GM NDC: 2019

BCA-IMDA Green Mark for New Data Centres

To achieve GREEN MARK Award

Prerequisite Requirement
All relevant prerequisite requirements for the specific Green Mark Rating are to be complied with

Section 1 - Energy Efficiency

1.1 Power Usage Effectiveness (PUE)
1.2 Cooling System Efficiency
1.3 Electrical System Efficiency
1.4 Hot Aisle/ Cold Aisle Containment
1.5 Renewable Energy

Section 2 – Water Efficiency

2.1 Water Usage Effectiveness (WUE)
2.2 Reduction in Cooling Towers Water Consumption
2.3 Water Monitoring and Leak Detection
2.4 Alternative Water Sources
2.5 Water Efficient Fittings

Section 3 – Sustainable Construction & Management

3.1 Refrigerants and Fire Suppressants
3.2 Green Products and Materials
3.3 Sustainable Construction
3.4 Environmental Credentials of Project Team
3.5 Commissioning of Energy Systems
3.6 Data Centre Design and Energy Management
3.7 Waste Management

Section 4 – Smart and Healthy Building

4.1 Indoor Air Quality Performance
4.2 Lighting Quality and Management
4.3 Data Centre Infrastructure Management (DCIM)

Section 5 – Advanced Green Effort

5.1 Other Green Features & Innovations

BCA-IMDA Green Mark for New Data Centres NDC: 2019

GM Criteria		Point Allocations
Section 1 – ENERGY EFFICIENCY		
1.1	Power Usage Effectiveness (PUE)	25
1.2	Cooling System Efficiency	20
1.3	Electrical System Efficiency	6
1.4	Hot Aisle/ Cold Aisle Containment	2
1.5	Renewable Energy	4
	Score for Section 1 – Energy Efficiency	**57**
Section 2 – WATER EFFICIENCY		
2.1	Water Usage Effectiveness (WUE)	1
2.2	Reduction in Cooling Towers Water Consumption	3
2.3	Water Monitoring and Leak Detection	2
2.4	Alternative Water Sources	1
2.5	Water Efficient Fittings	1
	Score for Section 2 – Water Efficiency	**8**
Section 3 – SUSTAINABLE CONSTRUCTION & MANAGEMENT		
3.1	Refrigerants and Fire Suppressants	3
3.2	Green Products and Materials	4
3.3	Sustainable Construction	4
3.4	Environmental Credentials of Project Team	2
3.5	Commissioning of Energy Systems	6
3.6	Data Centre Design and Energy Management	4
3.7	Waste Management	2
	Score for Section 3 – Sustainable Construction & Management	**25**
Section 4 – SMART AND HEALTHY BUILDING		
4.1	Indoor Air Quality Performance	1.5
4.2	Lighting Quality and Management	1.5
4.3	Data Centre Infrastructure Management	7
	Score for Section 4 – Smart and Healthy Building	**10**
Section 5 – ADVANCED GREEN EFFORT		
5.1	Other Green Features & Innovations	10
	Score for Section 5 – Advanced Green Effort	**10**
	Total Green Mark Score available	**110**

Green Mark Award Rating and Prerequisite Requirements

Green Mark Rating	Green Mark Score
Green Mark Platinum	70 and above
Green Mark Gold^{PLUS}	60 to <70
Green Mark Gold	>50 to <60

Prerequisite Requirements for New Data Centre Criteria

P.1 POWER USAGE EFFECTIVENESS (PUE)

Green Mark Rating	PUE at 25% IT Load
Green Mark Gold	1.60
Green mark Gold^{PLUS}	1.55
Green Mark Platinum	1.50

Note:
1) PUE is a metric that illustrates data centre efficiency using the total annual facility energy divided by total annual IT equipment energy. The IT equipment energy shall be measured at PDU output [PUE category 2]. Please refer to SS 564 for PUE definition.

2) PUE performance of the data centres shall be determined using energy modelling software at the 25%, 50%, 75% and 100% of IT load.

P.2 MINIMUM COOLING SYSTEMS' EFFICIENCY (Water + Air)

(i) For Data Centres using Water Cooled Cooling System:

Green Mark Rating	Cooling Load (RT)	
	< 500	≥ 500
	Efficiency(1) (3) (kW/RT)	
Gold	0.92	0.85
Gold^{PLUS}	0.85	0.80
Platinum	0.78	0.75

(ii) For Data Centres using Air Cooled Cooling System:

Green Mark Rating	Cooling Load (RT)	
	< 500	≥ 500
	Efficiency(1) (3) (kW/RT)	
Gold	0.95	Not applicable(2)
Gold^{PLUS}	0.85	
Platinum	0.78	

Note:
1) Performance of the system shall be subject to measurement and verification.

