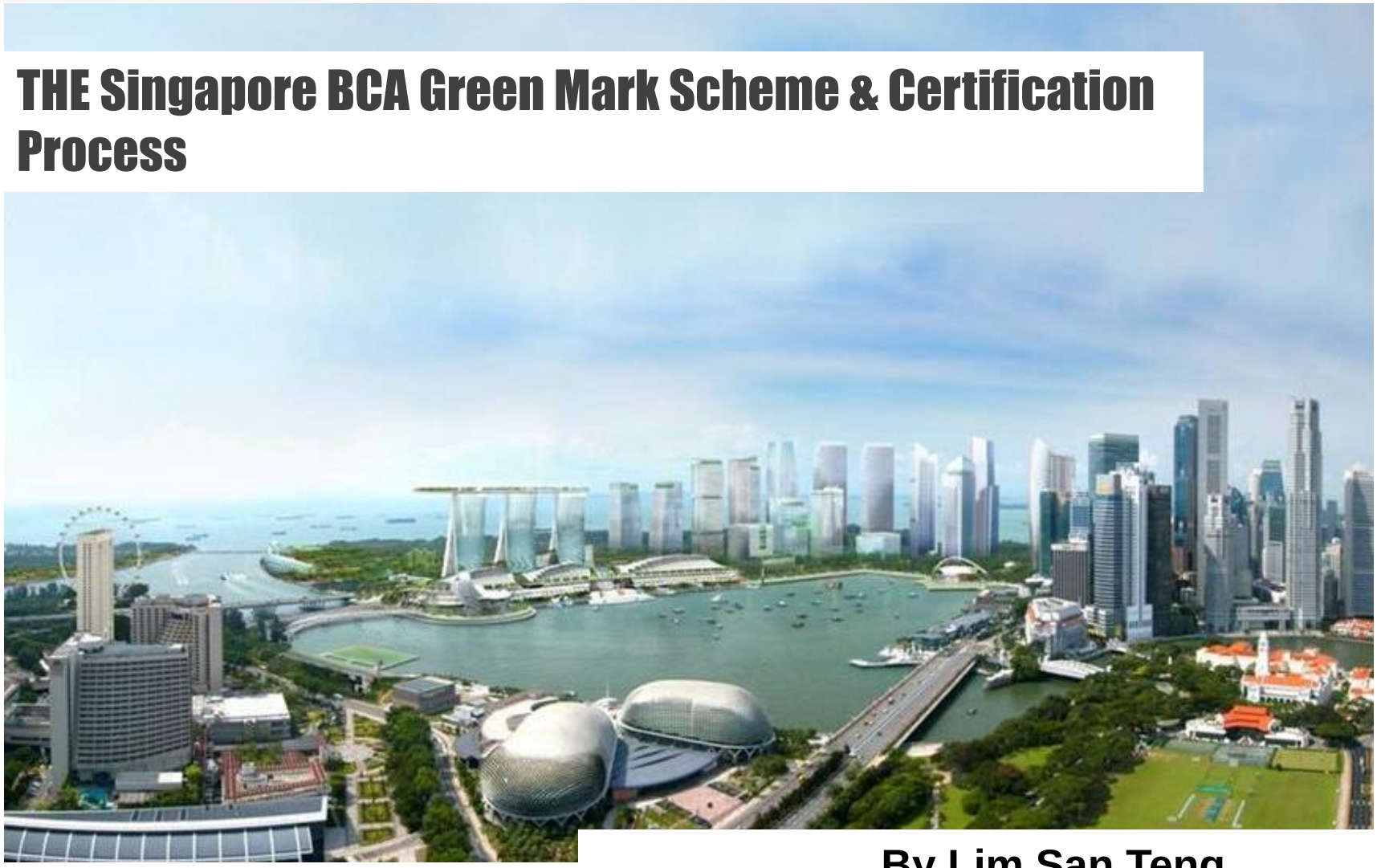

POWER AND COOLING CONSULTANTS MASTER CLASS 2016
HITTING THE GREEN MARK:
BEST PRACTICES IN DATA CENTER OPTIMIZATION
EMERSON
Network Power

THE Singapore BCA Green Mark Scheme & Certification Process





By Lim San Teng
Senior Consultants, BCA International
Executive Manager, GB Policy Department

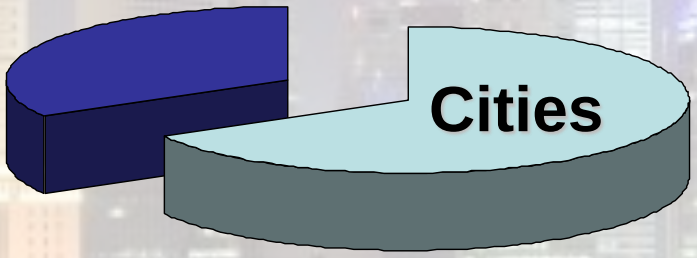
05 April 2016

Presentation Outline

- Global Challenge
- Singapore BCA Green Mark Scheme
- BCA-IDA Green Mark Scheme for New DC / Existing DC
- Application & Assessment Process
- Best Practices for EE in DC

Global Challenges

Global Energy Use



2/3 of global energy use consumed by cities

Also, cities emit 76% of world's energy-related CO2

www.thestarchallenge.com

We have a role to play…

- **Use of Resources:**

40% energy
30% mineral resources
20% water

- **Emissions/Pollution:**

40% CO2
30% solid wastes
20% water

20% during construction
80% during operation and use



Sources: UNEP Buildings, Resource Efficiency & Climate Change: The UNEP SBCI Platform (2009)

