-indicator 1.02c (i) *Greenery Provision*

Indicator 1.02c *Integrated Landscape and Waterscape*

P.27 Ventilation Simulation Requirements

Intent

To encourage the design for effective natural ventilation for thermal comfort, indoor environmental quality for all naturally ventilated spaces.

Scope:

Applicable to buildings with $\geq 2,000\text{m}^2$ of naturally ventilated functional spaces, excluding all transient spaces and M&E spaces with the exception of commercial building atria.

Applicable for the following Award levels:	Points
Gold^{PLUS}	4
Platinum	4

Assessment

The CFD simulations or wind tunnel testing are to be conducted based on the requirements within *BCA Green Mark Computational Fluid Dynamic Simulation Guidelines* and with reference to sub-indicator 1.03c (i) *Demonstrate Effective Natural Ventilation*. The project must achieve the following performance

Wind Speed:

Table P.27-1 Average Wind Speed results

Level of Award	Wind Speed Result	m/s
Gold^{PLUS}	Good	0.4m/s
Platinum	Very Good	0.6m/s

Projects should demonstrate the required wind speed for at least 70% of the applicable naturally ventilated areas in accordance with the *BCA Green Mark Computational Fluid Dynamic Simulation Guidelines*. Where the project is not able to demonstrate this wind speed the following options are applicable

Thermal Comfort

Predicted Mean Vote (PMV) and can be used as the thermal comfort indicator for the evaluation of the satisfaction level of the occupants in the building. Mixed mode ventilation can be considered.

The project must demonstrate 'moderate' wind speed performance of 0.2m/s for at least 70% of the floor area and use thermal comfort modelling to demonstrate:

Table P.27-2 Predicated Mean Vote

Level of Award	PMV
Gold^{PLUS}	-1.0 <PMV<+1.0
Platinum	-0.5 <PMV<+0.5

Indoor Air Quality

The project must demonstrate 'moderate' wind speed performance of 0.2m/s for at least 70% of the floor area and use air quality modelling to demonstrate:

Table P.27-3 Air Change Effectiveness

Level of Award	Air Change Rate	Air Change Efficiency
Gold^{PLUS}	≥ 4	≥ 10
Platinum	≥ 10	≥ 1.2

This is only applicable for the following building types:

- 1) Industrial warehouses with occupancy density no more than 50m²/person
- 2) Sports facilities

Guidance Notes

At Design Stage:

The ventilation simulation report shall be prepared and submitted in accordance with sub-indicator 1.03c (i) and assessed by a BCA CFD assessor as per requirements for 1.03c (i) *Demonstrate Effective Natural Ventilation*

Verification (As Built):

As per sub-indicator 1.03c (i) *Demonstrate Effective Natural Ventilation*

References

BCA Singapore; 'BCA Green Mark Computational Fluid Dynamic Simulation Guidelines'

P.28 Air Conditioning System Total System Efficiency

Intent

To ensure that buildings utilising air-conditioning systems are optimised for total system performance, which looks at the total cooling system including the distribution of the conditioned air into the space.

Scope:

Applicable to all air-conditioned buildings. The scope covers the total system efficiency of a building's air conditioning, including all the air conditioning systems normally in operation in the building and the resultant aggregated total system efficiency. The total system efficiency is measured in kW/RT and includes the air distribution system

Applicable for the following Award levels:

Gold^{PLUS}

Platinum

Assessment

The total air-conditioning design system efficiency shall not exceed the following:

Table P.28-1 Air Conditioning Total System Efficiency for Water Cooled Chilled Water plants

Building Cooling Load (RT)		
	<500RT	≥500RT
	<i>Minimum Design System Efficiency including air distribution system (kW/RT)</i>	
Gold^{PLUS}	0.95	0.9
Platinum	0.93	0.9

Table P.28-1 Air Conditioning Total System Efficiency for Air Cooled Chilled Water plants & Unitary Systems

Building Cooling Load (RT)		
	<500RT	≥500RT
	<i>Minimum Design System Efficiency including air distribution system (kW/RT)</i>	
Gold^{PLUS}	1.10	Total System Efficiency must demonstrate equivalency with Table P.28-1
Platinum	1.03	

The air distribution system efficiency for Gold^{PLUS} and Platinum projects should not exceed 0.25kW/RT. Except where there are instances of systems with high pressure drops, in which case with BCA's approval, the fan system input power can be adjusted based on table 2a and 2b under SS553: 2015. The total system efficiency (kW/RT) will be adjusted accordingly.

Guidance Notes

At Design Stage:

As per Indicator 2.01a *Air Conditioning System Efficiency*.

The air distribution (kW) shall be calculated based upon the fan input power for the Operational Design Load profile. Reference can be made to ASHRAE 90.1 (2013) Table G3.1.3.15 to calculate the part load fan input power for VAV fan systems. Results from energy modelling may also be used (total annual kWh input / total RTh of cooling)

Verification (As Built):

As per Indicator 2.01a *Air Conditioning System Efficiency*.

References

Singapore Standard 530 (2014) 'Code of Practice for Energy Efficiency Standard for Building Services and Equipment'; SPRING Singapore

Singapore Standard 553 (2015) 'Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings'; SPRING Singapore

ASHRAE Standard 90.1 (2013) 'Energy Standard for Buildings Except Low-Rise Residential Buildings'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

P.29 Renewable Energy Feasibility Study

Intent

To identify the project's potential in harnessing solar energy, and encourage installation of solar photovoltaic (PV) to the project's full potential.

Scope:

Applicable to buildings with a footprint greater than or equal to 1000m²

Applicable for the following Award levels:	Points
Gold	0.5
Gold^{PLUS}	0.5
Platinum	0.5

Assessment

The project shall complete a feasibility study for solar renewable energy as per requirements under Indicator 2.03a *Feasibility Study*.

Guidance Notes

As per requirements under Indicator 2.03a *Feasibility Study*.

Definitions

Building footprint is the area on a project site used by the building structure, defined by the perimeter of the building plan. Open car park spaces, landscapes, underground construction spaces and other non-building facilities (e.g. covered walkways, etc.) are not included in the building footprint.

P.30 Sustainable Construction

Intent

To encourage the adoption of building designs, building structures and construction practices that are environmentally friendly and sustainable.

Scope:

Applicable to building superstructure (including non-structural components). Substructure components are excluded

Applicable for the following Award levels:	Points
Gold	0.5
Gold^{PLUS}	1.5
Platinum	3

Assessment

As per requirements under 3.02a *Sustainable Construction* and achieve the minimum points required as indicated above

Guidance Notes

At Design Stage:

As per requirements under Indicator 3.02a *Sustainable Construction*

Verification (As Built):

As per requirements under Indicator 3.02a *Sustainable Construction*

P.31 Embodied Energy

Intent

To better quantify the environmental impact of a building and raise awareness among key decision makers.

Scope:

Applicable to all projects.

This involves the calculation of the embodied energy of a building through the use of the BCA Online Carbon Calculator through the minimum declaration of concrete, glass and steel.

Applicable for the following Award levels:	Points
Gold^{PLUS}	1
Platinum	1

Assessment

As per requirements under Indicator 3.02b *Embodied Energy and Life Cycle*.

Guidance Notes

As per requirements under Indicator 3.02b *Embodied Energy and Life Cycle*.

P.32 Sustainable Products

Intent

To ensure that due consideration is given to the specification and use of environmentally friendly products within the building

Scope:

Applicable to buildings:

Applicable for the following Award levels:	Points
Gold	2
Gold^{PLUS}	3
Platinum	4

Assessment

Projects shall submit the evidence and be assessed according to the requirements within 3.02c demonstrating their use of local approved certified products.

Guidance Notes

At Design Stage:

As per requirements under Indicator 3.02c *Sustainable Products*

Verification (As Built):

As per requirements under Indicator 3.02c *Sustainable Products*

References

Singapore Green Building Product (SGBP) Certification Scheme <http://www.sqbc.sg/green-certifications/product-certification/>

Singapore Green Label Scheme (SGLS) <http://www.sqsls.sec.org.sg/sqsls-standard.php>

P.33 Indoor Air Quality Audit

Intent

To ensure the building demonstrates good indoor air quality through an indoor air quality audit conducted by an accredited laboratory.

Scope:

Applicable to all building developments with air-conditioning systems. An IAQ audit should be conducted within one year after occupancy in reference to SS554: 2015 or NEA's *guidelines for Good Indoor Air Quality in Office Premises*.

Applicable for the following Award levels:	Points
Gold	0.5
Gold^{PLUS}	0.5
Platinum	0.5

Assessment

IAQ audit by an accredited laboratory under Singapore Accreditation Council and demonstrating good IAQ performance with reference to SS554: 2015 or NEA's *guidelines for Good Indoor Air Quality in Office Premises*.

Guidance Notes

At Design Stage:

As per requirements under sub-indicator 4.01a (i) *Indoor Air Quality (IAQ) Audit*.

Verification (As Built):

As per requirements under sub-indicator 4.01a (i) *Indoor Air Quality (IAQ) Audit*.

References

Singapore Standard 554 (2015) 'Code of Practice for Indoor air quality for air-conditioned buildings'; SPRING Singapore
National Environment Agency (1996) '[Guidelines for Good Indoor Air Quality in Office Premises](#)' Institute of Environmental Epidemiology, Singapore

P.34 Post Occupancy Evaluation

Intent

To gather building user feedback. A Post Occupancy Evaluation provides feedback on the indoor environmental conditions in the building and the occupant's satisfaction with their environment.

Scope:

Applicable to all building developments.

Applicable for the following Award levels:	Points
Gold^{PLUS}	0.5
Platinum	0.5

Assessment

A Post Occupancy Evaluation (POE) should be conducted within one year after occupancy for a representative sample of the full time equivalent occupants within the building.

Guidance Notes

At Design Stage:

As per requirements under sub-indicator 4.01a (ii) Post Occupancy Evaluation.

Verification (As Built):

As per requirements under sub-indicator 4.01a (ii) Post Occupancy Evaluation.

P.35 Enhanced Filtration Media

Intent

To effectively remove contaminants to enhance indoor air quality through high efficiency filters.

Scope:

Applicable to all air conditioned buildings with air handling units or dedicated treatment of outdoor air.

Applicable for the following Award levels:	Points
Gold^{PLUS}	0.5
Platinum	0.5

Assessment

The permanent provision of MERV 14 or F8 class of filter to treat outdoor air in air conditioning systems.

Guidance Notes

At Design Stage:

As per requirements under sub-indicator 4.01b (ii) *Enhanced Filtration Media*.

Verification (As Built):

As per requirements under sub-indicator 4.01b (ii) *Enhanced Filtration Media*.

References

Singapore Standard 553 (2015) 'Code of Practice for Air-conditioning and mechanical ventilation in buildings'; SPRING Singapore

P.36 System Handover and Documentation

Intent

To encourage control systems verification and to ensure operational continuity from construction to building maintenance and operation.

Scope:

Applicable to all buildings control systems, mechanical systems and electrical systems

Applicable for the following Award levels:	Points
Gold^{PLUS}	0.5
Platinum	0.5

Assessment

The handover of the building for operations shall include the relevant mechanical, electrical and control systems to be tested and verified to be operating within their desired parameters. The proper documentation of said systems shall be provided for the building operations team.

Guidance Notes

At Design Stage:

As per requirements under Indicator 4.03d *System Handover and Documentation*

Verification (As Built):

As per requirements under Indicator 4.03d *System Handover and Documentation*

References

CIBSE Commissioning Codes: A (Air Distribution Systems), C (Automatic Controls), L (Lighting), R (Refrigeration) – Chartered Institution of Building Services Engineers

ASHRAE Guideline 0 (2013) 'The commissioning Process'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASHRAE Guideline 1.1 (2007) 'HVAC & R Technical Requirements for the Commissioning Process'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASHRAE Guideline 1.4 (2014) 'Procedures for Preparing Facility Systems Manuals; American Society of Heating, Refrigerating and Air-Conditioning Engineers

P.37 Energy Modelling Requirements

Intent

To demonstrate the energy savings of the building compared to a prescribed reference model that reflects prevailing building standards and codes of practice.

Scope:

Applicable to all buildings. The energy modelling for evaluating the energy performance of a building shall be carried out in the prescribed manner to quantify the potential savings based on energy efficiency measures and improvements that reduce the cooling load over the reference model.

Important note, energy modelling is to compare the building to a code compliant building simulated as a reference model, and not the Green Mark 2015 reference building used under 2.02 Energy Effectiveness.

Applicable for the following Award levels:
Gold ^{PLUS}
Platinum

Assessment

The energy model shall be used to demonstrate the design performance and assessed in detail by a BCA energy modelling assessor. The simulation shall be conducted in accordance with the BCA *Green Mark Energy Modelling Guidelines*. At verification the measured performance and efficiencies shall be used to demonstrate compliance.

Table P.37-1 Minimum Energy Savings to be demonstrated through Energy Modelling

Level of Green Mark Award	Minimum Energy Savings
Gold ^{PLUS}	25%
Platinum	30%

Guidance Notes

At Design Stage:

The energy modelling simulation shall be carried out in accordance with the BCA *Green Mark Energy Modelling Guidelines*. The project must demonstrate the percentage energy savings for Gold^{PLUS} and Platinum as shown in table P.37-1 above. The Qualified Person (QP) and the appropriate practitioners shall certify that the energy modelling for the building has been conducted in accordance with the energy modelling methodology in the BCA *Green Mark Energy Modelling Guidelines* and ensure that the assumptions, inputs and results are bona fide.

Verification (As Built):

At stage 2 verification the project team shall complete and provide the following information:

- the operational system efficiency report for the air conditioning system
- the actual average building cooling load (W/m^2)
- the actual average receptacle load per functional space (W/m^2)
- The operational building EEI
- The building EUI, electricity bills and operational schedules
- A comparison to the energy modelling result submitted at design stage broken down in accordance to the format submitted at design stage

A project will have deemed to have met the pre-requisite where the key energy consuming components are operating to their designed efficiencies. A calibrated reference model shall not be required except for circumstances including

- A significant discrepancy in comparison with the energy model results
- Change of primary use
- A change of functional area distribution
- Changes in equipment specifications and performance
- Changes in GFA
- Change in ventilation modes

References

BCA Singapore; 'BCA Green Mark Energy Modelling Guidelines'

Singapore Standard 530 (2014) 'Code of Practice for Energy Efficiency Standard for Building Services and Equipment'; SPRING Singapore

Singapore Standard 553 (2015) 'Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings'; SPRING Singapore

ASHRAE Standard 90.1 (2013) 'Energy Standard for Buildings except Low-Rise Residential Buildings'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

P.38 Energy Efficiency Benchmarking

Intent

To provide a numerical benchmark for buildings to demonstrate their overall reduction in energy consumption.

Scope:

Applicable to all commercial buildings.

Applicable for the following Award levels:

Gold^{PLUS}

Platinum

Assessment

The Energy Efficiency Index (EEI) computation is based on the proposed model result from the Energy Model. The project should demonstrate a lower EEI than table P.38-1. Where the project exceeds the EEI stated, the team shall provide a reasoned explanation. The overall Energy Use Index (EUI) for the building and the separate Car park EUI shall also be presented.

Table P.38-1 EEI Benchmark for commercial buildings

Building Type	Benchmark for Energy Efficiency Index (EEI) (kWh/m ² /yr)
Office and Institution	160
Hotel	260
Retail	360

Guidance Notes

The normalised EEI for both the Proposed and Reference Models shall also be computed. The details are as follows and referenced to table P.38-2:

Calculation of EEI = $[(TBEC - DCEC - CPEC) / (GFA - DCA)] \times (NF/OH)$

Calculation of Building overall EUI (Exclude car park) = $(TBEC - CPEC) / (GFA)$

Calculation Car park EUI = $CPEC / CPFA$

Table P.38-2 EEI References for calculation

References		
(a)	TBEC	: Total building energy consumption (kWh/year)
(b)	DCEC	: Data centre energy consumption (kWh/year)
(c)	CPEC	: Car park energy consumption (kWh/year)
(d)	GFA	: Gross floor area (m ²)
(e)	CPFA	: Total floor area for car park (m ²)
(f)	DCA	: Data centre areas (m ²)
(g)	NF	: Normalising factor based on typical weekly operating hours of the building type: Office: 55 hours/week Retail : 84 hours/week Hotel and Industrial : 168 hours/week School & Institution : 60 hours/week Car Park : 168 hours/week
(h)	OH	: Weighted weekly operating hours (hours/week)

At Design Stage:

Submission of the EEI, EUI and carpark EUI in the following tabulated format:

Efficiency Indicators	Result
EEI (kWh/m²/yr)	
Green Mark Certified and Gold – Results from Energy Calculator	
Green Mark Gold Plus and Platinum – Results from Energy Modelling	
Explanation if EEI exceeds benchmark	
Building overall EUI (Exclude car park) (kWh/m ² /yr)	
Car park EUI (kWh/m²/yr)	

(TBEC) Total Building Energy Consumption (kWh/year)	(CPEC) Car park energy consumption (kWh/year)	(DCEC) Data centre energy consumption (kWh/year)	(OH) Weighted weekly operating hours (hours/week)	TBEC – CPEC – DCEC (kWh/year)

(GFA) Gross floor area (m ²)	(CPFA) Total floor area for car park (m ²)	(DCA) Data centre area (m ²)	(OA) Others Non-GFA area (m ²)	Total Area (m ²) (GFA + CPFA + OA)

Verification (As Built):

Submission of Stage 2 verification actual EEI and EUI as per the design submission format.

1. Climatic Responsive Design

Criteria	Points
1.01 Leadership	10
1.02 Urban Harmony	10
1.03 Tropicality	10
TOTAL	30
<i>Advanced Green Efforts</i>	<i>7</i>

Climatic Responsive Design Introduction

The long-term sustainability of the built environment, economy and society depends on the collective leadership of building owners in driving sustainable buildings.

The upstream leadership to push beyond the boundary of projects' fundamental requirements is the key towards shifting the needle towards developing climatic responsive designs.

To achieve climatic responsive design in a project, it is crucial to have an effective integrated design process that resonates among the stakeholders, including a shared vision of building a sustainable development and how the vision could be achieved.

The design team of a project should appreciate the site context, so as to capitalise on the physical environment and recognise opportunities for urban built form to maximise responsive design.

The built form should be considered to maximise its response to the local tropical climate, and establish a contemporary tropical vernacular. These are the essentials for impactful **Climatic Responsive Design**.

The criteria highlighted in yellow are scored under **Section 5. Advanced Green Efforts**. The points will form a part of the total Green Mark score, and contribute to the number of points in Section 5

1.01 Leadership

Intent

To recognise and promote the 'Leadership' needed to drive creative, organisational and technical improvements to the overall environmental credentials of projects, from the initial stages of the project through to building occupation and operation. To further stretch outcomes in substantially reducing the environmental impact while increasing the life-cycle quality of building projects.

Criteria	Points
1.01a Climatic & Contextually Responsive Brief	1
1.01b Integrative Design Process	2
1.01c Environmental Credentials of Project Team	2
1.01d Building Information Modelling	2
1.01e User Engagement	3
TOTAL	10
Advanced Green Efforts	3

1.01a Climatic & Contextually Responsive Brief

Scope

This involves the evaluation of all constraints and opportunities as well as conceptualisation of clear environmental sustainability targets and design approaches early at the onset of the project.

Assessment

Criteria	Points
Climatic & Culturally Responsive Brief	1

Demonstration of the above process through two parts:

Strategic Definition – Preliminary definition of the client’s sustainable aspirations for the project and identification of its green potential benchmarked against similar projects. Feasibility studies involving assessments of options against functional requirements and potential constraints should be prepared to rationalise the brief.

Preparation and Brief – Setting of agreed achievable formal sustainability targets for the project. In addition to the project’s targeted Green Mark rating, such targets should involve specific sustainable outcomes and indicators. The selection, deployment and responsibilities of the project team, builders and building operators in order to ensure an optimised building should be detailed as well. This includes the identification of at least one member of the project team to take the lead in coordinating sustainability efforts and tracking of the targets throughout the building design, construction and handover phase.

Guidance Notes

At Design Stage:

Submission of written statements, reports, documents, correspondences and notes of discussion demonstrating the particular project’s briefing process, endorsed by the client or client’s representative and acknowledged by the key project team members.

References

The Singapore Institute of Architects (2013) ‘Attributes of a Sustainable Built Environment’; SIA Publishing

Sinclair, D. (2013) ‘Guide to Using the RIBA Plan of Work 2013’; RIBA Publishing

1.01b Integrative Design Process

Scope

This encompasses the establishment of a collaborative framework for the project team during the briefing, concept design and technical design phase. Addressing and negotiating between the various needs of all stakeholders to achieve the common targets results in a more balanced and optimised design outcome. The integrative design process should be as consultative and non-hierarchical manner as possible to encourage value-added contributions and constructive discussions.

Assessment

Criteria	Points
Integrative Design Process	2

Demonstration of the above process through:

- (i) Appointment of all relevant consultants early in the design phase
- (ii) Identification of responsible parties within the project team to carry out the implementation of the relevant sustainability goals and targets
- (iii) Detailing of sustainable design methodology action plans and progress
- (iv) Addressing of opportunities and challenges with integrative team strategies to achieve the various targets
- (v) Design charrettes held at key stages within the project design, to
 - Jointly set and review sustainability targets, progress and outcomes
 - Serve as platforms for the various disciplines within the project team to voice opportunities to optimise design, and for the team to work together to evaluate the opportunities against other constraints.

Guidance Notes

At Design Stage:

Submission of reports, documents, correspondences and notes of discussions at the various project stages demonstrating the integrative design process.

References

ASHRAE Standard 189.1 (2010) 'Standard for the Design of High-Performance Green Buildings – Informative Appendix H – Integrated Design'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

Sinclair, D. (2013) 'Assembling a Collaborative Project Team, Practical Tools including Multidisciplinary Schedules of Services'; RIBA Publishing

Integrative Process (IP) - ANSI Consensus National Standard Guide (2012) 'Design and Construction of Sustainable Buildings and Communities'; American National Standards Institute

1.01c Environmental Credentials of Project Team

Scope

This pertains to the appointment of environmental specialists at building design, construction and operation stages to drive and coordinate the environmental design approach.

Assessment

Criteria	Points
Green Individuals	0.5
Green and Gracious Builder	0.5
Green Companies	1.5
	<i>Cap at 2 points</i>

Green Individuals:

0.25 points shall be awarded for a Certified Green Mark Manager (GMM) or Green Mark Facilities Manager (GMFM).

0.5 points shall be awarded for a Green Mark Professional (GMP) or Green Mark Facilities Professional (GMFP).

Green and Gracious Builder:

0.5 point shall be awarded where the main builder is a BCA certified Green and Gracious Builder.

Green Companies:

0.5 point shall be awarded where at least 3 of the following are ISO 14001 certified: Architect, M&E Engineer, C&S Engineer, Developer and Main Contractor.

0.5 point shall be awarded for each SGBC Green Services Certified firm.

