NANYANG TECHNOLOGICAL UNIVERSITY

Energy Research Institute @ NTU

BCA-IDA GREEN MARK

Green Mark Scheme for Data Centres

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Outline of Presentation

- Rating System for Green Data Centres in Singapore
- Green Mark Framework for Existing Data Centres
- Green Mark Framework for New Data Centres
- Key Concepts
- Energy-related Requirements
- Other Green Requirements
- Concluding Remarks

Rating of Green Data Centres

Scope

- Establish criteria that will capture the data centre **energy and environmental performance**
- Ensure the proposed rating system takes into account **local** data centre **operating environment** and **climatic conditions**
- Requirements should **encourage improvements** in energy efficiency of IT equipment, as well as data centre infrastructure and operations

- Collaborate with **Lawrence Berkeley National Laboratory** (LBNL). Developed data centre Environmental Performance Criteria (EPC) for the US Green Building Council and LEED.
- Work with **BCA** and **IDA** to model the DC rating system based on the **Green Mark** scheme.

Green Mark Scheme

To achieve GREEN MARK Award

<u>Pre-requisite Requirement</u>
All relevant pre-requisite requirements for the specific Green Mark Rating are to be complied with

Energy Related Requirements
Minimum 35 points

+

Other Green Requirements
Minimum 10 points

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

Framework for Existing Data Centre

Energy Related Requirements (88 points)
(Minimum 35 points to be scored)

Part 1 - Energy Efficiency
1-1 Overall Energy Efficiency
- Minimum Energy Performance
- Optimized Energy Performance (Full Load and Part Load)

1-2 Systems Energy Efficiency
- Cooling System
- Air Management System
- Electrical System
- IT Equipment

1-3 Energy/Environmental Policy and Management
1-4 Energy Monitoring and Assessment
- Energy Assessment and Energy Audit
- Building Management System
- Energy Metering and Reporting of PUE

1-5 Energy Efficient Features and Innovations

Other Green Requirements (37points)
(Minimum 10 points to be scores)

Part 2 - Water Efficiency
2-1 Water Use Efficiency
2-2 Alternative Water Sources
2-3 Cooling Towers Water Use

Part 3 – Sustainable Operation & Management
3.1 Refrigerants and Fire Suppressants
3.2 Sustainability Policy
- Sustainable Purchasing and Operation
- Waste Management

Part 4 - Indoor Environmental Quality
4-1 Indoor Air Quality and Ventilation
4-2 Lighting Quality and Management
4-3 Thermal Comfort and Noise Level

Part 5 – Other Green Features and Innovations

Framework for New Data Centre

Energy Related Requirements (83 points)
(Minimum 35 points to be scored)

Part 1 - Energy Efficiency
1-1 Overall Energy Efficiency
- Maximum Design PUE
- PUE Improvements over Reference Model (Full Load and Part Load)

1-2 Systems Energy Efficiency
- Cooling System (based on specified equipment)
- Electrical System (by design)
- IT Equipment (by design)

1-3 Energy Efficiency and Performance Verification
- Commissioning of Energy Systems
- Measurement and Verification Plan
- Energy Metering and Reporting of PUE

1-4 Data Centre Design & Energy Management
- Data Centre Planning and Design
- Data Centre Operations and Energy Mgmt

1-5 Energy Efficient Features and Innovations

Other Green Requirements (42 points)
(Minimum 10 points to be scores)

Part 2 - Water Efficiency
2-1 Water Use Efficiency
2-2 Alternative Water Sources
2-3 Cooling Towers Water Use

Part 3 – Sustainable Operation & Management
3.1 Refrigerants and Fire Suppressants
3.2 Sustainable Construction
3.3 Sustainability Policy
- Sustainable Purchasing
- Waste Management

Part 4 - Indoor Environmental Quality
4-1 Indoor Air Quality Performance
4-2 Lighting Quality and Management
4-3 Thermal Comfort and Noise Level