Singapore BCA Green Mark Scheme

Green Mark

- **Certification** scheme
  - ✓ Emphasis on **Energy Efficiency**
  - ✓ Tailored **to tropical climate: heat gain and cooling of spaces**
  - ✓ High standards of **measurement and verification**

- Energy and water efficient
- High quality and healthy indoor environment
- Integrated with green spaces
- Constructed from eco-friendly materials





Long Term Planning for Environment Sustainability

Singapore's Sustainability Blueprint & Green Building Masterplan



- ***New Buildings***
- ***Existing Buildings***
- ***Building Occupants & Tenants***

A sustainable & liveable city





80%

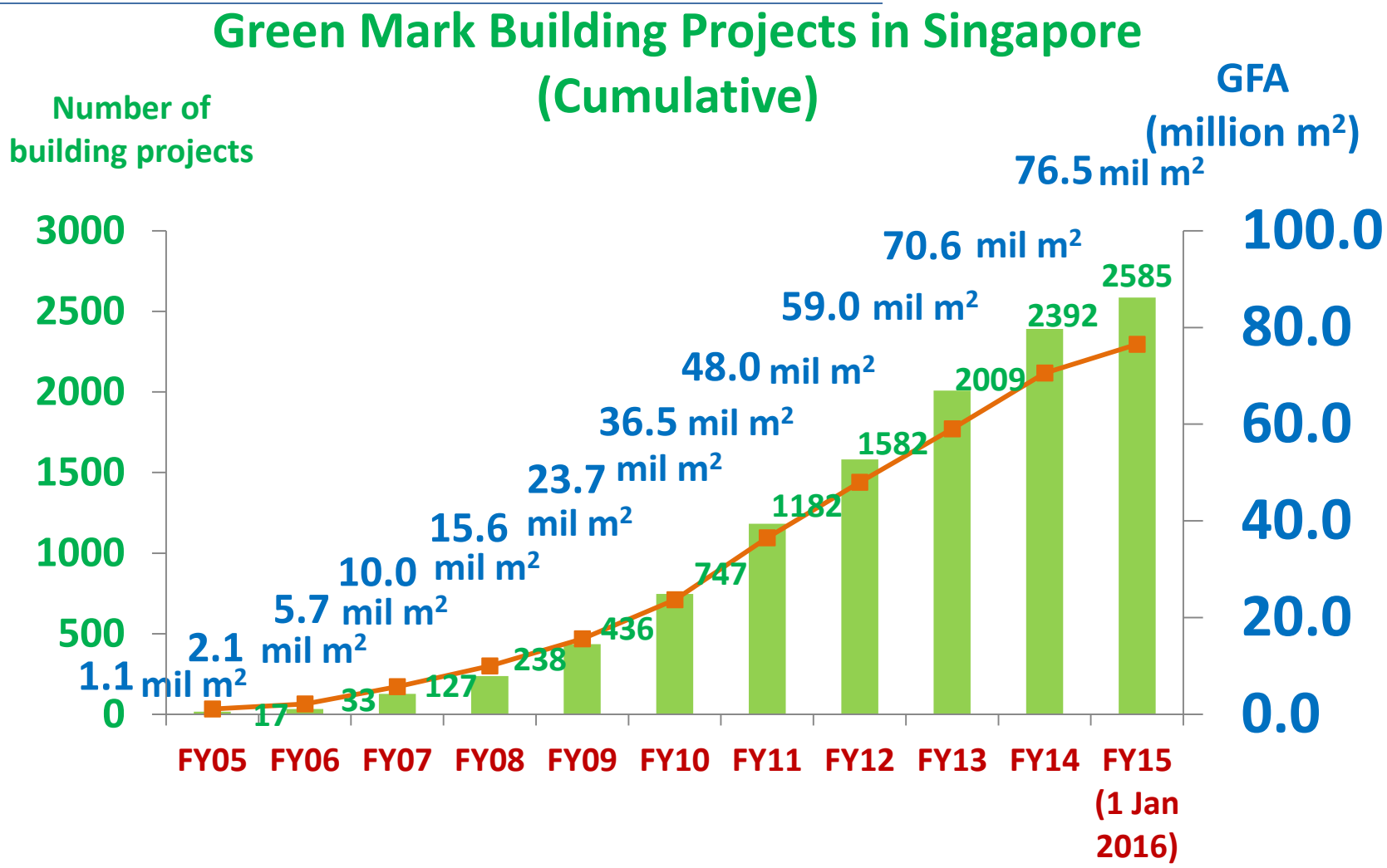
of buildings Green Mark certified by 2030







Green Mark Buildings in Singapore



Singapore as Green Building Hub for Our Region

Strong demand of GM overseas



China
Myanmar
Vietnam
India
Laos
Philippines
Thailand
Cambodia
Sri Lanka
Malaysia
Brunei
Indonesia
Tanzania
Australia

292 Applications
80 cities
14 countries

Green Mark Assessment Schemes

BCA GREEN MARK SCHEMES FOR NEW BUILDINGS

- BCA Green Mark for Non-Residential Buildings (Version 4.1) / Green Mark 2015 (pilot)
- BCA Green Mark for Residential Buildings (Version 4.1)
- BCA Green Mark for Landed Houses
- BCA Green Mark for Healthcare Facilities
- BCA Green Mark for Laboratories (under Development)