Guidance Notes

At Design Stage:

Submission of relevant valid certificates, notes of meetings, letters of appointment, as well as commitment letter endorsed by client on appointment intent for GMFM/GMFP if applicable.

Verification (As Built):

Submission of letter of appointment of GMFM/GMFP if applicable

References

BCA Singapore (2015) 'Certified GMFM / Certified GMFP / GMM/ GMP; Retrieved: http://www.bca.gov.sg/GreenMark/gm_manager.html

BCA Singapore (2015) 'Green and Gracious Builder Award'; Retrieved: http://www.bca.gov.sg/Awards/GGBA/builders_award.html

Singapore Green Building Council (2012) 'Green Services Certification Scheme'; Retrieved: <http://www.sgbc.sg/green-certifications/services-certification/>

ISO 14001 (2004) 'Environmental management'; International Organisation for Standardisation

1.01d Building Information Modelling (BIM)

Scope

This refers to the use of BIM as a tool to facilitate a coordinated design between all stakeholders in the construction value chain. BIM can be used to drive initial performance simulation, validate and fine tune performance downstream as well as to optimise construction methodologies.

Assessment

Criteria		Points
(i)	Integrative BIM	2
	<i>SMART BIM (Advanced Green Efforts)</i>	3

1.01d (i) Integrative BIM

Also referred to as social BIM or collaborative BIM, integrative BIM refers to the use of a coordinated BIM modelling framework that harmonises the various disciplines' designs in a 3D environment, to facilitate the co-ordinated spatial design and reduce clashes during construction. Integrative BIM models can also be used to form the base models for various building performance simulations, the results of which can be used to further optimise the building design. Many performance plug-ins are being developed that can evaluate building energy use, façade heat gains and ETTV, lighting and daylighting analysis, as well as natural ventilation performance.

Assessment

1 point for the coordinated use of BIM between the involved parties in the construction value chain. Minimally comprising of the Architect, the MEP Engineers and the Structural Engineer.

1 point for the use of BIM for environmental analysis, building performance simulation and clash detection purposes.

Guidance Notes

At Design Stage:

Submission of the following where applicable:

- BIM model
- Relevant project-specific procedural documents and specifications evidencing use of BIM in project
- Details of the analysis software used, processes and how this has been employed to optimise the building design.

References

BCA Singapore (2013) 'Singapore BIM Guide – Version 2'; Retrieved: https://www.corenet.gov.sg/media/586132/Singapore-BIM-Guide_V2.pdf

Sinclair, D. (2012) 'BIM Overlay to the RIBA Outline Plan of Work'; RIBA Publishing

SMART BIM (Advanced Green Efforts)

Smart BIM comprises of 3 levels:

1. 4D (Time) BIM – This links time information to the BIM model for project scheduling and coordination. By reflecting real time construction activity on site, the 4D model can be used to review progress against the construction programme and identify methods to assess delays, make up time and evaluate extensions of time (EOT) claims.
2. 5D (Cost) BIM – This consists of elemental details, finishes, fixtures and equipment within the model linked to data on performance, manufacturers and specifications. The 5D model can assist in the preparation of cost and quantity schedules and tracking of the project budget. The use of integrated scheduling tools can be incorporated including those tailor made for Singapore such as SIA Idol and INPQS.
3. 6D (Facilities Management) BIM – This involves the updated as built model of the building complete with the procured fixtures, finishes, equipment data.

Assessment

1 point each for 4D (Time) BIM, 5D (Cost) BIM or 6D (FM) BIM

Guidance Notes

At Design Stage:

Submission of the following where applicable:

- 4D/5D model
- Relevant project-specific procedural documents and specifications evidencing linking of relevant elemental attributes to the BIM model and how they are/will be used to optimise processes

Verification (As Built):

Submission of the as built 6D BIM model complete with material, equipment and finishing schedule data captured where applicable

1.01e User Engagement

Scope

This refers to the provision of relevant information and guidance to building occupants as to how they can contribute positively to the reduction of the building's environmental impact.

Assessment

Criteria	Points
Building User Guide	0.5
Green Fit-out Guidelines	1
Green Lease	3
	<i>(cap at 3)</i>

0.5 point for a building user guide to be disseminated to all eventual occupants in the building. The user guide should provide a detailed overview of the sustainable design strategies and all green features employed in the building and how they benefit the user, with an emphasis on occupant health and well-being. It should include clear O&M instructions related to the green features, written in a way the users can understand. The information detailed in Table 1.01e-1 in the subsequent page should not be excluded from the guide.

1 point for green fit out guidelines to be disseminated to the relevant tenant management/ personnel to assist them in making sustainable fit-out decisions. The guidelines should detail recommended energy and water efficiency, environmental protection and indoor air quality standards. It should also mention or provide links pertaining to other helpful information such as green tenant-centric certification schemes and green product certification bodies.

3 points for a comprehensive Green Lease (or equivalent) to be incorporated into the tenancy agreement, that establishes agreed levels of environmental performance between the landlord and the tenant for $\geq 60\%$ of the net lettable area.

Guidance Notes

At Design Stage:

Submission of the following where applicable:

- Building user guide, green fit-out guidelines and/or green lease prepared and endorsed by the client representative, complete with commitment that they will be circulated as specified above
- Official statements committing incorporation of green leasing for specified NLA into tenancy agreements with details of enforcement procedures

Verification (As Built):

Submission of the following where applicable:

- Official building user guide and green fit-out guidelines for circulation, and evidence of their circulation to the respective parties
- Tenancy agreement with Green Lease and enforcement procedures incorporated, complete with evidence of its application to the specific tenants

References

BCA Singapore (2014) 'BCA Green Lease Toolkit: Office Green Schedule 2014'; Retrieved: http://www.bca.gov.sg/GreenMark/others/Office_Green_Schedule.docx

BCA Singapore (2014) 'BCA Green Lease Toolkit: Retail Green Schedule 2014'; Retrieved: http://www.bca.gov.sg/GreenMark/others/Retail_Green_Schedule.docx

Table 1.01e-1: Recommended Information to be included in the Building User Guide

Introduction – an overview of the design, the passive and environmental strategies employed and how they benefit the user.

Energy

- i) Details of the low energy lighting fittings and their operational controls
- ii) Details of energy labelling for any supplementary equipment and advice on selection
- iii) Details on how to track energy consumption

Water

- i) Details of WELS labels of water fittings and water control strategies
- ii) External water use and water recycling that is taking place if any
- iii) Details on water saving measures and tips

Waste & Recycling

- i) Information on the waste collection strategies, and what needs to be segregated for recycling
- ii) Information on good practice and local waste facilities for items that are not under the normal waste contract

Green Transportation and Access

- i) Details of bicycle parking provisions and shower arrangements
- ii) Details of the local transportation options to and from the building

Local Amenities

- i) Details of the amenities and facilities within and around the building

Responsible & Healthy Fit Out

- i) Details of the green products used within the building
- ii) Importance of using green fit-out and low VOC materials
- iii) Embodied energy of building materials selection

Responsible Purchasing

- i) Advice on green procurement strategies relevant to the type of building occupant

Others

- i) The environmental impact of user behaviour
- ii) Information on good practices for sustainable building operations relevant to the building users including links to websites, publications and organisations providing information or guidance on environmentally sound operations, environmental tips and initiatives.

1.02 Urban Harmony

Intent

To identify the impact of the physical form of a building, which prefixes its sustainable performance, with respect to its immediate locale and larger context.

To also take into consideration a building's human-centricity – how its presence will affect its context as well as the movement and comfort of the people in its neighbourhood.

Criteria	Points
1.02a Sustainable Urbanism	5
1.02b Integrated Landscape and Waterscape	5
TOTAL	10
Advanced Green Efforts	2

1.02a Sustainable Urbanism

Scope

This involves conducting site analysis to develop a sustainable accessible and contextual response. This ensures that the development enhances the urban realm and minimises its environmental impact while creating minimal dis-amenity to the surrounding buildings.

Assessment

Criteria	Points
(i) Environmental Impact Statement	2
(ii) Response to Site Context	3
(iii) Urban Heat Island	1
(iv) Green Transport and Logistics	1
	<i>Cap at 5 points</i>
<i>Creation of possible new ecology and natural ecosystems (Advanced Green Efforts)</i>	1

1.02a (i) Environmental Impact Assessment and Statement

To empower building stakeholders through a holistic Environmental Impact Assessment and Statement (EIA). The EIA serves as a reporting framework to understand the environmental impacts of their decisions and thus make informed decisions to prevent environmental degradation.

To be conducted prior to the commencement of activities on site.

Assessment

1 point shall be awarded for a comprehensive EIA to identify the anticipated effects on the environment a proposed development or project may have. The EIA shall identify design measures to mitigate negative impacts to the site environment with a focus on climate change and ecological systems. It should describe how the project can contribute positively to the overall ecology and biodiversity of the site and its wider context.

1 point shall be awarded for the implementation of mitigation measures for the protection of valuable site ecology during construction.

The EIA should cover the following aspects listed under Table 1.02a-1

Guidance Notes

At Design Stage:

Submission of EIA, endorsed by the client or client representative

At Verification Stage:

Documentary evidence and photographs of implementation of the environmental mitigation measures undertaken during the construction and initial operation of the building.

Replacement is not able to compensate the points for features of identified value removed in the construction process or site clearance.

References

Environmental Protection Agency, Ireland (2002) 'Guidelines on the information to be contained in Environmental Impact Statements (EIS)'; Retrieved: <http://www.epa.ie/pubs/advice/ea/guidelines/#.VRks5-H1Jww>

European Commission (2015) 'Environmental Impact Assessment Guidance'; Retrieved: <http://ec.europa.eu/environment/eia/eia-support.htm>

U.S. Environmental Protection Agency (2000) 'National Environmental Policy Act (NEPA)'; Retrieved: <http://www.epw.senate.gov/nepa69.pdf>

Table 1.02a-1 Outline of the EIA

- The proposed development and its need
- The existing environment of the site
- The impacts of the proposed development and its alternatives on the environment covering:
 - Climate Change
 - Flora and Fauna (including aquatic life)
 - Soil
 - Air
 - Water
- The recommendations and measures to mitigate any adverse impacts and / or opportunities to improve the site beyond its original condition before the development, i.e. how the ecological features or areas of the site are to be adequately protected from damage or disturbance during the construction activities from site clearance and preparation through to practical completion and handover.
- A non-technical summary

Creation of possible new ecology and natural ecosystems (Advanced Green Efforts)

To demonstrate that the completed project 'heals the land' Beyond mitigation measures, by having a net positive impact on the ecological system

Assessment

1 point for details and strategies in the EIS on how the project will enhance the site ecology beyond its current state. The regenerative features should be quantified in terms of an overall net improvement vs the building not being constructed and the site remaining in the current context. Agreed metrics (such as the Singapore Index on Cities' Biodiversity) shall be used and tracked during the project completion.

Guidance Notes

At Design Stage:

As per 1.02a (i) Environmental Impact Assessment and Statement but with the relevant additional information

Verification (As Built):

A study utilising the agreed metrics at the design stage conducted at suitable intervals during the building's operational life that demonstrates the projects regenerative performance.

1.02a (iii) Response to Site Context

To demonstrate how the site topography, microclimate, access and connectivity has informed the design of the urban form and site layout. A site analysis should be conducted to identify the relationships between human and physical geography of the site and inform how the building responds to these factors.

Assessment

1 point shall be awarded for Level 1 site analysis and design that demonstrates sensitivity to the site conditions.

3 points shall be awarded for Level 2 analysis and optimised design via iterative simulations.

The site analysis report format and content is detailed in Table 1.02a-2.

Guidance Notes

At Design Stage:

Submission of the site analysis document endorsed by the client or client representative.

Table 1.02a-2 Site Analysis Document

- Executive Summary – *A non-technical summary that summarises the site analysis*
- Urban context – *The urban form, land use and its impact on the site. This shall include key vistas, view corridors, the urban grain as well nearby amenities*
- Site Topography & Hydrology – *Land and topographical survey of the site facilitating design decisions based on the site's topographical features, storm water runoff and other key features. This section can link to the EIS if conducted (1.02a)*
- Site Micro Climate - Sun/ Wind/ Acoustics/ Views/ Air Quality:
 - Level 1 – *Identification on plan and photographic evidence of the key micro climatic conditions of the site and how this will be considered in the design*
 - Level 2 – *Macro level simulations that analyse the site context*
- Site Access and Connectivity – *Details of pedestrian and vehicular traffic, site accessibility and public transport options. The analysis shall investigate the connectivity potential to connect the site to existing green infrastructure such as parks, gardens or cycle routes, as well as sheltered connectivity to public transport. The analysis should also look at physical connectivity feasibility to adjacent buildings (existing or planned)*
 - Level 1 – *Concept design studies demonstrating how the functional requirements of the project responds positively to the site context including enhancing site access*
 - Level 2 – *Iterative massing studies through macro simulations that identify how the urban form of the building has been optimised, the location of outdoor amenities have been located to take advantage of the site conditions, including outdoor thermal comfort analysis. The simulations should identify that the building minimises its impact on its neighbours*

1.02a (iv) Urban Heat Island

To mitigate the urban heat island (UHI) effect through the material selection of the landscape, (hardscape, softscape) and building surfaces. UHI refers to the increase in ambient temperature caused by the storage of shortwave radiation by urban materials.

Assessment

% Site coverage (at plan view)	Points
≥ 50% demonstrating mitigation measures	0.5
≥ 80% demonstrating mitigation measures	1

The site plan shall be used to calculate the site coverage of the UHI mitigation measures such as:

- Green and blue spaces for landscaping and roof
- Roofing materials or coatings or cool paints with high Solar Reflectance Index (SRI) > 40
- Unshaded hardscape areas with SRI > 39, inclusive of unshaded carparks, internal roads, plazas and pedestrian walkways
- Use of permeable paving strategies such as gravel or open paving systems
- Other performance based strategies that demonstrate UHI effect mitigation

Areas with renewable energy (photovoltaic panels) shall be deemed to comply.

Guidance Notes

At Design Stage:

Submission of the following where applicable:

- Site plan highlighting vegetated and waterbody areas, hardscape areas and roof areas
- Calculation of hardscape areas shaded by vegetation based on a midday sun i.e. the shadow shall correspond to the area directly under the tree canopies. The tree canopy size shall be based on the mature crown size as per NParks guidelines (also referenced under 1.02c (i) Greenery Provision)
- Material schedules or specifications of the roof and hardscape finishes with corresponding SRI values. Where such values are not provided, calculations in accordance to ASTM E1980 – 11 may be used supported by solar reflectance and thermal emittance specifications

Verification (As Built):

Submission of the following where applicable:

- Any design changes to be highlighted on the plan drawing and the areas recalculated
- Photographic evidences of the vegetated areas
- Delivery orders of the hardscape materials and roof finishes supported by technical specifications providing the SRI or solar reflectance and thermal emittance values

References

ASTM E1980 -11 (2001) 'Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low Sloped Opaque Surfaces'; ASTM International

1.02a (v) Environmentally-Friendly Urban Transport and Logistics

To reduce the emissions from vehicular transport to and from the building through the use of co-ordinated smart logistics systems, promotion of electric vehicles and the reduction of car parking lots.

Urban logistics facilities can be provided to facilitate aggregated distribution of goods through shared infrastructure, assets and consolidated deliveries to reduce the vehicular emissions associated with deliveries.

Where onsite vehicular parking is provided, there should be car park infrastructure to support electrical vehicles charging requirements.

Assessment

There is a cap of 1 point for this sub indicator.

- 1 point for the provision or utilisation of smart logistics facilities
- 0.5 points for the provision of electrical vehicle charging and parking infrastructure
- 0.5 points for the reduction of car parking provision

Guidance Notes

At Design Stage:

Urban Logistics Facilities:

The project team shall demonstrate the estimated environmental benefits and details of the smart logistics scheme through:

The estimation of reduction in greenhouse gas emissions (nitrogen dioxide, sulphur dioxide, carbon dioxide, carbon monoxide, particulate matter, ozone) from delivery vehicles through an urban logistics scheme

The potential reduction of energy from lesser trips made using the goods lift

Electric Vehicle Charging Infrastructure

The location and number of electric parking lots and the provision of the electrical points ready for the charging infrastructure. There shall be at least 1 lot per 100 lots (cap at 5 lots)

Reduction of Parking lots:

Reduced carpark provision at minimally 20% below the prevailing car park standard

Note The Developer would be required to submit an application for 'Range Based Car parking Standard (RCPS)' for LTA's approval. The point should be awarded only if the RCPS application is approved by LTA

Verification (As Built):

As built drawings and photographs highlighting the provision of the committed features.

1.02b Integrated Landscape and Waterscape

Scope

Projects are encouraged to integrate a verdant landscape and waterscape that is accessible for all to enjoy into their building design.

Assessment

Criteria	Points
(i) Greenery Provision (GnPR)	3
(ii) Tree Conservation	1
(iii) Sustainable Landscape Management	1
(iv) Sustainable Stormwater Management	1
	<i>Cap at 5 points</i>
<i>GnPR greater than 5.0 (Advanced Green Efforts)</i>	<i>1</i>

1.02b (i) Greenery Provision

To provide greenery within the development to enhance the biodiversity around the development and provide visual relief to building occupants and neighbours.

Assessment

GnPR	Points Allocation
0.5 to <1.0	0.5
1.0 to <2.0	1.0
2.0 to <3.0	2.0
3.0 to <4.0	2.5
≥ 4.0	3.0
≥ 5.0	1 (Advanced Green Effort)

The GnPR is a calculation that demonstrates the total leaf area of the greenery within the site over the total site area. The greenery applicable includes any rooftop gardens, sky terraces, landscape areas.

Guidance Notes

At Design Stage:

Submission of the following where applicable:

- Plan layouts or software showing the site area as well as the greenery that is provided within the development (including a listing of the number of trees, palms, shrubs, turf and the respective sub category and LAI values with reference to Table 1.02b-1
- Calculation showing the extent of the greenery provision in the GnPR calculation template

Verification (As Built):

- As built drawings showing the landscape plans with the delivery orders of the plants.
- Re-computation of GnPR for any deviations using the GnPR calculation template

References

National Parks Board (2006) '1001 Garden Plants in Singapore, 2nd edition'; NParks Publication

National Parks Board (2009) 'Trees of our Garden City, 2nd edition'; NParks Publication

National Parks Board (2013), 'NParks Flora and Fauna Web'; Retrieved: <https://florafaunaweb.nparks.gov.sg/>

Table 1.02b-1: LAI values

Plant Group	Trees	Palms	Shrubs & Groundcover	Turf
Leaf Area Index (LAI)	Open Canopy = 2.5 Intermediate Canopy = 3.0 Dense Canopy = 4.0	Solitary = 2.5 Cluster = 4.0	Monocot = 3.5 Dicot = 4.5	2.0
Fixed Area:	Columnar = 12m ² Non Columnar = 60m ²	Solitary = 20m ² Cluster = 17m ²	Planted Area	Planted Area
	If the trees or the palms are planted at ≤ 2.0m centres trunk to trunk, the leaf area shall be calculated as a product of the LAI value and the planted area (m ²)			

1.02b (ii) Tree Conservation

To encourage preservation of existing trees on-site to prevent disturbance to established habitats. Where trees are felled the project team are encouraged to replant an equivalent number of similar or native species of equivalent LAI.

Assessment

Tree Conservation	Points
Preservation of Existing Trees	0.5
Replacement of Felled trees	0.5

Full points may be scored here for projects that had scored the full points under *1.02b Environmental Impact Assessment* by demonstrating preservation of existing trees as one of the mitigation efforts.

Guidance Notes

At Design Stage:

Submission of the following where applicable:

- Site layouts showing the exiting final locations (where trees are being transplanted) and number of the trees to be conserved or relocated
- Existing site plans showing the location and numbers of trees that are to be felled with the identification of the tree species and LAI values. The proposed landscape plans shall show the proposed equivalent number and tree species with LAI values of the replacement trees

Verification (As Built):

- As built drawings, transplanting records and on site photographs of the conserved trees
- As built drawings and photographs of the replaced trees

References

National Parks Board (2009) 'Trees of our Garden City, 2nd edition'; NParks Publication

National Parks Board (2013) 'NParks Flora and Fauna Web'; Retrieved: <https://florafaunaweb.nparks.gov.sg/>

1.02b (iii) Sustainable Landscape Management

To ensure the landscape enhances the native biodiversity through effective sustainable management of the landscape of a development.

Assessment

1 point shall be awarded for projects certified under NParks Landscape Excellence Assessment Framework (LEAF) certification.

For projects not certified under leaf certification, 0.5 points may be awarded for each of the following:

- (i) The adoption of native species of greenery > 50% of the flora selected wherever possible to maintain the local ecosystem
- (ii) Projects that scored full points under *1.02b Environmental Impact Assessment*
- (iii) A landscape management plan established that covers:
 - a. The use of organic composts from horticultural wastes
 - b. The potential for onsite composting
 - c. General landscape maintenance and management plan during building occupation

Guidance Notes

At Design Stage:

Submission of the following where applicable:

- Extracts of the tender, or a signed commitment from the developer / building owner that NParks LEAF certification will be applied for
- Landscape plan outlining the native species with a calculation of the % of site coverage
- Submission of the draft landscape management plan with supporting tender specifications

Verification (As Built):

Submission of the following where applicable:

- The letter of award or LEAF certificate
- Delivery orders of the native species and quantity to be prepared and submitted. Any variations would require a re-tabulation
- The completed landscape management plan and implementation records supported by photographic evidence, delivery orders of composts with reports of soil/ compost mixes as well as the landscape maintenance manual

References

National Parks Board (2006) '1001 Garden Plants in Singapore, 2nd edition'; NParks Publication

National Parks Board (2009) 'Trees of our Garden City, 2nd edition'; NParks Publication

National Parks Board (2013) 'NParks Flora and Fauna Web'; Retrieved: <https://florafaunaweb.nparks.gov.sg/>

National Parks Board (2015) 'Landscape Excellence Assessment Framework (LEAF)'; Retrieved: <https://www.nparks.gov.sg/partner-us/landscape-industry/leaf>

1.02b (iv) Sustainable Storm Water Management

To reduce storm surges and to improve the quality of water entering the public drains through infiltration or design features.