2) In general, for data centres with cooling load of more than 500 RT, the use of air cooled cooling system is not applicable for Green Mark Certification. However, if the system

efficiency of the air-cooled cooling system is comparable with the stipulated efficiency of water-cooled cooling system, it will be assessed on a case-by-case basis.

3) The prescribed system efficiency shall be achieved at 25%, 50% and 75% of the design IT load.

4) For data centres with purchased cooling, the efficiency of the cooling system shall be provided for assessment and verification. If the efficiency of the cooling plant is not available, the default plant efficiency of 0.8 kW/RT shall be applied. *Please refer to GM NRB: 2015 Technical Guide 2.1 (c) on DCS baseline efficiency.*

P.3 PERMANENT MEASUREMENT & VERIFICATION (M&V) FOR COOLING SYSTEM OPERATING EFFICIENCY

Permanent measuring instruments for monitoring of cooling system operating efficiency shall be provided. The installed instrumentation shall have the capability to calculate the resultant operating system efficiency (i.e. kW/RT) within 5% of its true value and in accordance with SS 591: 2013 - Code of practice for long-term measurement of central chilled water system energy efficiency. Each measurement system shall include the sensor(s), any signal conditioning, the data acquisition system and wiring connecting these components.

- Location and installation of the measuring devices to meet the manufacturer's recommendation; location of measuring devices should be within reach to facilitate site maintenance and verification
- All data logging with capability to trend at 1-minute sampling time interval, and recorded to the 3rd decimal digit
- Computation and display of water-side and air-side efficiency
- Magnetic in-line flow meter, with 1% uncertainty and capable of electronic in-situ verification to within ±2% of its original factory calibration. If installation of magnetic in-line meters is not possible, ultrasonic flow meters may be used
- Temperature sensors are to be provided for chilled water and condenser water loop and shall have an end-to-end measurement uncertainty not exceeding ±0.05°C over the entire measurement range. Provisions shall be made for each temperature measurement location to have test plugs or additional thermo-wells located before and after each temperature sensor for verification of measurement accuracy. All thermo-wells are recommended to be installed in a manner that ensures the sensors can be in direct contact with the fluid flow. There shall be valid justification if direct immersion of the temperature sensor(s) is/are not possible. Such projects will be assessed on a case-by-case basis
- Dedicated power meters of accuracy Class 1 or better and metering current transformers, where applicable, of Class 1 or better, are to be provided for each of the following groups of equipment: chillers, chilled water pumps, condenser water pumps, cooling towers fans and air side equipment
- A heat balance substantiating test for the water-cooled chilled-water/chiller system is to be computed in accordance to SS 591 for verification of the accuracy of the M&V instrumentation. The heat balance shall be computed over the entire normal operating hours with more than 80% of the computed heat balance within ± 5% over a 1-week period

P.4 ENERGY METERING AND REAL-TIME REPORTING OF PUE

(i) All forms of energy related to PUE calculation shall be measured and trended over time; the data centre owners and/or operators shall verify that the energy related systems are performing according to design.

(ii) The data centre shall, at a minimum, be equipped with energy metering to provide total facility energy, total IT equipment energy at PDU output, in order to provide real-time display and data collection of PUE, and to compute the annual average PUE.

(iii) All sources of energy serving the data centre shall be measured, including but not limited to electricity, natural gas, steam and chilled water. Power meters of Class 1 or better shall be used to measure electricity.

P.5 DISPLAY GREEN MARK CREDENTIAL

To display the Green Mark Decal or Plaque at prominent location when the project is completed.

<table>
<tr><th>Section 1 - Energy Efficiency</th><th>Green Mark Points (57 Points)</th></tr>
<tr><td>1.1 Power Usage Effectiveness (PUE)

Use a computer simulation to assess the energy performance of the proposed data centre to achieve the most efficient design.

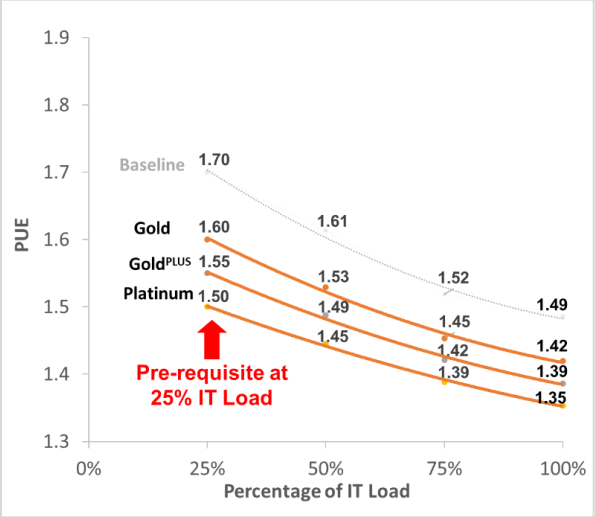
Compute PUE at various load points, 25%, 50%, 75% and 100% of the IT load under Singapore climatic conditions.