BCA GREEN MARK SCHEMES FOR EXISTING BUILDINGS

- BCA Green Mark for Non-Residential Buildings (Version 3)
- BCA Green Mark for Residential Buildings
- BCA Green Mark for Existing Schools

BCA GREEN MARK SCHEMES FOR BEYOND BUILDINGS

- BCA-NParks Green Mark for Existing Parks
- BCA-NParks Green Mark for New Parks
- BCA Green Mark for Infrastructure
- BCA Green Mark for Districts (Version 2)
- BCA-LTA Green Mark for Rapid Transit System
- BCA Green Mark for Roads (under development)

BCA GREEN MARK SCHEMES FOR WITHIN BUILDINGS

- BCA Green Mark for Office Interiors
- BCA Green Mark for Restaurants
- BCA Green Mark for Retail
- BCA Green Mark for Supermarkets
- BCA-IDA Green Mark for Data Centres

17 GM SCHEMES

Building and Construction Authority

User-Centric BCA Green Mark Schemes



Green Mark for Retail (2012)



Green Mark for Office Interiors (2009)

Green Mark for Restaurants (2011)



Green Mark for Supermarkets (2012)



Green Mark for Data Centre - Existing (2012) - New (2013)





- Energy Efficiency
- Water Efficiency
- Environmental Protection
- Indoor Environmental Quality

BCA GREEN MARK

Data Centre Energy Use and Concerns

Energy Use

- IT Industry – 2% of global carbon emission
- Energy – 12% of DC Expenditure (Gartner)
- 100 – 200 times standard office building (US DOE)

Historical Concerns

- Availability
- Performance
- Security
- Resilience
- Reliability

Why Green Mark Data Centre?

BCA-IDA GREEN MARK

- In 2012 Survey by IDA –
  - 50 colocators; Estimated value ~ USD 1.75 billion
  - consume 2952 GWh per year ~ 6.9% of electricity consumption in Singapore in 2012.
- 10 largest data centres consume the equivalent of 130,000 households
- Electricity cost ~ 50% of data centre operating cost - due to high cooling demands and high cost of electricity.

The DC's Current Challenges

- Higher and higher power (IT) requirement
- High heat load densities
- Rapidly changing technology
- Exponential increase in storage demand
- Security, Risk management and Flexibility

About the Green Mark for Data Centre Scheme

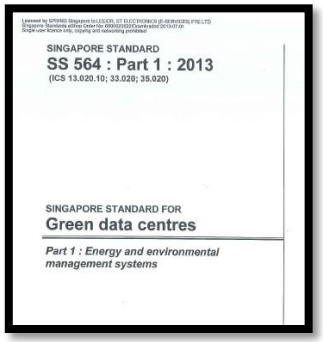
Objectives

- Promote environmental awareness, energy efficient design, technologies and system in the early stage of planning and design
- Promote design and site consideration
- Provide recognition to developers' and consultants' effort
- Identify and share best practices

Benefits

- Reduce environmental impact of DC development
- Help individual DCs to leverage on sustainable platform, leading to sustainable built, use and operate environment
- Create green awareness among the community
- Reduce energy use and improve operating cost
- Improve business sustainability and market-competiveness

BCA-IDA Green Mark for Data Centre scheme

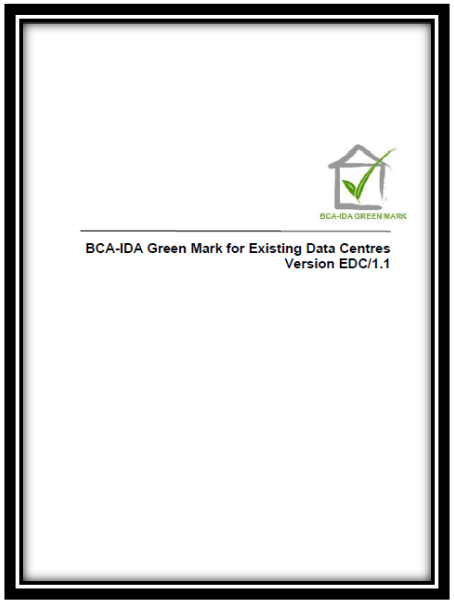


Singapore

- SS564 address "*How to go green*", it serves as a guide for designing green DC.
- BCA-IDA Green Mark scheme for DC (New or Existing) addresses "*How green the DC is*", it serves to rate (how green) the DC's environmental sustainability, looking at the tangible – e.g. energy use and intangible benefits (e.g. IEQ, etc.) of going green.