Assessment

Sustainable Storm water Management	Points
PUB Active, Beautiful and Clean Waters (ABC Waters) certification	1
OR	
Treatment of storm water run-off through the provision of infiltration or design features before discharge to the public drains	
(i) Treatment of $\geq 35\%$ of run off from total site area	1
(ii) Treatment of $\geq 10\%$ of run off from total site area	0.5

Guidance Notes

At Design Stage:

Submission of the following where applicable:

PUB ABC Waters certification application form

OR

Site layout plans indicating the total site area, the total paved area within the site as well as the total catchment areas of the site for which the run-off shall be treated. Treatment areas, and hydraulic retention time of the design features are to be included as a part of the calculation that demonstrates the percentage of storm water run off that can be treated through the proposed strategies

- Proposed strategies for the treatment of the storm water run-off shown through:
 - Drainage plans
 - Schematic drawings
 - Location plan
 - Sectional details of the drainage feature
 - Specification of the filtration, transition layers, sub soil drainage layer and system, overflow arrangement
 - Design calculations and simulations (where applicable)

Verification (As Built):

Submission of the following where applicable:

ABC Waters certificate

OR

As built drawings and photographs documenting the construction and implementation of the storm water management system

References

Public Utilities Board (2014) 'Active Beautiful Clean Waters Design Guidelines, 3rd Edition'; Retrieved: http://www.pub.gov.sg/abcwaters/abcwatersdesignguidelines/Documents/ABC_DG_2014.pdf

1.03 Tropicality

Intent

To consider the passive design aspect of the building, including its orientation, facades as well as interior layout to reduce its heat load and energy usage as well as enhance effective daylight design and thermal comfort.

Criteria	Points
1.03a Tropical Façade Performance	4
1.03b Internal Organisation	2
1.03c Ventilation Performance	4
TOTAL	10
Advanced Green Efforts	2

1.03a Tropical Façade Performance

Scope

A responsive tropical façade is one that reduces the heat gain into the building, providing perceptive comfort through reducing the direct sunlight into the building. From a performance point of view, it should be highly permeable in areas of natural ventilation and air tight in areas of air conditioning to reduce air leakage.

Assessment

Criteria	Points
Tropical Façade Performance	4
<i>Vertical Greenery on the East and West Facade (Advanced Green Features)</i>	1

Up to 4 Points shall be awarded based on the façade performance assessed through meeting or exceeding the limits in table 1.03b-2 and 1.03b -3 or through building simulation.

Where simulations have been used, documents shall include screen shots of the model vs the notional model and the results. BCA will check the model as a part of the assessment.

Guidance Notes

The ETTV pre-requisite must be met for the level of award that the project is targeting. This will also be verified at the as built stage.

At Design Stage:

A notional façade is detailed in Table 1.03a-1.

Points shall be awarded based on the façade performance. There are 2 scoring options:

1. **Simulation based:** for (1) Air conditioned commercial buildings with a WWR greater than 0.5, and (2) Air Conditioned industrial buildings with a WWR greater than 0.25. The façade performance is evaluated through a building physics model that demonstrates a performance advantage against the notional façade for that building type. Points shall be scored based on the heat load reduction of the envelope and solar insolation reduction of the fenestrations the notional façade shall follow Table 1.03b -1.

Cooling load reduction (%)	Points
Meeting Notional Facade	1
5%	2
10%	3
15%	4

2. **Checklist based:** for commercial or industrial buildings that are not required to undertake a simulation - Points are awarded based on table's 1.03a-2 and 1.03a-3. For projects that demonstrate exceptional facades, an additional 1 point can be scored.

Greenery on the East and West Façade (Advanced Green Efforts)

- a. 1 for $\geq 30\%$ of applicable façade area
- b. 0.5 for $\geq 15\%$ of applicable façade area

Verification (As Built):

- Qualified Person (QP) endorsed As Built drawings of the façade including construction details
- A report highlighting any changes to the façade from that committed at the stage of design assessment and how this affects the performance
- The delivery orders of the materials used in the envelope
- Testing or commissioning reports of façade performance where applicable

References

ASHRAE Standard 90.1 (2013) 'Energy Standard for Buildings Except Low-Rise Residential Buildings – Section 5.4'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

BCA Singapore (2008) 'Code on Envelope Thermal Performance for Buildings'; Retrieved: <http://www.bca.gov.sg/PerformanceBased/others/RETV.pdf>

CIBSE TM23 (2000) 'Testing Buildings for Air Leakage'; Chartered Institution of Building Services Engineers (UK)

CIBSE TM35 (2004) 'Environmental Performance Toolkit for Glazed Facades'; Chartered Institution of Building Services Engineers (UK)

Table 1.03a-1 Notional Façade for Simulation.

	Commercial & Institutional Buildings	Industrial
Weighted Window U-Value	2.8	5.4
Weighted Wall U-Value	0.7	1.5
Overall Envelope U-Value	1.6	2.4
WWR (each façade)	0.4	0.20
Total Effective Shading Coefficient (SC1 x SC2)	0.4	0.6
Maximal Air Leakage (AC Spaces only)	5m ³ /h/m ² @ 50Pa	10m ³ /h/m ² @ 50Pa
Roof U-Value	0.8	1.1
Sky light / Roof window U-Value	2.2	4.3
RTTV (where there are sky lights <i>for AC areas</i>)	50	50

Simulation Methodology

A model that accurately reflects the spatial parameters of the building shall be created using a DOE 2.0 or equivalent software. The façade shall be modelled as per the notional façade (Table 1.03b-1) and as per design. The comparison excludes any internal heat gains and internal zoning. The percentage cooling load reduction is determined through comparing the result against the notional façade model. The heat gain shall be computed based on relevant climate data (including solar heat gains) based on an annual simulation.

Note that Simulation is ONLY required for the following:

- 1) Commercial buildings with a WWR greater than 0.5, and
- 2) Industrial buildings with a WWR greater than 0.25

Table 1.03a-2 Non Simulation Score for Commercial Buildings:

	Baseline	Points for Improvement
Overall weighted Envelope U-Value	1.6 Wm ⁻² K ⁻¹	0.5 points for meeting U value of 1.6Wm ⁻² K ⁻¹ Additional 0.5pts for every 0.2Wm ⁻² K ⁻¹ reduction. <i>Cap at 2 points</i>
WWR (Excludes façade openings/voids)	0.4 (Overall) <i>East and West facades not to exceed 0.3%</i>	WWR 0.4 -1pt WWR 0.35 – 1.5pts WWR 0.3 – 2pts
Glass Shading Coefficient (SC1)	0.4	SC 0.4 = 0.5pt SC 0.35 = 1pt SC 0.3 = 1.5pt SC 0.25 = 2pt
Effective Sun Shading (North and South)	-	≥ 10% effectiveness 1pt
Effective Sun Shading East and West)	-	≥30% effectiveness 1pt
Air Leakage (AC Spaces)	5m ³ /h/m ² @ 50Pa	5m ³ /h/m ² @ 50Pa = 1pt 3.5m ³ /h/m ² @ 50Pa = 2pt
Roof U-Value	0.8 W m ⁻² K ⁻¹	1pt for meeting 0.8 W m ⁻² K ⁻¹
Sky light / Roof window U-Value	2.2 W m ⁻² K ⁻¹	0.5points for meeting U-Value
Total Points (Cap at 4)		

Table 1.03a-2 Non Simulation Score for Industrial Buildings:

	Baseline	Points for Improvement
Overall weighted Envelope U-Value	2.4 Wm ⁻² K ⁻¹	0.5 points for every 0.4 W m ⁻² K ⁻¹ reduction in U-Value compared to the baseline <i>Cap at 2 points</i>
WWR (Excludes Façade openings / voids)	0.2	WWR 0.2 -0.5pt WWR 0.15 – 1pt WWR 0.12 – 2pts
Glass Shading Coefficient (SC1)	0.6	SC 0.5 = 1pt SC 0.45 = 1.5pt SC 0.4 = 2 pt
Effective Sun Shading (North and South)	-	≥10% effectiveness 1pt
Effective Sun Shading East and West)	-	≥30% effectiveness 1pt
Air Leakage (AC Spaces)	10m ³ /h/m ² @ 50Pa	10m ³ /h/m ² @ 50Pa = 1pt 7m ³ /h/m ² @ 50Pa = 1.5pt 5m ³ /h/m ² @ 50Pa = 2pt
Roof U-Value	1.0 W m ⁻² K ⁻¹	0.5points for a reduction of 0.1 <i>Cap at 2 points</i>
Sky light / Roof window U-Value	4.0 W m ⁻² K ⁻¹	U-Value of 4 W m ⁻² K ⁻¹ = 0.5pt U-Value of 2 W m ⁻² K ⁻¹ = 1pt
Total Points (Cap at 4)		

1.03b Internal Organisation

Scope

The internal spatial organisation of a building provides opportunities to improve the operational efficiency of the building over its entire life. Strategic decision-making including the location of non-critical building services, transient spaces and vertical transportation all have lasting effects on the building's performance.

Assessment

Criteria	Points
Zoning of building services and transient spaces to reduce occupied spaces heat gains	1
Transient spaces to be passively designed	1

1 point shall be awarded for locating building services such as lift cores, staircases, WC's, M&E spaces and other non-thermally critical non-air-conditioned spaces on east and west facing walls to reduce the thermal heat gain into the functional spaces.

1 point shall be awarded by number of all Common spaces are non-air-conditioned, such as toilets, staircases, corridors, lift lobbies, atriums etc.

Common Area	Mode of Ventilation (MV = 0.5 point, NV = 1 point, AC = 0 points)
Toilets	
Staircases	
Corridors	
Lift Lobbies	
Atriums	
Others (e.g. Pantry spaces)	
Total	= sum of points/number of applicable common spaces

Guidance Notes

At Design Stage:

Submission of the following where applicable:

- Plans and elevations marking the locations of the building services and non-thermally critical non air-conditioned spaces and the subsequent reduction of conditioned areas directly exposed to eastern and western solar gains.
- Plans and details of the common spaces including façade openings and ventilation modes

Verification (As Built):

Submission of as built drawings of the approved spaces

1.03c Ventilation Performance

Scope

This refers to the design of naturally ventilated functional areas of buildings including atria to be thermally comfortable and healthy for the building occupants.

Applicable for naturally ventilated functional spaces and gathering spaces such as building atria.

Assessment

Criteria	Points
Demonstrate Effective Natural Ventilation	4 points
<i>Wind Driven Rain Simulation (Advanced Green Efforts)</i>	<i>1 point</i>

1.03c (i) Demonstrate Effective Natural Ventilation

To encourage the design for effective natural ventilation for thermal comfort, indoor environmental quality for all naturally ventilated spaces.

Assessment

Points shall be awarded based through the following options:

Criteria	Points
Ventilation performance checklist	3 points
Full Computational Fluid Dynamics (CFD) Simulation	4 points

Ventilation Performance Checklist

Up to 3 points shall be awarded as follows:

Parameter	Description	Points
Openings towards Prevailing Wind directions (including Atria)	0.1 point for every 10% of units or rooms with openings facing towards the prevailing winds (North & South for Singapore)	1
Depth of Room vs Opening <i>*Effective opening >5% floor area (Building Code)</i>	<p><u>Single sided ventilation:</u> the limiting depth(W) for effective ventilation is twice the floor-to-ceiling height (H) [$W \leq 2H$]</p> <p><u>Cross Ventilation:</u> the limiting depth(W) for effective ventilation is five times the floor-to-ceiling height (H) [$W \leq 5H$]</p> <p><u>Combination with stack effect atria:</u> 15m limiting depth of space from façade to atria.</p> <p><i>Note:</i> <i>Atria to have an effective opening >10% floor area.</i> <i>Atria can be 1.5x the depth of room (above), or 2 x where the use of fixed fans or mixed mode systems are employed.</i></p>	<p>1 Point <i>Where</i> <i>≥50% of applicable spaces meet</i></p> <p>2 Points <i>Where</i> <i>≥70% of applicable spaces meet</i></p>
Total 3 Points		

CFD Simulation

A ventilation performance report shall be produced that documents the approach to the ventilation of the relevant spaces.

Detailed CFD simulations shall follow the *BCA Green Mark Computational Fluid Dynamic Simulation Guidelines*. Points shall be scored based on table 1.03c-2.

Guidance Notes

Design Stage:

Ventilation Performance

Compliance to the checklist performance in table 1.03c-1.

Full CFD Simulation

The CFD simulations or wind tunnel testing are to be conducted based on the requirements in the *BCA Green Mark Computational Fluid Dynamic Simulation Guidelines*. For Gold Plus and Platinum projects with $\geq 2,000\text{m}^2$ of naturally ventilated functional spaces (excluding all transient spaces and M&E spaces with the exception of building atria) P.27 must be met.

1. Wind Speed:

The simulation results and the recommendations derived are to be implemented to ensure optimised natural ventilation with minimum weighted average wind velocity. Moderate, Good and Very Good levels of performance are identified within the *Computational Fluid Dynamic Simulation Guidelines*, where Very Good represents the pre-requisite for *Platinum* and Good for *Gold Plus* within the occupied space.

Or

The simulation results and the recommendations derived are to be implemented to ensure optimised natural ventilation to the Moderate level as stated in the *Computational Fluid Dynamic Simulation Guidelines*. The project team can further demonstrate their ventilation performance through either:

2.1 Thermal Comfort:

For occupied spaces where the area weighted wind velocity is less than Very Good for *Platinum* and Good for *Gold Plus*, thermal comfort modelling shall be performed and shall meet the thermal comfort criteria for naturally ventilated spaces in tropical climate based on the checklist approach.

2.2. Air Quality:

For occupied spaces where the area weighted wind velocity is less than Very Good for *Platinum* and Good for *Gold Plus*, air quality modelling shall be performed and shall meet the air quality criteria for naturally ventilated spaces in tropical climate based on the checklist approach.

Note: Option 2.2 is only applicable for the following building types:

- 1) Industrial warehouses with occupancy density no more than $50\text{m}^2/\text{person}$
- 2) Sports facilities

References

BCA Singapore; 'BCA Green Mark Computational Fluid Dynamic Simulation Guidelines'

CIBSE Applications Manual 10 (2005) 'Natural Ventilation in Non-Domestic Buildings'; Chartered Institution of Building Services Engineers (UK)

Table 1.03c-1 – For at least 70% of applicable naturally ventilated areas to meet

Points	Wind Speed Result	Thermal Comfort	Air Quality
3	Moderate (0.2m/s)	-	-
4	Good (0.4m/s)	-1.0 <PMV<+1.0	Air Change Rate ≥4 Air Exchange Efficiency of ≥ 1
(Platinum)	Very Good (0.6m/s)	-0.5 <PMV<+0.5	Air Change Rate ≥10 Air Exchange Efficiency of ≥ 1.2

Note: No part of any room or space (other than a room in a warehouse) that is designed for natural ventilation shall be more than 12.0 m from any window/opening that is ventilating the space.

Windows or other openings shall be located such that they are open to the exterior of the building, or an air well with a minimum width of 3.0m and a minimum area open to the sky (table 1.03c-2), or a recess (void) exceeding 3.0m from the external building wall of minimum width 3.0m

For a functional space to be considered naturally ventilated there shall be one or more openable windows or other openings with an aggregate area of not less than 5% of the floor area of the space required to be ventilated. The effective open area of a sliding window is the unobstructed area when the sliding window is opened fully. The effective open area of any opening installed with fixed louvers shall be assumed to be 50% of the area of the opening. For any casement windows installed with restrictors and can be opened at least 30 degrees or more, the effective open area of the window shall be assumed to be 50% of the window opening.

Table 1.03c-2 – Minimum airwell size:

Height (m)	Minimum airwell size (m ²)
≥30m	10m ²
Every subsequent 3m	+1m ²

1.03c (ii) Wind Driven Rain Simulation (Advanced Green Efforts)

Use of wind driven rain simulation modelling to identify the most effective building design and layout that minimises the impact of wind-driven rain into naturally-ventilated occupied spaces

Assessment

1 points shall be awarded for the use wind driven rain simulation modelling to demonstrate compliance to the Wind Driven Rain Simulation Methodology and Requirement within the *BCA Green Mark Computational Fluid Dynamic Simulation Guidelines*

Guidance Notes

Design Stage:

Submission of simulation results and proof of adherence to the performance requirements listed in the *BCA Green Mark Computational Fluid Dynamic Simulation Guidelines*

References

BCA Singapore; 'BCA Green Mark Computational Fluid Dynamic Simulation Guidelines'

2. Energy Performance

Criteria	Points
2.01 Energy Efficiency	7
2.02 Energy Effectiveness	15
2.03 Renewable Energy	8
TOTAL	30
<i>Advanced Green Efforts</i>	12

Energy Performance Introduction

The energy performance of a building is measured through the efficiency of its active systems. In the urban tropics, this is mainly attributed to air conditioning systems, artificial lighting and hot water production in some building types.

The built environment is an important contributor towards reducing global carbon emissions and fossil fuel consumption. This section builds on Section 1 – Climatic Responsive Design, where building projects should also demonstrate the optimisation of building energy systems to reduce the environmental impact.

Combining climatic responsive design and optimisation of building energy systems, as well as tapping on opportunities to adopt renewable energy, the energy performance of building projects can be improved significantly.

In this version of Green Mark, an Energy Performance Points Calculator* has been formulated to aid the design team to understand the buildings' energy performance, while providing options to reduce energy consumption. This calculator shall be used by the project team to compute this section's points, and to demonstrate the building's energy performance.

* In spreadsheet format

The criteria highlighted in yellow are scored under **Section 5. Advanced Green Efforts**. The points will form a part of the total Green Mark score, and contribute to the number of points in Section 5

2.01 Energy Efficiency

Intent

To encourage buildings to stretch boundaries in optimising the efficiency of their high consumption mechanical systems, namely the air conditioning and lighting systems.

Criteria	Points
2.01a Air Conditioning Total System Efficiency	4
2.01b Lighting Efficiency	3
TOTAL	7

2.01a Air Conditioning Total System Efficiency

Scope

Covers the total system efficiency of all the air conditioning system equipment normally in operation in the building, inclusive of chillers, unitary systems, associated pumps, cooling towers and air distribution systems.

Non-air-conditioned building projects shall score full points under this indicator.

Assessment

Criteria	Points
Air Conditioning Total System Efficiency	4

The Energy Performance Points Calculator shall be used to calculate the total system efficiency of the air conditioning systems used in the project. The relevant points shall be scored based on the table below:

	Building Cooling Load (RT)	
	<500 RT	≥500RT
	Total Design System Efficiency (kW/RT)	
Baseline	1.08	0.98
1 point for every 6% improvement from baseline		

The design system efficiency of the chilled water plant (air or water cooled) shall be computed based on the simulated total building cooling load profile of the operational design load. This refers to the power inputs of the various system components selected over the operating range of the cooling load conditions, as defined in P04. The air distribution system efficiency shall be based upon the fan input power over the operational design load. Where the fan input power cannot be determined, the nameplate power shall be used.

For unitary systems the efficiency shall be based on the total weighted COP and the weighted operational load. The air distribution efficiency shall be based upon the weighted cooling load with the fan speed assumed to be at the high level for FCU's.

The peak building cooling load is determined based on design day conditions, namely where solar gains and outdoor temperatures are at their highest and there is full occupancy.

Points can only be scored provided that the air distribution system efficiency does not exceed 0.28kW/RT. *For Air distribution systems with high pressure drops due to the functional requirements of the system, BCA will permit a fan power pressure drop adjustment based on table 2a and 2b under SS553: 2015. The baseline of total system efficiency (kW/RT) will be adjusted accordingly*

Guidance Notes

At Design Stage:

Submission of the following if applicable:

Energy Performance Points Calculator

Technical specifications and product information of all air-conditioning systems including:

- part load curves and calculations
- Detailed calculations of fan input power for each PAU, AHU and FCU in the building based on operational design load.
Pump head calculations
- Duct static pressure calculations
- ACMV layout plan
- Weighted COP and weighted cooling load calculations for Unitary systems

Verification (As Built):

Submission of the following if applicable:

- Energy Performance Points Calculator reflecting as-built information
- Delivery orders of air conditioning system including the air distribution systems
- Completed Operational System Efficiency report of the air conditioning system including the power for the air distribution system detailing the total operational performance measured over a 1 week period.
- Power consumption of the unitary systems

References

Singapore Standard 530 (2014) 'Code of Practice for Energy Efficiency Standard for Building Services and Equipment'; SPRING Singapore

Singapore Standard 531 (2013) 'Code of Practice for lighting of work places - Indoor'; SPRING Singapore

ASHRAE Standard 90.1 (2013) 'Energy Standard for Buildings Except Low-Rise Residential Buildings'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

2.01b Lighting System Efficiency

Scope

This refers to the savings in using energy efficient lighting against code requirements.

Applicable to all building lighting excluding carpark and emergency lighting.

Assessment

Criteria	Points
Lighting System Efficiency	3

The Energy Performance Points Calculator shall be used to calculate the savings of the building's lighting power density in comparison with the lighting power budget in SS 530: 2014. 1 point shall be scored for every 15% savings over code.

The lighting shall include tenant lighting calculated through the base lighting fit out or a Green Lease in accordance to *1.01e Green Users* which shall stipulate the maximum lighting power density permissible.

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Energy Performance Points Calculator
- Lighting layout plans and schedules
- Luminaries data sheets
- Lighting level simulation showing the resultant lux level and uniformity of the lighting design that meets or surpasses prevailing code requirements

Verification (As Built):

Submission of the following if applicable:

- Energy Performance Points Calculator reflecting as-built information
- As built lighting layout, lighting schedule and luminaries data sheets
- Purchase orders and delivery orders of the luminaries used in the project
- Documentation of onsite verification of the as built lighting lux level achieved

References

Singapore Standard 530 (2014) 'Code of Practice for Energy Efficiency Standard for Building Services and Equipment'; SPRING Singapore

Singapore Standard 531 (2013) 'Code of Practice for lighting of work places - Indoor'; SPRING Singapore

2.02 Energy Effectiveness

Intent

To consider the energy effectiveness of a building holistically, in terms of the extent of use of energy systems in addition to their efficiencies when compared to a reference building. The elements of the building's energy consumption are calculated and summarised in the Energy Performance Points Calculator that accompanies this section. This methodology guides projects through the process of understanding their building energy performance and evaluation of the strategies to reduce their building consumption. This serves to steer projects towards making sustainable decisions from first principles by (i) first considering the necessity of use of energy systems within spaces to adequately fulfil functional end user requirements, before (ii) designing for the optimisation of such systems.

The Energy Performance Points Calculator also calculates the project's EEI as well as the carpark EUI which can be used to benchmark the building's performance.

The consumption and savings figures under this indicator are static in nature for the purposes of calculation of energy savings against a static reference model. Thus the figures are only an indicative representation of the actual building performance.

For projects targeting Green Mark Gold^{PLUS} and Platinum, dynamic energy simulations shall be conducted in accordance with the Green Mark 2015 Energy Modelling guidelines and shall demonstrate the prescribed energy savings as stated in P37 and P38 respectively.

Criteria	Points
2.02a Building Energy	11
2.02b Carpark Energy	2
2.02c Receptacle Energy	2
TOTAL	15
Advanced Green Efforts	2

2.02a Building Energy

Scope

This encompasses the total energy of the base building, excluding carpark and receptacle loads, based on normalised operational hours.

Assessment

Criteria	Points
Building Energy	11
Advanced Green Efforts	2

The Energy Performance Points Calculator shall be used to generate the energy savings of the building against a static reference model.

