Building and Construction Authority

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Technology Development Division

DID : 6804 4721

Fax : 6334 2561

E-mail : Leong-Kok_Su_Ming@bca.gov.sg

Dear Sir / Madam,

CIRCULAR ON BCA GREEN MARK CERTIFICATION STANDARD FOR NEW NON-RESIDENTIAL BUILDINGS (GM VERSION 4.1) CLARIFICATIONS TO APPENDIX E, ENERGY MODELLING METHODOLOGY AND REQUIREMENTS

Objective

1. This circular is to clarify on the common questions raised on the requirements of Energy Modelling under Green Mark Version 4.1.

Background

2. The purpose of Energy Modelling is to adopt an integrated approach to building design in order to improve energy efficiency and achieve a superior performance in energy consumption. Improvement in energy consumption is measured by comparing the annual power consumption of the Proposed Model (design building) against the Reference Model (baseline building). For Green Mark Gold^{PLUS} buildings, the simulation results from the Proposed Model must show at least 25% savings in annual energy consumption compared to the Reference Model. For Green Mark Platinum buildings, the simulation results from the Proposed Model must show at least 30% savings in annual energy consumption compared to the Reference Model.

This circular is to clarify on the requirements in Appendix E, Energy Modelling Methodology and Requirement of Green Mark standards for New Non-Residential building (GM Version 4.1).

List of Annex

Annex A Summary of the Clarifications

For Clarification

10. We would appreciate it if you could convey the contents of this circular to the members of your organisation. For clarification, you may email bca_enquiry@bca.gov.sg or contact the following officers:

Name	**Email**
Chris Tay	Chris_TAY@bca.gov.sg
Leow Yock Keng	LEOW_Yock_Keng@bca.gov.sg
Dr Li Ruixin	LI_Ruixin@bca.gov.sg

Thank you.

Yours faithfully,

LEONG-KOK SU MING

DIRECTOR

GREEN MARK DEPARTMENT (NEW DEVELOPMENT)

BUILDING AND CONSTRUCTION AUTHORITY

Annex A

Summary of the Clarifications

Green Mark for New Non-Residential Building Criteria - Appendix E

Energy Modelling Methodology and Requirements

Criteria / Requirements	Green Mark Version NRB 4.1	Clarifications
2.1 Air-conditioning and Mechanical Ventilation (ACMV) System	Reference system to be used will be based on the peak building cooling load: (i) For buildings with peak building cooling load of 500 RT or more, the reference system will be centrifugal chiller. (ii) For buildings with peak building cooling load of less than 500RT, the reference system will be screw chiller. (iii) For buildings with peak building cooling load of less than 500RT and the air-conditioned floor areas is less than 5000 m^2, the reference system will be of the same type as the proposed system. For VRV system, the baseline of constant COP of 3.37 (for Version 4.1) shall be adopted.	(i) Peak building cooling load ≥ 500 RT (a) 1 number x centrifugal chiller (less than 800 RT per chiller) (b) N numbers x centrifugal chiller (equally sized with less than 800 RT per chiller) (ii) Peak cooling load < 500 RT and A/C areas ≥ 5000 m^2 (a) 1 number x screw chiller (if peak cooling load is less than 300 RT per chiller) 2 x screw chiller equally sized (equally sized with equal or more than 300 tons per chiller) (iii) Peak building cooling load < 500 RT and A/C areas < 5000 m^2 (a) same as proposed Reference to ASHRAE 90.1, Table G3.1.3.7, Type and Number of Chillers Additional chiller or A/C configuration to be considered if baseline chiller is running at less than 50% loading for more than 20% of the time.

<table>
<tr><th>Criteria / Requirements</th><th>Green Mark Version NRB 4.1</th><th>Clarifications</th></tr>
<tr><td>2.2 Chiller Efficiency and Efficiency Curve</td><td>SS 530 – Code of Practice for Energy Efficiency Standard for Building Services and Equipment</td><td>
<u>Default Chiller Curve and Chiller Configuration (Reference SS503:2006 for GM version 4.1)</u>