As data centres often operate at part load, the design of data centre and cooling systems should aim to achieve good efficiency at part load.

<table>
<tr><th></th><th>PUE at 25% IT load</th></tr>
<tr><td>Baseline</td><td>1.7</td></tr>
</table>

This PUE shall be verified in accordance to the requirement in Section 3.6 Commissioning of Energy Systems.

Refer to Annex A for Energy Modelling Guideline.</td><td>PUE Reference Curve

Up to 25 Points

<u>PUE Scoring Methodology:</u>

PUE at 25% IT load is used for base point calculation; However, if PUEs at 50% or 75% cannot meet the reference PUE curve of respective ratings, points will be deducted, i.e.

Base Point = 1.4 * (Percentage Improvement at 25% IT load from Baseline PUE)

Final Point = Point scored x [1- (20 x highest % deviation from the reference PUE curve at 50% or 75% IT load)]*

Note: The PUE Deviation Percentage shall be capped at 2%. For project with PUE<1.4, there are maximum another 3 points available in sec 5 (h)

Refer to Annex B for working examples.</td></tr>
<tr><td>1.2 Cooling System Efficiency

To encourage the use of high efficiency cooling system in equipment efficiency and system configuration to minimize the energy consumption.

The total cooling system efficiency (kW/RT) shall include both the water-side and air-side system.

(a) Water-cooled Cooling System

*Note 1): Water-Cooled Cooling system includes Water cooled package and any other system that consumes water for evaporative effect.</td><td>Up to 20 Points

System Efficiency is based on the <u>highest number (kW/RT) at 25%, 50% and 75% of the IT load</u></td></tr>
</table>

<table>
<tr>
<td>*Note 2): For data centres with purchased cooling, the efficiency of the cooling system shall be available for verification. If the efficiency of the chilled water plant is not available, the default plant efficiency is 0.8 kW/RT.

(b) Air-cooled Cooling System

*Note: Where there is a combination of different type of system, points scored will be pro-rated based on the weighted cooling consumption by the respective systems.</td>
<td>(a) Water-cooled Cooling System:
<table><tr><th></th><th colspan="2">Cooling load</th></tr><tr><td></td><td>< 500 RT</td><td>≥ 500 RT</td></tr><tr><td>Baseline (kW/RT)</td><td>0.97</td><td>0.90</td></tr></table>Point scored = 0.72 x (% improvement)

(b) Air-cooled Cooling System:
<table><tr><th></th><th colspan="2">Cooling load</th></tr><tr><td></td><td>< 500 RT</td><td>≥ 500 RT</td></tr><tr><td>Baseline (kW/RT)</td><td>1.05</td><td>0.98</td></tr></table>Point scored = 0.6 x (% improvement)

Refer to Annex C for working example.</td>
</tr>
<tr>
<td>1.3 Electrical System Efficiency

To achieve the most efficient electrical power supply system while providing the required level of redundancy.

(a) Distribution Transformer Efficiency

Data Centres should provide energy efficient transformers that surpass the minimum efficiency requirement for distribution transformers, Table 8 of SS530: 2014 - Code of practice for energy efficiency standards for building services and equipment.

(b) UPS Efficiency

Energy efficient Uninterruptible Power Supply (UPS) provides reliability while reducing energy consumption of data centres. UPS should have efficiency rating better than 95% at 25% of IT load.

(c) IT Power Chain Efficiency

The IT power chain efficiency should include the components such as transformers, transmission lines, switchgears, UPSs and PDUs serving the IT equipment.</td>
<td>1 point

1 point

2 points for achieving IT power chain efficiency of 85%
0.17 point for every percentage improvement in IT power chain efficiency better than 85%

Point scored = 0.17 x (% improvement)

