



BCA Green Mark Certification - Verification Audit

Workflow & Compliance Requirement Checklist

History of amendments

S/N	Brief Description of changes	Revision date
1.0	Updated form EM-2 in Appendix D	22 Nov 2013
2.0	New chapters 9,10,11 and 12 to explain the workflow for GLS programme projects	26 May 2014

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BCA Green Mark Verification Audit For New Buildings

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1. CERTIFICATION PROCESS

The Building and Construction Authority (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 requirement for BCA Green Mark Gold^{Plus} and Platinum rating where applicable.
- Letter of award showing the BCA Green Mark rating will be issued at this stage.
- Site verification to be conducted upon project completion.
- For projects with BCA Gold^{Plus} and Platinum rating, energy modeling for reference model using actual data is to be carried out to ascertain the energy savings.

The Verification Audit is the last step of the BCA Green Mark Certification Process which is to be completed within the validity of the certification.

2. OBJECTIVE

The intent of this BCA Green Mark Certification Process – Verification Audit Document is to set out the verification audit workflow and requirements of the building owners and developers for BCA to conduct the site verification upon project completion.

The objective of the verification audit is for BCA to validate and for building developers/owners to demonstrate compliance with the committed design specifications in terms of:

- 1) Implementation of the green features site installation and/or control strategies; operation functionalities and performance; and
- 2) Energy savings over the code-compliance buildings

which were committed during the Actual Assessment.

The Workflow and Checklist of Documentation Requirement below outlines the Verification Audit Process.

If you need clarification on any aspect of this Document, please contact BCA, Singapore.

3. 2-STAGE VERIFICATION FOR GREEN MARK CERTIFICATION

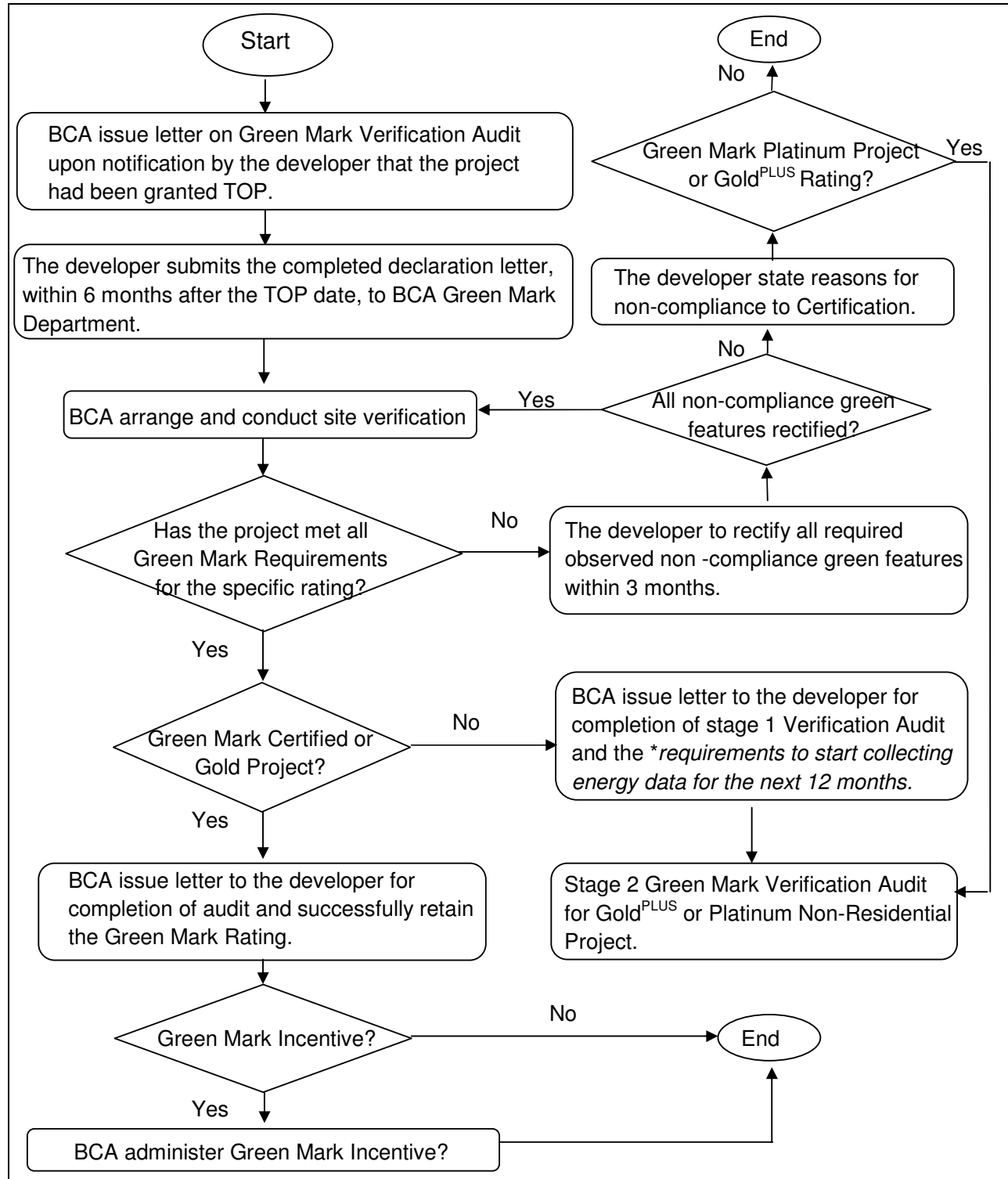
The 2-stage verification audit is as follows:

Stage 1: The building developer/ owner is to determine the functionality and performance of the green features which resulted in the certification and demonstrate compliance with to the committed design specification through documentary evidences and site verification.

During the course of site verification, key observations of the green features, photos will be taken for record purpose.

Stage 2: Applicable only for BCA Green Mark Gold^{PLUS} and Platinum certified **Non-Residential** projects. The developer/ owner is to determine the energy savings for the building over its reference model using 12-month actual operation data and demonstrate compliance to the committed energy savings which resulted in the certification.

4. VERIFICATION AUDIT WORKFLOW FOR GREEN MARK CERTIFICATION PROJECTS – STAGE 1 VERIFICATION AUDIT WORKFLOW



**Only applicable for Non-Residential projects.*

5. VERIFICATION AUDIT FOR GREEN MARK CERTIFICATION PROJECTS - STAGE 1 COMPLIANCE REQUIREMENTS FOR NON-RESIDENTIAL BUILDING

Part 1: Energy Efficiency

Criteria	Compliance Requirement
NRB 1-1 Building Envelope - ETTV	<u>Documentary Evidences</u> <ul style="list-style-type: none"> • Purchase orders/ delivery orders, for the brands/models of the installed glazing, stipulating the U-value and SC specifications, to demonstrate compliance with the committed building façade thermal performance i.e. ETTV. • Product catalogue as supplementary documents to PO/DO for making reference of the installed glazing U-value and SC specifications.
NRB 1-2 Air- Conditioning System (a)(i) Air-Conditioned Plant	<u>Documentary Evidences</u> <ul style="list-style-type: none"> • Determine the efficiency of the chilled-water plant using the list of required trend logged operations data stipulated below, and demonstrate compliance with the committed design specifications. • Operating Chiller Plant Efficiency Report (refer to Appendix B for report template). • BMS raw data in Microsoft excel file format for all relevant chiller plant operating performance parameters • Temperature sensors calibration certificates from accredited laboratory and/or factory calibration certificates from manufacturers.

Criteria	Compliance Requirement
NRB 1-2 Air- Conditioning System (a)(i) Air-Conditioned Plant	<p><u>Site Requirements</u></p> <ul style="list-style-type: none"> • Determine the chilled-water plant efficiency using the following operation data/ installations to demonstrate compliance with the design specifications: <ul style="list-style-type: none"> ▪ From Building Management System <ul style="list-style-type: none"> i. Chilled-water plant kW/RT; ii. Chilled-water supply & return temperatures of the header to be checked for consistency against the temperatures of individual chillers and/or individual branches; iii. Condenser water supply & return temperatures of the header to be checked for consistency against the temperatures of individual chillers and/or individual branches; iv. Chilled-water header flow rate to be checked for consistency against the flow rate(s) of individual branches v. Condenser water header flow rate to be checked for consistency against the flow rate(s) of individual branches vi. The accuracy of the programmed formula for the computation of the kW/RT of the chiller plant. ▪ From the operating Chiller panel(s): <ul style="list-style-type: none"> i. Chilled-water supply & return temperatures to be checked for consistency against the BMS data; ii. Condenser water supply & return temperatures to be checked for consistency against the BMS data; iii. Approach of chilled-water supply – refrigerant evaporating temperature; iv. Approach of chilled-water supply – refrigerant evaporating temperature. ▪ Location of the chilled-water flow meter(s) installed to comply with manufacturer's recommendations. ▪ Location of the chilled-water temperature sensors installed to comply with manufacturer's recommendations & demonstrate accuracy compliance to the requirements.