BCA-IDA Green Mark for Data Centre scheme

Existing DC (Oct 2012)



New DC (Mar 2013)



Approach and Rationale

Green Mark for Data Centre (New/Existing)

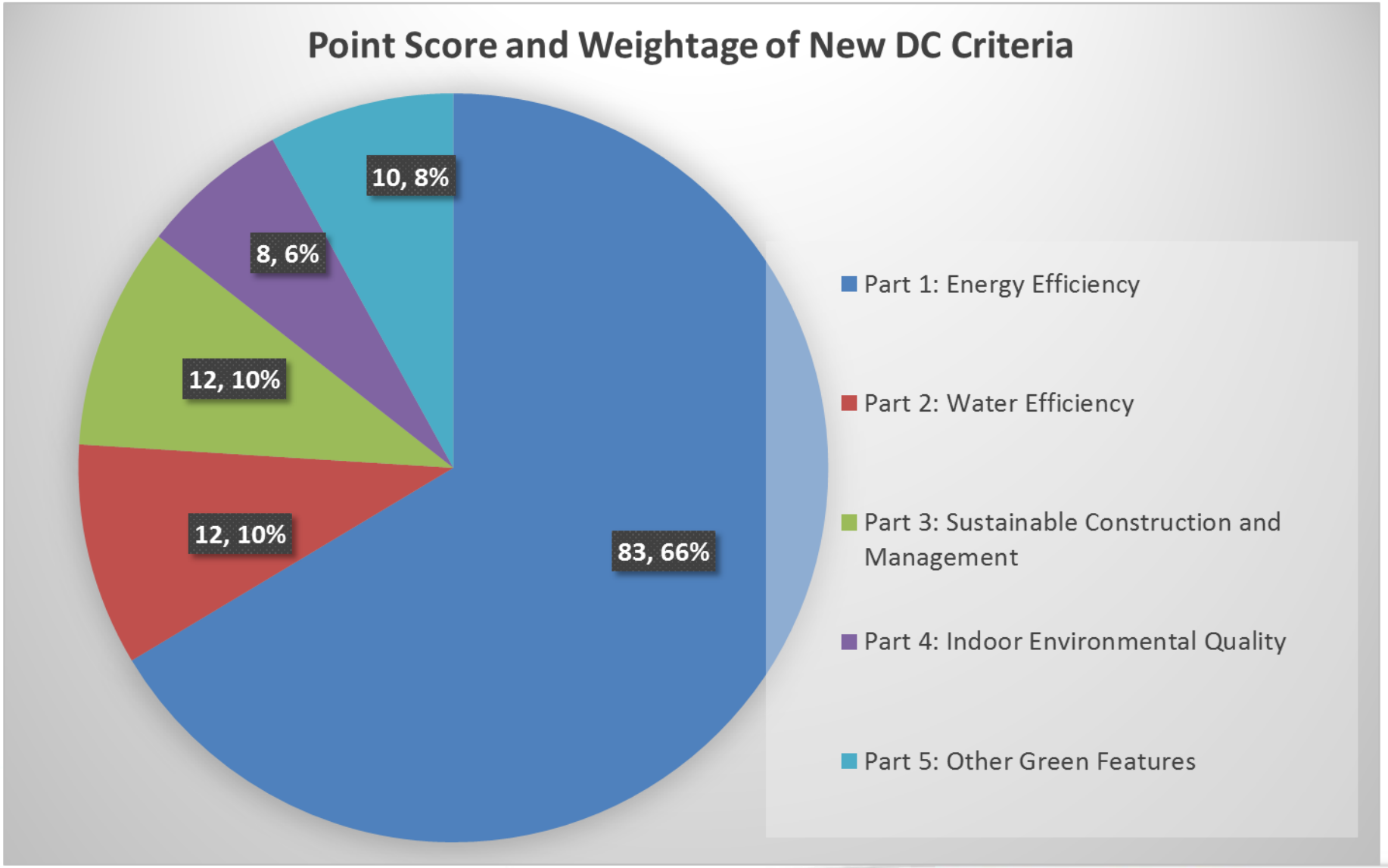
- **Energy Efficiency**
  - 
  - 
- **Water Efficiency**
  - 
  - WELS Water Efficiency Labelling Scheme
- **Sustainable Construction/ Operation Management**
  - CUI
  - RCA WCS GGBC
  - Refrigerants, Fire Suppressants
  - 
  - Sustainability Policy
- **Indoor Environmental Quality**
  - VOC
  - 
  - monitor CO_2
  - Thermal Comfort and Noise

- New DC v1.1 and Existing DC v1.1 seeks to achieve a **more holistic framework** for environmentally sustainable data centres

OVERVIEW OF POINTS ALLOCATION for NDC

CATEGORY	Points Allocation (% weightage)
	NDC v1.1
Part 1: Energy Efficiency	83 (66.4%)
Part 2: Water Efficiency	12 pts (9.6%)
Part 3: Sustainable Construction and Management	12 pts (9.6%)
Part 4: Indoor Environmental Quality	8 pts (6.4%)
Part 5: Other Green Features	10 pts (8%)
TOTAL	**125 pts (100%)**