The points scored shall be as follows:

- 1 point for every 3% energy saving.
- Advanced Green Efforts = 1 point for $\geq 40\%$, 2 points for $\geq 50\%$

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Energy Performance Points Calculator
- Technical specifications and product information of all air-conditioning systems

Verification (As Built):

Submission of the following if applicable:

- Energy Performance Points Calculator reflecting as-built information
- As built equipment, spatial schedules and relevant drawings, schematics
- Equipment delivery orders and purchase orders

References

ASHRAE Standard 90.1 (2013) 'Energy Standard for Buildings Except Low-Rise Residential Buildings'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

Singapore Standard 530 (2014) 'Code of Practice for Energy Efficiency Standard for Building Services and Equipment'; SPRING Singapore

Singapore Standard 553 (2009) 'Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings'; SPRING Singapore

CIBSE Guide F (2012) 'Energy Efficiency in Buildings'; Chartered Institution of Building Services Engineers (UK)

2.02b Carpark Energy

Scope

This applies to the total energy of a building's carpark systems, taking into consideration the lighting and ventilation systems.

For projects with no carpark, the full points under this indicator may be scored.

Assessment

Criteria	Points
Car Park Energy	2

The Energy Performance Points Calculator shall be used to calculate the savings of the car park energy systems.

0.5 Point shall be awarded for demonstrating 30% energy saving, and thereafter 0.5 point for every subsequent 10% energy saving

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Energy Performance Points Calculator
- Carpark drawings showing the parking layout and any loading bays
- The lighting power density calculation and supporting documentation including schedules, layouts, data sheets and lux level simulations
- Mechanical ventilation schematics, data sheets and calculations
- Mechanical ventilation control strategies

Verification (As Built):

Submission of the following if applicable:

- Energy Performance Points Calculator reflecting as-built information
- The as built drawings of the carpark including the mechanical and electrical schedules, relevant data sheets
- Purchase orders and delivery orders of the installed systems
- Documentation of onsite verification of the as built lux level achieved

References

Singapore Standard 530 (2014) 'Code of Practice for Energy Efficiency Standard for Building Services and Equipment'; SPRING Singapore

Singapore Standard 553 (2009) 'Code of Practice for Air-Conditioning and Mechanical Ventilation in Buildings'; SPRING Singapore

2.02c Receptacle Energy

Scope

This refers to projects who work with their occupants to procure energy efficient receptacle equipment, including plug loads and process equipment.

Applies to non-speculative buildings which can reasonably calculate the receptacle equipment schedule at design stage.

Assessment

Criteria	Points
Receptacle Energy	2

The Energy Performance Points Calculator shall be used to calculate savings in the receptacle loads in the building.

Reduction in Receptacle Load	Points
30% Energy Reduction	1
35% Energy Reduction	1.5
40% Energy Reduction	2

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Energy Performance Points Calculator
- Commitment to procure/ evidence of procurement of energy efficient receptacle equipment
- Technical specifications of receptacle equipment
- The energy associated with each equipment shall be calculated and a W/m² value derived. Guideline figures are listed in the Energy Performance Points Calculator which can be used
- For refrigerators or other NEA tick-labelled systems the baseline shall be a 1 tick system
- Process loads shall be compared to the industry norm and savings shall be justified through empirical evidence

Verification (As Built):

Submission of the following if applicable:

- Energy Performance Points Calculator reflecting as-built information
- Purchase orders and delivery orders of the installed systems
- Onsite logged measurements or sub metered readings of receptacle load

References

ASHRAE Standard 90.1 (2013) 'Energy Standard for Buildings Except Low-Rise Residential Buildings'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

NABERS Energy Guide to Tenancy Energy Estimation (2011); National Australian Built Environment Rating System

2.03 Renewable Energy

Intent

To encourage the generation and utilisation of renewable energy, and raise the awareness of viable solar opportunities within the development. In combination with energy effective solutions, the criteria aims to motivate buildings to work towards the vision of zero energy or net positive energy low rise buildings and low energy high rise buildings

Criteria	Points
2.03a Feasibility Study	0.5
2.03b Solar Ready Roof	1.5
2.03c Replacement Energy	6
TOTAL	8
Advanced Green Efforts	10

2.03a Feasibility Study

Scope

This study involves an evaluation of the building footprint's potential in harnessing solar energy, and encourages installation of solar photovoltaic (PV). The building footprint refers to the area on a project site used by the building structure, defined by the perimeter of the building plan. Open carpark spaces, landscape, underground construction and non-building facilities (i.e covered walkways) are not included in the building footprint.

Assessment

Criteria	Points
Feasibility Study	0.5

0.5 point shall be scored for a solar feasibility report that follows the recommended format for the report found under Table 2.03-1.

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Solar feasibility report acknowledged by the QP/PE (Electrical)/ energy consultants, and the project manager
- Any considerations for shading due to external factors beyond the project site area supplemented with site drawings (or future development plans) that depict the estimated height of shading source

References

Singapore Standard CP 5 (2008) 'Code of Practice for electrical installations'; SPRING Singapore

BCA (2008) Green Handbook –Photovoltaic (PV) systems in buildings,
http://www.bca.gov.sg/GreenMark/others/pv_guide.pdf

EMA & BCA (2008) Handbook for Solar Photovoltaic (PV) Systems
http://www.bca.gov.sg/publications/others/handbook_for_solar_pv_systems.pdf

Table 2.03-1 Renewable Energy Feasibility Report Format

Executive Summary – A non-technical summary of the potential for solar adoption for the building.

Roof Characteristics and Shading Considerations – description of the roof 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 project (e.g. M&E services, lamp posts, etc.) are to be considered and quantified.

Technical Solar Energy Generation Potential – Based on the shading consideration and any site specific constraints, the following information is to be provided using the prescribed list of assumptions provided below. Any unique assumptions are to be clearly stated.

- i) Expected solar capacity (in kWp) potential on the roof based on shading consideration and layout
- ii) Expected annual electricity generation (in kWh) based on solar capacity potential

Economics of Solar Installation - Using the electricity generation potential, the economics of the solar installations are to be quantified with the following considerations.

- i) Upfront costs of installation
- ii) Expected maintenance costs
- iii) Expected annual electricity bills based on energy consumption calculation
- iv) Expected costs saving for generation of electricity to be consumed on site
- v) Expected revenue from solar electricity sold to grid (if applicable)
- vi) Payback period/Discount rate

Guiding Assumptions

- i) Solar PV technologies (unshaded) with area efficiency of 0.1 kWp/m² and annual generation yield of 1200 – 1300 kWh/kWp can be assumed if project has not decided on the specific PV technology to be used
- ii) Tariff at \$0.23 per kWh for low tension rate and \$0.18 per kWh for high tension rate can be assumed if project has not have information on potential electricity tariff.

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

Roof Optimisation Recommendations – Recommendations for the spatial optimisation of the roof design to facilitate including M&E equipment locations to maximise the usable roof space.

Acknowledgement from QP/PE and Developer - Acknowledgements from QP/PE (Electrical) / Energy Consultants AND Developer's Project Manager are to be provided for the feasibility study report.

2.03b Solar Ready Roof

Scope

To recognise the roof as a resource and encourage an optimised roof area for the deployment of renewable energy or other relevant uses.

Assessment

Criteria	Points
Solar Ready Roof	1.5

The project shall demonstrate its design for solar readiness, or for other roof top use (such as green roof or roof terraces) where solar energy is not feasible through the design optimisation of the M&E systems and the structural and electrical readiness.

Roof Readiness	Description
Structural Readiness	<ul style="list-style-type: none"> Design of roof spaces should facilitate ease of solar installation. Some examples are as follows: <ul style="list-style-type: none"> For metal roofs, use roof profile with suitable seams that allow easy application of roof clamps, and avoid trapezoidal or corrugated profile. For trellis, ensure trellis has 10-15° slope instead of horizontal top surface, to facilitate optimal module tilt angle. For RC roof, provide for a solution that does not require heavy ballast to prevent modules from lifting off in strong wind. (eg provide anchors points for solar support systems prior to waterproofing) Roof layout designed to maximise solar installation. Shade-casting structures such as staircase doghouses, lift motor rooms, water tanks and M&E equipment should be shifted away from the east-west sun path, where possible.
Electrical Readiness	<ul style="list-style-type: none"> Provide space for Balance of Systems (eg. inverters, circuit breaker switch boards and cabling shafts) Correctly dimension enough circuit breakers for PV feed-in.
Use Other than Solar	<ul style="list-style-type: none"> Details of other roof space feasibility (such as Green Roof) and the readiness of the roof for these uses

Guidance Notes

At Design Stage:

Detailed drawings showing the roof readiness including the location of the relevant access, firefighting measures, structural readiness and electrical readiness. For solar energy at least 50% of feasible roof area (based on feasible capacity stated in feasibility study report) has to be set aside and used as the basis for design.

Verification (As Built):

As built drawings and on site photographs of:

- Solar roof anchors
- Roof layout and space provisions for solar systems
- Evidence of roof readiness for other systems which are being adopted where applicable

References

BCA (2008) *Green Handbook –Photovoltaic (PV) systems in buildings*,
http://www.bca.gov.sg/GreenMark/others/pv_guide.pdf

EMA & BCA (2008) *Handbook for Solar Photovoltaic (PV) Systems*
http://www.bca.gov.sg/publications/others/handbook_for_solar_pv_systems.pdf

Singapore Standard CP 5 (2008) 'Code of Practice for electrical installations'; SPRING Singapore

2.03c Adoption of Renewable Energy

Scope

This involves the use of renewable energy sources within the building development to reduce consumption of power from the grid and the building's carbon emissions.

Assessment

Criteria	Points
(i) Replacement Energy	6
<i>Additional Replacement Energy (Advanced Green Efforts)</i>	5
<i>Low to Zero Energy Building (Advanced Green Efforts)</i>	5

The Energy Performance Points Calculator shall be used to calculate savings from replacement of the building electricity consumption through the use of renewable energy.

Points shall be awarded based on the following:

Expected Energy Efficiency Index (EEI) [kWh/m ² /yr]	% Replacement of Electricity (based on building electricity consumption) by Renewable Energy	
	%	Capped at 6 Points
≥ 120	1 point for every 0.5%	3%
80 ≤ EEI < 120	1 point for every 1%	6%
50 ≤ EEI < 80	1 point for every 1.5%	9%
< 50	1 point for every 2.5%	15%

For Additional Replacement Energy (Advanced Green Efforts):

Expected Energy Efficiency Index (EEI) [kWh/m ² /yr]	% Replacement of Electricity (based on building electricity consumption) by Renewable Energy		
	%	1 point for % additional replacement	Capped at 5 Bonus Points
≥ 120	3%	Every 0.5%	5.5%
80 ≤ EEI < 120	6%	Every 1%	11%
50 ≤ EEI < 80	9%	Every 1.5%	16.5%
< 50	15%	Every 2.5%	27.5%

For Low to Zero Energy Building (Advanced Green Efforts):

% Annual Energy Replacement	Bonus Points
60%	1
70%	2
80%	3
90%	4
100% (Net Zero)	5

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- The Energy Performance Points Calculator
- Technical product specifications
- Detailed drawings showing the location and renewable energy provisions
- Calculations of the expected energy yield and assumptions

Verification (As Built):

Submission of the following if applicable:

- As built drawings and on site photographs of the renewable energy source(s)
- Technical specifications and integration reports of the installed system(s) including total capacity installed
- Testing and commissioning report
- Logging of the energy production and calculated energy replacement rate

For buildings using renewable energy to demonstrate energy savings for Gold^{PLUS} and Platinum projects, the annual energy replacement at stage 2 verification shall require the following:

- Extracts of data logging and monitoring generated with minimum annual peak (kWp), average peak (kWp) and annual cumulative energy generated (kWh)
- Calculation of the replacement of electricity generated from renewable energy e.g. solar PV panel. EEI to be calculated based on operating EEI

References

BCA (2008) *Green Handbook –Photovoltaic (PV) systems in buildings*,
http://www.bca.gov.sg/GreenMark/others/pv_guide.pdf

EMA & BCA (2008) *Handbook for Solar Photovoltaic (PV) Systems*
http://www.bca.gov.sg/publications/others/handbook_for_solar_pv_systems.pdf

Singapore Standard CP 5 (2008) 'Code of Practice for electrical installations'; SPRING Singapore

3. Resource Stewardship

Criteria	Points
3.01 Water	8
3.02 Materials	18
3.03 Waste	4
TOTAL	30
<i>Advanced Green Efforts</i>	<i>7</i>

Resource Stewardship Introduction

With global use of resources increasing in the backdrop of the limited carrying capacity of the Earth, it is imperative that we work towards conserving the Earth's resources for future generations. The built environment sector can contribute to this cause by reducing the impact of materials used in construction, re-using materials where possible and recycling construction waste.

The term "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 from the stages of construction through to building operations and occupancy. Resources covered include water as well as mineral and material resources.

Projects are encouraged to identify ways to reduce environmental footprint through reduction of operational water, making material and construction choices which reduce carbon footprint and designing for operational waste management. In facilitating building user stewardship, projects can yield significant cost savings in the development process, while also help advance our built environment to new heights of design quality and environmental sustainability.

The criteria highlighted in yellow are scored under **Section 5. Advanced Green Efforts**. The points will form a part of the total Green Mark score, and contribute to the number of points in Section 5

3.01 Water

Intent

To encourage responsible use of water in buildings through water efficient, monitoring and potable water replacement strategies.

Criteria	Points
3.01a Water Efficient Systems	3
3.01b Water Monitoring and Leak Detection	2
3.01c Use of Alternative Water Sources	3
TOTAL	8
Advanced Green Efforts	1

3.01a Water Efficient Systems

Scope

This refers to the design of water efficient mechanical systems to reduce the rate of water usage by the development.

Assessment

Criteria	Points
(i) Landscape Irrigation	1
(ii) Water Consumption of Cooling Towers	2
<i>(iii) Water Efficiency Measures and System Audit (Advanced Green Effort)</i>	1.5

3.01a (i) Landscape Irrigation

To encourage the use of water efficient automated irrigation systems and measures to reduce portable water use for landscape irrigation.

Applicable to developments with landscape irrigation.

Where the landscape is planned for the use of drought tolerant plants points may be scored here.

Assessment

1 point shall be scored if at least 70% of the landscape areas are served by water efficient irrigation systems with features such as automatic sub-soil drip irrigation system with moisture or rain sensor control. OR

1 point shall be scored if at least 50% of the landscape areas comprise of drought tolerant plants

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Extracts of the tender and design specification showing the provision and details of the water efficient irrigation system
- Relevant layout plans showing the overall landscape areas and the areas that would be served using the system
- Calculation showing the percentage of the landscape areas that would be served using the system
- Relevant layout plans showing the overall landscaping and areas that use drought tolerant plants.
- Calculation showing the percentage of the landscape areas that use drought tolerant plants

Verification (As Built):

As-built layout plans showing the location of the water efficient irrigation systems and calculation showing the percentage of landscape areas that would be served using the system or with drought tolerant plants if there are changes to the original design.

3.01a (ii) Water Consumption of Cooling Towers

To encourage water efficient design of cooling towers.

Applicable to building developments with cooling towers.

Assessment

Criteria	Points
Achieving > 7 cycles of concentration (CoC) beyond P.10	0.5
Reduction of water drift	0.5
Reduction of heat rejection required through the cooling towers	1

0.5 point shall be awarded for the use of water treatment methods that will help to increase solubility of water and facilitate a higher CoC of > 7 cycles beyond P.10.

0.5 point shall be awarded for the provision of water efficient drift eliminators or structural features that reduce water drift to not more than 0.002% of recirculated water flow.

1 point shall be awarded for the provision of devices that are designed to reduce heat load to be removed through the cooling towers such as heat pumps.

Guidance Notes

At Design Stage:

Submission of the following if applicable:

Water Treatment achieving > 7 CoC

- Technical specification of the water treatment methods adopted and the methodology to enable higher cycle of concentration without compromising on the water quality and operational performance
- Maintenance regime of the water treatment methods adopted

Reduction of water drift

- Calculation of cooling tower water drift and technical specification showing the efficiency of the drift eliminators or structural features

Reduction of heat rejection

- Technical and design specification of devices such as heat pumps and the calculation of the water savings using the following formula:

$$\text{Water saving at cooling tower} = \frac{\text{Heat diverted (Latent heat of evaporation)}}{\text{Density of water}}$$

Verification (As Built):

Submission of the following if applicable:

Water Treatment achieving > 7 CoC

- Submission of onsite testing reports showing the cycles of concentration achieved and maintained most of the time

Reduction of water drift

- Delivery order of the cooling tower with the drift elimination features

Reduction of heat rejection

- Commissioning report of the heat pump or equivalent system and the resultant reduction of heat rejection requirement through the cooling towers

Water Efficiency Measures and System Audit (Advanced Green Effort)

To encourage the selection of all water efficient fittings with better WELS rating over the prescribed standard stated in P.18 and to facilitate further water reduction opportunities through system audit

Applies to all buildings with water fittings and products installed.

Assessment

0.5 point shall be awarded should the project demonstrate the use of better WELS rated water efficient fittings used for 100% of the applicable water fittings as prescribed in P.18 whilst ensuring user requirements are not compromised:

1 point shall be awarded should the system audit is conducted to establish the baseline water usage requirement once the building operation is in a steady state. The actual water consumption data and the respective breakdowns in water end use are to be collated for a period of at least 12 months.

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Extracts of the tender design specification showing all the water fitting provisions for the development
- Water fitting schedules showing the numbers, types and the selected WELS rating of all proposed fittings in the prescribed tabulated format as P.18 which includes those fittings that are subject to mandatory standards stipulated in the Singapore Standard CP 48- Code of Practice for Water Services
- Commitment to conduct the water system audit in writing with specific mention of the major water use to be included.

Verification (As Built):

Submission of the following if applicable:

- As-built water fitting schedules showing the number, brand/model no, types and the WELS rating of all installed fittings in the prescribed tabulated format as P.18.
- Details of the audit showing the actual water consumption of the building based on the water bills and the proportion of total incoming water that is cascaded to multiple end uses before discharge. The breakdown of all the major water use as outlined in Table 3.01b-1 is to be presented.

References

Singapore Standard CP 48 (2005) 'Code of Practice for water services'; SPRING Singapore

Water Efficient Building Certification (2014) Public Utilities Board Singapore

PUB Singapore (2013) 'Water Efficiency Labelling Scheme (Voluntary and Mandatory)'; Retrieved from http://www.pub.gov.sg/wels/rating/Documents/WELS_Guidebook.pdf

3.01b Water Monitoring and Leak Detection

Scope

This refers to the use of private water metering and leak detection system for better control and monitoring, as well as the incorporation of the monitored information into a water use portal and dashboard for end user awareness and setting of consumption reduction targets.

Assessment

Criteria	Points
(i) Water monitoring and leak detection	1
(ii) Water usage portal and dashboard	1

3.01b (i) Water monitoring and leak detection

To facilitate continual monitoring of water use within the development through water metering and remote monitoring.

Assessment

Criteria	Points
Provision of water meters	0.5
Smart water metering	0.5

0.5 point can be scored if private meters are provided for all major water uses in the development, see table 3.01b-1.

0.5 point can be scored where a remote metering system is in place for leak detections and monitoring purposes. There shall be alert features that can be set and triggered to detect the possibility of water leakage during operation.

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Extracts from tender specification stating the provision of water metering for all major water uses
- Schematic drawings of cold water distribution system showing the location of the private water metering provided
- Extracts from tender specification and schematic drawings showing the location of remote metering system, how it connects to the building management system and highlights of the specific alert features to detect water leakage.

Verification (As Built):

Submission of the following if applicable:

- As-built schematic drawings of the cold water distribution system showing the location of the private water metering provided
- As-built schematic drawings showing the location of the remote metering system. Screen shots of the BMS system integration and the water leak detection alert settings.

Table 3.01b-1 Common Major Water use for building types

Building Type	Private meters to be installed to monitor the amount of water used for the following usage areas where applicable
Hotels	<ul style="list-style-type: none"> • 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 installation)	<ul style="list-style-type: none"> • Cooling Towers* • Toilets for each block • Washing Areas • Swimming Pool • Food and Beverage Outlets / Kitchens}
Hospitals	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Cooling Towers* • Exhibits or enclosures • Washing areas • Toilets • Food and Beverage Outlets • Irrigation • Swimming Pools
Office or Retail Buildings , or any other buildings that are not specifically stated	<ul style="list-style-type: none"> • Cooling Towers* • Toilets • Pantries • Food and Beverage Outlets • Production and Processes

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

3.01b (ii) Water usage portal and dashboard

To make accessible water portal, dashboard or other equivalent forms, e.g. web-based, mobile applications, to building management to allow for monitoring and setting of consumption targets.

To provide such information to tenants to facilitate user engagement programmes and encourage water conservation behavioural changes.

Assessment

0.5 point will be scored for the provision of water portal, dashboard or other equivalent forms accessible that display metered data and trending of water consumption and cost indices by area and use to building management.

An additional 0.5 point will be scored if such systems are made easily accessible to individual tenants as well and which display trending for their specific usages.

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Specifications of the water portal, dashboard or other equivalent forms and their requirements to provide the relevant water usage consumption and cost by area and use. The data acquisition system should be able to store the measured data for at least 24 months, and to create reports minimally monthly and annual water consumption associated with each meter.
- Plans and schematics to illustrate location and means of access of the portal.
- Water single line diagram of the sub-metering scheme.

Verification (As Built):

Submission of screenshots of the installed water portal and dashboard or equivalent form showing display of the metered water data by area or use, and cost of water used as well as trending and computed benchmarks.

3.01c Use of Alternative Water Sources

Scope

This refers to the use of alternative water sources to reduce the total potable water consumption of the building.

Assessment

Points shall be awarded based on the types of systems used and the extent of non-potable water replacement. Non-potable water use refers to such as landscape irrigation, toilet flushing, cooling tower make-up water or external area or carpark washing.

Description	Points
AHU condensate collection where >75% total condensate is collected	0.5
Use of NEWater	0.5
Rainwater harvesting tank which meets the following criteria: 2m³ volume per 1000m² GFA) with a minimum size 7m³, cap at 100m³	1
On-site recycled water system	1

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Layouts showing the rainwater harvesting tank, the volume of the tank, the catchment area and what the rainwater shall be used for
- AHU condensate collection schematic and calculations
- Schematic for greywater recycling

Verification (As Built):

Submission of the following if applicable:

- As-built schematic drawings and photographs of the water savings strategies
- Delivery orders of the relevant systems
- Commissioning reports of specialist systems such as on-site water recycling systems, smart water controls, rain water harvesting and AHU condensate systems

3.02 Materials

Intent:

To encourage the reduction of the environmental impact of the building through sustainable construction practices, understanding of embodied energy (carbon footprint) and life cycle and use of sustainable fit-out systems.

To aid the industry with understanding embodied energy, BCA have developed an online carbon calculator that can be used by project teams to identify their carbon debt and allow a benchmarking of projects over time.

Green fit-outs are considered to encourage the adoption of more sustainable materials and approaches within the building. This also includes the recognition of designing for off form finishes reducing the need for fit out products

Criteria	Points
3.02a Sustainable Construction	8
3.02b Embodied Carbon	2
3.02c Sustainable Products	8
TOTAL	18
Advanced Green Efforts	6

3.02a Sustainable Construction

Scope

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

Applicable to building superstructure (including non-structural components). Substructure components are excluded.

