Appendix A

ENERGY MODELING METHODOLOGY AND REQUIREMENTS

Revision	Description	Date Effective
1.1	Issued for implementation (With NRB 1.1)	1st June 2013
1.2	Revised version for implementation (With NRB 1.2)	1st June 2014
2.0	Revised version for implementation (With NRB 2.0)	1st June 2015
3.0	Revised version for implementation (With NRB 3.0)	1st October 2015
3.1	Revised version for implementation (With NRB 3.0)	15th March 2018
3.2	Revised version for implementation	1st July 2020

A1 General

The energy modeling for evaluating the energy performance of a building should be carried out in a prescribed manner to quantify the potential savings over the Reference Model.

A2 Simulation Software

The simulation software used for energy modeling should meet the following criteria:

(a) It must have the capability to model the thermal performance of buildings in a multi-zone format and calculate the building's total energy consumption over a continuous 12-months period.

(b) It must be tested by a recognized institution in accordance to the Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs – ANSI/ASHRAE STD 140 or another equivalent standard.

A3 Reference Model

The simulation model for calculating the baseline building performance (known as Reference Model) shall be developed in accordance with the requirements in the following Table A3.

Table A3: Baseline Standard

<table>
<tr><th>S/No.</th><th>Component</th><th>Baseline Standard</th><th>Minimum Requirement</th></tr>
<tr><td>1</td><td>Building Envelope Design</td><td>MS1525:2019

MS 1525:2019 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice (Chapter 5.5 - Roofs)</td><td>(a) OTTV shall not exceed 50 W/m²

(b) For roof with skylight, RTTV shall not exceed 50 W/m²

(c) For roof with skylight, the average U value of the gross area of the roof shall not exceed the limit below :

Maximum Thermal Transmittance for Roof of air-conditioned buildings
<table>
<tr><th>Roof Weight Group</th><th>Maximum U-Value (W/m²K)</th></tr>
<tr><td>Light (Under 50 kg/m²)</td><td>0.4</td></tr>
<tr><td>Heavy (Above 50 kg/m²)</td><td>0.6</td></tr>
</table>
(d) All windows on the building envelope shall not exceed the air leakage rates specified in MS1525:2019 Item 5 Air Leakage

(e) Where the door opening of any commercial unit is located along the perimeter of the building envelope, that unit shall:-

(i) be completely separated from the other parts of the building ; and

(ii) has its air-conditioning system separated from and independent of the central system</td></tr>
</table>

S/No.	Component	Baseline Standard	Minimum Requirement
2	Chiller Efficiency	MS1525:2019	Minimum energy efficiency standard stated (a) Refer to GreenRE assessors for baseline chiller efficiency curve
3	Pump Efficiency (for chilled water and condenser water)	MS1525:2019	Chiller Water Pump maximum power consumption shall not exceed 97 W/(m^3/h) Condenser Water Pump energy consumption shall not exceed 84 W/(m^3/h) <u>7.11.6 Pumping system design criteria</u> (a) Piping systems should be designed at a friction pressure loss rate of no more than 4.0m of water per 100 equivalent metre of pipe
4	Cooling Tower	ASHRAE 90.1 – Table 6.8.1G	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
5	Mechanical Fans	CP 13:1999 – Code of Practice for mechanical ventilation and air-conditioning in buildings (Cl 7.11.5 – Fan system design criteria)	Fan power shall not exceed 0.47 W per m^3/h and 0.74 per m^3/h for CAV and VAV system respectively. <u>7.11.5 Fan system design criteria</u> (a) For fan systems which provide a constant air volume whenever the fans are running, the power required by the motor for the combined fan system at design conditions shall not exceed 0.47 W per m^3/h of supply air (b) For fan systems which are able to vary system air volume automatically as a function of load, the power required by the motors for the combined fan system at design conditions shall not exceed 0.74 per m^3/h of supply air.
6	Lighting	MS 1525:2019 –Energy Efficiency and Use of Renewable Energy for Non-Residential Building - Code of Practice	(a) Lighting power budget (b) Stipulated luminance level

Important notes:

1. For industrial buildings, process loads shall be omitted from Reference and Proposed models. General office area (i.e 16 w/m2) power density shall be considered for process areas. Heat load from process loads shall be considered for proper estimation of HVAC system cooling performance.

2. For restaurants, kitchen equipment may be omitted from Reference and Proposed models. Heat load from kitchen equipment shall be considered for proper estimation of HVAC system cooling performance.

3. For receptacle loads, Table A below is for reference

Table A: Receptacle Loads	**Nominal Values**
Computer intensive Offices	22.0 W/m²
General Office Areas	16.0 W/m²
Large Conference areas	11.0 W/m
Server/Computer rooms	540.0 W/m²

4. Where there is no baseline standard for certain energy related features such as chilled beams, underfloor air distribution systems, receptacle loads, lifts and escalators, hot water systems, reference can be made to ASHRAE 90.1:2019 Appendix G. For buildings with special requirements where there is no reference based on ASHRAE 90.1:2019 Appendix G, the baseline set for similar building type can be considered.