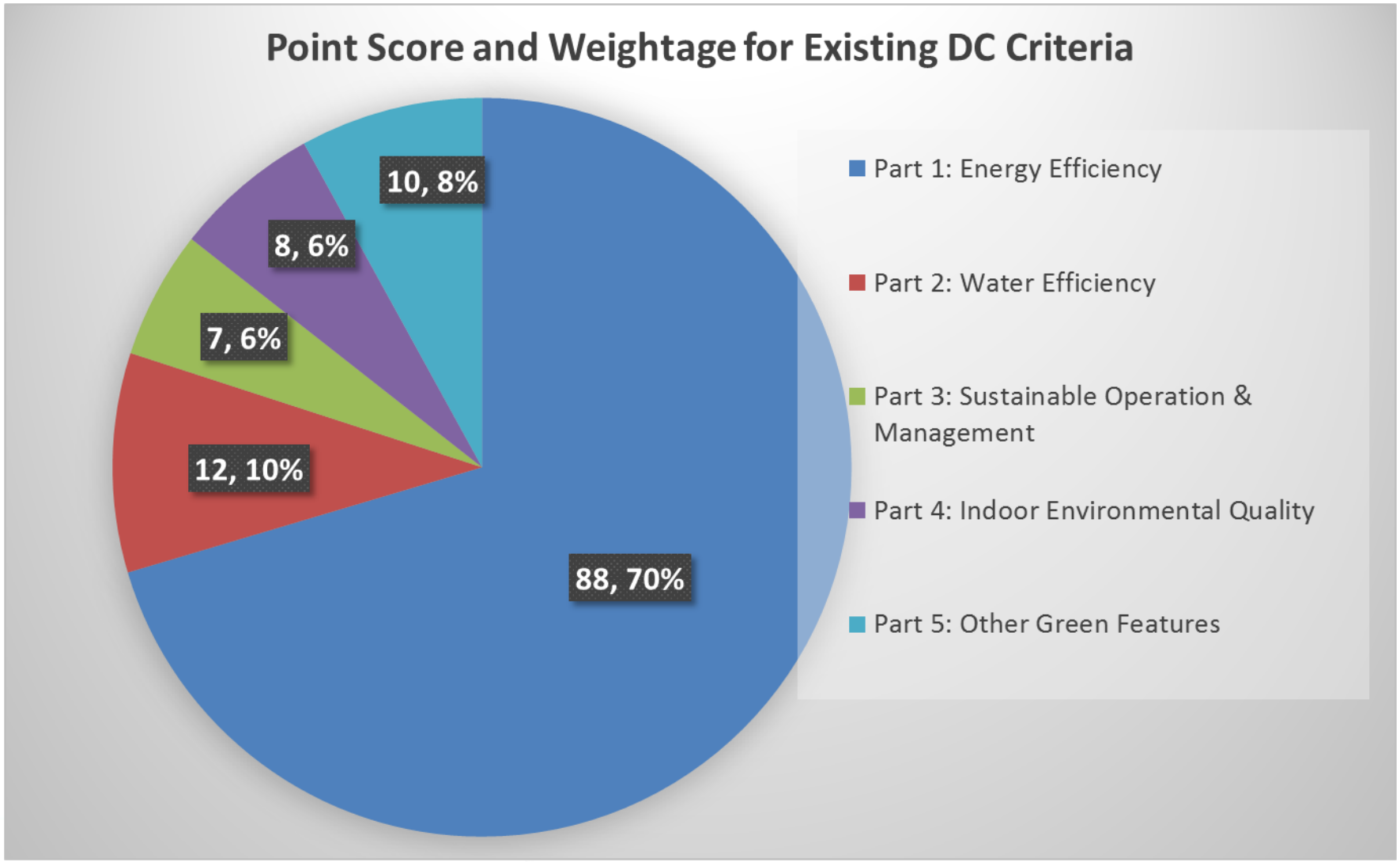
OVERVIEW OF POINTS ALLOCATION for NDC



OVERVIEW OF POINTS ALLOCATION for EDC

CATEGORY	Points Allocation (% weightage)
	EDC v1.1
Part 1: Energy Efficiency	88 pt (70.4%)
Part 2: Water Efficiency	12 pts (9.6%))
Part 3: Sustainable Operation & Management	7 pts (5.6%)
Part 4: Indoor Environmental Quality	8 pts (6.4%)
Part 5: Other Green Features	10 pts (8%)
TOTAL	**125 pts (100%)**

OVERVIEW OF POINTS ALLOCATION for EDC



GREEN MARK AWARD RATINGS & PRE-REQUISITES

Green Mark (New & Existing DC)

GM NDC/EDC v 1.1	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

BCA-IDA GREEN MARK

BCA-IDA Green Mark for New Data Centres

Version NDC/1.1



Green Mark for Data Centre criteria can be downloaded at this link:
http://www.bca.gov.sg/GreenMark/green_mark_criteria.html

GM New DC (v 1.1) Framework

To achieve GREEN MARK Award

Pre-requisite Requirement
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

Part 1 – Energy Efficiency

Part 2 – Water Management
Part 3 – Sustainable Construction & Management
Part 4 – Indoor Environmental Quality
Part 5 – Other Green Features

GM New DC (v 1.1) Framework

Part 1 – Energy Efficiency

1-1 Overall Energy Efficiency

1-2 System Energy Efficiency

- Cooling System
- Electrical System
- IT Equipment

1-3 Energy Efficiency and Performance Verification

1-3 Data Centre Design and Energy Management

1-5 Energy Efficient Features and Innovation

Part 2 – Water Efficiency

2-1 Water Efficient Design

2-2 Alternative Water Source

2-3 Cooling Tower Water Use

Part 3 – Sustainable Construction and Management

3-1 Refrigerants and Fire Suppressants

3-2 Sustainable Construction

3-3 Sustainable Policy

GM New DC (v 1.1) Framework

Part 1 - Energy Efficiency

1-1 Overall Energy Efficiency
1-2 Systems Energy Efficiency
- Cooling System
- Electrical System
- IT Equipment

1-3 Energy Efficiency and Performance Verification
1-4 Data Centre Design and Energy Management
1-5 Energy Efficient Features and Innovations

Part 2 - Water Efficiency

2-1 Water Efficient Design
2-2 Alternative Water Sources
2-3 Cooling Tower Water Use

Part 3 – Sustainable Construction & Management

3-1 Refrigerants and Fire Suppressants
3-2 Sustainable Construction
3-3 Sustainability Policy