Assessment

Criteria	Points
(i) Resource Efficient Building Design	4
(ii) Construction Resource Recovery	1
(iii) Sustainable Construction Resource Usage	3
<i>(iv) Using BIM to Calculate Concrete Usage Index (CUI) (Advanced Green Efforts)</i>	1

3.02a (i) Resource Efficient Building Design

To optimise concrete use through the calculation of the project's Concrete Usage Index (CUI) and encourage adoption of sustainable building systems.

Assessment

Criteria	Points
CUI	Capped at 4 points
Adoption of Sustainable Building Systems	
<i>Using BIM to Calculate Concrete Usage Index (CUI) (Advanced Green Efforts)</i>	1

CUI:

Points shall be scored for CUI are based on the following table:

Table 3.02a-1 CUI scoring Matrix:

Project's CUI	Points
≤ 0.60	0.5
≤ 0.50	1
≤ 0.45	1.5
≤ 0.40	2
≤ 0.35	3

Adoption of sustainable building systems

Points shall be scored for the adoption of sustainable building systems (refer to Table 3-02a-2) based upon the extent of their use and the calculated project's CUI.

Adoption of Sustainable Building System = Project's CUI (points) x % Extent of use of sustainable building system elements

Use of BIM to calculate CUI (Advanced Green Efforts)

1 point shall be scored under Additional Green Efforts where BIM is used to compute CUI.

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Calculation showing the quantity of concrete for each floor level which should include all the concrete building elements, such as non-load bearing and architectural concrete components Calculation should be presented in the prescribed tabulated format (see BCA Green Mark CUI calculation template).
- BIM model or Architectural and structural plan layout, elevation and sectional plans showing the type of building elements/ systems used, the dimensions and sizes of all the building and structural elements and

- Technical product information (including drawings and supporting documents) of the building systems;
- Calculations of the extent of use of alternative construction methods supported by detailed design drawings

Verification (As Built):

Submission of as-built drawings. If there is deviation of the building design, or usage scope of the building systems points shall be recalculated.

Definitions:

Concrete Usage Index (CUI) serves as an indicator of the amount of concrete used to construct the superstructure that includes both the structural and non-structural elements. CUI does not include the concrete used for external works and sub-structure works such as basements and foundations.

It is defined as the volume of concrete in cubic meters needed to cast a square meter of constructed floor area:

$$\text{Concrete Usage Index} = \text{Concrete Volume in m}^3 / \text{Constructed Floor area in m}^2$$

References

Singapore Standard EN 12620 (2008) 'Specification for aggregates for concrete'; SPRING Singapore

Singapore Standard EN 197-1 Cement - Part 1 (2014) 'Composition, specifications and conformity criteria for common cements'; SPRING Singapore

Singapore Standard EN 206-1 Concrete - Part 1 (2014) 'Concrete: Specification, performance, production and conformity'; SPRING Singapore

Singapore Standard 544-1 Concrete (2014) 'Complementary to SS EN 206-1 - Part 1- Method of specifying and guidance for the specifier'; SPRING Singapore

Singapore Standard 544-2 Concrete (2014) 'Complementary Singapore Standard to SS EN 206-1 – Part 2: Specification for constituent materials and concrete'; SPRING Singapore

Singapore Standard 557 (2010) 'Code of Practice for Demolition'; SPRING Singapore

Table 3.02a-2 Examples of sustainable building systems:

Sustainable Building Systems
Pre-stressed Concrete Elements
Hollow Core or Voids Concrete Elements
Light Weight Concrete Elements
High Strength Concrete Elements
Structural Steel Elements
Composite Structural Elements
Engineered Timber
Prefabricated Prefinished Volumetric Construction (PPVC)

% Applicable area is based on volume replacement.

3.02a (ii) Resource Recovery

To reward conservation of existing building structures and recovery of demolished building materials for reuse or recycling.

Applicable for projects built on sites with existing building structures.

Where the existing building on site is conserved and not demolished, the full points can be scored.

Assessment

Where existing building structures on site are demolished, 1 point can be awarded for enhanced demolition protocol, where a recovery rate of >35% crushed concrete waste from the demolished building is sent to approved recyclers with proper facilities.

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Pre-demolition assessment records of demolition site showing clear recovery/ recycling targets and estimated quantities of salvageable materials
- Method statement detailing how sequential demolition is to be carried out
- Waste management plans such as plan layout showing locations of recycling bins for collection and storage of different recyclable waste, records of waste movement from site to recycling facilities, proposed usage of the various types of recovered waste
- Details of best practice pollution prevention policies and procedures at construction and demolition sites

Verification (As Built):

Submission of detailed records of the volume of waste sent to the relevant approved recyclers.

References

BCA Singapore Demolition Protocol (2009) 'Pre-Demolition Audit, Sequential Demolition and Site Waste Management Plan'; Retrieved from https://www.bca.gov.sg/SustainableConstruction/sc_demolition.html

Singapore Standard 557 (2010) 'Code of Practice for demolition'; SPRING Singapore

3.02a (iii) Sustainable Construction Resource Usage

To replace the use of concrete within a project with green cements and recycled aggregates

Applicable for superstructure works only

Assessment

Criteria	Points
Use of green cements	1
Replacement of fine and coarse aggregates	2

Use of green cements

0.5 point shall be awarded for every 10% replacement of Ordinary Portland Concrete (OPC) with green cements through the use of industrial by products such as Ground Granulated Blast-furnace Slag (GGBS), silica fume or fly ash. The percentage replacement mix shall be calculated by mass for all of the concrete used in the superstructure. The maximum clinker content should not exceed 400 kg/m³ for grades up to C50/60, according to the performance requirements in the specifications.

OPC Replacement Rate	Points
10%	0.5
20%	1

**the concrete mix should be designed with provisions for increased risk of drying shrinkage cracks in thin sections, early thermal cracking or damage due to alkali silica reactions and delayed ettringite formation*

Use of RCA and WCS

Up to 2 points can be scored based on the use of recycled concrete aggregates (RCA) and washed copper slag (WCS) from approved sources to replace coarse and fine aggregates for concrete production. The replacement rate is based upon the total replacement rate of the total concrete mix used in the project for the super structure by mass.

The applicable usage in tonnes for RCA shall not fall below 1.5% x GFA and WCS 0.75% x GFA for points scoring. However, the use of RCA and WCS in structural applications the mix shall be limited to 10% replacement by mass unless relevant approval is gained by the relevant authorities.

0.5 point for every 2.5% replacement rate of RCA and WCS (cap at 2 points)

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Extract of tender specification or proposed concrete mix design showing the OPC replacement rate and maximum clinker content and/or the detailed usage of RCA and WCS
- Calculation showing the quantity of OPC replacement/RCA/WCS to be used for the project

Verification (As Built):

Submission of the following if applicable:

- As-built drawings, highlighting if there is deviation of the building design or usage scope clinkers/RCA/WCS in the project. Where there are variations a re-calculation of points will be required
- Delivery orders and details of the actual concrete mix used in the project showing the usage of clinkers/RCA/ WCS

3.02b Embodied Carbon

Scope

This involves the computation of the carbon footprint of the development and the building life cycle analysis to better quantify the environmental impact of a building and raise awareness among key decision makers.

Assessment

Criteria	Points
Use of BCA Online Embodied Carbon Calculator	2
<i>Provide Own Emission Factors with Source Justification (Advanced Green Efforts)</i>	1
<i>Compute the Carbon Footprint of the Entire Development (Advanced Green Efforts)</i>	2

BCA's Online Embodied Carbon Calculator shall be used for carbon computation.

Up to 2 points can be scored for computing the carbon footprint of the development:

Description	Points
Declaration of Concrete, Glass and Steel	1
Declaration of additional materials	0.25 points per material (cap at 1 point)

Additional points can be scored under Advanced Green Efforts for:

- Provide own material emission factors through BCA's online embodied carbon calculator (0.25points per material, cap at 1 point)
- Computing the carbon footprint of the entire development and develop detailed carbon footprint report based on **ALL** the materials used within the project. (2 points)

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- Embodied carbon footprint computation saved and exported in PDF format via BCA's online embodied carbon calculator and submitted with the relevant supporting documentation and calculations.
- For declaration of emission factors via BCA's online embodied carbon calculator, project team must provide the sources of the emission factors with the relevant detailed calculations
- Detailed report of the carbon footprint of the development including the quantum and types of materials used within the development, the emission factors with supporting documentation.

References

ISO/TS 14067 (2013) 'Greenhouse gases – Carbon footprint of products – Requirements and guidelines for quantification and communication'; International Organisation for Standardisation

3.02c Sustainable Products

Intent

To promote resource efficient and environmentally friendly specifications of products in a building to minimise the resources used in the fit-out of the building.

Applicable to non-structural building architectural and mechanical components.

Assessment

Criteria	Points
(i) Functional Systems	8
(ii) Singular Sustainable Products outside of Functional Systems	2
	Cap at 8 Points
<i>(iii) Use of SGBP Very Good or above rated products (Advanced Green Effort)</i>	2

Points can be scored for environmentally friendly products certified by approved local certification bodies.

For specification purposes, the products would be based upon the listed functional systems (3.02c(i)) which recognises off form finishes (where additional products or finishes are not required)

For singular products outside these functional groups such as certified hardscape, softscape and building service products, these shall be scored in 3.02c(ii).

To recognise the use of products that are certified to higher tiers of environmental performance under Singapore Green Building Product Certification scheme points are given for products used which are certified as 2 ticks or above.

3.02c (i) Functional Systems

To facilitate the wider adoption of sustainable products within the built environment the main functional systems of the building have been identified to group products together. It is in these functional systems that projects shall be able to score.

This indicator looks at the environmental performance of materials, through their recycled content, environmental considerations in their production and resource extraction. 4.01c (iii) Low VOC emitting interior finishes assesses the interior finishes based on their VOC emissions and VOC content. The design team should pay due reference to both indicators when specifying the relevant interior finishes.

Assessment

Up to 8 points can be scored through the specification and use of green products certified by approved local certification bodies. In Singapore this is the Singapore Green Building Council and the Singapore Environment Council.

Points are scored through the following methodology:

System	Flooring (excluding structural floor)	Ceiling (excluding structural floor above)	Roofing	External Wall	Internal Wall	Door
Level 1	Base System (100% base material)					
Points	>60% of applicable areas – 2 pts/ system					
Level 2	Finishes					
Points	>60% of applicable areas – 1 pt/ system					

The scope of assessment includes all tenant areas.

Guidance Notes

Table's 3.02c-1 to 3.02c-6 provide more details on the product groupings within the functional systems. For systems which have an off form finish, such as exposed ceilings, these areas will be considered deemed to comply (i.e. green labelled). Products exclude structural systems such structural floors, the structural walls, structural roof.

All products used in in the base system for the stipulated percentage area (60% coverage) must be certified green products for points to be scored for the respective functional level

For scoring under the functional systems, level 1 shall be achieved before level 2 can be scored.

When specifying the finishes the design team should make reference to Healthy Building indicator 4.01c Contaminants, as the relevant finishes can be scored under 4.01c (iii) for being low VOC emitting Certified low VOC Paints are a pre-requisite (P.20).

At Design Stage:

- Extracts of the tender design specification showing the building functional systems and descriptions of each.
- Design drawings marking the extent of use for each compliant functional system and the calculation of the extent of use.
- Design details of the systems used within each functional system
- Product certificates

Verification (As Built):

- As built drawings showing the extent of use of green products within the functional systems
- Delivery orders of products with their corresponding green product certificates

References

Singapore Green Building Product (SGBP) Certification Scheme <http://www.sqbc.sg/green-certifications/product-certification/>

Singapore Green Label Scheme (SGLS) <http://www.sqsls.sec.org.sg/sqsls-standard.php>

Table 3.02c-1 – Flooring

	Description	Points
Level 1 (Base system)	<u>Typical products:</u> Levelling base, floor screed, waterproofing	2
Level 2 (Finishes)	<u>Typical products:</u> <ul style="list-style-type: none"> • Raised floor systems (Insulation, underlay, carpets/ carpet tiles) • Floor finishes including underlays, carpets, vinyl's, tiles, laminate flooring, timber flooring, 	1

Table 3.02c-2 – Ceiling

	Description	Points
Level 1 (Base system)	<u>Typical products:</u> Plastering, ceiling boards, insulation (excluding fixing and bracing). <i>Note where the ceiling is an off form finish (no false ceiling, no plastering, this is deemed to comply)</i>	2
Level 2 (Finishes)	<u>Typical products:</u> All finishes including skim coat. (excluding paints)	1

Table 3.02c-3 – Roof

	Description	Points
Level 1 (Base system)	<u>Typical products:</u> <ul style="list-style-type: none"> For RC flat roofs: Levelling base, screed, waterproofing, insulation For Framed Roof: Framing, waterproofing, insulation 	2
Level 2 (Finishes)	<u>Typical products:</u> All finishes including metal sheets	1

Table 3.02c-4 – External Wall

	Description	Points
Level 1 (Base system)	<u>Typical products:</u> curtain wall, lightweight wall panels, blocks with plastering adhesives, jointing, grouting, pointing, (excluding fixing brackets)	2
Level 2 (Finishes)	<u>Typical products:</u> All external finishes, skim coats, cladding, external paints (including primers), external coatings	1

Table 3.02c-5 – Internal Wall

	Description	Points
Level 1 (Base system)	<u>Typical products:</u> Lightweight wall panels, drywalls, blocks, waterproofing, jointing, grouting, plastering, insulation (excluding fixing brackets/ frame)	2
Level 2 (Finishes)	<u>Typical products:</u> All finishes including skim coat, corner beads, corner protectors, fabrics, wall papers, wall tiles etc. (Excludes internal paints)	1

Table 3.02c-6 – Doors

	Description	Points
Level 1 (Base system)	<u>Typical products:</u> Door leaf	2
Level 2 (Finishes)	<u>Typical products:</u> All finishes including laminates, veneers	1

3.02c (ii) Singular Sustainable Products outside of Functional Systems

To encourage the use of sustainable products that do not fall into the functional systems in 3.02c(i)

Assessment

Up to 2 points can be scored for the use of sustainable products certified by an approved local certification body in the following categories:

Category	Description
Hardscape	Includes items such as composite timber decking, outdoor play equipment, pre-cast kerbs and drains, wheel stoppers in car parks, Drainage cells, planter trays etc.
Building Services	Mechanical, electrical and plumbing equipment or products such as chillers, circuit boards, transformers, water pipes

0.25 points for each product used for $\geq 90\%$ of the applicable use

Guidance Notes

At Design Stage:

Extracts from the tender specification and drawings showing the requirements to incorporate the environmentally friendly products that are certified by the approved local certification body

Verification (As Built):

- As built drawings showing the extent of use of green products within the functional systems
- Delivery orders of products with their corresponding green product certificates

References

Singapore Green Building Product (SGBP) Certification Scheme <http://www.sqbc.sg/green-certifications/product-certification/>

Singapore Green Label Scheme (SGLS) <http://www.sqsls.sec.org.sg/sqsls-standard.php>

3.02c (iii) SGBP Products Rated Very Good or Above (Advanced Green Effort)

(Advanced Green Effort) To encourage the use of products with a very good rating (2 tick) or above under the Singapore Green Building Product (SGBP) certification scheme.

Assessment

Up to 2 points can be scored for the use of Very Good or higher rated products within the project. These products can form part of the functional systems or be standalone products scored under 3.02(ii)

SGBP Rating	Points per product (≥ 90% of the applicable use)
Very Good (2-ticks)	0.25
Excellent (3-ticks)	0.5
Leader (4-ticks)	1

0.25 points for each product used for ≥ 90% of the applicable use

Guidance Notes

At Design Stage:

Points per product and ≥ 90% of the applicable use can be defined for example as 90% of all ceiling boards within a development shall be certified to SGBP Very Good or higher. These can be through a range of different brands. Where a mix of ratings is used (e.g. waterproof screed), the lowest rating shall be used to calculate the score.

Documentary evidence:

- Extracts from the tender specification and drawings showing the requirements to incorporate the environmentally friendly products that are certified by the approved local certification body
- Product certificates

Verification (As Built):

- As built drawings showing the extent of use of green products within the functional systems
- Delivery orders of products with their corresponding green product certificates

References

Singapore Green Building Product (SGBP) Certification Scheme <http://www.sqbc.sg/green-certifications/product-certification/>

3.03 Waste

Intent

The waste criteria essentially encourages facilities and systems to be provided to manage the building construction waste during building development and the building operational waste so as to minimise the need for landfill disposal. Segregation of waste at source with provision of appropriate collection and recycling facilities is encouraged.

Criteria	Points
3.03a Environmental Construction Management Programmes	1
3.03b Operational Waste Management	1
3.03c Provision of Recycling System for Horticultural or Wood Waste	1
TOTAL	3

3.03a Environmental Construction Management Programmes

The construction process should be managed effectively to reduce the environmental impact of the actual construction itself. Construction waste is especially important to minimise given the large quantity of resources that are used in producing construction materials. A holistic environmental management plan is thus important to monitor, benchmark and continually improve the environmental performance of the construction process

Assessment

1 point can be awarded for effective implementation of environmental friendly programmes/ best practices at construction sites through setting targets, recording and monitoring to reuse building and construction resources e.g. water, construction waste.

An environmental construction management programme with targets for the site to meet shall be submitted at design stage and tracked during the construction stage and a construction report with details of where the project has exceeded benchmarks stipulated at design stage and the reasons for this.

Guidance Notes

At Design Stage:

Submission of the environmental construction management plan that shall be implemented on site including definitive energy, water and waste targets.

Verification (As Built):

Submission of the construction environmental management report that demonstrates the performance of the construction process against the benchmarks submitted at design stage. A written narrative shall form part of the report that details reasons for exceeding the benchmarks or for abnormal measurements.

Environmental Construction Management Plan

Executive Summary – non technical summary of the environmental construction management plan, the targets, the method and frequency of monitoring required.

Energy Targets: - The total energy consumption target for the construction programme which includes the quantity of diesel, electricity from the grid (kWh).

The benchmark shall be normalised to the energy consumption/GFA of the build to facilitate future benchmarking for projects.

Detailed recommendations for onsite energy management strategies shall form part of the management plan.

Water Targets: - The total water consumption target for the construction programme in m³.

The benchmark shall be normalised to the water consumption (m³)/GFA of the build to facilitate future benchmarking for projects.

Detailed recommendations for onsite water management strategies shall form part of the management plan

Waste Targets: - the amount of waste in a construction project is a vital area in which the construction industry needs to improve upon.

- (1) A waste benchmark shall be established (Waste kg/m² GFA) to reduce the construction waste.
- (2) A waste recycling rate shall be established to ensure that of the construction waste produced, x% is diverted from landfill or incineration.

Monitoring and Reporting Method: - The method statement for the targets and environmental management programmes to be implemented on site.

Note this Environmental construction management plan is in addition to the existing regulatory construction management requirements.

3.03b Operational Waste Management

Recognising projects that design in operational waste management plans that facilitate recycling. The provision of recycling facilities shall be applicable to the building type and occupancy base. Locations of recycling facilities should be based upon the convenience of use for the building users and the expected waste stream

Assessment

1 point for the provision of facilities for the collection and storage of different common recyclables such as paper, glass, metal and plastic.

1 point for buildings with large volumes of food waste (such as hotels, retail malls, and various institutional buildings) to have provisions for food waste recycling.

Guidance Notes

At Design Stage:

- Waste management plan detailing the separation of waste expected within the building based on its use
- Plan layout showing the location of the recycling facilities for collection and storage of different common recyclables such as paper, glass, metal and plastic.
- For buildings with large volumes of organic food waste, the provision of systems for the segregation of food waste for separate collection, or the provision of an onsite food waste recycling system

Verification (As-Built):

The implementation of the waste management plan including as built plans highlighting the recycling facilities, the waste collection contracts entered into and on site photographs of the relevant recycling facilities.

3.03c Provision of Recycling System for Horticultural or Wood Waste

Landscaping is an important part of the built environment, with landscape areas comes the horticultural waste which can be composted and reused on site to maintain a healthy landscape.

Where the development produces wood (timber) waste, this waste can be segregated and recycled off site for various horticultural and non-horticultural uses

Assessment

1 point for the provision of system or facilities for the horticultural or wood waste for recycling.

Guidance Notes

At Design Stage:

Horticultural Waste:

Provision of composting facilities for the collection and composting of horticultural waste. For smaller sites with limited greenery, the use of compost from horticultural waste for the limited green areas in the project can be used to score this point.

Wood Waste:

For projects that produce volumes of timber or wood waste, the provision of recycling facilities for the wood including the location and volume of these facilities designed for. Where there a contract entered into for the offsite recycling of wood waste, this can be considered.

Verification (As-Built):

Horticultural Waste:

Onsite photographs of the compost bins and landscape contract highlighting that the landscape contractor shall compost the horticultural waste generated by the site.

For projects with limited landscape areas, delivery orders of the soil mix used on site to be from horticultural waste.

Wood Waste:

Onsite photographs of the wood waste recycling facilities or contract with waste recycler

4. Smart & Healthy Building

Criteria	Points
4.01 Indoor Air Quality	10
4.02 Spatial Quality	10
4.03 Smart Operations	10
TOTAL	30
<i>Advanced Green Efforts</i>	6

Smart & Healthy Building Introduction

Contemporary research has shown that poor indoor environmental quality is an attributing factor to sick building syndrome symptoms, respiratory illnesses, and general loss in productivity. As people spend longer hours in buildings, research has also indicated that the cost of poor indoor environmental quality could well be even higher than energy costs, although the latter has by far been the more recognised cost concern by stakeholders. In fact, measures to improve the indoor environment will be highly cost-effective, in the aspects of monetary savings from improved health, well-being and productivity of building occupants. For employers, a healthy and happy workforce is crucial to the success of businesses in the long-run.

Managing well a building's indoor environmental quality is equivalent to operating the building smartly. Smart controls, direct access to building data and early fault detection allow the facility management team area fundamental components of a smart building. A good understanding of the building's health allows intervention and optimisation to suit the occupants' health and well-being.

Thus, beyond designing buildings to be climatically responsive, low energy and resource efficient, a sustainable building must be a **Smart and Healthy Building**.

The criteria highlighted in yellow are scored under **Section 5. Advanced Green Efforts**. The points will form a part of the total Green Mark score, and contribute to the number of points in Section 5

4.01 Indoor Air Quality

Intent

To ensure good air quality within building functional spaces where occupants are expected to work or remain in for an extended period of time. Most of us spend a substantial proportion of our time within buildings. Given this it is important to provide healthy indoor environments that reduce the risk of illnesses which affects not only the productivity of the business, but more importantly the wellbeing of the occupants.