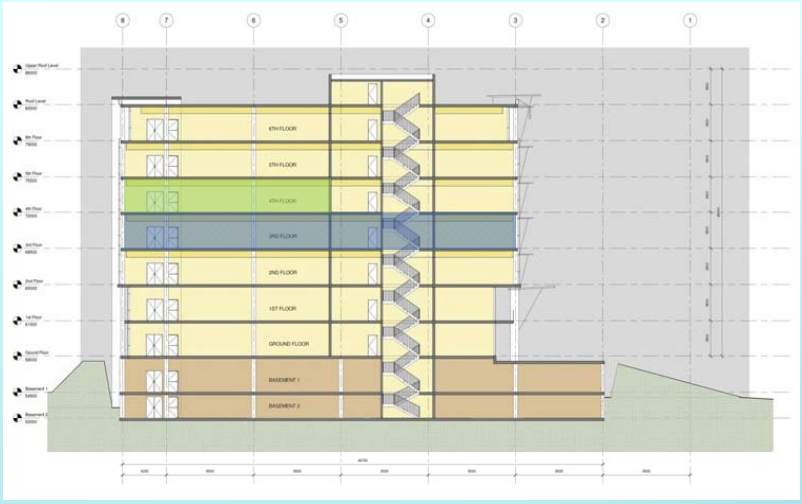
Part 5 – Other Green Features and Innovations

Key Concepts (I)

- **Boundary** of the Data Centre in assessment
- **Internal elements dominate**. External influences, such as building facade, orientation, greenery, etc do not significantly change its energy performance.

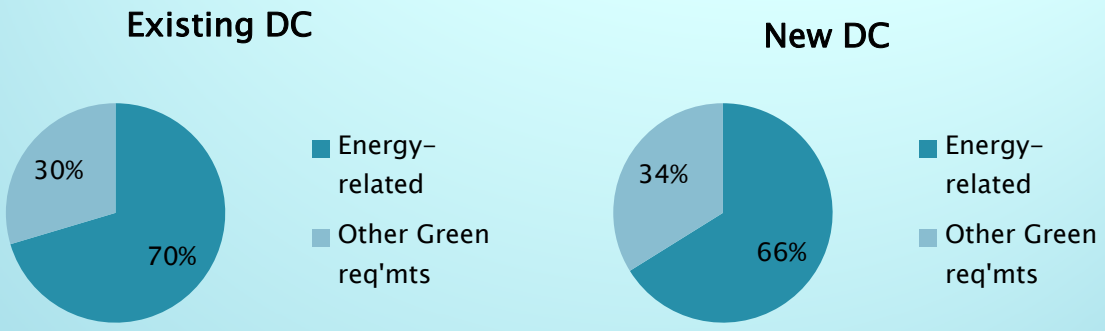
A DC can be
- part of a floor
- a whole floor or
- an entire building

DC can be treated similarly based on elements w**ithin the control of the data centre management**.



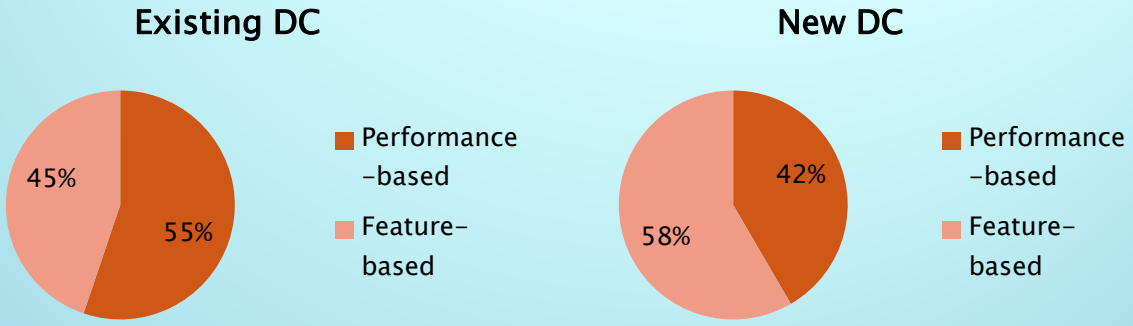
Key Concepts (II)

- **Energy** affect **DC** performance, the majority of the credits allocated to energy-related requirement.
- **Other green requirements** are focused on DC operational policies such as **water** use in cooling systems, **sustainable** operation and maintaining proper IEQ for occupants.