Criteria	Compliance requirement
NRB 1-2 Air- Conditioning System (a)(ii) Unitary Air-conditioners	<u>Documentary Evidences</u> <ul style="list-style-type: none"> • Purchase orders/ delivery orders, for the brands/models of the installed unitary air-conditioners • Product catalogue as supplementary documents to PO/DO for making reference of the installed unitary air-conditioners. <u>Site Requirements</u> <ul style="list-style-type: none"> • Demonstrate compliance with the committed design specifications.
NRB 1-2 Air- Conditioning System (a)(iii) Air Distribution System (c) Sensors and automatic control devices for regulating of outdoor air	<u>Site Requirements</u> <ul style="list-style-type: none"> • Determine the sensors installations and the functionality of the control strategies implemented for the air distribution systems using operation data and demonstrate compliance with the design specifications: <ul style="list-style-type: none"> ▪ Location of the CO₂ sensors for monitoring of the return air CO₂ level; ▪ From Building Management System (BMS) <ul style="list-style-type: none"> i. CO₂ level of the return air and the resultant percent opening of the ventilation air dampers to checked for regulation of outdoor air; ii. Supply air off-coil temperature and the resultant percent opening of the modulating valves to checked indoor thermal comfort; iii. Chilled-water supply & return temperatures to be checked for consistency against the chilled-water plant header and/or branches temperatures;
NRB 1-3 Building Envelope	<u>Site Requirements</u> <ul style="list-style-type: none"> • Demonstrate compliance with the committed design specifications making reference to the as-built drawings.

Criteria	Compliance requirement
NRB 1-4 Natural Ventilation (exclude car parks)	<u>Site Requirements</u> <ul style="list-style-type: none"> Demonstrate compliance with the committed design specifications making reference to the as-built drawings.
NRB 1-5 Daylighting	<u>Site Requirements</u> <ul style="list-style-type: none"> Determine the effectiveness of the daylighting design strategies implemented and demonstrate compliance with the committed designed specifications.
NRB 1-6 Artificial Lighting	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Purchase orders/ delivery orders of the installed lighting fixtures to demonstrate compliance with the committed design specifications.
NRB 1-7 Ventilation in Car Parks	<u>Site Requirements</u> <ul style="list-style-type: none"> Determine the sensors installations and the functionality of the control strategies implemented for the car park ventilation systems using operation data and demonstrate compliance with the design specifications: <ul style="list-style-type: none"> (i) CO sensors (ii) Ductless fans (iii) From BMS: CO level and the resultant supply and exhaust fans' frequency to check for modulation of the demand based ventilation system
NRB 1-8 Ventilation in Common areas	<u>Site Requirements</u> <ul style="list-style-type: none"> Demonstrate compliance with the committed design specifications.

Criteria	Compliance requirement
NRB 1-9 Lifts and Escalators	<p><u>Documentary Evidences</u></p> <ul style="list-style-type: none"> • Purchase orders/ delivery orders of the installed lifts and/or escalators to demonstrate compliance with the committed design specifications. • Product catalogue as supplementary documents to PO/DO for making reference of the installed lifts and/or escalators. <p><u>Site Requirements</u></p> <ul style="list-style-type: none"> • Demonstrate compliance with the committed design specifications.
NRB 1-10 Energy Efficient Features	<p><u>Documentary Evidences</u></p> <ul style="list-style-type: none"> • Determine the functionality, performance and savings of energy efficient systems using trend logged operations data and demonstrate compliance with the committed design specifications. <p><u>Site Requirements</u></p> <ul style="list-style-type: none"> • Determine the functionalities of the energy efficient features implemented and demonstrate compliance with the committed designed specifications. <ul style="list-style-type: none"> ▪ From Building Management System: <ul style="list-style-type: none"> • Determine the performance of the energy efficient systems by using measured and/or monitored operation data and demonstrate compliance with the committed design specifications.

Criteria	Compliance requirement
NRB 1-11 Renewable Energy	<p><u>Documentary Evidences</u></p> <ul style="list-style-type: none">• Determine the performance of the renewable energy generation system(s) by using trend logged data of the energy generated and demonstrate compliance to the committed design specifications, <p><u>Site Requirements</u></p> <ul style="list-style-type: none">• Demonstrate the implementation and functionalities of the renewable energy generation systems and determine compliance with the committed designed specifications.

Part 2 Water Efficiency

Criteria	Compliance requirement
NRB 2-1 Water Efficient Fittings	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Purchase orders/ delivery orders, for the brands/models of the installed sanitary fittings to demonstrate compliance to the committed design specifications. <u>Site Requirements</u> <ul style="list-style-type: none"> Determine the flow rate of the sanitary fittings using e.g. a beaker and stop watch and demonstrate compliance with the committed design specifications.
NRB 2-2 Water Usage and Leak Detection	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Water consumption monitoring and trend logged data of major water usage to demonstrate compliance to the committed design specifications. <u>Site Requirements</u> <ul style="list-style-type: none"> Demonstrate the provision of water sub-meters and determine compliance with the committed design specifications. <ul style="list-style-type: none"> From Building Management System: <ul style="list-style-type: none"> Demonstrate the monitoring of major water usage and determine compliance with the committed design specifications.
NRB 2-3 Irrigation System and Landscaping	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Purchase orders/ delivery orders, for the species of drought tolerant plants <u>Site Requirements</u> <ul style="list-style-type: none"> Demonstrate the use of non portable water for landscape irrigation and determine compliance with the committed design specifications. Demonstrate the provision of water efficient irrigation system and determine compliance with the committed design specifications.

Criteria	Compliance requirement
NRB 2-4 Water Consumption of Cooling Tower	<u>Documentary Evidences</u> <ul style="list-style-type: none">Determine the cycles of concentration of the condenser water treatment system achieved, by using water test report and demonstrate compliance to the committed design specifications. <u>Site Requirements</u> <ul style="list-style-type: none">Demonstrate the provision of NEWater supply for the condenser water make-up.

Part 3 Environmental Protection

Criteria	Compliance requirement
NRB 3-1 Sustainable Construction	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Purchase orders/ delivery orders, for the brands/models of the environmental friendly products, to demonstrate compliance with the committed design specifications, and/or undertaking from the developer.
NRB 3-2 Greenery	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Demonstrate compliance with the committed trees planting design making reference to the as-built drawings. Demonstrate the use of compost recycled from horticulture waste. <u>Site Requirement</u> <ul style="list-style-type: none"> Demonstrate the restoration, conservation and/or relocation of trees on site.
NRB 3-3 Environmental Management Practice	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Demonstrate the monthly graphical plots and bills of energy use, water use and construction waste throughout the course of construction works. CONQUAS Certification Demonstrate the provision and circulation of the Building Users' Guide. <u>Site Requirement</u> <ul style="list-style-type: none"> Demonstrate the provision of recycling facilities.

Criteria	Compliance requirement
NRB 3-4 Public Transport Accessibility	<u>Site Requirement</u> <ul style="list-style-type: none"> • Demonstrate the site accessibility to public transportation or provision of private shuttle bus service. • Demonstrate the provision of adequate bicycle parking lots. • Demonstrate the connection of covered walkway from the development to public transport services
NRB 3-5 Refrigerants	<u>Site Requirement</u> <ul style="list-style-type: none"> • Demonstrate the implementation and functionalities of the refrigerant leak detection system.
NRB 3-6 Stormwater Management	<u>Site Requirement</u> Demonstrate the implementation and functionalities of the stormwater management system and determine compliance with the PUB's ABC Water Design Guidelines.

Part 4 Indoor Environmental Quality

Criteria	Compliance requirement
NRB 4-1 Thermal Comfort	<u>Site Requirements</u> <ul style="list-style-type: none"> Determine the thermal comfort of the applicable air-conditioning spaces using measured and/or monitored operation data and demonstrate compliance with the committed design specifications.
NRB 4-2 Noise Level	<u>Site Requirements</u> <ul style="list-style-type: none"> Determine the noise level of the applicable spaces using measured and/or monitored operation data and demonstrate compliance with the committed design specifications.
NRB 4-3 Indoor Air Pollutants	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Purchase orders/ delivery orders of low VOC paints and/or adhesive certified under SGLS to demonstrate compliance with the committed design specifications.
NRB 4-4 Indoor Air Quality Mangement	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Purchase orders/ delivery orders of filtration media to demonstrate compliance with the committed design specifications and SS 554: Clause 4.3.4.5 & Annex E. IAQ management plan test report to demonstrate compliance with guidelines in SS554: Clause 4.6 & Annex F. <u>Site Requirements</u> <ul style="list-style-type: none"> Determine the differential pressure sensor installations and the functionality of the control strategies implemented for the air distribution systems and demonstrate compliance with the design specifications via the BMS.
NRB 4-5 High Frequency Ballast	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Purchase orders/ delivery orders of high frequency ballast to demonstrate compliance with the committed design specifications.

Part 5 Other Green Features

Criteria	Compliance requirement
NRB 5-1 Green Features and Innovations	<u>Site Requirement</u> <ul style="list-style-type: none">Demonstrate the implementation and functionalities of the green features and determine compliance with the committed design specifications.