Criteria	Points
4.01a Occupant Comfort	2
4.01b Outdoor Air	3
4.01c Contaminants	5
TOTAL	10
Advanced Green Efforts	1.5

This criterion is applicable for normally occupied functional air-conditioned spaces except residential, industrial production, laboratory and hospital spaces/ facilities

4.01a Occupant Comfort

Scope

This refers to testing, evaluation and display of indoor environmental quality parameters to ensure quality of the indoor air for occupant comfort.

Assessment

Criteria	Points
(i) IAQ Audit	1
(ii) Post Occupancy Evaluation	0.5
(iii) Indoor Air Quality Display	0.5
(iv) Indoor Air Quality Trending (Advanced Green Efforts)	2

4.01a (i) Indoor Air Quality (IAQ) Audit

To test the indoor air quality of the building and demonstrate good IAQ performance.

Assessment

An IAQ audit should be carried out within one year after occupancy, using either the benchmarks within SS554: 2015 Clause 6 or NEA's Guidelines for Good Indoor Air Quality in Office Premises, to demonstrate good IAQ performance. The audit should be conducted by an accredited laboratory under Singapore Accreditation Council

0.5 point can be scored if the audit is based on the indicative method described in SS554: 2015.

1 point can be scored if the audit is based on the reference method described in SS554: 2015.

For non-air conditioned buildings, points here can be scored based if full points are scored under sub-indicator 4.01a (ii) *Post Occupancy Evaluation*.

Guidance Notes

At Design Stage:

Submission of extracts of the tender specifications showing the requirements to conduct an IAQ audit within one year after occupancy

Verification (As Built):

Submission of an IAQ audit report by an accredited laboratory to the methodology within SS554:2015 or NEA's Guidelines for Good Indoor Air Quality in Office Premises' that demonstrates good IAQ performance. For functional spaces outside of the SS554 remit, industry good practice shall be determined based on prevailing industry standards.

References

Singapore Standard 554 (2015) 'Code of Practice for Indoor air quality for air-conditioned buildings'; SPRING Singapore

National Environment Agency (1996) '[Guidelines for Good Indoor Air Quality in Office Premises](#)' Institute of Environmental Epidemiology, Singapore

4.01a (ii) Post Occupancy Evaluation

To seek occupant feedback through a post occupancy evaluation as a guide to improve the quality of the internal environment.

Applicable to all building developments.

Assessment

0.5 point can be scored if a Post Occupancy Evaluation (POE) is conducted and corrective actions are taken.

The POE should be conducted within one year after occupancy in reference to SS554: 2015 and the below POE guide. It should include assessments of occupant wellbeing, and interactions with their indoor environment. The POE completes the feedback loop, and is essential for the management and improvement of operational practices in high-performing buildings. The POE should be written in an easy to understand manner tailored to the building type and the user. A generic POE guide is shown on the next page. References to how to write post occupancy evaluations and examples of POEs are widely available online and it is recommended that the project team pay due consideration to these as well as reference to SS554: 2015 Annex I.

Guidance Notes

At Design Stage:

Submission of extracts of the tender specifications showing the requirements to conduct a POE within one year after occupancy.

Verification (As Built):

Submission of the summary of the POE including:

- The post occupancy evaluation survey contents
- The response rate of the POE meeting the sample size of 10% of building occupants cap at 100 occupants
- Evaluation of the POE results and the list of the corrective actions based on the respondents' comments

References

Singapore Standard 554 (2015) 'Code of Practice for Indoor air quality for air-conditioned buildings'; SPRING Singapore

Building Occupants Survey System Australia (BOSSA), University of Sydney, Australia
<http://www.bossasystem.com/occupant-survey>

Occupant Indoor Environment Quality (IEQ) Survey, Centre for Built Environment, University of California Berkeley, United States
<http://www.cbe.berkeley.edu/research/survey.htm>

Building User Survey (BUS), United Kingdom <http://www.busmethodology.org.uk/>

4.01a -1 Post Occupancy Evaluation Guide

The post occupancy evaluation survey can follow this guide however the questions and language should be tailored to suit the building occupants to yield meaningful data. There should be room for occupant comments.

General Information:

- Basic data of the individual
- Location within the building
- Nature of work
- Time spent within the building (average week)

Lighting Quality:

- Lighting system with adequate intensity (brightness) and even distribution
- Appropriate lighting for each different activity area
- Appropriate lighting controls and zoning
- Access and quality of natural light
- Discomfort glare / daylight control

Acoustic Quality:

- Appropriate sound levels for each different activity area
- Acoustic/ speech privacy
- Background noise
- Noise transmission between rooms / spaces

Indoor Air Quality:

- Temperature (thermal comfort)
- Humidity
- Smell
- Air movement
- Freshness of the air (perceived air quality)
- Ability to control indoor conditions

Environment:

- Cleanliness of the work spaces
- Cleanliness of the common areas (toilets, pantry's, lobbies, terraces etc.)
- General building maintenance
- Waste sorting and recycling strategies or programmes
- Corporate environmental policies and programmes

Health:

- Respiratory irritations (blocked, runny, itchy nose)
- Sore throat
- Chronic cough
- Irritated eyes
- Chronic fatigue
- Linking these symptoms to the building

4.01a (iii) Indoor Air Quality Display

To raise awareness among the building occupants of the internal conditions of the space.

Applicable to all building developments with air-conditioning systems.

Assessment

0.5 points can be scored for providing display systems for temperature and relative humidity at each floor and at each tenanted area.

Guidance Notes

At Design Stage:

Submission of the following:

- Extracts of the tender specifications showing the requirements to display temperature, and relative humidity
- Plan layouts showing the locations of the fixed display panels for each floor and each tenanted area

Verification (As Built):

Submission of the following:

- Pictures showing locations of temperature, relative humidity sensors for display
- Technical specifications of the sensors
- Plan layouts showing the actual display locations and the types of sensors used

4.01a (iv) Indoor Air Quality Trending (Advanced Green Effort)

Studies have shown that sick building syndrome (SBS) symptoms are linked to the characteristics of buildings and indoor environments. Identified risk factors for SBS symptoms include air-conditioning, lower ventilation rates and higher concentrations of some types of volatile organic compounds, excess dirt and moisture in buildings. To permanently monitor the indoor air quality to continually optimise the indoor environmental quality for health and comfort.

Assessment

0.5 point can be scored for the provision of monitoring and trend logging of temperature, relative humidity through a centralised system and 1.5 point for the monitoring and trend logging of common indoor air pollutants such as formaldehyde at each floor

Guidance Notes

At Design Stage

Submission of the following:

- Extracts of the tender specifications showing the requirements to monitor and trend-log temperature and relative humidity through a centralised system
- Plan layouts showing the locations of the sensors that are monitored and trend-logged

At Verification (As Built) Stage:

Submission of the following:

- Pictures showing locations of temperature and relative humidity sensors for monitoring
- Technical specifications of the sensors
- Plan layouts showing the actual display locations and the types of sensors used for monitoring
- Two-week trend-logging data from the centralised monitoring system

References

Singapore Standard 554 (2015) 'Code of Practice for Indoor air quality for air-conditioned buildings'; SPRING Singapore

National Environment Agency (1996) '[Guidelines for Good Indoor Air Quality in Office Premises](#)' Institute of Environmental Epidemiology, Singapore

4.01b Outdoor Air

Scope

Adequate ventilation is of fundamental importance for the health and comfort of the occupants. Modern buildings with tightly sealed windows can lead to insufficient ventilation without careful design considerations which may in turn cause an increase in the concentration of contaminants emitted indoors.

The quality of the air entering the building is dependent on the location of the building and the fresh air intake locations. Good air filtration provides a way to 'clean the air' to remove particulate contaminants in the air and enhanced filtration media are advocated within this criteria.

Operational knowledge of the quantity and quality of outdoor air entering the building is important to maintain a healthy indoor environment for the occupants.

Applicable to all building developments with ACMV systems supplying outdoor air to occupied spaces.

Non air-conditioned buildings shall score the full points for this indicator.

Assessment

Applicable to all building developments with ACMV systems supplying outdoor air to occupied spaces.

Criteria	Points
(i) Ventilation Rates	1.5
(ii) Enhanced Filtration Media	1
(iii) Dedicated Outdoor Air System	0.5

4.01b (i) Ventilation Rates

To promote awareness on the volume of outdoor air entering the building to ensure that the minimum ventilation rates are being met during building operation.

Assessment

Criteria	Points
Measurement and Monitoring of Outdoor Air Volume	1
Use of Demand Control ventilation systems	0.5

Measurement and Monitoring of Outdoor Air Volume

Points shall be awarded for effective measurement and monitoring of the outdoor air into the building by volume to ensure that the desired ventilation rates are being met during building operation:

0.5 point can be awarded for outdoor airflow measured at Precool Air Handling Units (PAU) and Precool Fan Coil Units (PFCU) only.

OR

1 point can be awarded for outdoor airflow measured at all air handling units (AHU) and Fan Coil Units (FCU)

Demand Control Ventilation Strategy

0.5 point can be awarded for the use of demand control ventilation strategies including the use of carbon dioxide sensors or equivalent devices to regulate the quantity of fresh air and ventilation required in a space to achieve good indoor air quality whilst conserving energy through the ability to match the volume of fresh air with the space demand. Where demand control ventilations strategies are utilised, they should adhere to guidelines within ASHRAE Standard 62.1-2013 Section 6.2.7.1.2 and SS553: 2015 Section 6.3.6.

Guidance Notes

At Design Stage:

Submission of the following where applicable:

Measurement and Monitoring of Outdoor Air Volume

- Provision of detailed 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 $\pm 10\%$.
- Linkage to the BMS system for monitoring the outdoor air volume
- Programmed alerts when the outdoor air volume drops below the minimum set points and varies by $> 15\%$ above the airflow set point
- Provision of access panel for regular maintenance of airflow sensors

Demand Control Ventilation Strategy

- Plan layouts and schematics showing the locations and the types of control devices utilised.
- Method statement of how the devices regulate the outdoor air volume to maintain indoor air quality.

- Alerts should be programmed into the BMS where the CO₂ levels exceed the set point with reference to recommendations by SS554:2015 or NEA's Guidelines for Good Indoor Air Quality in Office Premises'.

Verification (As Built):

Submission of the following where applicable:

Measurement and Monitoring of Outdoor Air Volume

- Delivery orders, technical specifications, as built drawings and onsite photographs of the airflow measurement devices
- BMS logged data (minimum of a 2 week period) of the outdoor air volume and flowrate

Demand Control Ventilation Strategy

- Delivery orders, technical specifications, as built drawings and onsite photographs of the demand control devices.
- Handover and testing report of the devices installed on site and their function.
- During site inspection the verification officer may ask to see the devices in operation using the BMS system

References

Singapore Standard 553 (2015) 'Code of Practice for Air-conditioning and mechanical ventilation in buildings'; SPRING Singapore

ASHRAE Standard 62.1-2013 'Ventilation for Acceptable Indoor Air Quality'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASHRAE Standard 189.1 (2014) 'Standard for the Design of High-Performance Green Buildings'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

National Environment Agency (1996) '[Guidelines for Good Indoor Air Quality in Office Premises](#)' [Institute of Environmental Epidemiology, Singapore](#)

4.01b (ii) Enhanced Filtration Media

To effectively remove contaminants to enhance indoor air quality through high efficiency filters.

Assessment

0.5 point shall be awarded for the permanent provision of Minimum Efficiency Rating Value (MERV) 14, (ASHRAE 52.2) or F8 (EN779) class of filter or equivalent to Precool AHU's (PAU's) for the filtration of outdoor air to occupied spaces within the building.

1 point shall be awarded for the permanent provision of MERV 14, or F8 class of filter or equivalent to all AHUs.

Guidance Notes

At Design Stage:

Submission of the following:

- Extracts of tender specification for the provision MERV 14 (ASHRAE 52.2) or F8 (EN779/EN1822) class or equivalent filters for air distribution system
- Technical specifications and air filtration classification testing report for the filters to be used for each air distribution system

Verification (As Built):

Submission of the following:

- Pictures showing filter locations and installations
- Technical specifications and filtration classification testing report for the actual filters used on site

References

Singapore Standard 553 (2015) 'Code of Practice for Air-conditioning and mechanical ventilation in buildings'; SPRING Singapore

ANSI/ASHRAE Standard 52.2-2012 'Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

EN 779:2012 – Particulate air filters for general ventilation. Determination of the filtration performance

4.01b (iii) Dedicated Outdoor Air System

To encourage effective treatment of outdoor air for temperature, relative humidity, which in addition facilitates greater potential for the use of heat recovery devices such as passive heat pipes and desiccant dehumidification.

Assessment

0.5 point can be scored for the provision of a dedicated outdoor air system, such as a precool AHU/FCU system.

Guidance Notes

At Design Stage

Submission of the following:

- Details of the air-conditioning air distribution system and the design intent.
- Schematics of the air distribution system that are connected to the dedicated outdoor air system (Precool AHU/FCU system)

At Verification (As Built) Stage:

Submission of the following:

- Pictures showing locations and actual installations of the dedicated outdoor air system (Precool AHU/FCU system)
- As Built drawings of the air distribution systems that are connected to the dedicated outdoor air system (Precool AHU/FCU system).

4.01c Contaminants

Scope

This promotes and recognises the design and fit out decisions that safeguard the building occupant's health through pollution control measures and air treatment strategies.

Assessment

Criteria	Points
(i) Local Exhaust and Air Purging System	2
(ii) Use of Ultraviolet Germicidal Irradiation (UVGI) System	0.5
(iii) Low VOC emitting interior finishes	2.5

Note:

4.01c (i) is applicable to mechanically ventilated buildings and air conditioned buildings. Naturally ventilated buildings which have processes that require localised extraction / exhaust and pollution control strategies for occupant health should demonstrate their performance within this indicator to achieve the full points. All other naturally ventilated buildings shall score the full points

4.01c (ii) is applicable to all building developments with air-conditioning systems. Non air-conditioned buildings shall score the full points for these.

4.01c (iii) is applicable to all projects. The finishes exclude interior paints which are a pre-requisite requirement P16

4.01c (i) Local Exhaust and Air Purging System

To facilitate the removal and containment of operational pollutants generated through daily use of the building thus providing a higher indoor air quality to the building occupants.

Applicable to all mechanically ventilated buildings and air conditioned buildings

Assessment

Criteria	Points
Local Exhaust	1
Air Purging	1

1 point can be scored for the provision of local isolation and exhaust systems to remove the source of pollutants, i.e. from printing or photocopying equipment, to prevent the contamination of the functional areas. The exhausted air shall not be recycled to other spaces. For speculative projects, the exhaust system fans must be installed as a part of the base building.

1 point can be scored for the provision of air purging system to replace contaminated indoor air with outdoor fresh air.

Guidance Notes

At Design Stage

Submission of the following:

Local Exhaust:

- Extracts of the tender specifications showing the requirements to provide local exhaust riser
- Plans and schematics and mechanical drawings showing the location of the exhaust risers and the exhaust fans
- A written description on the attributes of the isolation strategies and exhaust system and how tenants shall connect to the exhaust risers for indoor pollutant removal

Air Purging:

- Written air purging strategy including any requirements for dedicated fresh air intakes and indoor pollutant exhausts

At Verification (As Built) Stage:

Submission of the following:

Local Exhaust:

- Pictures showing locations of exhaust systems installed
- As-built drawings showing the installed locations of the exhaust risers, exhaust outlets and the tenants' connection points and isolation strategies

Air Purging:

- Air purging method statement and BMS schedules and screen shots of air purging programme for the project

References

Singapore Standard 553 (2015) 'Code of Practice for Air-conditioning and mechanical ventilation in buildings'; SPRING Singapore

4.01c (ii) Ultraviolet Germicidal Irradiation (UVGI) system to control airborne infective microorganisms

Ultraviolet Germicidal Irradiation is a method of sterilisation that uses ultraviolet (UV) light using UVC irradiation at a wavelength of 254 nanometres (nm) to lethally damage airborne microorganisms within the air distribution system to provide healthier air within the conditioned space.

Assessment

0.5 point can be scored for the provision of UVGI system in AHUs and FCUs (UV wavelength to be 254nm and safety interlock must be provided).

Guidance Notes

At Design Stage:

Submission of the following:

- Extracts of the tender specifications showing the requirements to provide UVGI system in AHUs and FCUs
- Schematics of the UVGI systems at AUHs and FCUs
- Technical specifications of the UVGI system (UV wavelength to be 254nm and safety interlock must be provided)
- Location of the UVGI shall be adjacent to and after the cooling coils so that it can also help reduce biofilms on the coils

At Verification (As Built) Stage:

Submission of the following:

- Pictures showing locations and actual installations of UVGI system
- Schedule of AHUs and FCUs indicating provision of UVGI system
- Product specifications of the UVGI system (UV wavelength to be 254nm and safety interlock must be provided)

4.01c (iii) Low VOC emitting interior finishes

To encourage the use of interior fit out and finishes that safeguard the occupant's health through the reduction of the emission of harmful volatile organic compounds (VOC's).

This indicator looks purely at the VOC emissions of the relevant interior finishes. 3.02c (i) looks at the other aspects of product sustainability. The design team should pay due reference to both indicators in their specification of interior fittings and finishes.

Assessment

Criteria	Points
Certified Low VOC emission interior fittings and finishes	2
Use of Persistent Bioaccumulative and Toxic (PBT) free lighting	0.5

Certified Low VOC emission interior fittings and finishes

Applicable to all building developments and assesses:

- The flooring, wall and ceiling finishes where $\geq 90\%$ of the applicable areas must be met (1 point):
 - a. Adhesives & sealants (including tile grouting),
 - b. Floor coverings such as carpets, laminates and vinyl flooring (excluding tiles),
 - c. Ceiling coverings such as ceiling boards,
 - d. Wall coverings (excluding tiles)
 - e. Varnish, stains, lacquers or other trims
- Use of Low VOC doors where $\geq 90\%$ of the applicable furniture shall meet the VOC emissions limit (0.5 point)
- The fixed and system furniture where $\geq 60\%$ of the applicable furniture shall meet the VOC emissions limit (0.5 point)

The products should be certified from an approved local certification body such Singapore Green Building Council. The use of certified Low VOC Interior paints is a pre-requisite requirement (P16) and thus excluded from this computation.

$$\frac{\text{Compliant surface area of (adhesives + sealants + floor + wall + ceiling coverings + varnish/trims)}}{(\text{Total applicable surface area})}$$

Use of Persistent Bioaccumulative and Toxic (PBT) free lighting

0.5 points shall be awarded for the use of PBT free lighting for $\geq 90\%$ of light fittings in the project.

Guidance Notes

At Design Stage

Table 4.01c-1 includes information of VOC emissions requirements and extent of application. Submission of the following if applicable:

Certified Low VOC emission interior fittings and finishes

- Specification of the interior products shall be produced that demonstrate the VOC emission levels and formaldehyde emissions to the relevant testing standards
- Calculations of the extent of application to demonstrate compliance with table 4.01c-1. And includes tenanted areas of the building
- Enforceable fit out guideline or Green Lease if scoring for items to be provided by tenants

Use of PBT free lighting

- Specification of the luminaries used within the project and their requirement to be PBT free. This shall include details that the quality of PBT luminaries for > 90% of the luminaries used within the project

At Verification (As Built) Stage:

Submission of the following if applicable:

Certified Low VOC emission interior fittings and finishes

- As built drawings and calculation of the use of certified low VOC emitting products. Documentary evidence shall include:
 - Product certificates and data sheets of the VOC emissions
 - Delivery orders of the products
 - Where furniture has been scored, details of the furniture systems within the occupied spaces and their certification. This information is subject to gathering the required evidence from the tenanted areas

Use of PBT free lighting

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

References

Singapore Standard 554 (2015) 'Code of Practice for Indoor air quality for air-conditioned buildings'; SPRING Singapore

Table 4.01c-1 – VOC emission requirements and extent of application required for points

Parameter	Description	Points
Flooring, wall and ceiling finishes	<p>≥90% of the applicable areas shall be certified low VOC emitting products under approved local certification schemes:</p> <ul style="list-style-type: none"> • TVOC emission rate shall be $\leq 0.25 \text{ mg m}^{-3} \text{ h}^{-1}$ after 24 hours • Formaldehyde emission rate shall be $\leq 0.02 \text{ mg m}^{-3} \text{ h}^{-1}$ after 48 hours • VOC content for trim, stains and varnishes shall be $\leq 75 \text{ g L}^{-1}$ <p>Applicable internal finishes include:</p> <ul style="list-style-type: none"> • Adhesives and sealants used for the flooring, wall or ceilings (including tile grouts and sealants, carpet adhesives, wall covering adhesives.) • Floor coverings such as carpets, laminates and vinyl's • Wall coverings such as laminates, fabrics and wall papers • Ceiling coverings such as ceiling boards • Varnish, stains, lacquers or other finishes <p><i>Applicable coverings exclude: painted walls (P16), bare ceilings with a painted finish, natural or concrete tiles.</i></p> <p><i>Applicable area = total surface area of each applicable internal finish</i></p>	1
Doors	<p>≥90% of the applicable areas shall be certified low VOC emitting products under approved local certification schemes</p> <p>TVOC, Formaldehyde emissions and stains and varnishes shall be as above.</p>	0.5
Furniture	<p>≥60% of the applicable system furniture used within the development shall be certified low VOC by an approved local certification scheme.</p> <p>Furniture includes:</p> <ul style="list-style-type: none"> • Desks • Chairs • Cabinetry • Cubicle partitions 	0.5

VOC emissions rate limits for products are based upon ASTM D5116-90, "Standard Guide for Small-Scale Environmental Chamber Determinations of Organic Emissions from Indoor Materials/Products"

Test methods for paints and coatings shall comply with ISO 17895 or ISO 11890

4.02 Spatial Quality

Intent

The spatial quality of a building is assessed through the experiential value of both the physical and social qualities of the spaces within the development. Many spatial quality indicators are qualitative and the relationship between the indicators and the health and wellbeing of the occupants is not fully understood, and are not within the scope of a Green Building Rating tool. However there are a number of commonly agreed upon indicators that act as a reliable proxy to determine the projects spatial quality that can enhance the indoor environment and the wellbeing of the occupants and visitors to the building. These include access to quality daylight and artificial lighting, being an acoustically comfortable space, and a building with a range of accessible and quality spaces that provide semi-public / semi private spaces with a connection to nature.

Criteria	Points
4.02a Lighting	6
4.02b Acoustics	2
4.02c Wellbeing	2
TOTAL	10

4.02a Lighting

Scope

The quality of the lighting in a building is important to provide well-lit and comfortable spaces for the building occupants and users.

It is easy to underestimate the significance of daylight, and of sunlight, in the character of a building and in the lives of the people who use it. Current research shows that people value daylight highly. Daylight is the light to which we are naturally adapted; it is the light against which we measure all other kinds of light, in which we try to view things if we want to know what they 'really' look like. Access to sufficient daylight has been shown to increase healing times in hospitals, improve students' performance, increase productivity in the workplace, fight depression and lethargy, and even increase sales in retail environments. A well-designed daylight building also uses less electric lighting energy, conserving natural resources and reducing air pollution.