(Up to 4 points for Sec 1.3 (c))</td>
</tr>
</table>

1.4 Hot Aisle / Cold Aisle Containment Implement effective and complete physical separation of the hot air (IT equipment outlet) from the cold air (IT equipment inlet) to eliminate hot and cold air mixing, thus reducing energy consumption, e.g. full aisle containment with blanking plates at empty IT cabinet spaces.	2 points
1.5 Renewable Energy **(a) Solar Energy Feasibility Study** To assess the data centre's potential and viability to harness and leverage on solar energy and photovoltaics solution(s) adoption. **(b) Solar Ready Roof** To encourage the adoption of photovoltaic, roof design should be ready for future photovoltaic installation, such as Structural, Electrical and Spatial readiness **(c) Adoption of Renewable Energy** To encourage on-site generation of renewable energy to reduce the building's energy consumption from the grid and carbon emissions.	0.5 point 0.5 point each 1 point for every 0.01% replacement of total energy (based on building energy consumption at 25% IT load) (Up to 2 points for Sec 1.5(c))

Section 2 - Water Efficiency	Green Mark Points (8 Points)
2.1 Water Usage Effectiveness (WUE) Provide permanent water meters to monitor and track the water consumption. To calculate the following: (a) WUE; ***and*** (b) m^3/RTh	1 point WUE (m^3/MWh/year) = $\frac{\text{Annual Water Consumption } (m^3)}{\text{Annual IT energy (MWh)}}$ m^3/RTh = $\frac{\text{Annual Cooling Tower Make up Water Consumption } (m^3)}{\text{Building's annual cooling consumption (RTh)}}$
2.2 Reduction in Water Consumption of Cooling Towers (a) Use of a cooling tower water treatment system which can achieve 7 or better cycles of concentration (COC) with acceptable water quality. (b) Use of alternate water for cooling tower make-up water such as rainwater, AHU condensate water, NEWater, etc…). (c) Provision of cooling tower water conductivity sensors for real-time COC trending and monitoring.	1 point 1 point 1 point
2.3 Water Monitoring and Leak Detection Provide private meters and water leak detection system for better control and monitoring of water consumption. (a) Private meters to measure the water consumption at the cooling tower make-up water tank. (b) Smart remote metering system with alert features for leak detection and monitoring purposes. (c) Display metered data, trending of water consumption and relevant parameters.	0.5 point 0.5 point 1 point

<table>
<tr><td></td><td></td></tr>
<tr><td>2.4 Alternative Water Sources

Utilize alternative water sources for non-potable uses, such as toilet flushing to reduce use of potable water.

*Note: Non-potable uses exclude cooling tower make-up water.</td><td><table>
<tr><th>Percentage (%) Reduction of Potable Water Consumption</th><th>Point</th></tr>
<tr><td><50%</td><td>0.5</td></tr>
<tr><td>≥50%</td><td>1</td></tr>
</table></td></tr>
<tr><td>2.5 Water Efficient Fittings

To encourage the use of efficient water fittings under PUB’s Water Efficient Labelling Scheme (WELS).

Use of minimum 2-tick MWELS water fittings and 3-tick MWELS fittings for basin taps.</td><td>1 point</td></tr>
</table>

<table>
<tr><th>Section 3 - Sustainable Construction & Management</th><th>Green Mark Points (25 Points)</th></tr>
<tr><td>

3.1 Refrigerants and Fire Suppressants

To encourage the responsible use of refrigerants/suppressants and to minimise the impact on the environment.

Points will be awarded based on the Ozone Depleting Potential (ODP) and Global Warming Potential (GWP) for the following:

(a) Refrigerant

(b) Fire Suppressant in server, UPS and Battery rooms

(c) Refrigerant Leak Detection System

An automated refrigerant leak detection system should be installed with detection points at critical areas in the plant room(s) housing the chillers and/or other equipment that contain refrigerants.

</td><td>

ODP and GWP of Refrigerant/ Fire Suppressant	Point(s)
ODP=0 **and** GWP<750	0.5
ODP=0 **and** GWP<10	1

Up to 1 point

Up to 1 point

1 point

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

3.2 Green Products and Materials

(a) Green Products

To encourage use of building services and mechanical and electrical (M&E) products certified by an approved local certification body.

Examples of green products include:
• Chillers
• Auto-tube cleansing system
• Pumps
• Transformers
• ICT equipment with Energy Star rating

(b) Green Materials

To encourage the use of building components/ products certified by an approved local certification body.

Points will be awarded based on the weightage and the extent of the coverage and impact (i.e. weightage * extent of coverage and impact).

</td><td>

Point per Green Product			
Good	**Very Good**	**Excellent**	**Leader**
0.25	0.5	0.75	1.0

(Up to 2 points)

Weightage Based on Extent of Environmental Friendliness of Material			
Good	**Very Good**	**Excellent**	**Leader**
0.25	0.5	0.75	1.0

Factor Based on Extent of Coverage and Impact of the Material	
High Impact	1
Low Impact	0.5

(Up to 2 points)
Note: High impact refers to ≥50% of usage; low impact refers to <50% usage of applicable areas

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

3.3 Sustainable Construction

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

(a) Conservation and Resource Recovery

- The existing structures are conserved and not demolished; ***or***
- The existing structures are demolished with an enhanced demolition protocol, where a recovery rate of > 35% crushed concrete waste from the demolished building is sent to approved recyclers with proper facilities.