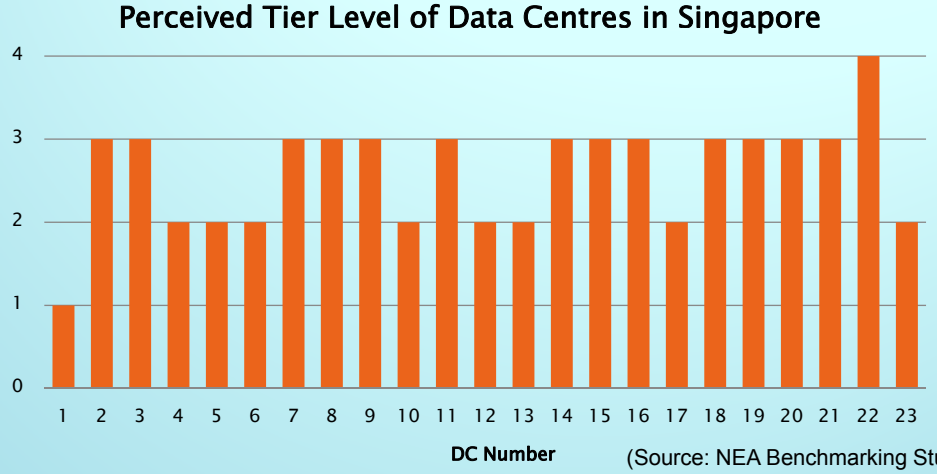
Key Concepts (III)

- To drive continual improvements in the facility's assets, a large proportion of the criteria, especially the energy-related ones, will be **performance-based**.
- **Existing DCs - monitored data** trended over at least a **2-week period** to obtain an accurate picture of the DC operation.
- **New DCs - energy model performance** compared with a reference model to determine the percentage energy improvement.



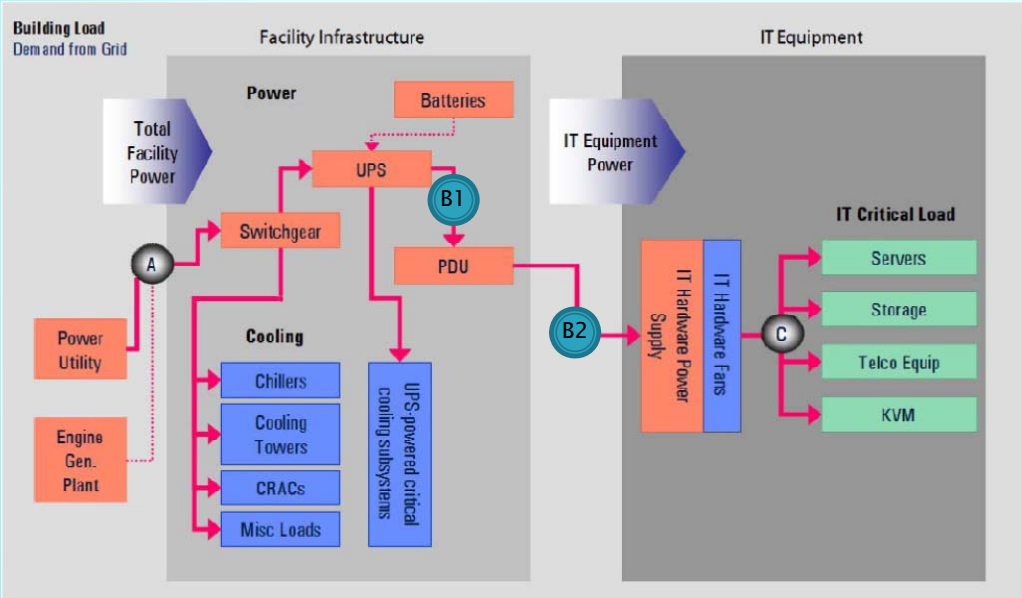
Key Concepts (IV)

- **Tier Levels -** a measure of a data centre's resiliency in coping with interruptions. Higher Tier levels can negatively affect energy efficiency. Data centres in Singapore are mostly at Tier 3.
- Redundancy provisions for Green Mark are pitched at 2N for UPS and N+1 for Cooling. Additional redundancy is considered a business decision.