Currently most of the research on daylight and the design guidelines are suited to temperate climates. Here in the tropics care must be taken in maximising the useful (effective) daylight without over lighting the space or compromising the façade's thermal efficiency. Care must be taken in the interior design of the project to ensure that it works with the daylight provisions of the building without compromising the occupants comfort. Green Mark 2015 has taken care to tropicalise and streamline the daylighting design rules of thumb and the simulation methodology so that it is a meaningful tool for the design team in optimising their building for natural lighting.

The lighting illuminance forms part of the pre-requisite requirements (P17) that ensure that the energy considerations are balanced with a lighting strategy that is fit for purpose within the project. Going beyond illuminance, good colour rendering that is fit for purpose for the normally occupied functional spaces

Assessment

Criteria	Points
(i) Effective Daylighting and Potential for Visual Discomfort	5
(ii) Quality of Artificial Lighting	1
TOTAL	6

4.02a (i) Effective Daylighting and Potential for Visual Discomfort

To encourage effective daylighting and potential for visual discomfort mitigation strategies within the building. Performance for daylighting can be through the performance checklist method (2 points) OR through effective daylighting simulation (3 points). Daylight control strategies should be implemented to allow the building occupants to alter the level of daylight to suit their needs. A predictive glare simulation can further be conducted where required to aid with design solutions to reduce the potential for visual discomfort and inform the interior design of the project.

Assessment

Points shall be awarded based on the following options:

Criteria	Points
Daylight performance checklist OR Full Daylighting simulation with predictive glare model where applicable	4
Potential Glare and daylight control measures	1

Daylight Performance

Up to 3 points can be awarded where the building is designed so that the applicable functional spaces have access to effective daylighting. Points are scored based on table 4.02a-1. The checklist method takes reference to tables [to insert] which are found in the *BCA Green Mark Daylighting and Glare Simulation Guidelines*.

Full Daylight Simulation

Up to 3 points can be awarded where daylighting simulations are conducted based on the requirements in the *BCA Green Mark Daylighting and Glare Simulation Guidelines*. Analysis shall identify areas where there are issues of over exposure and potential for visual discomfort. Points are scored based on the results and performance levels based on table 4.02a-1. Where there is a low potential for visual discomfort (no requirement for a predictive glare model), 1 point can be scored in addition to table 4.02a-2 (total 4 points).

Daylight Control Measures

1 point for simple strategies to allow building occupants to adjust their environment to reduce discomfort glare during certain times of the day, whilst allowing daylight effective daylight to enter the functional areas. The project will need demonstrate that at least 90% of the applicable areas (excludes atria) have effective daylight control strategies.

It is advised that the POE in 4.01a includes questions on the quality of daylighting and if there are issues of discomfort glare.

Predictive Glare Model

1 point can be scored for the use of a predictive glare model where required. A predictive glare analysis would advise where the daylight simulation demonstrates a high or extreme potential for visual discomfort. The predictive glare analysis will use a methodology based on the *BCA Green Mark Daylighting and Glare Simulation Guidelines* to identify and implement effective discomfort glare mitigation. The effectiveness of the glare mitigation devices shall be analysed with their effect on daylight penetration within the occupied spaces. The analysis shall be used to demonstrate meeting the unified glare rating in SS531: 2006.

Guidance Notes

The applicable functional spaces are listed in table 4.02a-4

At Design Stage:

Submission of the following:

Daylight Performance:

Calculations and detailed drawings that demonstrate the checklist performance in table 4.02a-1. Where there are areas prone to discomfort glare, glare mitigation measures shall be recommended in order to score for this point.

Full Daylight Simulation

A daylight modelling report showing the effective daylight for the representative functional spaces that shall include the following information:

- Summary table of each space modelled and the effective daylighting simulation results
- The calculation of the % area meeting daylight autonomy (DA)
- Glare mitigation recommendations where there are areas that are shown to have a high potential for visual discomfort.

Daylight Control Measures

Drawings and specifications showing the locations of the daylight control devices installed and their control strategies.

Predicative Glare Model

A predictive glare modelling report that includes the results of the predictive glare model and the resultant Unified Glare Rating (UGR). This is applicable where the daylight simulation shows a potential for visual discomfort which is indicated through a Useful Daylight Illuminance >3000lux level in the space for 10% of occupied hours ($UDI_{>3000lx/10\%}$) extending more than 1.25 meters beyond the façade into the space as per a simulated result or per facades identified as a 'high' or 'extreme' risk of visual discomfort in the *BCA Green Mark Daylighting and Glare Simulation Guidelines*.

Verification (As Built):

Submission of the following:

Daylight

As built drawings of the façade and layouts of the functional spaces. Performance spot measurements of the effective daylighting through lux measurements and photographs of the applicable functional spaces.

Daylight Control Measures

Delivery orders and photographs of the potential for visual discomfort mitigation strategies.

References

BCA Singapore 'BCA Green Mark Daylighting and Glare Simulation Guidelines'

Singapore Standard 531: Part 1 (2006) 'Code of Practice for Lighting of work places Part 1: Indoor'; SPRING Singapore

CIBSE Lighting Guide 10 (2014) 'Daylighting - A guide for Designers'; Chartered Institution of Building Services Engineers, UK

Reinhart, Christoph F., John Mardaljevic, and Zack Rogers. "Dynamic daylight performance metrics for sustainable building design." Leukos 3.1 (2006): 7-31.

Reinhart, Christoph F., and Daniel A. Weissman. "The daylit area—Correlating architectural student assessments with current and emerging daylight availability metrics." Building and environment 50 (2012): 155-164.

IES Approved Method (2013) 'IES Spatial Daylight Autonomy (sDA) and Annual Sunlight Exposure (ASE)'; Illuminating Engineering Society, USA

Table 4.02a-1 Points matrix for checklist based performance for effective daylight.

Points	% of the Applicable Area that Demonstrates Access to Effective Daylight
0.5	≥35%
1	≥40%
1.5	≥45%
2	≥55%
2.5	≥65%
3	≥75%

Note: The floor area that receives effective daylight is based upon the detailed tables in the *BCA Green Mark Daylighting and Glare Simulation Guidelines* which outlines the penetration of effective daylight from the façade based on the window to wall ratio, the orientation of the façade, the details of the shading devices, and the view to sky. These tables indicate where there façade design has a high chance of potential glare. In these cases points shall only be granted where glare mitigation measures are implemented. Where there are multiple floors with the same layout, representative floors can be used to calculate the daylight effectiveness.

Table 4.02a-2 Points matrix for daylight simulation

Functional Space	Description	Points
Office & Institutional spaces	<u>Moderate:</u> DA _{500lux/50%} ≥40% of the applicable areas	1
	<u>Good</u> DA _{500lux/50%} ≥55% of the applicable areas	2
	<u>Very Good</u> DA _{500lux/50%} ≥75% of the applicable areas	3
Hotels and residential style occupancy	Moderate DA _{200lux/50%} ≥40% of the applicable areas	1
	Good DA _{200lux/50%} ≥55% of the applicable areas	2
	Very Good DA _{200lux/50%} ≥75% of the applicable areas	3
Other Space Types	Moderate DA _{300lux/50%} ≥40% of the applicable areas	1
	Good DA _{300lux/50%} ≥55% of the applicable areas	2
	Very Good DA _{300lux/50%} ≥75% of the applicable areas	3

Note: The daylight autonomy (DA_{xux/50%}) a metric describing annual sufficiency of ambient daylight levels in the interior area. It is defined as the percentage of an analysis area (the area where calculations are performed) that meets a minimum daylight illuminance level for a specified percentage of the operational hours per year. The illuminance level (Lux) and percentage of the operational hours are expressed in subscripts such as DA_{500Lux/50%} which means an area would be considered to meet the DA when it achieves ≥500lux for ≥50% of the operational hours a year.

For areas with a low Useful Daylight Illuminance (UDI > 3,000, 10%) glare mitigation measures shall be installed and simulated within the model to calculate the DA to reflect the in use operation of the building. Where there is a mixture of functional spaces, the area weighted result shall be used to compute the overall points.

Table 4.02a-3 Daylighting control strategies for functional areas

Control device	Description
Blinds and Screens	<p><u>Controllable translucent blinds:</u> Controls must be operable by the building user. Automatic controls are acceptable provided there is a user override. Blinds shall either be installed externally, internally or between the glazed panes.</p> <p>Translucent refer that blinds when drawn provide the ability for building occupants to maintain a visual connection with the outside and don't shut out all of the light for commercial spaces. These include roller blinds, moveable exterior louvres, bottom-up blinds, moveable screens, curtains and venetian blinds. For areas which require darkness the translucent requirement is not applicable.</p>
Light Shelf	<p><u>Use of a light shelf or equivalent:</u> to direct sunlight towards the ceiling to provide increased levels of indirect light penetration within the floor space whilst providing solar shading for the windows below the light self.</p>
Glazing treatments	<p><u>Variable Opacity Glazing:</u> Such as electro chromatic or thermochromic glass that darkens the glazing where the solar intensity exceeds pre-programmed thresholds</p> <p><u>Bi-level Glazing:</u> Different glazing visible light transmittance properties for different areas. For example for eye level glazing a lower transmittance coupled with higher transmittance for glazing at higher levels.</p>
Clerestories	<p><u>Clerestories:</u> The design for high level glazing on the façade (above eye level) to maximise the depth of natural light without the risks of glare. These should be minimally 600mm in height (sill to head)</p>

Table 4.02a-4 Applicable functional spaces

Functional Space	Description
Office & Institutional spaces	<u>Open Plan office spaces:</u> excludes data centres, server rooms, storage rooms.
	<u>Cellular offices (Executive / individual offices)</u> Although the most equitable floor plans locate individual offices towards the core (along with meeting rooms) there are building typologies with executive floors or where the floor spaces are designed for individual offices. These areas shall form part of the assessment for effective daylighting and glare
	<u>Classrooms</u> Classrooms, seminar rooms, student activity rooms and teaching spaces. Excludes auditoria and lecture theatres
	<u>Library spaces</u> Reading rooms, shared work spaces and writing areas
Hotels and residential style occupancy	Dorm rooms
	Hospital patient rooms
	Hotel guest rooms / Serviced apartments
	Hotel Lobbies
Other Space Types (Industrial, sports facilities, retail areas, building atria)	<u>Atria</u> <ul style="list-style-type: none"> • Retail • Commercial • Hotel
	Note: atria are excluded from the Glare and daylight control measures criteria
	Exhibition halls
	Gymnasium
	Occupied production areas (including laboratories)
	Sports halls / multipurpose halls
	Waiting lounges
	Warehouse handling areas

4.02a (ii) Quality of Artificial Lighting

To achieve good lighting quality for occupant space and allow individual control of lighting levels. Minimum lighting comfort is a requirement for all projects within the pre-requisite requirements with flicker free lighting (P13) and minimum illuminance level (P17) that ensure that the energy considerations are balanced with a lighting strategy that is fit for purpose within the project.

Assessment

Criteria	Points
Lighting Quality	0.5
Occupant Lighting Controls	0.5

Lighting Quality:

0.5 points shall be scored for the following:

- Meeting the minimum colour rendering index (R_a or CRI) in clause 5 of SS 531:2006 in all areas.
- Good Light-output over life with a minimum lifespan rating of L80
- Ensuring a regular colour temperature / colour uniformity for functional areas. Where LEDs are used to ensure that the lamps have small Binning/McAdam Steps (≤ 2 steps)

Occupant Lighting Controls:

0.5 points shall be scored where individual occupants have the ability to control the lighting level in their immediate environment in normally occupied functional areas, i.e. an individual workstation or desk area.

Guidance Notes

At Design Stage:

Submission of the following:

Lighting Quality:

- Detailed specifications and the schedule of luminaires shall be provided to demonstrate the minimum R_a and Lifespan Rating are met from published IESNA standard testing data.
- Colour temperature and colour uniformity of luminaires used and the space.

Occupant Lighting Controls:

- A description of the individual control strategies suitable for each of the functional areas.
- Detailed specifications and drawings shall be accompanied along with fit out guidelines or Green Lease clauses where the controls are not provided as part of the base building

Verification (As Built):

Lighting Quality:

- Submission of lighting delivery orders and data sheets for the lamps used in the project that includes authenticated R_a , Lifespan, colour temperature, Binning/McAdam steps data.

Occupant Lighting Controls:

- As built schematics, drawings and photographs of the occupant lighting control strategies
- Delivery orders of task lights if utilised

References

Singapore Standard 531: Part 1 (2006) 'Code of Practice for Lighting of work places Part 1: Indoor'; SPRING Singapore

IESNA LM-79-08 (2008) 'Approved Method Electrical and Photometric Measurements of Solid-State Lighting Products'; Illuminating Engineering Society of North America

IESNA LM-80-15 (2015) 'Approved Method Measuring Luminous Flux and colour Maintenance of LED Packages, Arrays and Modules'; Illuminating Engineering Society of North America

IESNA TM-21-11 (2011) 'Projecting Long Term Lumen Maintenance of LED light sources'; Illuminating Engineering Society of North America

4.02b Acoustics

Scope

Projects should demonstrate an improved acoustical performance for normally occupied spaces. This is important as green buildings often have quieter M&E systems, higher performing facades and thus the acoustical quality of the finishes and sound transmission between spaces becomes increasingly important. Appropriately designed acoustics enhances the spatial quality of the interior environment through improved occupant aural comfort within the space, facilitating communication, reducing unwanted sound and aiding in speech privacy. All of these contribute to comfort and productivity.

Acoustical design considerations are an important component to the overall indoor environmental quality of the building

Assessment

Criteria	Points
(i) Sound Transmission and Reverberation Design	0.5
(ii) Aural Comfort	1.5

4.02b (i) Sound Transmission Reduction and Reverberation Design

Acoustical separation and acoustical quality of space is important for the comfort of the building occupants. The indicator provides a number of options to demonstrate acoustical comfort.

Assessment

Criteria	Points
Sound Transmission Reduction Calculation	0.5
Reverberation Control Calculation	

Sound Transmission Reduction:

The project shall demonstrate that the acoustic performance of the internal partitions between adjoining spaces are constructed to achieve the performance as stated in table 4.02b-1.

Reverberation Time:

0.5 points can be awarded where reverberation times in relevant functional areas are designed to comply with table 4.02b-2

Guidance Notes

At Design Stage:

Submission of the following:

Sound Transmission Reduction:

- Recognised design guidelines, field or laboratory test results by certified/accredited agency or design calculations.

Reverberation Time:

- Detailed design calculations or acoustic modelling

Verification (As Built):

Sound Transmission Reduction:

Submission of the following:

- STC - demonstrated through product specifications and the as built details
- Where there have been on site changes a re-calculation or onsite measurement shall be conducted.

Reverberation Time:

- As built calculations of reverberation time

Definitions:

The sound transmission class (STC) is the rating of how well a partition attenuates airborne sound. The higher the STC the higher the sound reduction.

References

ASHRAE (2010) 'Performance Measurement Protocols for Commercial Buildings' American Society of Heating, Refrigerating and Air-Conditioning Engineers

AS/ NZS 2107 (2000) 'Acoustics – Recommended design sound levels and reverberation times for building interiors' Standards Australia

BS 8233 (2014) 'Guidance on sound insulation and noise reduction for buildings'; British Standards Institution

BS EN ISO 10140 (2010) Acoustics. Laboratory measurement of sound insulation of building elements. Various parts. British Standards Institution.

ISO 16283-1 (2014) 'Acoustics - Field measurement of sound insulation in buildings and of building elements -- Part 1: Airborne sound insulation'; International Standards Organisation

Table 4.02b-1 Sound Transmission Reduction Requirements for different metrics

Metric Used	Description
Sound Transmission Class (STC)	<u>Between General Office spaces:</u> STC: 40-50
	<u>Hotel Rooms, Classrooms, Lecture Theatres, Meeting Rooms, Conference Rooms*</u> STC: 50-60 <i>* and spaces where confidential speech are required</i>
	<u>Between Mechanical/ Equipment spaces and occupied spaces:</u> STC: 50-60

Note: The consultant can use equivalent sound transmission metrics and qualify the range.

Table 4.02b-2 Reverberation Requirements (adapted from AS/ NZS 2107)

Functional Space	Recommended Reverberation Time (<i>T60 seconds averaged between 500, 1000 and 2000Hz</i>)	
Office	Open Plan Office	≤ 1
	Conference / Meeting Rooms	≤ 0.8 (0.4 for rooms with tele or video conference)
Institutional (Schools, Civic buildings)	Classrooms	0.6 - 1.0
	Seminar / tutorial rooms	0.6 - 0.8
	Libraries	<1.0
	Reading rooms	0.6 - 0.8
	Music Rooms	0.5 - 0.7
	Music Studios	0.7 - 0.8
	Multi-Purpose Halls	<1.5
Hotel	Gymnasiums	<1.5
	Meeting Room	<0.8
	Large Banquet Room/Hall	<1.2
Atria/ Commercial Lobby	Retail, office, institutional, or hotel atria or main lobby spaces.	(reduce as far as practicable for noise control)

Calculation of reverberation time can be calculated by hand where:

$$(1) A = (\alpha_1 S_1 + \alpha_2 S_2 + \alpha_3 S_3 + \dots + \alpha_n S_n)$$

$$(2) RT = 0.163 \times V/A$$

A - Total equivalent sound absorption area of a room (in Sabin or m^2)

$\alpha_{1,i}$ - the sound absorption coefficient for different materials $1 \rightarrow i$ as specified/used in a space/room.

$S_{1,i}$ - the total surface area of different materials, $1 \rightarrow i$ corresponding to the respective absorption coefficient (m^2).

RT – Reverberation Time in seconds.

V – Room Volume (m^3)

4.02b (ii) Aural Comfort

To design and verify basic internal background noise levels to promote aural comfort within the building.

Assessment

1.5 points can be awarded for an acoustic design and verification report for the project based on the acoustic report guidance (next page). The report should be prepared by a qualified acoustician who is part of the design team and who has responsibility for coordinating the acoustic design.

Guidance Notes

At Design Stage:

Submission of the acoustic design report based demonstrating the acoustic response to site, the internal design to achieve a high quality environment.

Verification (As Built):

An acoustic verification report of onsite testing and measurements to demonstrate that the acoustic objectives have been met, with recommendations for continued operational performance, where defects due to workmanship are found these should be corrected.

For sound insulation measurements, a representative sample of partitions shall be tested, i.e. 10% of the total (lower quantity if there is extensive repetition). For façade noise ingress measurements and reverberation time measurements, a selection of rooms shall be used for testing, i.e. 5% of the total (lower quantity if there is extensive repetition). Testing shall be conducted in accordance with ISO3382.

References

AS/ NZS 2107 (2000) 'Acoustics – Recommended design sound levels and reverberation times for building interiors' Standards Australia

BS 8233 (2014) 'Guidance on sound insulation and noise reduction for buildings'; British Standards Institution

ISO 16283-1 (2014) 'Acoustics - Field measurement of sound insulation in buildings and of building elements -- Part 1: Airborne sound insulation'; International Standards Organisation

ISO 3382 Acoustics - Measurement of room acoustic parameters

Acoustic Design and Verification Report

ACOUSTIC DESIGN REPORT:

Executive Summary – Summary of the key design recommendations for the project

Acoustic Considerations:

- (1) Impact of the project on the immediate noise environment, especially noise sensitive accommodation, including both the construction and operational stages of the building.
- (2) External noise sources and propagation affecting the development
- (3) Internal noise sources, acoustical design and criteria used within the building
- (4) Internal layout planning, finishes selection and acoustical performance of the building
- (5) Site massing, landscaping and facades design to mitigate the adverse impacts of external noise

Facade Noise Ingress Control Criteria:

- (1) Noise survey methodology and standards
- (2) Results
- (3) Recommendations for façade treatment & spatial arrangement of interior spaces

Internal Acoustic Design Criteria:

- (1) Sound transmission reduction targets
- (2) Reverberation time targets
- (3) Sound reinforcement systems and/or public address system (where applicable)

Internal Acoustic Design Proposals

- (1) Proposals for sound absorptive finishes and supporting calculations for typical areas
- (2) Proposals for sound insulation with supporting calculations or field or laboratory test results by certified/accredited agency for typical areas.

ACOUSTIC VERIFICATION:

Environmental Noise & Survey (As-Built):

- (1) Methodology and testing standards
- (2) External impact of development on the surroundings

Façade Noise Ingress Control (As-Built)

Façade ingress noise measurement for internal areas

Internal Acoustics (As-Built):

- (1) Sound Insulation measurements
- (2) Reverberation times measurements
- (3) Commissioning and handover of noise masking or sound reinforcement systems (*where applicable*)

4.02c Wellbeing

Scope

Wellbeing refers to the state of being comfortable, healthy or happy. From a building perspective this means providing a space that nurtures the building users, reduces stress for the occupants through ease of access and wayfinding, providing places of respite, as well as having a strong access to nature.

Assessment

Criteria	Points
(i) Biophilic Design	2
(ii) Universal Design Mark	1
(iii) Provision of communal private spaces	1
	<i>Cap at 2 points</i>

4.02c (i) Biophilic Design

Including elements of nature in comfortable spaces to nurture the human-nature relationship is important for the health and happiness of the building users. We see the value of greenery in improving our quality of life. This indicator aims to facilitate even more accessible greenery to further enhance the building occupant and user's environment, and overall wellbeing.

Assessment

1 point shall be awarded for the provision of accessible sky gardens, sky terraces, internal courtyards and rooftop gardens that can be used as areas for respite. They should include at least one outdoor refreshment area for building users, and where applicable the wider public.

0.5 point shall be awarded for the provision for at least 10% of the common areas (based on floor area) to have fixed indoor planting, i.e. atria, main entrance foyers and lift lobbies. Plants shall not be concentrated in one location but shall be distributed across the applicable areas.

0.5 point shall be awarded for fixed planting that covers at least 1% of functional floor areas (by NLA). For speculative buildings, a commitment to meet this target can be demonstrated through fit out guidelines or a clause in the Green Lease.

Guidance Notes

At Design Stage:

Submission of the following if applicable:

- A short design and access statement explaining the proposed urban gardens through sketches, artist impressions that represent the spatial quality of the proposed areas of respite and details on how the landscaped areas are planned as an area serving the building occupants and the public where applicable
- Landscape plans of the relevant accessible sky gardens, sky terraces, internal courtyards and rooftop gardens that indicate the outdoor furniture, the outdoor refreshment area
- Plan layouts and perspectives of the interior planting design at the applicable areas with calculations that demonstrate the plant coverage as a percentage of the relevant floor areas. Note that the greenery must be distributed throughout the relevant areas. This would mean that 80% of applicable areas (by number) should have access to greenery

Verification (As Built):

Submission of the following:

- As built drawings and photographs of the relevant accessible sky gardens, sky terraces, internal courtyards and rooftop gardens and the location of the outdoor refreshment areas.
- Photographs of the outdoor furniture, the outdoor refreshment area

References

CS E09:2012 - *Guidelines on planting of trees, palms and tall shrubs on rooftop* (2012), NParks

A Selection of Plants for Green Roofs in Singapore 2nd Edition (2008), NParks

Concise Guides to Safe Practices on Rooftop Greenery and Vertical Greenery (2013), NParks:

URA LUSH 2.0

4.02c (ii) Universal Design Mark

The BCA UD Mark is a voluntary certification scheme launched in October 2012 as an initiative to raise the bar on Universal Design (UD) adoption in development. UD Mark accords recognition to developments and stakeholders that adopt a user-centric philosophy in their design, operations and maintenance. It also aims to raise greater public awareness towards user-friendly buildings.