Based on chilled water supply temperature at 6.67°C and condenser temperature of 29.44°C
<table>
<tr><th rowspan="2">Equipment Type</th><th rowspan="2">Size Category</th><th colspan="10">COP</th></tr>
<tr><th>10%</th><th>20%</th><th>30%</th><th>40%</th><th>50%</th><th>60%</th><th>70%</th><th>80%</th><th>90%</th><th>100%</th></tr>
<tr><td rowspan="3">Rotary Screw and Scroll</td><td><528kW</td><td>2.994</td><td>3.413</td><td>3.622</td><td>3.772</td><td>3.897</td><td>4.012</td><td>4.122</td><td>4.230</td><td>4.339</td><td>4.450</td></tr>
<tr><td>≥ 528kW and < 1055 kW</td><td>3.297</td><td>3.758</td><td>3.989</td><td>4.153</td><td>4.291</td><td>4.418</td><td>4.539</td><td>4.658</td><td>4.778</td><td>4.900</td></tr>
<tr><td>≥ 1055 kW</td><td>3.700</td><td>4.218</td><td>4.477</td><td>4.662</td><td>4.817</td><td>4.959</td><td>5.095</td><td>5.229</td><td>5.363</td><td>5.500</td></tr>
<tr><td rowspan="3">Centrifugal</td><td><528kW</td><td>1.461</td><td>2.537</td><td>3.323</td><td>3.891</td><td>4.297</td><td>4.581</td><td>4.773</td><td>4.897</td><td>4.968</td><td>5.000</td></tr>
<tr><td>≥ 528kW and < 1055 kW</td><td>1.622</td><td>2.816</td><td>3.688</td><td>4.319</td><td>4.770</td><td>5.085</td><td>5.298</td><td>5.435</td><td>5.514</td><td>5.550</td></tr>
<tr><td>≥ 1055 kW</td><td>1.782</td><td>3.095</td><td>4.054</td><td>4.747</td><td>5.242</td><td>5.589</td><td>5.823</td><td>5.974</td><td>6.061</td><td>6.100</td></tr>
</table>
</td></tr>
</table>

Criteria / Requirements	Green Mark Version NRB 4.1	Clarifications
2.3 Air-conditioning Hydronic Systems	<u>Pumping system design criteria</u> For air-conditioning hydronic systems having a total pump system power exceeding 7.5 kW, the pump power limitation for chilled water systems shall be 349 kW/m^3/s. The pump power limitation for condensing water systems is 301 kW/m^3/s. Motors exceeding 15 kW shall have controls/ and/or devices that will result in pump motor demand of no more than 30% of design wattage at 50% of design water flow.	<u>VSD application for pumps</u> (i) Chilled water pump: (a) Pump with VSD, applicable for motors greater than 15kW. (b) Pump without VSD, applicable for motors less than 15kW. (ii) Condenser Water Pump: (a) Baseline shall be the equivalent of a constant speed pump.

Criteria / Requirements	Green Mark Version NRB 4.1	Clarifications
2.4 Cooling Tower	Performance requirement for heat rejection equipment. <u>Propeller or axial fan cooling towers</u> Cooling Tower performance shall not be less than 3.23 L/s/kW. <u>Centrifugal fan cooling towers</u> Cooling Tower performance shall not be less than 1.7 L/s/kW.	In the absence of a suitable reference, affinity law can be applied to derive the part-load efficiency of Cooling Tower with VSD. Minimum operating load at 25Hz.

Criteria / Requirements	Green Mark Version NRB 4.1	Clarifications
2.5 Air-conditioning Fan Systems	The ratio of fan system power to the supply fan air flow rate (main fan) of each Air-conditioning system at design conditions shall not exceed allowable fan system power. <u>Fan System design criteria</u> (a) For fan system having a motor nameplate power exceeding 4 kW, the fan power limitation in air-conditioning system that is the allowable fan system input power shall be as follows : (i) Constant volume shall not exceed 1.5 kW/m3/s (or 0.42 W/CMH) of supply air (ii) Variable volume shall not exceed 2.1 kW/m3/s (or 0.58 W/CMH) of supply (b) For fan system having a motor nameplate power not exceeding 4 kW, the allowable fan system input power shall not exceed 0.6 kW/m3/s (or 0.17 W/CMH) of supply air. <u>Part load fan power limitation</u> (c) Individual VAV fans with motors 11 kW	<u>Fan System design criteria</u> (a) For fan system having a motor nameplate power exceeding 4 kW. (i) No exception to the baseline for cases when proposed fan power exceeds the baseline power limitation. (b) For fan system having a motor nameplate power not exceeding 4 kW. (i) Exception to the baseline for cases when proposed fan power exceeds the baseline power limitation. Energy consumption of the proposed fan can be applied to the baseline. <u>Airflow Rate For Reference Model</u> (a) The airflow rate for baseline shall be based on the simulated results from the reference Model. (b) Exception: Fan Coil Unit(FCU) serving the hotel guest room can adopt the airflow rate of the proposed FCU if airflow rate simulated from the reference model is lower than the smallest FCU available. <u>VSD Application For Fans</u> (a) Variable Air Volume (VAV) system: (i) Baseline control strategy for VAV system shall come with VSD without exemption for small fans less than 11kW.