1 point for either case

(b) Resource Efficient Building Design

- Concrete Usage Index (CUI)

Project CUI (m^3/m^2)	Point
>0.5 to ≤ 0.6	0.5
≤ 0.5	1

- Adoption of sustainable building systems

List of Sustainable Building Systems

- Pre-stressed Concrete Elements
- Hollow Core or Voided Concrete Elements
- Light Weight Concrete Elements
- High Strength Concrete Elements (Concrete grade >60MPa)
- Structural Steel Elements
- Composite Structural Elements
- Engineered Timber Elements
- Prefabricated Prefinished Volumetric Construction units
- Precast Concrete Elements
- Leave-in Formwork
- Others (to be accepted by BCA on case-by-case basis)

Total Concrete Area	Points
≥ 25% to < 50% of CFA	0.5
≥ 50% to <75% of CFA	1
≥ 75% of CFA	1.5

(c) Replacement of Coarse and Fine Aggregates

Recycled Concrete Aggregates (RCA) and Washed Copper Slag (WCS) from approved sources for the superstructure concrete mix. The usage should not fall below 1.5% x GFA for RCA and/ or 0.75% x GFA for WCS for points scoring.

Recycled Material	Point
Use of RCA	0.5
Use of WCS	0.5

(Up to 0.5 point for Sec 3.3(c))

***Note**: for 3.3b) and c), please refer to GM NRB: 2015 Technical Guide for the Worked Example*

3.4 Environmental Credentials of Project Team

To recognise green professionals who can effectively guide the project team towards sustainable design, construction and operation.

(a) Green Individuals: • Green Mark Accredited Professional [GMAP]or Green Mark Accredited Professional (Facilities Management) [GMAP(FM)]; • Green Mark Advanced Accredited Professional [GMAAP] or Green Mark Advanced Accredited Professional (Facilities Management) [GMAAP(FM)] **(b) Green and Gracious Builder:** • The main builder is a BCA Certified Green and Gracious Builder. **(c) Green Companies:** • Companies with ISO14001 certification: Architect, M&E Consultant, C&S Consultant, Developer and Main Builder • Singapore Green Building Council (SGBC) Certified Green Services Companies	0.25 point each 0.5 point each (Up to 0.5 point for Sec 3.4(a)) 0.25 point for Certified or Merit; or 0.5 point for Excellent or Star rating (Up to 0.5 point for Sec 3.4(b)) 0.25 point each 0.25 point each (Up to 1.5 points for Sec 3.4(c)) (**Up to 2 points for Sec 3.4**)
3.5 Commissioning of Energy Systems **(a)** Commissioning shall be carried out at multiple part loads (25%, 50%, 75% and 100% of IT load) and under normal utility operations, maintenance and failure conditions. The commissioning shall include verification of the PUE according to design. **(b)** Adoption of an Energy Performance Contract (EPC) from firms accredited by SGBC or equivalent to achieve measurable performance outcomes **i) Energy Performance Contract for design/construction:** • Centralised chilled-water system with guaranteed efficiency of 0.6 kW/RT or better • Air distribution system with guaranteed efficiency of 0.2 kW/RT or better **ii) Energy Performance Contract for maintenance with a minimum period of 3 years:** • Centralised chilled-water system with guaranteed efficiency of 0.6 kW/RT or better • Air distribution system with guaranteed efficiency of 0.2 kW/RT or better	2 points 1 point 1 point 1 point 1 point

3.6 Data Centre Design and Energy Management **(a) Data Centre Planning and Design** Promote scalable expansion by building up capacity in a modular approach to improve energy efficiency. **(b) SS 564 Certification** Management system committed to be in line with SS 564 - including intent, measures and implementation strategies to achieve energy target set over the next three years. **Or** Obtain SS 564 certification	1 point 1 point **Or** 3 points (**Up to 4 points for Sec 3.6**)
3.7 Waste Management **(a) Environmental Construction Management Plan** An effective and holistic management plan can facilitate better environmental performance of the construction process and promote waste minimisation. **(b) Recycling Facilities** Provide facilities or recycling bins for collection and storage of different recyclable waste such as: (i) IT related waste such as electronic equipment (ii) Other general waste such as plastic waste, paper waste or metal waste.	1 point 0.5 point 0.5 point