Part 4 – Indoor Environmental Quality

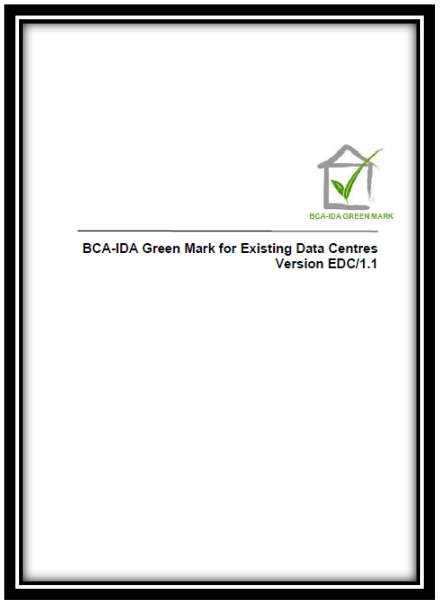
4-1 Indoor Air Quality Performance
4-2 Lighting Quality and Management
4-3 Thermal Comfort and Noise Level

Part 5– Other Green Features

5-1 Other Green Features and Innovation

BCA-IDA GREEN MARK

BCA-IDA Green Mark for Existing Data Centres Version EDC/1.1



Green Mark for Data Centres criteria can be downloaded at this link:
http://www.bca.gov.sg/GreenMark/green_mark_criteria.html

GM Existing DC (v 1.1) Framework

To achieve GREEN MARK Award

Pre-requisite Requirement
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

Part 1 – Energy Efficiency

Part 2 – Water Management
Part 3 – Sustainable Operation and Management
Part 4 – Indoor Environmental Quality
Part 5 – Other Green Features

GM Existing DC (v 1.1) Framework

Part 1 – Energy Efficiency

1-1 Overall Energy Efficiency

1-2 System Energy Eifficiency

- Cooling System
- Air Management System
- Electrical System
- IT Equipment

1-3 Energy/Environmental Policy and Management

1-4 Energy Monitoring and Assessment

1-5 Energy Efficient Features and Innovation

Part 2 – Water Efficiency

2-1 Water Efficient Design

2-2 Alternative Water Source

2-3 Cooling Tower Water Use

Part 3 – Sustainable Operation and Management

3-1 Refrigerants and Fire Suppressants

- Sustainable Purchasing and Operation
- Waste Management

3-2 Sustainable Policy

GM Existing DC (v 1.1) Framework

Part 1 - Energy Efficiency

1-1 Overall Energy Efficiency
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
1-5 Energy Efficient Features and Innovations

Part 2 - Water Efficiency

2-1 Water Use Efficiency
2-2 Alternative Water Sources
2-3 Cooling Tower Water Use

Part 3 – Sustainable Operation & Management

3-1 Refrigerants and Fire Suppressants
3-2 Sustainability Policy

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

5-1 Other Green Features and Innovation

Application for Green Mark Assessment

1. Application form is available at BCA website:
http://www.bca.gov.sg/GreenMark/green_mark_criteria.html

- Submit the completed application form to BCA.
- On-line application is available (GreenMarkOnline)

For more information, please visit
https://www.bca.gov.sg/GreenMarkOnline/
https://www.bca.gov.sg/GreenMark/gm_manager.html



2. BCA will process the application and reply to applicant together with a fee.

3. Applicant pays the fee and process of assessment will start with BCA assessor contacting the applicant for an assessment schedule.

Certification Process for BCA Projects - NDC

Application

A1. Submission of application form by Client/ Building Owner/ESD consultants with relevant supporting documents

A2. BCA processes application and provides invoice with fee

A3. BCA provides an invoice for payment

A4. Client/ Building Owner makes payment

A5 The assigned BCA assessors will contact the Client/ Building Owner/ Client's representative to arrange for assessment.

Pre-Assessment

B1. Assigned BCA assessors will fix up the Pre-Assessment date

B2. A pre-assessment audit conducted

B3. Project Presentation by project team/DC owners

B4. DC's representative briefing on goals, scope and criteria of project.

B5 Aassessors review readiness of DC and availability of information

Final Assessment (*Leading to Letter of Award)*

C1. Assigned BCA assessors will fix up the Final Assessment dates

C2. Project Presentation by project team/DC owners

C3. Final Assessment conducted once the detailed design and documentary evidences are ready

C4. Detailed assessment conducted on documents, drawings, equipment specification and design

C5: Examination of EM Modelling on all ratings based on input, parameters , equipment selection, operating strategy and output results.

C6. Green Mark presentation to BCA's Senior management for Gold^{Plus} & Platinum projects

C7: Letter of Award (certification shall be valid for 3 years) stating the Green Mark rating would be issued.

Verification (*Leading to Letter of Completion)*

D1. For projects under design and construction phase. Client/Project team to arrange for verification of the green features installed upon project completion.

D2. Review of all as-built assessment information, P.O. DO. , ad-built drawings, data trend logging, monitoring values.

D3. Revisit all assessment points to ensure that project still meeting the final assessment points and rating.

D4. Letter of Completion stating the Green Mark rating will be issued.