	and larger shall meet one of the following requirements: (i) Be driven by a mechanical or electrical variable speed drive or the fan shall be vane-axial fan with variable pitch blades; (ii) Have other controls and devices for the fan that will result in fan motor demand of less than 30% of design wattage at 50% of design air volume when static pressure setpoint equals one-third of the total design static pressure based on manufacturer's certified fan data.	(ii) Reference to ASHRAE 90.1, Table G3.1.3.15, Part-Load Performance for VAV Fan systems, Method 2 – Part-Load Fan Power Equation for part load fan power calculation, minimum operating load shall be cap at 25Hz. $$P_{fan} = 0.0013 + 0.1470 \times \mathrm{PLR}_{fan} + 0.9506 \times (\mathrm{PLR}_{fan})^2 - 0.0998 \times (\mathrm{PLR}_{fan})^3$$ where P_{fan} = fraction of full-load fan power and PLR_{fan} = fan part-load ratio (current L/s / design L/s) (b) Constant Air Volume (CAV): (i) Baseline control strategy for CAV system shall be constant speed. Baseline for FCU serving the hotel room shall be a CAV system.

Criteria / Requirements	Green Mark Version NRB 4.1	Clarifications
2.6 Mechanical Ventilation Fan Systems	The ratio of fan system to the supply fan air flow rate (main fan) of each mechanical ventilation system at design conditions shall not exceed allowable fan system power. <u>Fan system design criteria</u> (a) For fan system having a motor nameplate power exceeding 4 kW, the fan power limitation in air-conditioning system that is the allowable fan system input power shall not exceed 1.5 kW/m^3/s (or 0.42 W/CMH) of supply air (b) For fan system having a motor nameplate power not exceeding 4 kW, fan system input power shall not exceed 0.6 kW/m^3/s (or 0.17 W/CMH) of supply air. <u>Part load fan power limitation</u> (c) Individual VAV fans with motors 11 kW and larger shall meet one of the following requirements: (i) Be driven by a mechanical or electrical variable speed drive or the fan shall be vane-axial fan with variable pitch blades; (ii) Have other controls and devices for the fan that will result in fan motor demand of less than 30% of design wattage at 50% of design air volume when static pressure setpoint equals one-third of the total design static pressure based	<u>Fan System design criteria</u> (c) For fan system having a motor nameplate power exceeding 4 kW. (ii) No exception to the baseline for cases when proposed fan power exceeds the baseline power limitation. (d) For fan system having a motor nameplate power not exceeding 4 kW. (ii) Exception to the baseline for cases when proposed fan power exceeds the baseline power limitation, and to apply the energy consumption of the proposed fan to the baseline. <u>Airflow Rate For Reference Model</u> (c) The airflow rate for baseline shall be based on the simulated results from the reference Model. (d) Exception: Fan Coil Unit(FCU) serving the hotel guest room can adopt the airflow rate of the proposed FCU if airflow rate simulated from the reference model is lower than the smallest FCU available. <u>VSD Application For Fans</u> (c) Variable Air Volume (VAV) system: (iii) Baseline control strategy for VAV system shall come with VSD without exemption for small fans less than 11kW.

	on manufacturer's certified fan data.	(iv) Reference to ASHRAE 90.1, Table G3.1.3.15, Part-Load Performance for VAV Fan systems, Method 2 – Part-Load Fan Power Equation for part load fan power calculation, minimum operating load at 25Hz. $P_{fan} = 0.0013 + 0.1470 \times \mathrm{PLR}_{fan} + 0.9506 \times (\mathrm{PLR}_{fan})^2 - 0.0998 \times (\mathrm{PLR}_{fan})^3$ where P_{fan} = fraction of full-load fan power and PLR_{fan} = fan part-load ratio (current L/s / design L/s) (d) Constant Air Volume (CAV): Baseline control strategy for CAV system shall be constant speed. Baseline for FCU serving the hotel room shall be a CAV system.
Criteria / Requirements	**Green Mark Version NRB 4.1**	**Clarifications**
2.8 Water Heaters	Water heating equipment efficiency and performance stated in SS 530.	For domestic hot water (for general consumption), the baseline COP of 1 shall be adopted. Note: Adequate meters shall be installed to measure and justify the energy savings claimed from the operational demand at verification.