Section 4 – Smart and Healthy Building	Green Mark Points (10 Points)
4.1 Indoor Air Quality Performance To promote a healthy indoor environment for **occupied areas**: **(a) Demand Control Ventilation** Use of demand control ventilation strategies with dedicated outdoor system, such as provision of carbon dioxide (CO2) sensors or equivalent devices, to regulate the quantity of fresh air supplied to the building's occupied air-conditioned spaces (b) **In occupied areas (such as offices, meeting rooms, etc.)** Permanent provision of MERV14 or equivalent filters to all Dedicated Outdoor Air System (DOAS) units (e.g. pre-cooling AHUs) for effective removal of harmful pollutants from the building's ventilation system **(c) Indoor Air Quality (IAQ) Surveillance Audit** Committed to conduct an IAQ surveillance audit within one year after occupancy or after reasonable occupancy rate has been reached. The audit shall be conducted by an accredited laboratory under Singapore Accreditation Council with respect to the recommended IAQ parameters and acceptable limits stated in Table 1 of SS 554: 2016 – *Code of practice for Indoor air quality for air-conditioned buildings*.	0.5 point 0.5 point 0.5 point
4.2 Lighting Quality and Management To encourage good lighting quality and to improve occupant comfort in workplaces. (a) For occupied spaces such as offices, meeting rooms, etc… The lighting shall be designed to the recommended lux levels in SS 531: 2013- Code of practice for lighting of work places. Occupancy-based controls shall be provided for fluorescent luminaries or LED. Lighting should be designed to avoid flicker and stroboscopic effects with high frequency ballasts for fluorescent lamps (frequency >20 kHz) and LED (⩽ 30% flicker).	0.5 point

(b) For unoccupied spaces such as machine spaces/ server rooms: The lighting in machine spaces/server rooms shall be designed to the recommendations in SS 564 and adopt sensors for occupancy-based control or/and bi-level lighting. Applicable to 100% of the machine spaces/ server rooms.	1 point
4.3 Data Centre Infrastructure Management (DCIM) To encourage the provision of an energy portal and/or dashboard, which presents the building's energy use data in a relevant manner, to the following groups: (a) To display, monitor and track the following: (i) Total PUE of the data centre facility (ii) PUE of individual data hall (iii) The electricity consumption, operating load and efficiency of the electrical equipment/system, e.g. generator, UPS, DRUPS (iv) The electricity consumption for mechanical system, its operating load and efficiency, e.g. chilled water plant, PAU, CRAC/CRAH (v) Power chain loss (vi) The efficiency of the UPS should be available to the internal building facility management team, in the form of a digital display or web-based and mobile applications. (b) Power control of ICT equipment, power capping. (c) Software control technologies such as virtualization and optimizing algorithms or dynamic control of equipment to minimize energy utilisation. (d) Monitoring ICT or server equipment utilisation.	0.5 point each (Up to 3 points for Sec 4.3(a)) 1 point 2 points 1 point

Section 5 – Advanced Green Effort	Green Mark Points (10 Points)
Green Features and Innovations To encourage the use of innovative energy efficient equipment, system or design features. To qualify, the features must achieve significant, measurable improvement of energy performance in the following areas:	Each feature or innovation shall demonstrate the following: • The intent of the proposed innovation • The additional environmental benefits delivered • The proposed requirements for compliance • The proposed performance metrics (Up to 10 Points)
(a) Innovative cooling systems or features including free air-cooling, direct liquid cooling etc.	2 points
(b) Innovative power supply, back-up power or UPS systems, etc.	2 points
(c) Purchase green power generated locally from licenced retailers for a minimum contract period of 10 years (0.5 point for every 1% replacement).	Up to 10 points
(d) Computational Fluid Dynamics (CFD) Simulation to analyse and improve the air management inside data halls	2 points
(e) Building Information Modelling (BIM) based design, such as 4D, 5D and 6D	1 point each
(f) Thermal mapping of the racks to identify area of overcooling or undercooling	1 point
(g) Integration and Analytics Whole system optimisation using a network of HVAC equipment (e.g. drive the pumps minimally to satisfy "thirstiest" valve).	1 point
(h) Provision of Persistent Bio-cumulative and Toxic (PBT) free lamps $\geqslant$ 90% of the lamps in the facility.	0.5 point
(i) PUE < 1.4 at 25% of IT load, refer to Section 1.1 for PUE scoring formula	Up to 3 points

ANNEX A

Energy Modelling Guideline

The simulation shall be conducted in accordance with the Green Mark NRB: 2015 Technical Guide and Requirements - Annex C: Energy Modelling Methodology and Requirements, where applicable.