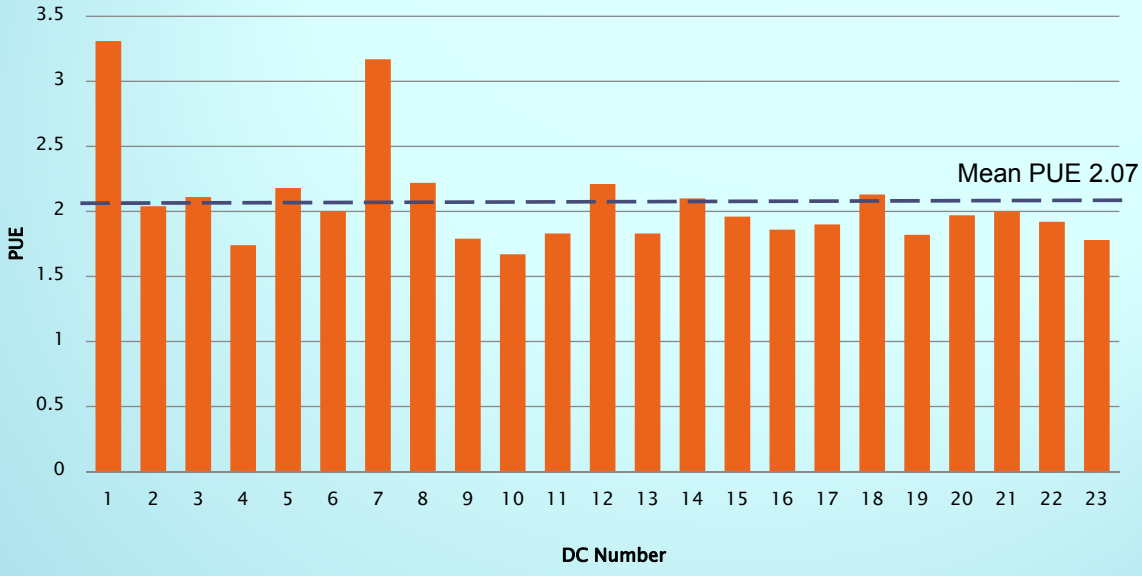
(Source: NEA Benchmarking Study)

Energy-related Requirements (I)
– PUE-1 Overall Efficiency Metric



Power Usage Effectiveness $PUE-1=\frac{A}{B1}$; $PUE-2=\frac{A}{B2}$

PUE of Data Centres in Singapore

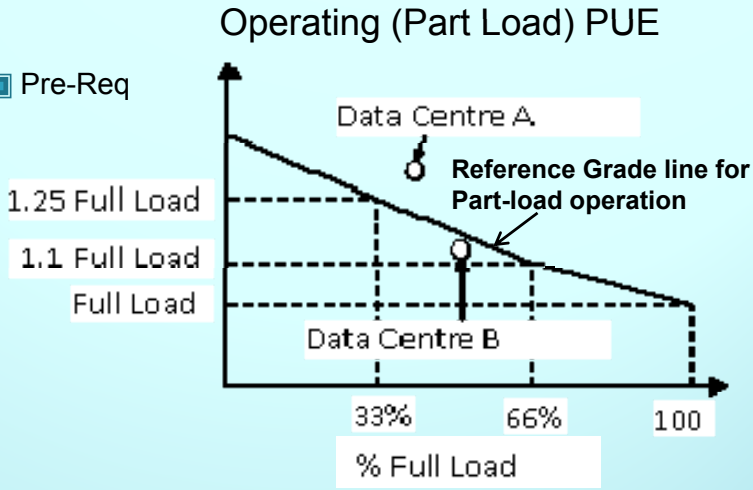


(Source: NEA Benchmarking Study)