5. Detailed calculations to be provided to justify the savings in energy consumption by salient energy efficient features/equipment, e.g. if sensors or VVVF motors are used in the Proposed Models. Where justification cannot be provided, the same input parameters for good design practice shall apply to both the Reference and Proposed Model. The potential energy savings shall be capped as per Table B below:

Table B: List of System / Devices	**Cap on Energy Savings**
Escalator	30%
Lift with regenerative features	18%
CO Sensors	15%
Occupancy Sensors	15%
Photo Sensors	15%
Renewable Energy	5%

6. Passive Design Features – For projects that demonstrate considerable efforts to reduce air-conditioning energy consumption, a cap of 3% of additional energy savings from passive design features over it's Reference model can be considered. For savings to be justified, design strategies that enhance ventilation and thermal comfort of the designated non-airconditioned spaces must be demonstrated. A written justification detailing the design strategies used and evidences accompanied with simulation and / or calculation of the energy saving estimate will be required for evaluation. Example would be circulation spaces such as atria if these spaces are sizeable and designed to be non-airconditioned.

A4 Energy Modelling Methodology

A4.1The simulation model of the proposed design (known as Proposed Model) shall be developed in accordance with the design parameters of the building. This includes:

(i) Building design layout in terms of shape, size and orientation.
(ii) Materials for walls, windows, roofs, floors, doors and permanent shading devices, internal partitions between conditioned and non-conditioned spaces.
(iii) Internal loads such as levels and schedules for occupancy, lighting systems, equipment, appliances and machinery within the building
(iv) ACMV equipment's, controls and other associated components selected for use in the building

A4.2 The Reference Model shall be developed using similar data as stated in paragraph A4.1

A4.3 The simulations for the Reference Model and Proposed Model shall be calculated using

(i) The same software
(ii) The same weather data[1]
(iii) The same operating schedules
(iv) The same occupancy rates
(v) The same building design in terms of shape, size and orientation
(vi) The same receptacle loads
(vii) The same indoor environmental conditions in terms of thermal comfort level[2], and
(viii) The same internal illuminance levels (lux) for space lightings

A4.4 The overall energy consumption of the Reference Model is to be computed over a period of one (1) year using the building envelope and all energy consuming equipment that are selected during the design stage. This includes energy consumed by chillers, air handling systems, plant equipment (e.g. water pumps, cooling towers, tube cleaning devices, chillers, etc.), and non-ACMV systems such as lightings, lifts, escalators, ceiling fans and receptacle loads from equipment (e.g. photo copiers, printers, fax machines, computers, laptops, fridges, projectors, audio-cum video system, water heaters, dryers, washers, etc). Similarly, the overall energy consumption of the Proposed Model can be computed over a period of one (1) year.

[1]Appropriate up-to-date weather set should be used for energy modeling such as ASHRAE's International Weather for Energy Calculation data for Malaysia.
[2]If a different condition such as higher space temperature is used in the Proposed Model, there must be evidence to demonstrate that the overall thermal comfort level is not lower than that of the Reference Model.

A4.5 The improved performance of the proposed building design can then be obtained by making comparison of the overall energy consumption of the Reference Model against the Proposed Model.

A4.6 The Energy Efficiency Index for both the Reference and Proposed Models shall also be computed. The details are as follows:

Calculation of EEI:

$$EEI = [(TBEC - CPEC) / (GFA_{\text{excluding carpark}} \times VCR)] \times (NF/OH)$$

Where:

(a) TBEC : Total building energy consumption (kWh/year)
(b) CPEC : Carpark energy consumption (kWh/year)
(c) GFA : Gross floor area (exclude car park area)(m^2)
(d) VCR : Weighted floor vacancy rate of gross lettable area (%)
(e) NF : Normalizing factor based on a typical weekly operating hour that is 52 Hrs/week
(f) OH : Weighted weekly operating hours (hrs/week)

A5 Documentation Requirements

A5.1 The Qualified Person (QP) and the appropriate practitioners shall certify that the energy modelling for the building has been carried out in accordance with the requirements using the Energy Modelling methodology. The appropriate practitioner shall ensure that the assumptions and inputs used for energy modelling are bona fide. Whilst the energy modelling specialist shall certify and be responsible for the correctness of the modelling included proper usage of the relevant software

A5.2 The QP and the appropriate practitioners shall ensure the following documents and records are available as evidences to demonstrate compliance with the energy modelling framework and validation of the potential energy savings during assessment. They are:

(a) Certification showing that the simulation software is tested and meet the criteria in accordance with the ASHRAE Standard 140

(b) Detailed drawings and other necessary information of proposed design

(c) Detailed system design calculation

(d) Summary of Space and OTTV of the Building Envelope as in Table A5.2-1(a) and Table A5.2-2(a)

(e) List of data such as
    i. 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.)
    ii. Schedules for each individual operating zone (e.g. lighting, occupants, mechanical fans, AHUs, other mechanical and electrical equipment, etc.)
    iii. Executable input data files used in the generation of the energy estimates for the Proposed and Reference Models
    iv. Output data on the monthly energy consumption by mechanical and electrical system components (e.g. Air-conditioned systems, Lighting systems, Receptacle equipment, Lifts, Escalators etc.)