6. VERIFICATION AUDIT FOR GREEN MARK CERTIFICATION PROJECTS - STAGE 1 COMPLIANCE REQUIREMENTS FOR RESIDENTIAL BUILDING

Part 1: Energy Efficiency

Criteria	Compliance Requirement
RB 1-1 Building Envelope - RETV	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Purchase orders/ delivery orders for the brands/ models of the installed glazing, stipulating the U-value and SC specifications, to demonstrate compliance with the committed building façade thermal performance i.e. RETV. Product catalogue as supplementary documents to PO/DO for making reference of the installed glazing U-value and SC specifications.
RB 1-2(a) Dwelling Unit Indoor Comfort	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Purchase orders/ delivery orders for the brands/ models of the installed air-conditioners to demonstrate compliance with the committed design specifications. Product catalogue as supplementary documents to PO/DO for making reference of the installed air-conditioners Singapore Energy Labelling Scheme rating. <u>Site Requirements</u> <ul style="list-style-type: none"> Demonstrate compliance with the committed design specifications making reference to the as-built drawings.
RB 1-2(b) Natural Ventilation in Common Areas	<u>Site Requirements</u> <ul style="list-style-type: none"> Demonstrate compliance with the committed design specifications making reference to the as-built drawings.

Criteria	Compliance Requirement
RB 1-3 Daylighting	<u>Site Requirements</u> <ul style="list-style-type: none"> Determine the effectiveness of the daylighting design strategies implemented and demonstrate compliance with the committed designed specifications.
RB 1-4 Artificial Lightings	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Purchase orders/ delivery orders of the installed lighting fixtures to demonstrate compliance with the committed design specifications. Product catalogue as supplementary documents to PO/DO for making reference of the installed lighting fixtures specifications. <u>Site Requirements</u> <ul style="list-style-type: none"> Demonstrate compliance with the committed design specifications making reference to the as-built drawings.
RB 1-5 Ventilation in Car Parks	<u>Site Requirements</u> <ul style="list-style-type: none"> Determine the sensors installations and the functionality of the control strategies implemented for the car park ventilation systems and demonstrate compliance with the design specifications: <ul style="list-style-type: none"> (iv) CO sensors Ductless fans
RB 1-6 Lifts	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Purchase orders/ delivery orders of the installed lifts to demonstrate compliance with the committed design specifications. Product catalogue as supplementary documents to PO/DO for making reference of the installed lifts specifications.

Criteria	Compliance Requirement
RB 1-7 Energy Efficient Features	<p><u>Documentary Evidences</u></p> <ul style="list-style-type: none"> Determine the performance of the energy efficient systems by using measured and/or monitored operation data and demonstrate compliance with the committed design specifications. <p><u>Site Requirements</u></p> <ul style="list-style-type: none"> Determine the functionalities of the energy efficient features implemented and demonstrate compliance with the committed designed specifications.
RB 1-8 Renewable Energy	<p><u>Documentary Evidences</u></p> <ul style="list-style-type: none"> Determine the performance of the renewable energy generation system(s) by using trend logged data of the energy generated and demonstrate compliance to the committed design specifications, <p><u>Site Requirements</u></p> <ul style="list-style-type: none"> Demonstrate the implementation and functionalities of the renewable energy generation systems and determine compliance with the committed designed specifications.

Part 2 Water Efficiency

Criteria	Compliance requirement
RB 2-1 Water Efficient Fittings	<u>Documentary Evidences</u> <ul style="list-style-type: none"> • Purchase orders/ delivery orders, for the brands/models of the installed sanitary fittings to demonstrate compliance to the committed design specifications. • Product catalogue as supplementary documents to PO/DO for making reference of the installed sanitary fittings specifications. <u>Site Requirements</u> <ul style="list-style-type: none"> • Determine the flow rate of the sanitary fittings using e.g. a beaker and stop watch and demonstrate compliance with the committed design specifications.
RB 2-2 Water Usage Monitoring	<u>Site Requirements</u> <ul style="list-style-type: none"> • Demonstrate the provision of water sub-meters and determine compliance with the committed design specifications.
RB 2-3 Irrigation System and Landscaping	<u>Documentary Evidences</u> <ul style="list-style-type: none"> • Purchase orders/ delivery orders, for the species of drought tolerant plants <u>Site Requirements</u> <ul style="list-style-type: none"> • Demonstrate the use of non portable water for landscape irrigation and determine compliance with the committed design specifications. • Demonstrate the provision of water efficient irrigation system and determine compliance with the committed design specifications.

Part 3 Environmental Protection

Criteria	Compliance requirement
RB 3-1 Sustainable Construction	<u>Documentary Evidences</u> <ul style="list-style-type: none"> • Purchase orders/ delivery orders, for the brands/models of the environmental friendly products, to demonstrate compliance with the committed design specifications. • Product catalogue as supplementary documents to PO/DO for making reference of the environmental friendly products specifications.
RB 3-2 Greenery Provision	<u>Documentary Evidences</u> <ul style="list-style-type: none"> • Demonstrate compliance with the committed trees planting design making reference to the as-built drawings. • Demonstrate the use of compost recycled from horticulture waste. <u>Site Requirement</u> <ul style="list-style-type: none"> • Demonstrate the restoration, conservation and/or relocation of trees on site.
RB 3-3 Environmental Management Practice	<u>Documentary Evidences</u> <ul style="list-style-type: none"> • Demonstrate the monthly graphical plots and bills of energy use, water use and construction waste throughout the course of construction works. • CONQUAS and/or Quality Mark Scheme certification. • Demonstrate the provision and circulation of the Building Users' Guide. <u>Site Requirement</u> <ul style="list-style-type: none"> • Demonstrate the provision of recycling facilities.

Criteria	Compliance requirement
RB 3-4 Public Transport Accessibility	<u>Site Requirement</u> <ul style="list-style-type: none">• Demonstrate the site accessibility to public transportation.• Demonstrate the provision of adequate bicycle parking lots.• Demonstrate the connection of covered walkway from the development to public transport services.
NRB 3-6 Stormwater Management	<u>Site Requirement</u> <p>Demonstrate the implementation and functionalities of the stormwater management system and determine compliance with the PUB's ABC Water Design Guidelines.</p>