For Existing Data Centres – Importance of Operation under Part Load

Design PUE	Points
2.2	10
2.1	12
2.0	14
1.9	16
1.8	18
1.7	21
1.6	24
1.5 and below	27

Pre-Req

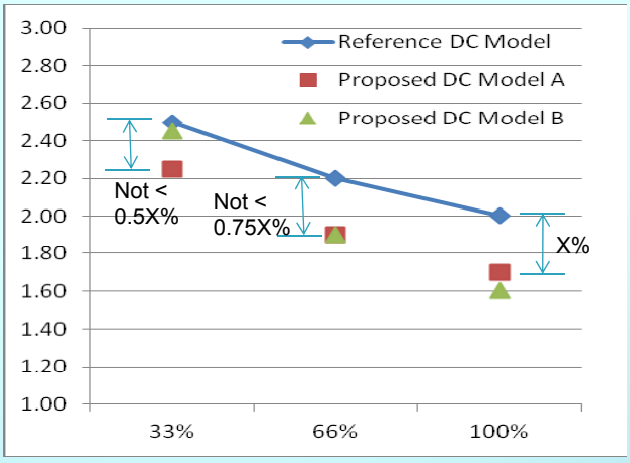


- Max PUE = 2.2 (to be certified)
- Higher credits for PUE of 1.8 and below

- Accounts for Part Load operation
- DC-A has poor part load performance (will get 75% of full-load points)

For New Data Centres – PUE Improvements over Reference Model

Design Full Load PUE	Energy Savings over Ref Model %	Points
2.0	0%	10
1.9	5%	12
1.8	10%	14
1.7	15%	16
1.6	20%	19
1.5	25%	22
1.4 and below	30% and above	25



- Max PUE = 2.0 (to be certified)
- Higher credits for PUE of 1.7 and below

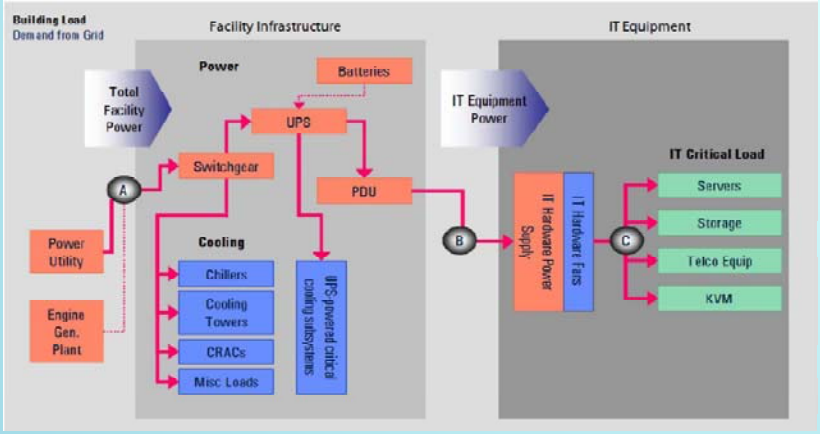
- Accounts for Part Load design
- DC-B has poor part load design (will get 75% of full-load points)

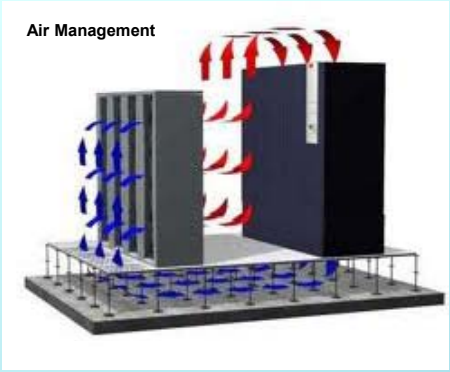
Energy Model for New Data Centres

- Approved energy assessment software - Typical **building energy simulation program with** the following **enhancements**:
  - The program must be able to accept a **high proportion of internal loads** from electrical equipment
  - **Losses in the power supply chain** (transformers, UPSs, PDUs and switchgear) under various load conditions shall be included as additional internal loads at the locations where these equipment are located.
  - The system configurations must be able to **accept redundant equipment** and sequencing arrangements that enable the spare equipment capacity to be **on "hot" standby**.
- Improvements in energy performance over the reference model will come primarily from facility infrastructure design, selection of equipment, their capacities and part-load characteristics and how they are operated. Savings related to the IT load energy use will not be assessed in the model.