The energy performance of a **Data Centre Facility** shall take into consideration data centres' unique design such as N+1 or 2N design. Energy modelling shall be used to assess PUE and system efficiency in multiple loads, i.e. IT load at 25% 50%, 75% and 100%. A separate calculator or software shall be used to estimate the electrical losses in the power supply chain (transformers, switchgear, UPSs, PDUs and electrical cables.) under various load conditions - 25%, 50%, 75% and 100% IT load. These losses shall then be included as internal loads, dissipated as heat in the thermal zone.

The energy performance improvements may come from facility infrastructure design, selection of equipment, their capacities and part load characteristics and how they are operated. The designer may use the opportunity to determine the optimal operating configuration of equipment and systems in terms of energy performance but must commit to the selection in the submission. The system configurations must consider the redundant equipment and sequencing arrangements that enable the spare equipment capacity to be on "hot" standby, i.e. running together with base capacity. Separate zones and schedules shall be modelled based on spaces with different temperature, e.g. raise floor, data hall and ceiling return.

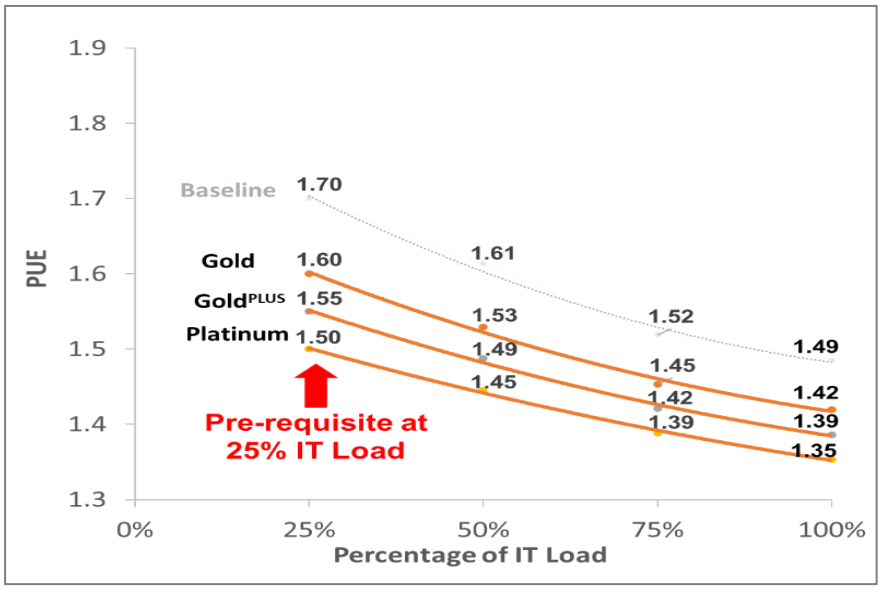
ANNEX B

PUE Point Scoring – Working Example

Used Case #1

Design PUE of Data Centre A

IT load	25%	50%	75%	100%
Design PUE	1.55	1.48	1.41	1.39



Target Green Mark rating is Gold^{PLUS}, hence the reference curve for Gold^{PLUS} shall apply.

Final Point = Base Point * (1 - (20 * PUE Deviation Percentage))

Where PUE Deviation Percentage refers to percentage deviation of the PUE at 50% and 75% IT load from the reference PUE curve, whichever is higher. The PUE Deviation Percentage shall be capped at 2%. If the PUE at 50% and 75% IT load are better than the PUE Reference for the specific Green Mark rating, then the PUE Deviation Percentage is zero.

Base Point (at 25% IT load) = $1.4 * \left(\frac{1.7 - 1.55}{1.7}\right) * 100 = 12.3$

As the PUE at 50% and 75% is better (and lower than) the PUE Reference for Gold^{PLUS}, the PUE Deviation Percentage is zero.