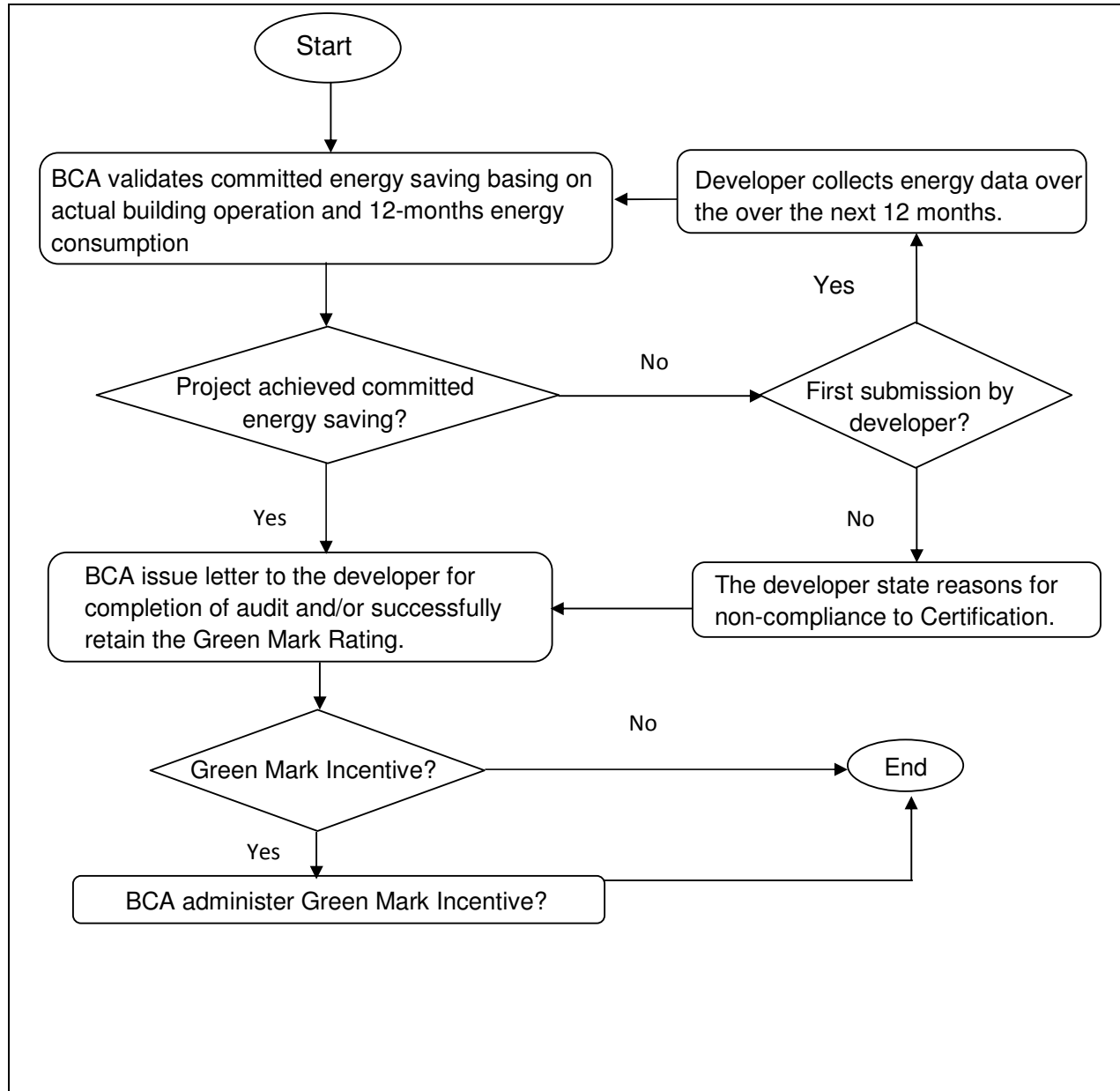
Part 4 Indoor Environmental Quality

Criteria	Compliance requirement
RB 4-1 Noise Level	<u>Site Requirements</u> <ul style="list-style-type: none"> Determine the noise level of the applicable spaces using measured and/or monitored operation data and demonstrate compliance with the committed design specifications.
RB 4-2 Indoor Air Pollutants	<u>Documentary Evidences</u> <ul style="list-style-type: none"> Purchase orders/ delivery orders of low VOC paints and/or adhesive certified under SGLS to demonstrate compliance with the committed design specifications. Product catalogue as supplementary documents to PO/DO for making reference of the SGLS products specifications.
RB 4-3 Waste Disposal	<u>Site Requirements</u> <ul style="list-style-type: none"> Demonstrate compliance with the committed design specifications making reference to the as-built drawings.

Part 5 Other Green Features

Criteria	Compliance requirement
RB 5-1 Green Features and Innovations	<u>Site Requirement</u> <ul style="list-style-type: none"> Demonstrate the implementation and functionalities of the green features and determine compliance with the committed design specifications.

7. VERIFICATION AUDIT WORKFLOW FOR GREEN MARK CERTIFICATION PROJECTS – STAGE 2 VERIFICATION AUDIT WORKFLOW



8. VERIFICATION AUDIT FOR GREEN MARK CERTIFICATION PROJECTS – STAGE 2 VERIFICATION AUDIT COMPLIANCE REQUIREMENT

A) Validation of Committed Energy Savings

- When the building starts to operate in a steady state, the developer shall within 2 years after TOP, commence to gather data on actual site operation for the next 12 months period. Using the data on actual site operation, a revised energy modelling shall be performed to compare the annual energy consumption of the Reference Model with the actual consumption of the building.

B) Documentary evidences

- The developer should submit Green Mark Certification – Stage 2 Verification Audit Report of content in accordance to Appendix C.

9. VERIFICATION AUDIT FOR GOVERNMENT LAND SALES PROGRAMME PROJECTS – VERIFICATION AUDIT COMPLIANCE REQUIREMENT

For building development under the Government Land Sales Programme, the building development will be subjected to the Building Control (Environmental Sustainability) Regulations 2008 under Section 4(1)(c). Please make arrangements with the Green Mark lead assessor before TOP application, or earlier, for site verification once the building systems are commissioned. Please note that for building development, the issuance of TOP is condition on the project meeting its environmental sustainability performance which must be validated through site verification.

VERIFICATION AUDIT FOR PROJECTS THAT ARE SUBJECT TO MANDATORY HIGHER GREEN MARK STANDARD UNDER GOVERNMENT LAND SALES PROGRAMMES IN SELECTED STRATEGIC AREAS

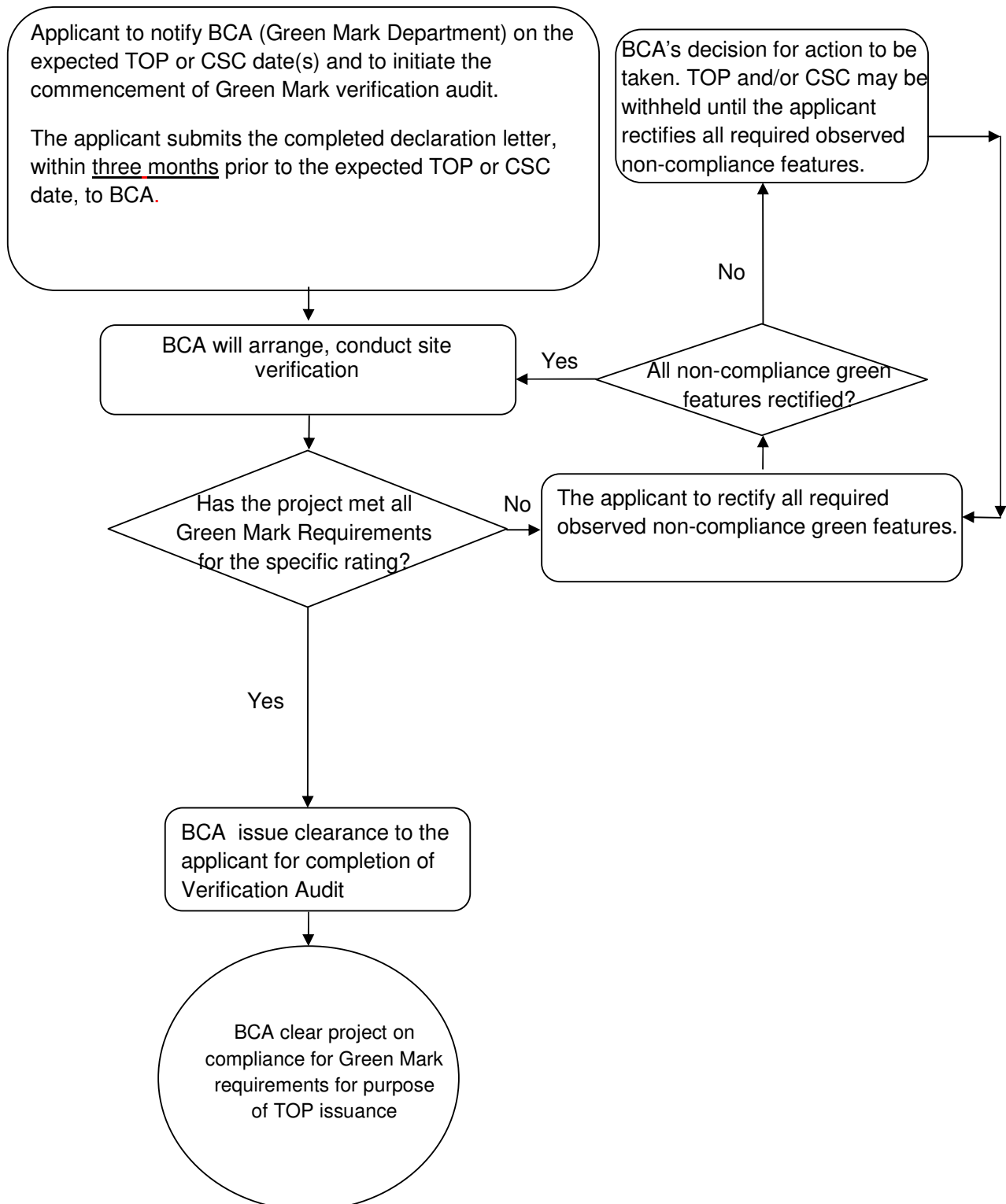
Projects that are developed on land sold under the Government Land Sales (GLS) Programme sites in the selected strategic areas will be subject to higher Green Mark Standards under the Building Control (Environmental Sustainability) Regulations 2008. The building works subject to this requirement are to be designed and certified to meet the prescribed Green Mark rating as shown in the following table.

Selected Strategic Areas <i>Exact Location to refer to the Building Control (Environmental Sustainability) Regulations 2008</i>	Requirements for building wholly or partly within area that is on land sold under the Government Land Sales Programme
Marina Bay	Green Mark Platinum Rating
Downtown Core – including areas within the CBD located next to Marina Bay	Green Mark Gold ^{Plus} Rating
Jurong Lake District	Green Mark Gold ^{Plus} Rating
Kallang Riverside	Green Mark Gold ^{Plus} Rating
Paya Lebar Central	Green Mark Gold ^{Plus} Rating