Energy-related Requirements (II) – Use of System Level Efficiencies

- **Component Systems Efficiencies**:
  - IT Equipment
  - Electrical (Power) System (incl. Transformers, UPS, PDU)
  - Cooling System (incl. Chillers, Pumps, Cooling Towers/HRUs)
  - Air Management System (incl. CRAHs, Fans, Flow Management)





IT System Efficiency

Aim: Efficient ICT systems which manage the power demand, such as

a) Using **Energy-rated** IT equipment (where available)

b) Enabling on-board **compute/ storage power management/ control features** technologies

c) Use of **application software control** technologies (including optimising algorithms and virtualisation)

d) Monitoring of **IT Equipment Utilisation**

Applied only to data centres which have control over their IT equipment operation (especially Enterprise DCs). Not performance-based at this time but **based on organisational policies** and records on actual use of appropriate technologies

Electrical (Power) System Efficiency

Aim: Efficient power distribution while maintaining reliability and high load factors

a) Building Transformers

Transformation efficiency ≥ 98%.

b) IT Power Chain Efficiency

(based on industry norms)

UPS Load Factor	Minimum IT Power Chain Efficiency
25%	73%
33%	78%
50%	83%
66%	85%
75%	86%
100%	88%

UPS Load Factor

$$= \frac{\text{Total UPS Output}}{\text{Total Installed UPS Capacity}}$$

IT Power Chain Efficiency

$$= \frac{\text{Sum of PDU Output}}{\text{Total UPS Input}}$$

Cooling System Efficiency

Minimum Water-cooled Plant Performance for Existing DCs

Green Mark Rating	Peak Data Centre Cooling Load	
	< 500 RT	≥ 500 RT
	Efficiency (kW/RT)	
Certified	0.95	0.85
Gold	0.90	0.80
Gold^{Plus}	0.85	0.78
Platinum	0.80	0.75

Minimum Water-cooled Plant Performance for New DCs

Green Mark Rating	Peak Data Centre Cooling Load	
	< 500 RT	≥ 500 RT
	Efficiency (kW/RT)	
Certified	0.90	0.80
Gold	0.90	0.80
Gold^{Plus}	0.80	0.75
Platinum	0.80	0.75

* Similar criteria available for Air-cooled Plant

- Cooling Plant efficiency requirements are based on the same criteria as Green Mark for Buildings, but adjusted to account for N+1 configuration.
- For existing DCs, the plant performance should be from actual measurements averaged over a 2-week period to take account of any sequencing arrangements for the standby equipment.
- For new DCs, the plant performance should simulated based on the proposed system operating configuration (e.g. N+1, 2N, etc) including the running of spare equipment on hot standby.

Effect of N+1 Cooling Infrastructure

- "Hot standby" may be needed to address response time of equipment during interruptions
- Some allowance is made to maintain an additional chiller and auxiliary equipment running as compared to a conventional building cooling system
- But need to discourage the common practice of "over-provisioning"

Building	
Cooling	820 RT
Chiller	1 x 1000RT
% Load	82%
Chiller Eff	0.50 kW/RT
Pumps/CT Eff	0.22kW/RT
System Eff	0.72 kW/RT

Data Centre	
Cooling	820 RT
Chillers (N+1)	2 x 500RT + 1 x 500RT
% Load	55%
Chiller Eff	0.56 kW/RT
Pumps/CT Eff	0.26 kW/RT
System Eff	0.82 kW/RT

Air Management System

Aim: Matching cooling delivered to the demands of the server hall

a) **CRAU Air Flow Efficiency**
Baseline: 0.25 W/CMH. Additional points for improvement over baseline.

b) **Good Air Management Design**
Low bypass and recirculation.
Return Temperature Index (**RTI**) **≥ 70%**