Assessment

1 point can be awarded for projects that are awarded under the BCA UD mark scheme. Points shall be awarded based upon the UD mark rating achieved:

Criteria	Points
UD Mark Certified or Gold Award	0.5
UD Mark Gold ^{PLUS} or Platinum Award.	1

Guidance Notes

At Design Stage:

Tender documentation and written commitment from the developer / building owner that the project shall be applying for BCA UD Mark and the targeted level of award or the letter of award that the project has achieved the relevant UD Mark (design) rating

Verification (As Built):

The completed BCA UD Mark award.

References

BCA Singapore (2013) [‘Code on Accessibility in the Built environment 2013’](#)

4.02c (iii) Provision of Communal - Private Spaces

Healthy indoor environments should be designed with a range of private spaces designed for a broad spectrum of human activities that are suitably adaptable for collaborating, resting and relaxing. The provision of such spaces especially in a working environment help reduce stress, provide places of focus and refuge for occupants

Assessment

1 point can be awarded based on the extent of the communal spaces that are enclosed and acoustically separated from open spaces to facilitate privacy. These spaces shall range in size to cater for a range of functions including collaborative working and brainstorming, relaxing, resting and for dealing with matters of a private nature. Consideration shall be given to the furnishing of these spaces, the lighting design and colour temperature and the interior decoration.

Guidance Notes

At Design Stage:

Communal – private spaces shall be identified on the plan which details the acoustic separation from the working environment, the interior design considerations and the soft furnishings. There should be one such space of at least 7.5m² for every 2,000m² of nett lettable area (NLA).

Verification (As Built):

Submission of as built drawings and photographs of the furnished spaces

4.03 Smart Building Operations

Intent

To encourage the use of automation and data and behavioural science that enable building professionals to boost and maintain energy efficiency by optimising equipment and related processes for energy reduction and comfort requirements. A three-level taxonomy is defined to classify the maturity of smartness as a framework to help building professionals review which “Smart Green” technology options suit its operations best. Finally the importance of a detailed handover to the facilities and operations team cannot be understated in terms of its importance in ensuring that the sustainable design is translated into actual operational performance.

Criteria	Points
4.03a Energy Monitoring	3
4.03b Demand Control	3
4.03c Integration and Analytics	3
4.03d System Handover and Documentation	1
TOTAL	10
Advanced Green Efforts	4

4.03a Energy Monitoring

Scope

This refers to the tracking a building's energy use with the data presented in a relevant manner to engage its occupants to be involved in managing energy consumption. Related to this ideal of sharing building data openly is the need to apply open standards to future-proof the building's management system and to facilitate data exchange between subsystems

Assessment

Criteria	Points
(i) Energy Portal and Dashboard	2
(ii) BAS and Controllers with Open Protocol	1

4.03a (i) Energy Portal and Dashboard

To provide visualisation of energy consumption indices by area and use/load, trend, cost and target/benchmark to occupants in an easy and accessible manner.

Assessment

1 point will be scored for the provision of an energy portal or dashboard, and additional 1 point if the portal is made available to tenants, showing the energy consumption in their respective leased spaces.

The energy portal or dashboard could be in the form of digital displays in common areas, or web-based and mobile applications.

Guidance Notes

At Design Stage:

Submission of the following:

- Specifications of the portal's requirements to provide energy use by area or use, trend and cost; and to compute a target/benchmark. The data acquisition system, typically a building or energy management system (BMS or EMS), must be able to store the measured data for at least 36 months, and to create reports showing hourly, daily, monthly, and annual energy consumption associated with each meter with option to export data to a text format.
- Plans and schematics to illustrate:
 - Location and means of access of the portal
 - Electrical single line diagram of the sub-metering scheme and links to a BMS or EMS

Verification (As Built):

Submission of photographic evidence of the installed energy portal and dashboard reflecting:

- Display of the metered energy data by area or use, and cost of energy used.
- Energy use trends and computed benchmarks.

References

Singapore Standard 553 (2015) 'Code of Practice for Air-conditioning and mechanical ventilation in buildings'; SPRING Singapore

4.03a (ii) BAS and Controllers with Open Protocol

To encourage the use of open standards to future-proof the building's network and to facilitate the exchange of data with other systems.

Applicable to all the buildings equipped with building management systems (BMS). If the building does not have a BMS or other equivalent building management, control and monitoring system, no points will be scored.

Assessment

1 point can be scored for using BACnet, Modbus or any other non-proprietary protocol as the network backbone for the building management system and the system is able to provide scheduled (at least daily) export of a set of any chosen data points to commonly used file formats.

Guidance Notes

At Design Stage:

Extracts of the specification of BMS or other equivalent building management, control and monitoring system that demonstrates that the building automation network and controllers comply with open and non-proprietary protocols, such as BACnet, Modbus and KNX, and provides interfaces to enable the easy integration of new devices and subsystems and facilitate scheduled and automated data export to widely-used file format such as CSV.

Verification (As Built):

Submission of the commissioning report of the building management or building automation system.

References

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

The Modbus Organisation and Specifications (<http://www.modbus.org/specs.php>)

KNX Association (<http://www.knx.org>)

4.03b Demand Control

Scope

Encourage usage-based control of temperature and ventilation demand at the applicable transient areas and occupied areas to reduce energy use.

Various simulation studies have shown that by conditioning and lighting spaces based on occupancy, annual savings of up to 20% may be achieved while maintaining room temperature effectiveness and good indoor environmental quality.

Applicable to all specified transient and occupied areas in a building.

Assessment

Criteria	Points
(i) ACMV controls	2
(ii) Lighting Controls	1

Transient areas include:

- Pantries
- Toilets
- Staircases
- Corridors
- Lift lobbies
- Carparks

Occupied areas include:

- Offices
- Meeting and function rooms
- Theatrettes
- Classrooms

At least 80% coverage must be demonstrated for points to be awarded.

4.03b (i) ACMV Demand Control

To encourage the use of occupancy based controls of the temperature and ventilation demand of the applicable areas.

For naturally ventilated buildings 4.03b(i) can be pro-rated and scored as a part of 4.03b(ii).

Assessment

Points shall be awarded based on the following:

Criteria	Points
ACMV controls for transient areas	1
ACMV controls for occupied areas	1

Transient areas:

0.5 point shall be awarded for the use of binary sensing or 1 point for the use of occupancy-based sensing.

Occupied areas

0.5 point shall be awarded for the use of binary sensing or 1 point for the use of occupancy-based sensing.

Guidance Notes

At Design Stage:

Submission of the following:

- Location plans of the relevant sensors demonstrating that at least 80% of the applicable areas are covered
- Specifications of the sensors and a method statement of the ACMV controls including the sensor regulation of temperature and fresh air supply

Verification (As Built):

Submission of the following:

- Delivery orders of the sensors
- The specifications of the sensors installed and the associated controllers
- As-built building floor plan marked with the sensor deployment
- As-built control system screens showing the sensor inputs and the corresponding controller outputs.

References

EN 15232 Standard: Energy Performance of Buildings – Impact of Building Automation, Controls, and Building Management

4.03b (ii) Lighting Demand Control

To encourage the use of occupancy based controls of the lighting demand of the applicable areas.

Assessment

Points shall be awarded based on the following:

Criteria	Points
Lighting occupancy based controls for transient areas	0.5
Lighting occupancy based controls for occupied areas	0.5

Transient areas:

0.5 point shall be awarded for the use of occupancy-based (non-binary) sensing to moderate brightness of the luminaries

Occupied areas

0.5 point shall be awarded for the use of occupancy-based (non-binary) sensing to moderate brightness of the luminaries.

Guidance Notes

At Design Stage:

Submission of the following:

- Location plans of the relevant sensors that demonstrates that at least 80% of the applicable areas are covered.
- Specifications of the sensors and a method statement of the lighting controls including the sensor regulation of lighting level (brightness).

Verification (As Built):

Submission of the following:

- Delivery orders of the sensors
- The specifications of the sensors installed and the associated controllers
- As-built building floor plan marked with the sensor deployment
- As-built control system screens showing the sensor inputs and the corresponding controller outputs.

References

EN 15232 Standard: Energy Performance of Buildings – Impact of Building Automation, Controls, and Building Management

4.03c Integration and Analytics

Scope

Encourage innovative and integrative use of BIM and sensor data for optimising workflow or to attain persistence of high performance and energy efficiency in a building.

Applicable to all buildings.

Assessment

Points shall be awarded based on the following:

Criteria	Points
4.03c (i) Basic Integration and Analytics	0.5 point for each feature
4.03c (ii) Advanced Integration and Analytics	1 point for each feature
	<i>Cap at 3 points</i>
<i>Additional advanced integration and analytical features beyond the points cap (Advanced Green Effort)</i>	1 point

4.03c (i) Basic Integration and Analytics

Encourage the use of basic integration and use of sensor data in order to optimise and operate the building in an informed and effective manner.

Assessment

0.5 point shall be awarded for each basic feature. Categories of basic integration and analytics feature include, but are not limited to:

- Basic fault detection and diagnostics (FDD) of sensors, e.g. faulty, stuck or miss-calibrated sensors
- Provision of adaptive control algorithms based on outdoor weather conditions
- Equipment exceptions monitoring, e.g. abnormal set point, detecting equipment that run beyond intended operating hours

Specific examples of such features:

- Basic detection and diagnostics of deviation from normal expected behaviour:
 - Comparison of outputs (controllers) set points to actual conditions to find failed devices (i.e. broken/leaking valves, broken/stuck dampers, sensors out of calibration);
 - Systems with the wrong set points and operating schedules
 - Unintentional manual overrides
 - Short cycling of equipment
 - Identify when the chiller plant deviates from statistically expected performance
- Installation of condensing water temperature reset controls in cooling towers
- Installation of chilled water temperature reset controls, e.g. adjust the chilled water temperature based on outside air temperature
- Monitoring of chiller evaporator and condenser tube bundle pressure drops for cleaning frequency.
- Optimization of air filter replacement or cooling coil cleaning by monitoring changes in filter or coil pressure drop

This list is not exhaustive, and alternative or novel features may be proposed for scoring in this section

Guidance Notes

At Design Stage:

Submission of tender specifications and detailed method statements for the system integration, sensors and control strategies.

Verification (As Built):

Submission of relevant delivery orders, user manuals and system integration and installation reports.

4.03c (ii) Advanced Integration and Analytics

Encourage the use of advanced integration and analytics such as BIM and root-cause analysis to provide enhanced efficacy in lowering energy use, raising staff productivity and asset reliability, and improving the user experience.

Assessment

1 point shall be awarded for each advanced feature. Categories of advanced integration and analytics feature include, but are not limited to:

- Advanced detection and diagnostics of deviation from normal expected behaviour of a network of equipment such as AHUs, VAVs, fans, pumps and chillers, for root causes of equipment or system-wide faults or inefficiencies
- Prioritise equipment maintenance using machine condition monitoring
- De-silo building subsystems to optimise resource use or improve the user experience
- Demand Response Control (DRC) to curtail energy use subject to equipment constraints and occupants' comfort
- Use of BIM or similar applications that provide location-based visualisation of the building's state.

Specific examples of such features are

- Advanced detection and diagnostics of deviation from normal expected behaviour of a network of equipment:
 - Excessive oscillation (hunting) of control points.
 - Diagnose flow measurement systems to ensure readings are in range of expectations.
 - Excessive outdoor air intake and conditioning.
- Chiller sequencing such that each one is part-loaded enough to keep it in its most efficient operating zone.
- Optimise lift-versus-pump power by adjusting pump power to minimize chiller and pump energy consumption in a centrifugal chiller.
- Categorise faults according to various priorities - energy, comfort, and system maintenance impact.
- Demand response using thermal mass, e.g. pre-cool the building before demand response events, then curtail load during the event to get utility incentives.
- Integration of ID card access system with hot-desking scheme.
- Use of video analytics to direct lifts to a crowded floor.
- A Web or mobile application that has occupants provide direct feedback and adjust temperature and airflow to a specific zone accordingly.
- Use of BIM application to provide location-based visualisation in facility management, e.g.
 - a. Provide location-based energy or water consumption patterns.
 - b. Spatial condition such as temperature, humidity.
 - c. Use sensors' reading to trigger facility maintenance such as cleaning or waste collection.

This list is not exhaustive, and alternative or novel features may be proposed for scoring in this section.

An additional 1 point can be awarded for additional advanced integration and analytical features beyond the points cap (Advanced Green Effort)

Guidance Notes

At Design Stage:

Submission of tender specifications and detailed method statements for the system integration, sensors and control strategies.

Verification (As Built):

Submission of relevant delivery orders, user manuals and system integration and installation reports.

4.03d System Handover and Documentation

Scope

Design and delivery integration is essential to delivering an operationally energy efficient building. These criteria indicate the presence of a quality assurance plan to maintain the desired energy efficiency and indoor comfort. Successful commissioning of building starts at the beginning – during the design phase, and not at the end of installation, as commonly happens today. Mechanical specifications need to be clear in intent so that adequate cost allowances and functionality tests are provided by the controls specialist.

The Project (Construction) manager must provide a realistic time frame and co-ordinate the installation and testing of controls system with outstanding building works.

Assessment

Criteria	Points
(i) System Handover and Documentation	1
(ii) <i>Expanded Post Occupancy Performance Verification by a 3rd Party (Advanced Green Effort)</i>	2
(iii) <i>Energy Performance Contracting (Advanced Green Effort)</i>	1

4.03d (i) System Handover and Documentation

To encourage control systems verification and to ensure operational continuity from construction to building maintenance and operation.

Applicable to all buildings control systems, mechanical systems and electrical systems.

Assessment

1 point shall be awarded for a proper system verification and handover.

Guidance Notes

At Design Stage:

Submission of the list of the relevant mechanical, electrical and control systems to be tested and verified to be operating within their desired parameters, with client commitment that it will be carried out.

Verification (As Built):

Submission of the following complete with the building owner's endorsement:

Provision of verification requirements and schedules for:

- All control actions to meet functional requirements
- Integration test, including air and hydronic systems balancing
- Specified graphics and sensor data displays such as temperature, sub-meters
- Specified training arrangements and schedules
- Handover of all specified manuals, documentation and drawings, back-up copies of software, consumable spares

Provision of documentation including:

- Written description of plant operation and panel layout diagrams
- Control strategy or logic diagrams recording the final version of installed software
- Details of system application software configuration
- Point list, including hard and derived points
- Description of user adjustable points
- Data sheets for all control components and equipment
- Instructions for switching on, operation and switching off, isolation, fault finding and for dealing with emergency conditions
- Instructions for any necessary precautionary measures
- Instructions in the use of software routines for creating procedures, graphics reports etc.

References

CIBSE Commissioning Codes: A (Air Distribution Systems), C (Automatic Controls), L (Lighting), R (Refrigeration) – Chartered Institution of Building Services Engineers

ASHRAE Guideline 0 (2013) 'The commissioning Process'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASHRAE Guideline 1.1 (2007) 'HVAC & R Technical Requirements for the Commissioning Process'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASHRAE Guideline 1.4 (2014) 'Procedures for Preparing Facility Systems Manuals; American Society of Heating, Refrigerating and Air-Conditioning Engineers

ASHRAE Guideline 11 (2009) 'Field Testing of HVAC Controls Components'; American Society of Heating, Refrigerating and Air-Conditioning Engineers

4.03d (ii) Expanded Post Occupancy Performance Verification by a 3rd Party (Advanced Green Effort)

Encourage the use of a third party post occupancy performance verification of major energy subsystems other than the chiller plant.

Assessment

0.5 point shall be awarded for each subsystem where the owner engages an independent competent professional to verify the operational performance of major energy systems and provide recommendations on system performance enhancement. This shall be conducted within one year from the buildings TOP.

The applicable subsystems include:

- Lighting controls
- Mechanical ventilation
- Hot water system
- Heat recovery system
- Renewable energy systems

The competent professional refers to either a BCA registered Energy Auditor or a Professional Engineer (PE) (Mech/Elect).

Guidance Notes

At Design Stage:

Submission of extracts of the tender documentation and method statement of the third party performance verification.

Verification (As Built):

Submission of the following:

- The verification report for each of the applicable building energy systems
- The recommendation report for energy optimisation
- Relevant operational manuals

4.03d (iii) Energy Performance Contracting (Advanced Green Effort)

Engage a SGBC Accredited Energy Performance Contracting (EPC) firm to implement and deliver energy efficiency, renewable energy and/or energy recovery project with an energy performance contract wherein the EPC firm's remuneration is based on demonstrated energy savings.

Assessment

1 point shall be awarded for engaging an Energy Performance Contracting (EPC) firm in a suitable project that guarantees operational system efficiency over a minimum of 5 years. The external EPC firm may be a company that provide one of more of these services:

- provision of energy efficient technology and services including financing, design, implementation and management of projects
- supply, installation and commissioning of cooling and/or heat-recovery systems
- supply, installation and commissioning of CHP or tri-gen power generation
- supply, installation and commissioning of solar PV or thermal systems
- solar leasing
- M&E contracting

Guidance Notes

At Design Stage:

Submission of extracts of the tender documentation to include the project deliverables, financial model and duration of performance contract.

Verification (As Built):

Submission of the extracts of contract

References

<http://www.sgbc.sg/green-certifications/services-certification/>

5. Advanced Green Efforts

Criteria	Points
5.01 Enhanced Performance	15
5.02 Demonstrating Cost Effective Design	2
5.03 Complementary Certifications	1
5.04 Social Benefits	2
TOTAL	20

Advanced Green Efforts

The Green Mark 2015 Advanced Green Efforts section recognises the implementation of industry leading performance or innovative strategies, designs or processes that demonstrate exceptional levels of sustainability. The 20 points in this section are bonus points that can be added to the base Green Mark score to help projects demonstrate their holistic environmental performance and achieve higher levels of Green Mark award.

The enhanced performance criteria has indicators placed within the 4 main sections of Climatic Responsive Design, Building Energy Performance, Resource Stewardship and Smart and Healthy Building that we have identified as practices that are pioneering initiatives in sustainable design.

The remaining criteria within this section recognise projects that undertake sustainability with the view of market transformation, such as demonstrating cost neutrality. Other criteria recognise broader aspects of sustainability including socio economic indicators or global sustainability benchmarking that address issues outside of green building rating tools.

Projects who score points under this section should be proud of their achievements in demonstrating their advanced green efforts.

5.01 Enhanced Performance

Scope:

Points shall be awarded based on the advanced green efforts indicators that are highlighted within the Green Mark 2015 criteria.

Alternatively where projects can demonstrate substantial performance to a specific sustainability indicator or outcome addressed within Green Mark will be reviewed on a case by case basis. Points shall be awarded based on the relative environmental benefits and improvement as compared to other Green Mark indicators

Assessment

Criteria	Points
Enhanced Performance	Cap at 15

BCA will cap the points at 15 points for enhanced performance indicators per project.

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

Guidance Notes

For projects claiming for enhanced performance indicators that are not listed within the main criteria the following guidance notes should be taken into consideration.

At Design Stage

The proposed enhanced performance indicator shall be assessed on a case by case basis. The project team is to submit a concise summary that articulates:

- The nature of the environmental benefit of their intervention
- Justify the impact of the intervention through detailed calculations and comparisons with industry norms
- Substantiate the calculations and comparisons with evidence and data.

At Verification (As Built):

Details of the implemented intervention including measurements and monitoring of the environmental performance including lessons learnt if the intervention does not perform as expected.

5.02 Demonstrating Cost Effective Design

Scope:

Projects that can demonstrate that they have achieved high levels of environmental performance without an increased capital expenditure are of great interest to promote market transformation and encourage the mass market to drive towards higher levels of environmental sustainability

Assessment

Criteria	Points
Cost neutral design	2

The assessment is based upon a detailed quality surveyor's report of the building compared with a code compliant building.

From BCA's experience costs can be saved through the following interventions, do note the list is far from exhaustive:

- Reduced size of Air conditioning plant due to optimised system and climatic responsive / energy efficient designs that reduce the heat loads & need for Air-conditioned areas
- Structurally efficient projects
- Integrated design process that reduce the construction time and abortive works
- Climatic responsive façade designs that reduce the requirement for high performance glazing
- Alternative construction methods including pre manufacturing
- Use of mixed-mode ventilation strategies

Guidance Notes

At Design Stage

The project Quantity Surveyor to submit a cost report that demonstrates that the project as designed is cost neutral (zero green premium) when compared to the conventional building design that meets the minimum code and regulatory requirements.

At Verification (As Built):

Upon project completion, the QS is to submit an updated as built report.

5.03 Complementary Certifications

Scope:

Green Mark is an assessment tool that assesses the environmental sustainability of a building. However sustainability is more than the building level. Recognition is given for the use of an approved local or international rating tool that rates sustainability beyond the built environment

Assessment

Criteria	Points
Complementary Certification	1

1 point can be scored where the project demonstrates that it is certified through an approved complementary certification or rating tool that assesses the project beyond the environmental indicators within Green Mark for non-residential buildings.

Examples being:

Green Mark for Data Centres for data centres within the building

Green Mark for Office Interior for the building management office

Earth Check certified for the leisure or tourism industry. *Other industries may have similar sustainability certifications and BCA will continue to update its guidance on approved complementary certification or rating tools.*

Guidance Notes

At Design Stage

Extract of the tender specification of the projects intention to apply for an approved complementary certification, where possible the letter of application and details of intended rating should be included.

At Verification (As Built):

Details and evidence of the certification achieved.

5.04 Social Benefits

Scope:

Green Mark focuses on environmental sustainability. This criterion rewards projects that are able to demonstrate that their project contributes to social sustainability.

Assessment

Criteria	Points
Social benefits	2

2 points can be scored for projects that demonstrate their social benefits or how social sustainability has been incorporated into the project.

Depending on the project context, the project location globally or in Singapore the definition of social benefit shall be different and can include enhanced considerations to, staff, worker or occupant wellbeing including design for an active office (staff exercise / fitness programmes or active furnishings), integration of urban farming and community gardens or others.

Internationally social benefits can range from community welfare, promotion of local labour, improving workers conditions, reducing discrimination stimulating local economies, cultivating local craft.

For international projects the World Green Building Council Rating Tools Task Group have produced a socio economic indicator toolkit that can be referenced in for this criteria.

Guidance Notes

At Design Stage

A description of the initiatives or the project and how it contributes to social sustainability

At Verification (As Built):

A report on the whether the intended social benefits were realised and lessons learnt.