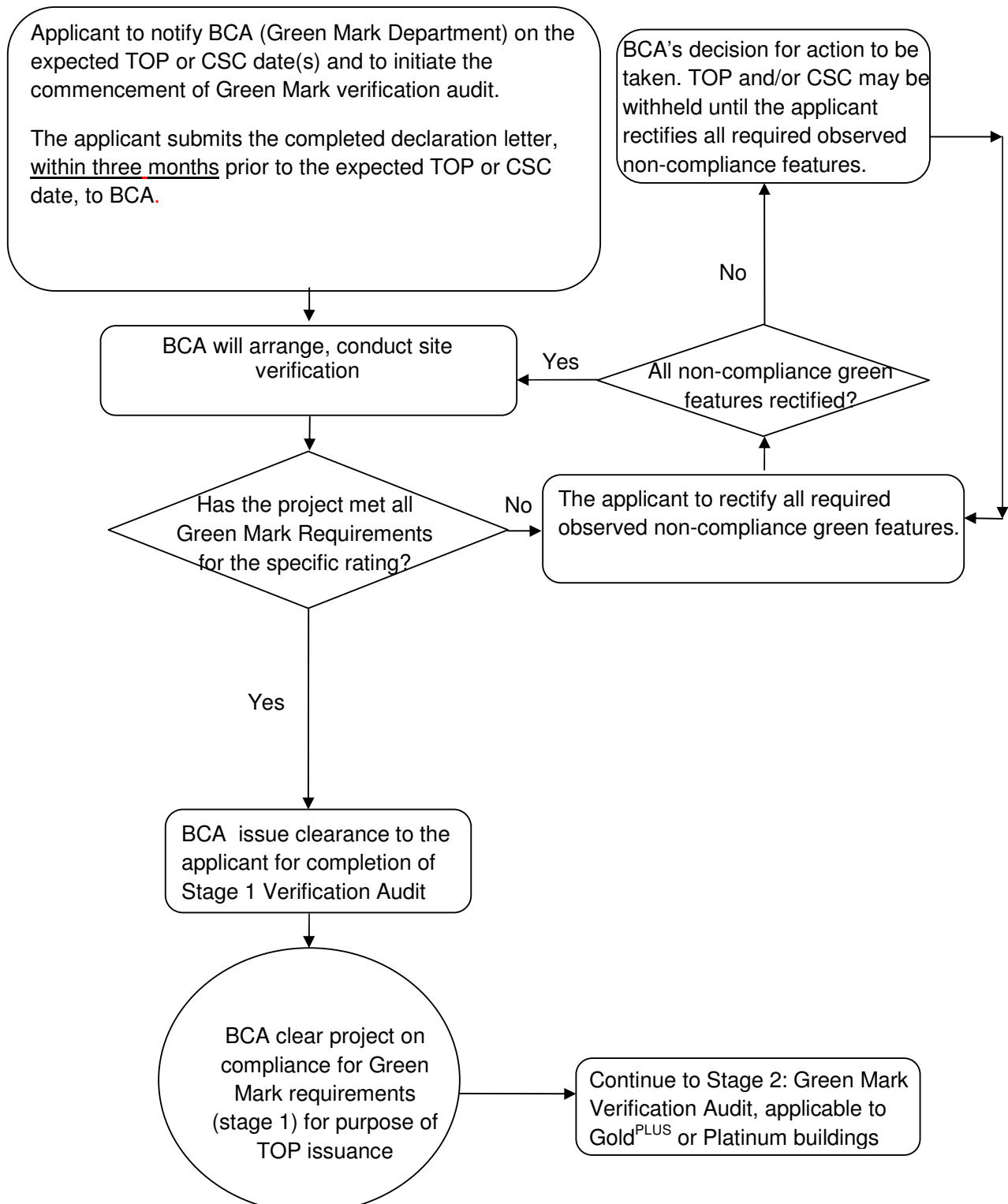
Upon completion of building works and commissioning of building system, the Qualified Person must inform the Green Mark Lead Assessor for the project to arrange for site verification before Temporary Occupation Permit (TOP) or Certificate of Statutory Completion (CSC) application whichever earlier.

It is important to note that the prescribed Green Mark Certification rating for the building has to be obtained and verified before a TOP/ CSC can be granted.

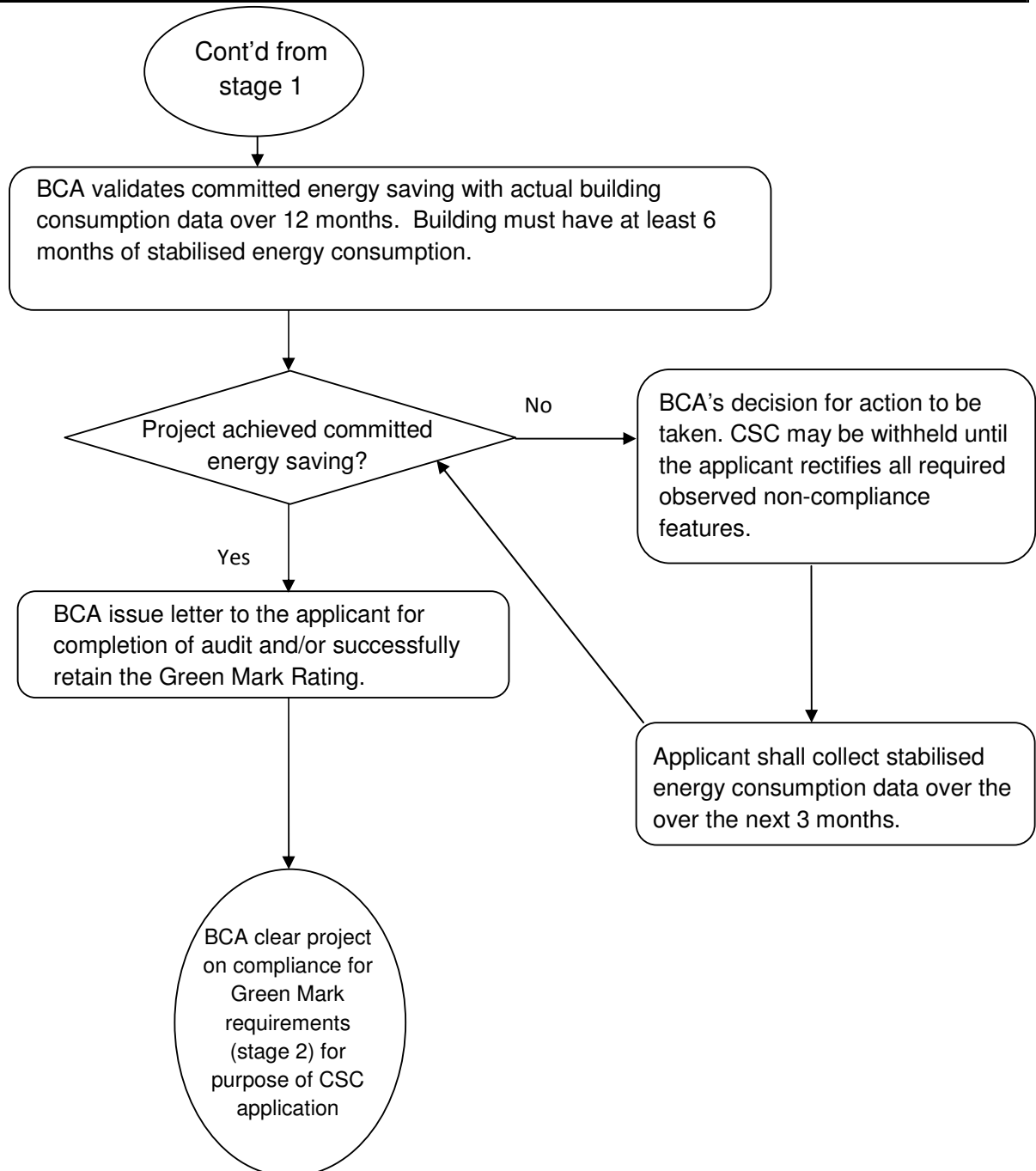
10. VERIFICATION AUDIT WORKFLOW FOR GOVERNMENT LAND SALES PROGRAMME PROJECTS (RESIDENTIAL) – SINGLE STAGE VERIFICATION AUDIT WORKFLOW



11. VERIFICATION AUDIT WORKFLOW FOR GOVERNMENT LAND SALES PROGRAMME PROJECTS (NON-RESIDENTIAL) – STAGE 1 VERIFICATION AUDIT WORKFLOW



12. VERIFICATION AUDIT WORKFLOW FOR GOVERNMENT LAND SALES PROGRAMME PROJECTS (NON-RESIDENTIAL) – STAGE 2 VERIFICATION AUDIT WORKFLOW (Applicable to Green Mark Gold^{PLUS} or Platinum buildings)



GREEN MARK FOR BUILDINGS**SITE VERIFICATION - DECLARATION LETTER**

(Date)

Director
Green Mark Department (New Development)
Building and Construction Authority
5 Maxwell Road
#17-00 Tower Block MND Complex
Singapore 069110

Dear Sir/ Madam,

DECLARATION ON GREEN MARK FEATURES IMPLEMENTED IN (project name)

We hereby declare the list of variations in project design and green features incorporated in the above-mentioned development, tabulated in Table 1: Variation List of Features. This is made in comparison with those features committed during the Green Mark actual assessment, held on (actual assessment dates).

Moreover, additional green feature(s) incorporated in the development which are not highlighted during the actual assessment, are listed in Table 2: List of Additional Features.

Besides the above-mentioned listed green features, we declare that there is no other variation in the project design and green features incorporated in the development as per commitment made during the actual assessment. Should there be any queries, please do not hesitate to contact us.

Thank you.