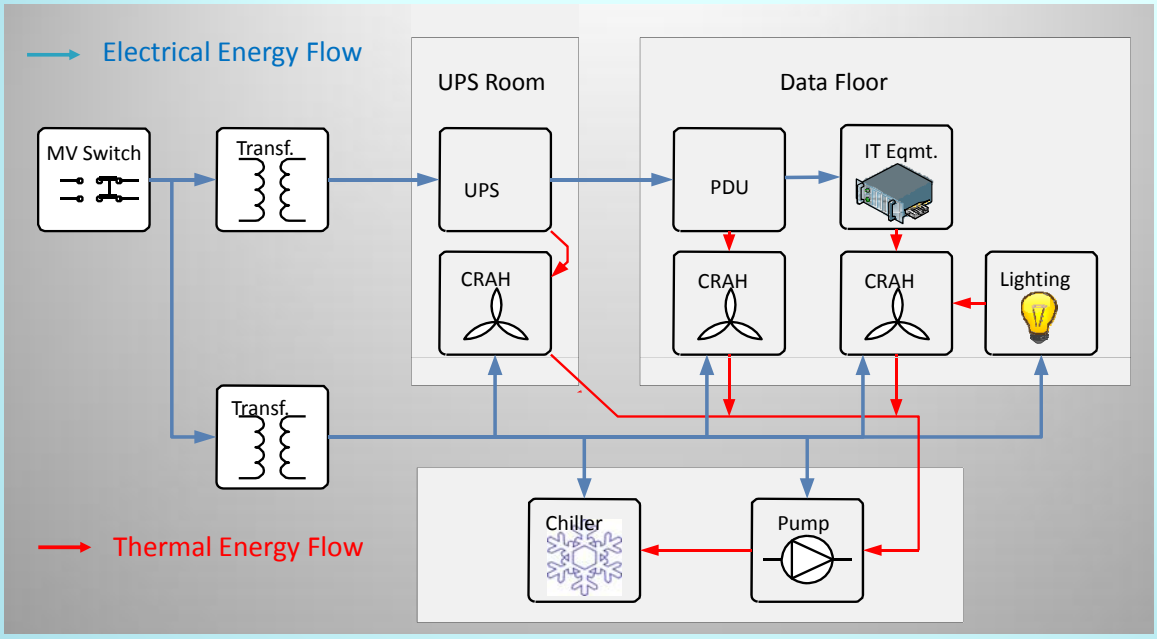
From SS564:
$$RTI = \frac{\Delta T_{CRAC}}{\Delta T_{rack}}$$

c) **Higher Ambient Temperature**
Operate at upper end of ASHRAE 2011 Thermal Guidelines. **Mean rack inlet temperature of 24°C** and above.

d) **Minimise Humidity Control**
Operate within ASHRAE 2011 Guidelines without need for humidity control. **Dew point of 12°C** and above.

For Existing DC only

Energy Interaction between Systems



- **Energy balance analysis** (not required currently) can reveal
  - sources of "waste" or "inefficiency"
  - how changes can affect the overall system performance

Energy-related Requirements (III)
– Energy Management for Existing DCs

Aim: To promote a year round emphasis on Energy Performance.

This criteria includes incentives for:

- Energy management system (**EnMS**) and **SS564** certification
- Systematic process of **energy assessment and auditing**
- **Computer-based** data centre **management system**
- **Continuous monitoring** and reporting **of PUE**
- **Energy metering** of the IT equipment, power supply and cooling plant.



Energy-related Requirements (III)
– DC Design and Commissioning for New DCs

Aim: To promote good design and installation practices.

This criteria includes incentives for:

- Design that achieve a good **balance between** energy **efficiency and resilience** in operation
- **Modular design** for scalable expansion
- Management commitment towards **energy management**
- **Performance verification** of design by commissioning of energy systems, including at multiple load points (33%, 66%, 100%)
- Putting in place a measurement and verification (**M&V**) **plan**
- **Energy metering** of IT equipment, power supply and cooling plant, including **continuous monitoring of PUE**.