Certification Process for BCA Projects - EDC

Application

A1. Submission of application form by Client/ Building Owner/ESD consultants with relevant supporting documents

A2. BCA processes application and provides invoice with fee

A3. BCA provides an invoice for payment

A4. Client/ Building Owner makes payment

A5. The assigned BCA assessors will contact the Client/ Building Owner/ Client's representative to arrange for assessment

Pre-Assessment

B1. Assigned BCA assessors will fix up the Pre-Assessment date

B2. A pre-assessment audit conducted

B3. Project Presentation by project team/DC owners

B4. DC's representative briefing on goals, scope and criteria of project.

B5. Assessors review readiness of DC and availability of information

Final Assessment (*Leading to Letter of Award)*

C1. Assigned BCA assessors will fix up the Final Assessment dates

C2. Final Assessment conducted once the detailed design and documentary evidences are ready

C3. Detailed assessment conducted

C4: Energy Audit Report on all ratings

C5. Review of all data trend logging to ascertain meeting operating target/index.

C6. Green Mark presentation to BCA's Senior management for Gold^{Plus} and Platinum projects

C7: Letter of Award (valid for 3 years) stating the Green Mark rating would be issued .

Pre-Requisites for GM's NDC and EDC v1.1

The main difference between the New & Existing Data Centres criteria is in Part 1 - Energy Efficiency requirements

- Whereas existing data centres assessment is based on readings from the meters already installed in the data centres and recordings from Building Automation System (BAS), new data centres energy performance assessment will be based on computer simulation.

- For new data centres, the maximum Design PUE at Full Load for the Proposed DC Model shall be 2.0. For existing data centres, the minimum energy performance of a data centre shall have a current operating PUE ≤ 2.2

- For new data centres, Green Mark points will be given for commissioning of the energy system including the verification of PUE. New DC will also need to develop and implement a M & V Plan (Measurement & Verification) to track at least 1 year of PUE performance at full load and part load operations.

New Data Centre Facility Energy Modelling

The computer simulation of the data centre facility and systems shall be carried out with an approved energy assessment software. A typical **building energy simulation program** may be used **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 appropriate locations. A separate calculator will be provided to estimate these losses.

- The system configurations must be able to accept redundant equipment and sequencing arrangements that enable the spare equipment capacity to be on “hot” standby.

The energy performance improvements 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.

Software Requirement

Capable of modelling thermal performance of buildings in multi-zone format and compute total energy consumption on hour-by-hour basis over 8,760 hours period (365 days)

- Tested and validated in accordance with Standard Method of Test for Evaluation of Building Energy Analysis Computer Programs - ANSI/ASHRAE 140 or equivalent standard.

- Software tool to estimate electrical power train losses such as transformers, UPS, and PDU which are not captured in usual building energy modelling software.

Other Pre-requisites for GM NDC v1.1

1 Overall Energy Efficiency

Green Mark Rating	Minimum points
Green Mark Certified	35 points
Green Mark Gold	42 points
Green mark Gold^{Plus}	50 points
Green Mark Platinum	60 points

2. Max PUE

The data centre must have a design Power Usage Effectiveness (PUE) at full load condition of no more than 2.0 for Green Mark certification.

3. Minimum System Efficiency

Prescribed system efficiency of cooling system to be met.

4. Energy Monitoring

Provision of permanent measuring instruments for monitoring of water-cooled system and air-cooled chilled water system operating system efficiency.

5. SS564 Certification

Certification for higher rating

Other Pre-requisite for GM EDC v1.1

1. Overall Energy Efficiency

Green Mark Rating	Minimum points
Green Mark Certified	35 points
Green Mark Gold	42 points
Green mark Gold^{Plus}	50 points
Green Mark Platinum	60 points

2. Max PUE

The data centre must have a design Power Usage Effectiveness (PUE) at full load condition of no more than 2.2 for Green Mark certification.

3. Minimum System Efficiency

Prescribed system efficiency of cooling system to be met.

4. Energy Monitoring and Reporting of PUE

Provision of permanent measuring instruments for monitoring of water-cooled system and air-cooled chilled water system operating system efficiency.

5. SS564 Certification

Certification for higher rating.

NDC Part 1-5 Energy Efficient Features and Innovations

1-5 Energy Efficient Features and Innovations Encourage the use of innovative energy efficient equipment, system or design features. To qualify, the features must achieve significant, measureable improvement of energy performance in one of the following areas: (a) innovative cooling systems or features (including free air-cooling, direct liquid cooling and two-phase systems, etc) (b) innovative power supply, back-up power or UPS systems (c) IT operations, maintenance or system upgrade strategies not covered by Section 1-2-3 above (d) radical changes in data centre design, operations or systems not covered in any section above. Encourage the application of renewable energy sources in data centres.	2 points for each innovation that demonstrate the following: • The intent of the proposed innovation • The additional energy benefits delivered • The proposed requirements for compliance • The proposed performance metrics to demonstrate compliance and the approaches (strategies) used to meet the requirements 2 points for every 1% replacement of electricity usage with renewable energy (Up to 10 points)

EDC Part 1-5 Energy Efficient Features and Innovations

1-5 Energy Efficient Features and Innovations Encourage the use of innovative energy efficient equipment, system or design features. To qualify, the features must achieve significant, measureable improvement of energy performance in one of the following areas: (a) innovative cooling systems or features (including free air-cooling, direct liquid cooling and two-phase systems, etc) (b) innovative power supply, back-up power or UPS systems (c) IT operations, maintenance or system upgrade strategies not covered by Section 1-2-4 above (d) radical changes in data centre design, operations or systems not covered in any section above. Encourage the application of renewable energy sources in data centres.	2 points for each innovation that demonstrate the following: • The intent of the proposed innovation • The additional energy benefits delivered • The proposed requirements for compliance • The proposed performance metrics to demonstrate compliance and the approaches (strategies) used to meet the requirements 2 points for every 1% replacement of electricity usage with renewable energy (Up to 10 points)