Yours faithfully,

(Person-in-charge)

(Company Name, Designation)

(Contact No., email address)

Table 1: Variation List of Features

[illegible]

Table 2: List of Additional Features

[illegible]

PROJECT INFORMATION:

Names of Contact Person for Site Verification	DID/ HP	Email Address

Date: DD/MM/YEAR

OPERATING SYSTEM EFFICIENCY REPORT

FOR

ENTER BUILDING NAME

Contents

- 1.0 Building Information**
- 2.0 Operating System Efficiency Information**
- 3.0 Chilled Water Plant information**
 - 3.1 Chilled Water Plant Normal Operating Hours
- 4.0 Instrumentations**
- 5.0 Chiller Plant Performance Analysis**
 - 5.1 Summary of Chilled Water Plant Performance
- 6.0 Summary of Heat Balance**

Table 1: Chiller Information (Example)

Table 2: Ancillary equipment Information (Example)

Table 3: Instrumentation Table (Example)

Table 4: Breakdown of chilled water plant efficiency

Table 5: Heat Balance Summary

Figure 1: Super-imposed plot of daily Cooling Load Profile (Example)

Figure 2: Histogram of Cooling Load Occurrences (Example)

Figure 3: Super-imposed plot of daily chiller plant efficiency (Example)

Figure 4: Scatter plot of chiller plant efficiency over cooling load (Example)

Figure 5: System Level Heat Balance Plot (Example)

1.0 Building Information

Enter a brief description of the building here.

Building Name :

Building Address :

Postal Code :

Building Type :

Gross floor area (GFA), m² :

Air conditioned area, m² :

2.0 Operating System Efficiency Information

Location : Enter location of chilled water plant

Date of submission in notice : Enter submission deadline stipulated in BCA notice

Data Logging Interval : 1 minute sampling

Trend Logged Parameters* :

- Chilled Water Supply main header temperature
- Chilled Water Return main header temperature
- Chilled Water flow rate at chilled water return main header
- Condenser Water Supply main header temperature
- Condenser Water Return main header temperature
- Condenser water flow rate at chilled water return main header
- Power input to Chiller(s)
- Power input to Chilled water pump(s)
- Power input to Condenser water pump(s)
- Power input to Cooling tower(s)

** Trend logged parameters are not limited to the above and may vary depending on the piping and electrical circuit design.*

3.0 Chilled Water Plant information*

Table 1: Chiller Information (Example)

APPENDIX B

ID	Description	Type	Name plate motor (kW)	Cooling Capacity (RT)	Chilled water LWT	Chilled water ΔT	Rated Efficiency kW/RT	Year Installed
CH01	Chiller 1	Centrifugal	150	1000	6.7 °C	5.5°C	0.55	2012
CH02	Chiller 2	VSD Screw	90	500	6.7 °C	5.5°C	0.52	2012

ID	Description	Name plate motor (kW)	Pump Head (m)	Flow rate (L/S)	Rated Pump/ Fan efficiency	Rated Motor Efficiency
CHWP01	Chilled water pump 1	55	30	151.2	85%	95%
CHWP02	Chilled water pump 2	30	30	75.6	85%	95%
CWP01	Condenser water pump 1	45	20	189	85%	95%
CWP02	Condenser water pump 2	22	20	94.5	85%	95%
CT01	Cooling tower 1	45	-	130	75%	92%
CT02	Cooling tower 2	45	-	130	75%	92%

Table 2: Ancillary equipment Information (Example)

**Based on equipment design specifications and name plate ratings.*

3.1 Chilled Water Plant Normal Operating Hours

Monday to Friday : 0730 – 1900 Hrs

Saturday : 0730 – 1300 Hrs

Sunday : No operations

Note: The operating hours should follow the table in clause 6.1.4

4.0 Instrumentations

Accurate measuring instruments complying with the Green Mark Version 4.1 (*or state relevant version*) criteria for non-residential buildings were used during the audit to gather information on the power consumption, temperatures and flow rate.

The points of measurements are listed in the following table:

ID	Description	Sensor Type	Installation Location	Measurement/ Calibration range	End to End Measurement Uncertainty (°C or %)	Last Calibration Date
TT01	CHWS Temperature	10K Ω Thermistor	CHWS Header	0°C - 40°C	± 0.03 °C	15/10/2012
TT02	CHWR Temperature	10K Ω Thermistor	CHWR Header	0°C - 40°C	± 0.03 °C	15/10/2012
TT03	CWS Temperature	10K Ω Thermistor	CWS Header	0°C - 40°C	± 0.03 °C	15/10/2012
TT04	CWR Temperature	10K Ω Thermistor	CWR Header	0°C - 40°C	± 0.03 °C	15/10/2012
FM01	CHW Flow	Magnetic Full Bore	CHWR Header	30 l/s- 200 l/s	0.5%	20/10/2012
FM02	CW Flow	Magnetic Full Bore	CWR Header	30 l/s- 200 l/s	0.5%	20/10/2012
kW01	Chiller 1 Power	True RMS, 3 phase	ACMSB1	60 – 600 kW	0.5%	30/10/2012
kW02	Chiller 2 Power	True RMS, 3 phase	ACMSB2	60 – 600 kW	0.5%	30/10/2012
kW03	CHW Pump 1 & 2 Power	True RMS, 3 phase		20 – 200 kW	0.5%	30/10/2012
kW04	CW Pump 1 & 2 Power	True RMS, 3 phase	CHW SB	20 – 200 kW	0.5%	30/10/2012
kW05	CT 1 & 2 Power	True RMS, 3 phase	CT Panel	15 – 150 kW	0.5%	30/10/2012

Table 3: Instrumentation Table (Example)

5.0 Chiller Plant Performance Analysis

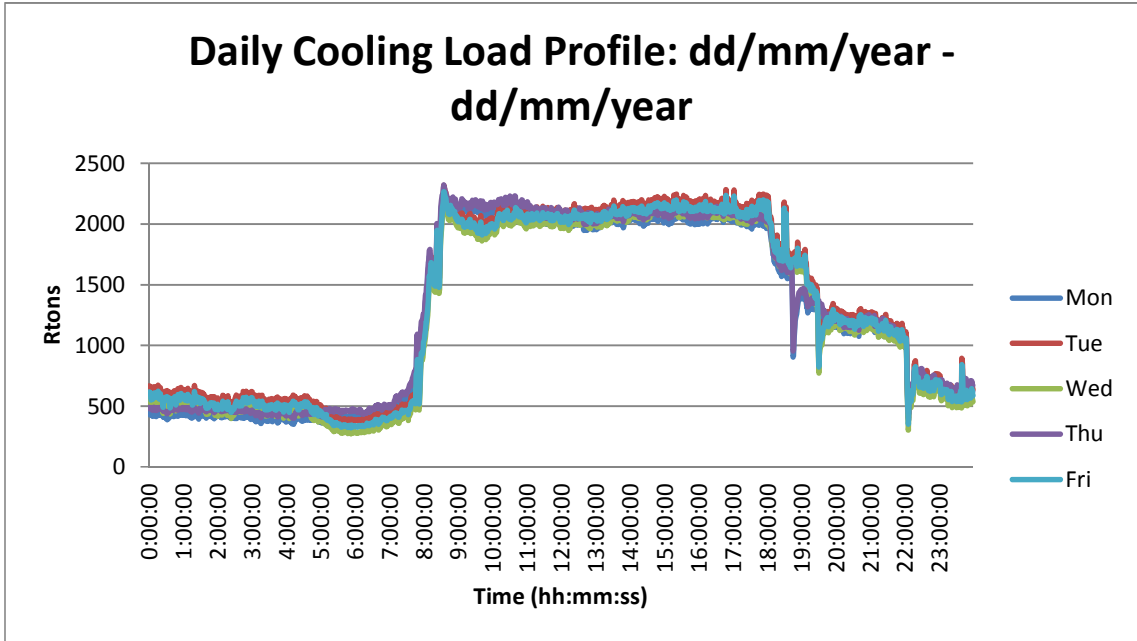


Figure 1: Super-imposed plot of daily Cooling Load Profile (Example)

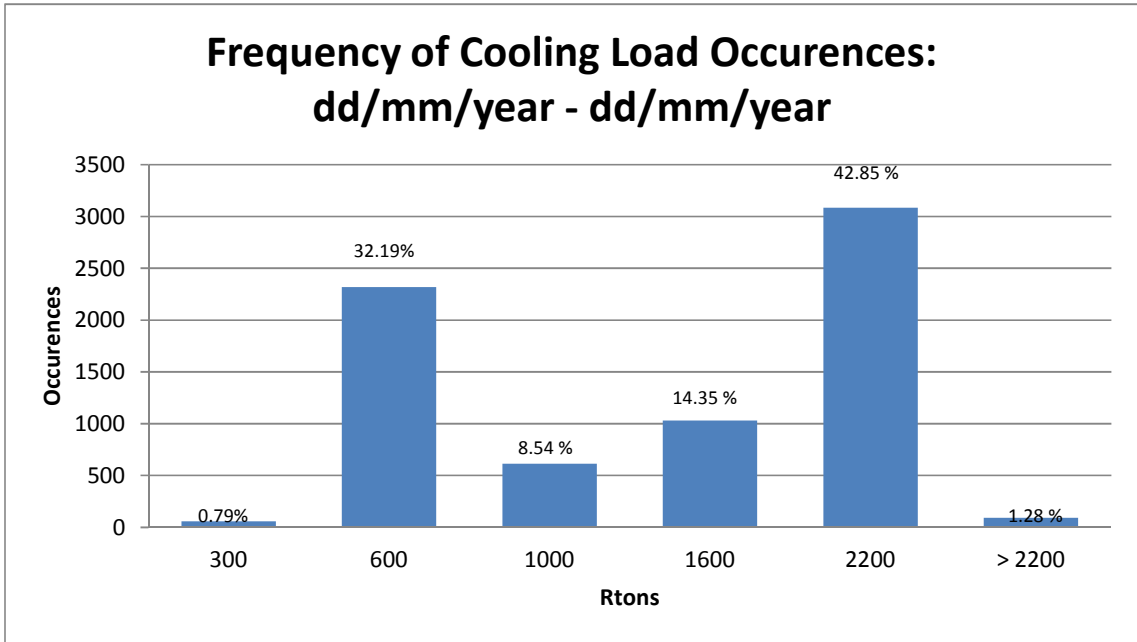


Figure 2: Histogram of Cooling Load Occurrences (Example)