Energy-related Requirements (IV)
– Energy Efficient Features and Innovations

Aim: Data Centres by nature "risk-adverse" with respect to its infrastructure and facilities. This criteria is to promote **adoption of innovative solutions**, including:

- Innovative **cooling systems** or features (e.g. use of free air-cooling, direct liquid cooling, immersion cooling, etc)
- Innovative **power supply**, back-up power or UPS systems
- **IT** system **optimisation** strategies (e.g. virtualisation, server consolidation, etc)
- Radical changes in **data centre design**, operations or systems
- Use of **renewable energy**

Features and solutions must be significant and have measurable improvement in energy performance not covered by earlier criteria

Other Green Requirements (I)
– Water Efficiency

Aim: Water is a precious resource for Singapore. Use should be minimised where possible, but not at the expense of energy use.

Water Use Efficiency.

- Water metering and water leak detection.
- Use of certified water efficient fittings.
- Water use improvement plans (for existing DCs only)

Alternative water sources

- Use of non-potable water e.g. NEWater, rainwater and condensate harvesting
- Based on % reduction in potable water usage of the applicable use.

Cooling Tower Make-up Water Use (for water-cooled systems only).

- For existing DCs: 7 cycles of conc. or better. Test certificate required.
- For new DCs: % savings over a baseline.

Other Green Requirements (II)
– Sustainable Operations and Management

Aims: Reduce global warming and damage to ozone layer;
Waste minimisation

Refrigerants and Fire Suppressants

- Refrigerants/Fire Suppressants with zero ODP and low GWP (< 100)
- Refrigerant leak detection
- Allowance for UPS and battery rooms

Sustainability Policy

- Establish policy for sustainable procurement and purchasing and use of environmental-friendly products
- Establish policy for promotion of waste management and recycling.

Other Green Requirements (II)
– Sustainable Construction for New DCs

- This criteria is applicable for **stand-alone data centres** only
- Based on Green Mark for New Buildings but with reduced points
  (a) Use of **sustainable and recycled materials**.
  (b) Concrete usage index (**CUI**)

Other Green Requirements (III)
– Indoor Environment Quality (IEQ)

Aim: To achieve basic levels of IEQ in occupied spaces for occupant comfort and productivity.

a) Healthy Indoor Environment

- Air quality monitoring in occupied space.
- Treated ventilation air on demand in server rooms
- Provide MV and not air-conditioning in chiller plant rooms.

b) Good workplace lighting quality

- Lighting level in occupied space to comply with SS531. User controllable fluorescent lamps with electronic ballasts or LED lamps.
- In machine spaces/server rooms provide lighting complying to SS564. Use occupancy sensors, bi-level lighting, task lighting.

c) Thermal and noise comfort in occupied space

- Thermal comfort must comply with SS 553.
- Room noise level must comply with SS 553.

Other Green Requirements (IV)
– Green Features and Innovations

Aim: To promote adoption of green practices not covered in earlier criteria.

Green Features that achieve significant, measurable environmental performance in the DC operations, maintenance or management. They must be able to demonstrate the following:

- intent of the innovation
- additional environmental benefits delivered
- requirements for compliance
- performance metrics to show compliance and the approaches (strategies) used to meet the requirements

Concluding Remarks

The Green Mark Scheme for Existing and New Data Centres have been developed, based on the following key concepts:

- Focus is on **internal elements** (equipment and operations) under the control of DC management.
- High weightage on **energy performance**.
- **Energy performance** of **overall facility** complemented by individual **sub-systems**. **Full-load** and **part-load** operation considered.
- Takes account of need for **redundant facilities** for system resilience.
- **Modular designs** which **balance resiliency with efficiency**.
- **Continuous energy monitoring** and performance evaluation.
- **Other green requirements** focused on **operational policies** rather than developmental aspects of the data centre. Includes **water efficiency, sustainable operations** and basic **IEQ** requirements.
- Support **adoption of innovative solutions** and features.

Concluding Remarks

Basic Premise:

Data Centres can achieve

Reliability and **Resilience**

without compromising on

Energy Efficiency

Thank You