Final Point = 12.3

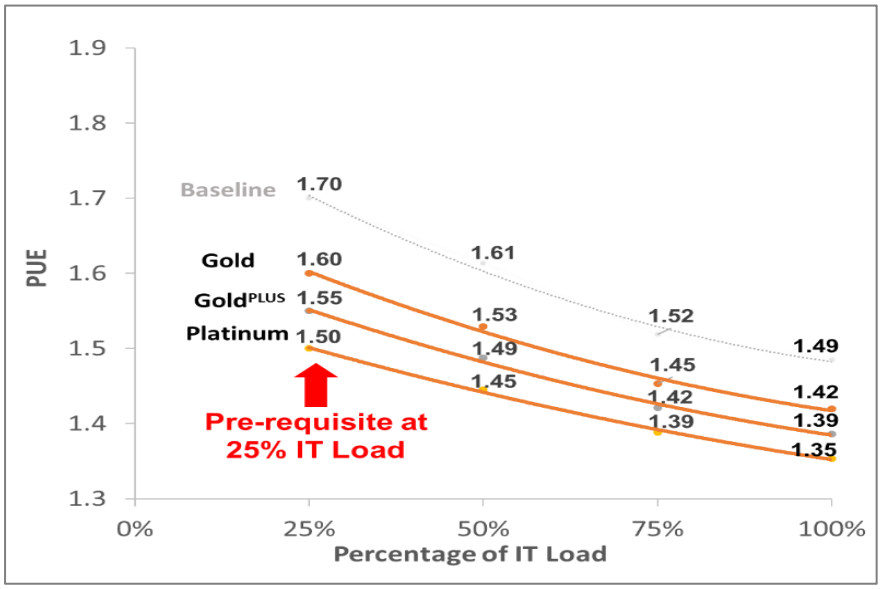
IT load	25%	50%	75%
Reference PUE curve	1.55 (Gold^{PLUS})	1.49	1.42
Data Centre A Design PUE	1.55	1.48	1.41

PUE Deviation Percentage	N.A
PUE Deviation Percentage to be applied (cap at 2%)	

Used Case #2

Design PUE of Data Centre B

IT load	25%	50%	75%	100%
Design PUE	1.47	1.46	1.41	1.32



Target Green Mark rating is Platinum, hence the reference curve for Platinum shall be applicable.

Final Point = Base Point * (1 - (20 * PUE Deviation Percentage))

Base Point (at 25% IT load) = $1.4 * \left(\frac{1.7 - 1.47}{1.7}\right) * 100 = 18.9$

Final Point = $18.9 \times (1 - (20 \text{ x } 1.44\%))$ **= 13.5**

Compare the percentage improvement of PUE at various load points at 50% and 75% IT load, reference to Platinum reference curve.

IT load	25%	50%	75%
Reference PUE curve	1.5 (Platinum)	1.45	1.39
Data Centre B Design PUE	1.47	1.46	1.41
PUE Deviation Percentage	N.A	$\frac{1.45 - 1.46}{1.45} \times 100$ $= -0.69\%$	$\frac{1.39 - 1.41}{1.39} \times 100$ $= -1.44\%$

PUE Deviation Percentage to be applied (cap at 2%)	**1.44%** (Higher deviation of 50% and 75% IT load)

ANNEX C

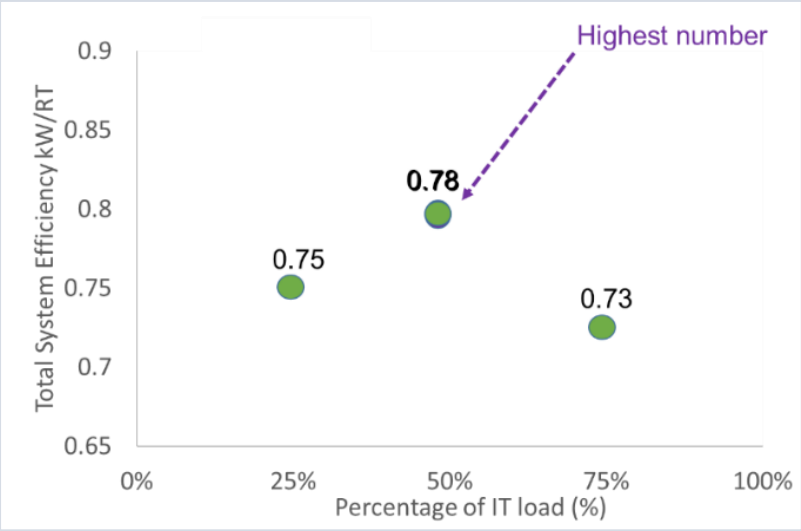
Cooling System Efficiency Point Scoring - Working Example

Used Case #1

Cooling Efficiencies of Data Centre A

IT load	25%	50%	75%	100%
Design cooling efficiency (Water + Air)	0.75	0.78	0.73	0.74

The cooling capacity at full IT load = 1,925 RT



In this example, the full design IT load is ≥500RT, thus the baseline efficiency shall be 0.9 kW/RT.

Compare efficiency of the cooling system at the various load points, 25%, 50% and 75% IT load. The highest efficiency value = **0.78 kW/RT at 50% IT load**.

Cooling System Efficiency Point = $0.72 \times (\frac{0.9-0.78}{0.9}) \times 100$ **= 9.6**