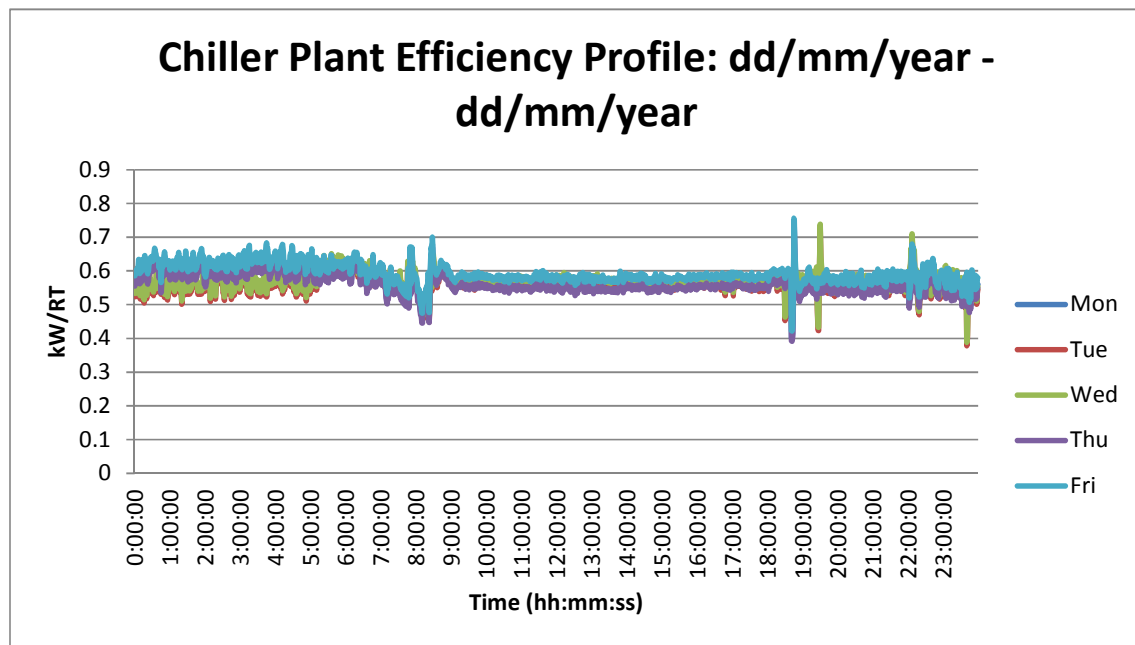


Figure 3: Super-imposed plot of daily chiller plant efficiency

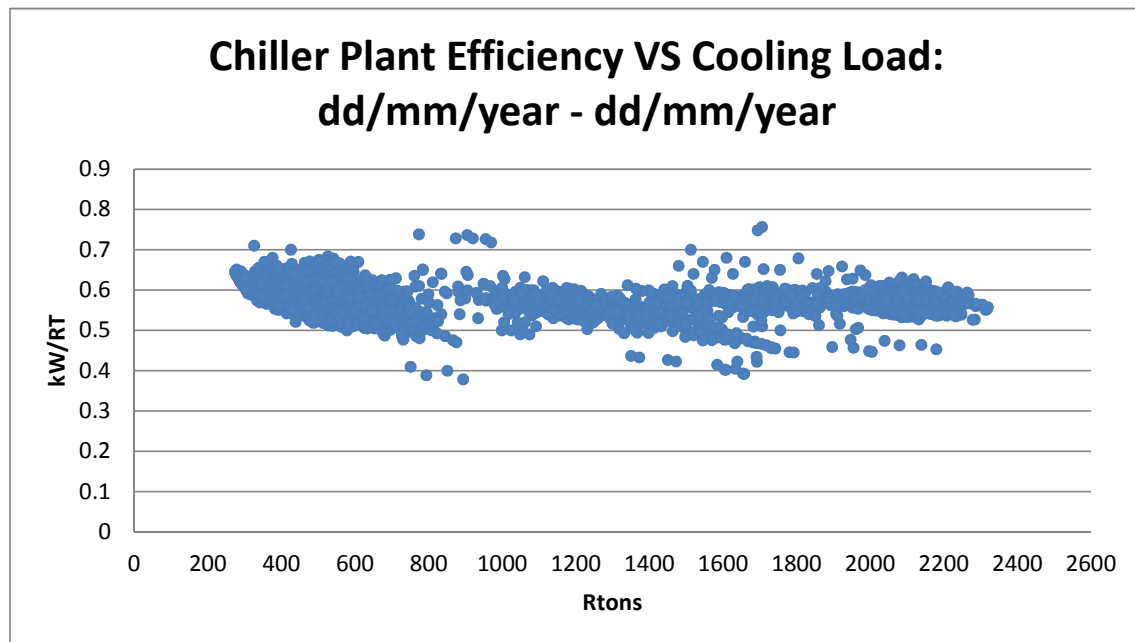


Figure 4: Scatter plot of chiller plant efficiency over cooling load

12.1 5.1 Summary of Chilled Water Plant Performance

	Unit	Unit
Chiller(s) efficiency		kW/RT

Chilled water pump(s) efficiency		kW/RT
Condenser water pump(s)*		kW/RT
Cooling tower (s)Efficiency*		kW/RT
Overall chiller plant efficiency		kW/RT

*Not applicable to air-cooled chilled water plant

6.0 Summary of Heat Balance

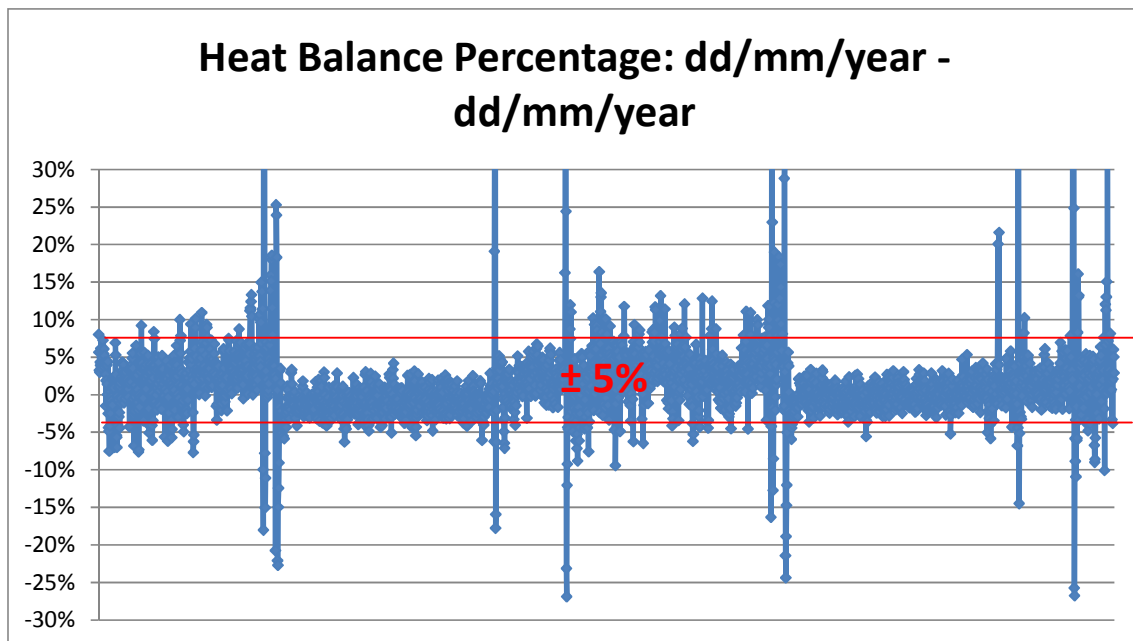


Figure 5: System Level Heat Balance Plot

	Quantity	Unit	Formula
Sum of total electrical energy used		kWh	(A)
Sum of total cooling produced		RTh	(B)
Sum of total heat rejected		RTh	(C)
Chiller Plant Efficiency		kW/RT	(A) / (B)
Total Heat Balance Data Count		-	(D)
Data Count > + 5% error		-	(E)
Data Count < - 5% error		-	(F)
Data Count within ±5% error		-	(G) = (D) – (E) – (F)
% Heat Balance within ±5% error		%	100 x (G) / (D)