NDC & EDC Part 5-1 Other Green Features and Innovations

Part 5 – Other Green Features (Total Points: 10)	Green Mark Points
5-1 Green Features and Innovations To encourage the use of other green features which are innovative or/and have positive environmental impact. Features must achieve significant, measurable environmental performance in the data centre operations, maintenance or management not covered in Parts 2, 3 and 4 above	2 points for each feature or innovation that demonstrate the following: • The intent of the proposed innovation • The additional environmental benefits delivered • The proposed requirements for compliance • The proposed performance metrics to demonstrate compliance and the approaches (strategies) used to meet the requirements (Up to 10 Points)

BCA-IDA Green Mark for Existing Data Centres (Version EDC 1.1)

Part 5 – Other Green Features (Total Points: 10)	Green Mark Points
5-1 Green Features and Innovations To encourage the use of other green features which are innovative or/and have positive environmental impact. Features must achieve significant, measurable environmental performance in the data centre operations, maintenance or management not covered in Parts 2, 3 and 4 above	2 points for each feature or innovation that demonstrate the following: • The intent of the proposed innovation • The additional environmental benefits delivered • The proposed requirements for compliance • The proposed performance metrics to demonstrate compliance and the approaches (strategies) used to meet the requirements (Up to 10 Points)

Best Energy Efficiency (EE) for DC

- Transformer - Efficiency of above 98% efficiency
- Diesel Rotary Uninterruptible Power Supply System (DRUPS)
- Ultra Efficient Modular UPS
- In row/in rack cooling
- Improved IT power chain loss
- Directional Perforated Panels
- Cold aisle/hot aisle containment

EE features and innovations

1-5 Other Energy Efficient Features / Innovations

1. Innovative cooling systems or features (e.g. use of outdoor air-cooling, direct liquid cooling, immersion cooling, cold/hot aisle with blanking panel and end cap doors, etc. Innovative power supply, back-up power, e.g DRUPS used as UPS

2. IT system optimisation strategies (e.g. virtualisation, server consolidation, Monitoring & tracking of overall energy data, PDU rack monitoring, etc.)

3. Radical changes in data centre design, operations or systems

4. Use of renewable energy, e.g. PV

All features submitted must be significant, measureable.

5 Green Features and Innovations

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

1. intent of the innovation
2. additional environmental benefits delivered
3. requirements for compliance
4. performance metrics to show compliance and the approaches (strategies) used to meet the requirements

e.g. Education Corner on Data Centre
Thermal storage tank

All features submitted must be significant, measureable.

Case Study

- Modular Design
- Energy Efficient IT equipment
- Deployment of virtualization technology

- Abbott Laboratories Singapore
- Enterprise
- Gold award (NDC)
- Saving 1 million kWh annual

13 Mar 2013, Asiaone

Summary

- Global Challenge
- Singapore BCA Green Mark Scheme
- BCA-IDA Green Mark scheme for New/Existing DC - Criteria
- Application and Certification Process
- Best Practices on EE



Thank You

"If a DC means Business, it must have Green Mark"

Reference : BuildGreen Magazine



Continued Leadership

Proven Sustainability Performance

Wider Collaboration & Engagement

http://www.bca.gov.sg/publications

Relevant Courses at BCAA

- Green Mark Manager Course (GMM)
- Green Mark Professional Course (GMP)
- Green Mark Facilities Manager (GMFM)
- Green Mark Facilities Professional (GMFP)
- Green Mark M & V (Measurement and Verification Course)

www.bcaa.gov.sg

Relevant Standards

- BCA Green Mark Certification Standards
- ASHRAE TC 9.9 - 2011 Thermal Guidelines for Data Processing Environments – Expanded Data Centre Classes and Usage Guidance
- AHRI 550/590 – Standard for Performance Rating for Water Chilling and Heat-Pump Package
- SS531 – Code of Practice for Lighting of Work Places
- SS554 – SS554-2009-Code of Practice for Indoor Air Quality for Air-conditioned Building
- SS553-2009-Code of Practice for Air-conditioning and Mechanical Ventilation in Building (Formerly CP13)
- SS564 – Singapore Standard for Green Data Centres (Energy and Environmental Management)
- SS591 - Code of practice for long term measurement of central chilled water system energy efficiency

Optional -

- SS587 – Management of end-of-life ICT Equipment

Guides/Information

- ISO 50001 – Energy Management System – Requirement with Energy for Use
- NEA, IDA : DC Benchmarking Study full report can be found at the URL address below:

http://app.e2singapore.gov.sg/DATA/0/docs/Resources/NEA%20DC%20Energy%20Benchmarking%20Summary-%20Final%20Report%20(3).pdf

- ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality (ANSI Approved).
- ASHRAE 90.1 - Energy Standard for Buildings Except Low Rise Residential Buildings
- ASHRAE 90.1 – User's Manual
- ASHRAE 189.1 – Standard for Design of High-Performance Green Buildings
- TIA – 942 Telecommunication Infrastructure Standard for Data Centre
- TUI 705 C Tier Communications Define Site Infrastructure Performance