Table 4: Heat Balance Summary

Green Mark Certification – Stage 2 Verification Audit Submission Report Content

The project developer or building owner should submit Stage 2 Verification Audit Report of at least, but not be limited to, the following content:

- 1) EM Form 2: Submission Form for Energy Modeling for Green mark Scheme (Validation After Project Completion) - Appendix D
- 2) Electricity bills (landlord and/or tenant bills if applicable)
- 3) Operating System Efficiency Report – Appendix B
- 4) As-built Electrical Single-line Schematics drawings
- 5) Description of deviations of the building operations to the Proposed Energy Model which was submitted for Green Mark Certification e.g. monthly building occupancy rate, receptacle loads, data centre addition etc.
- 6) BMS data log for the individual energy end use as in FORM EM – 2.2: Summary of Actual Consumption of Energy Use; kWh raw data in softcopy Microsoft Excel file format and categorized according to the meters as-built schematics design.
- 7) Temporary logging of energy end use as in FORM EM – 2.2: Summary of Actual Consumption of Energy Use; kWh raw data in softcopy Microsoft Excel file format.
- 8) Data Centre **Monthly** Energy Consumption - kWh raw data in softcopy (if applicable).
- 9) BMS **Hourly** and **Monthly** data log for renewable energy generation
- 10) For **Actual** Building Operations, state:
 - (i) operation hours for the spaces using the cooling load profiles
 - (ii) operation of chiller plant
 - Operating hours
 - Installed capacity
 - Duty and standby
 - Latest 1- week building cooling load
 - latest 1-week chiller plant efficiency profile
 - (iii) operation hours of other air-con systems e.g. unitary system for after office hours cooling demand
 - Spaces with after office hours demand
 - (iv) human load schedules
 - (v) lighting schedules
- 11) EEI Calculation

12) For **Reference Energy Model, state:**

- (i) operation hours for the spaces (Must be similar to actual operation)
- (ii) operation of chiller plant
 - capacity and configuration in simulation
 - simulated 1- week building cooling load
 - simulated 1-week chiller plant efficiency profile
- (iii) Operation hours of other air-con systems e.g. unitary system for after office hours cooling demand (Must be similar to actual operation)
 - Spaces with after office hours demand
- (iv) Human load schedules (Must be similar to actual operation)
- (v) Simulation file in softcopy

13) For GMIS projects, Form GMIS-1: Submission Form for energy Modeling for Green Mark Incentive Scheme (Finalisation of Building Design)

Form EM-2: Submission Form for Energy Modeling For Green Mark Scheme (Verification After Project Completion)				
Green Mark Department (New Development) Building & Construction Authority 5 Maxwell Road #16-00 Tower Block, MND Complex Singapore 069110	INSTRUCTIONS: (1) Please refer to the Explanatory Notes attached before completing the form. (2) Use a separate set of forms for each building. (3) *Delete accordingly			
Project	Ref.	No.:		
<hr/>				
Description	of	Building	/	Building Works:
<hr/>				
<hr/>				
<hr/>				
<hr/>				
*Lot / Plot *TS / MK				
<hr/>				
Address / Road : <hr/>				
<hr/>				
(1) As the Qualified Persons responsible for the design of M&E services for the above mentioned project, we declare that: <ul style="list-style-type: none"> a. the energy modeling conducted for the project is in accordance with the requirements of BCA's Framework for Energy Modeling for Green Mark Scheme and b. based on the results of the energy modeling, the building's actual energy consumption is ____% lower than that of the revised Reference Model. 				
(2) We attach the following documentations to support the above declaration: <ul style="list-style-type: none"> a. Summary of Space and ETTV of the Building Envelope (<i>required if there is change</i>) (Form EM-2.1) b. Summary of Actual Consumption of Energy by End Use including Efficiency Indicators (Form EM-2.2) c. Summary printout from energy modeling software for the revised Reference Model (required if there is change in space use, scheduling or occupancy). 				
Name, Address, Email and Tel of M&E Consultancy Firm for the project		(1) Name & Signature of Qualified Person (Mechanical PE)		
		(2) Name & Signature of Qualified Person (Electrical PE)		

FORM EM-2.1: Summary of Space and ETTV of the Building Envelope*(required if there is a change)*

(A) Space Summary			
Building Use	Air-Conditioned Area (m2)	Non Air-Conditioned Area (m2)	Total Area (m2)
1. Office			
2. Toilets			
3. Storage			
4. Corridor			
5. Atrium			
6. Foodcourt			
7. Mechanical / Electrical			
8. Staircase			
9. Conference			
10. Retail Outlets			
11. Carpark			
12. Others			
<i>Total</i>			

Note: The building use floor areas for both the Reference and Actual Building must be the same.

(B) Building Envelope Summary - ETTV			
Orientation of Façade	Gross Area of External Walls (m ²)	Reference Model ETTV (W/m ²)	Actual Building ETTV (W/m ²)
North			
North-East			
East			
South-East			
South			
South-West			
West			
North-West			
Average ETTV of the Building Envelope (W/m²)		50 W/m ²	

FORM EM-2.2: Summary of Actual Consumption of Energy by End Use including Efficiency Indicators

End Use	Reference Model Energy Consumption (kWh)	Actual Building Energy Consumption (kWh)	Tolerance (%)
Lighting – (Air-Conditioned Space)			
Lighting- (Non Air-Conditioned Space)			
Receptacle Equipment			
¹ Air-Conditioned Plant			
² Air System Fans			
Mechanical Ventilation Fans			
Lifts			
Escalators			
Domestic Water Systems			
Others			
Total Building Energy Consumption			

Renewable Energy Sources

End Use	Energy Produced (kWh)	Reference Model Energy Consumption (kWh)	Actual Building Energy Consumption (kWh)	Tolerance (%)
Photovoltaics				
Others				
Total Building Energy Consumption including Renewable Energy Sources				

¹ Chilled Water System (chillers, water pumps and cooling towers)

² Chilled water Air Handling and Fan Coil units

Building Energy Performance/ Operation Indicators

Efficiency Indicators	Reference Model	Actual Building
Total Energy Efficiency Index, EEI (kWh/m²/yr)		
Normalised Energy Efficiency Index, EEI (kWh/m²/yr) *		
System Efficiency of Air-Conditioned Plant (kW/RT)		
Air System Fans (kW/RT)		
Cooling Load Density (W/m²)		
Lighting and Receptacle Equipment System Efficiency (W/m²)		
Office		
Hotel		
Retail Mall – Retail Space		
Retail Mall – F&B Space		
Hospital		

***Normalised EEI Formula**

$$\text{Normalised EEI} = [(TBEC - DCEC) / (GFA - DCA)] \times (NF / OH)$$

Where:

- (a) TBEC : Total building energy consumption (kWh/year)
- (b) DCEC : Data centre energy consumption (kWh/year)
- (c) GFA : Gross floor area (m²)
- (d) DCA : Data centre area (m²)
- (e) NF : Normalising factor based on a typical weekly **55** operating hours (hrs/week)
- (f) OH : Weighted weekly operating hours (hrs/week)

Note:

- (1) All major energy consumption of equipments are to be included
- (2) EEI is to be normalized to 100% occupancy rate

EXPLANATORY NOTES FOR APPENDIX B – SUBMISSION FORM FOR ENERGY MODELING FOR GREEN MARK SCHEME (Validation After Project Completion)

To facilitate verification of the declared energy consumption, the submission forms shall be accompanied by the following:-

- (a) The detailed computation of the ETTV values for the Actual Building and revised Reference Model using APPENDICES 1 to 4 of “ETTV CALCULATION FORMAT IN RESPECT OF AN AIRCONDITIONED BUILDING” (*required if there is a change*).
- (b) Certification of the simulation program is tested in accordance to the ASHRAE Standard 140.
- (c) The input data of the simulation program for the revised Reference Model shall include:
 - 1. Space input data for all zones comprising detail information on construction materials and their properties designed for each individual zone. For example, room area, walls, windows, doors, floors, partitions, sensible and latent loads (lightings, occupancy rates, receptacles loads, Outdoor ventilation rates, misc loads etc).
 - 2. Schedules for each individual operating zone (eg. lighting, occupants, mechanical fans, AHUs, other mechanical and electrical equipment, etc.)

Note:

- 1. The developer shall furnish a softcopy of the executable input data file(s) used in the generation of the energy estimates for the Proposed and Reference models.
 - 2. The developer shall produce detailed shop drawings and other necessary information which is necessary for the comprehensive evaluation of the energy modeling before awarding the Green Mark Scheme, as and when requested by BCA.
- (d) The output data of the simulation program for the revised Reference Model shall include:
 - 1. Monthly energy consumption by Mechanical and Electrical system components (eg. Air-Conditioned Systems, Lighting Systems, Receptacle Equipment, Lifts, Escalators, etc).
 - (e) The FORM EM- 2 shall be signed by the Qualified Persons (both Mechanical and Electrical Professional Engineers) for the project.