(f) Detailed computation of the OTTV for both Reference and Proposed Models

(g) Comparison of Reference Model versus Proposed Model as in Table A5.2-1(c)

(h) Summary of Energy of End Use including Efficiency Indicators for both Reference and Proposed Models as in Table A5.2-1(b) and Table A5.2-2(b).

(i) Summary printouts of energy modelling software for the Reference Model including summary of weather data results

(j) Monthly energy consumption of mechanical and electrical system components such as air-conditioned system, lighting systems, receptacle equipment's, lift and escalator etc.

A5.3 Similar documentation requirements as above will also be required to reflect the as-built condition upon project completion for validation.

Table A5.2-1(a) Summary of Space and OTTV of the Building Envelope

(A) Space Summary			
Building Use	Air-Conditioned Area (m^2)	Non Air-Conditioned Area (m^2)	Total Area (m^2)
1. Office			
2. Toilets			
3. Storage			
4. Corridor			
5. Atrium			
6. Food court			
7. Mechanical/Electrical			
8. Staircase			
9. Conference			
10. Retail Outlets			
11. Car park			
12. Others			
Total			
Note: The building use floor areas for both the Reference and Proposed Models must be the same.			

(B) Building Envelope Summary – OTTV			
Orientation of Facade	Gross Area of External Walls (m^2)	Reference Model OTTV (W/m^2)	Proposed Model OTTV (W/m^2)
North			
North-East			
East			
South-East			
South			
South-West			
West			
North-West			
Average OTTV of the Building Envelope (W/m^2)		50 W/m^2	

Table A5.2-1(b): Summary of Energy by End Use including Efficiency Indicators

End Use	Reference Model Energy Consumption (kWh)	Proposed Building Energy Consumption (kWh)	Tolerance (%)
Lighting – (Air-conditioned Space)			
Lighting – (Non Air-conditioned Space)			
[3] Air-Conditioned Plant			
[4] 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)	Proposed Building Energy Consumption (kWh)	Tolerance (%)
Photovoltaic				
Others				
Total Building Energy Consumption Including Renewable Energy Sources				

Efficiency Indicators

Efficiency Indicators	Reference Model	Proposed Model
Building Energy Intensity, (EEI (kWh/m²/yr)		
System Efficiency of Air-Conditioned Plant (ikW/kW)		

[3] Chilled water system (chillers, water pumps and cooling towers)

[4] Chilled water Air handling and Fan Coil units

Table A5.2-1(c) Comparison of Reference Model versus Proposed Model

BUILDING ELEMENT	REFERENCE MODEL	PROPOSED MODEL
BUILDING ENVELOPE		
Wall Construction		
Opaque Doors		
Windows		
Floor		
Roof		
Window to Wall Ratio (WWR)		
Others		
ELECTRICAL SYSTEMS		
Lighting Power Density (W/m^2)		
Lighting Occupant Sensor Controls		
Receptacle Power (W/m^2)		
Lifts & Escalators		
Others		
Note: The Receptacle Loads for both the Reference and Proposed Models must be the same.		

RENEWABLE ENERGY SYSTEMS		
Photovoltaic		
Note: Renewable Energy contribution to Proposed model energy savings shall be capped at 3%.		
BUILDING ELEMENT	**REFERENCE MODEL**	**PROPOSED MODEL**
SCHEDULES		
Occupancy, Lighting & Equipment		
HVAC		
Note: The Occupancy Rates and Operating Schedules for both the Reference and Proposed models must be the same.		
MECHANICAL & PLUMBING SYSTEMS		
HVAC System Type		
AHU Fan Properties		
Boiler Efficiency		
Central Plant Efficiency		
Note: Central plant efficiencies and capabilities for chillers and cooling towers should be listed whenever the central plant is included as part of the energy model.		
HVAC Circulation Loop Properties		
Domestic Water System		
Mechanical Ventilation Fans		
OTHERS		

Description of differences between the Reference Model and Proposed Model not documented on other forms

☐ Not Applicable ☐ Attached

Table A5.2-2(a): Summary of Space and OTTV of the Building Envelope
(Required if there is a change)

(A) Space Summary			
Building Use	Air-Conditioned Area (m^2)	Non Air-Conditioned Area (m^2)	Total Area (m^2)
1. Office			
2. Toilets			
3. Storage			
4. Corridor			
5. Atrium			
6. Food court			
7. Mechanical/Electrical			
8. Staircase			
9. Conference			
10. Retail Outlets			
11. Car park			
12. Others			
Total			
Note: The building use floor areas for both the Reference and Proposed models must be the same			

(B) Building Envelope Summary – OTTV			
Orientation of Facade	Gross Area of External Walls (m^2)	Reference Model OTTV (W/m^2)	Proposed Model OTTV (W/m^2)
North			
North-East			
East			
South-East			
South			
South-West			
West			
North-West			
Average OTTV of the Building Envelope (W/m^2)		50 W/m^2	

Table A5.2-2(b): Summary 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)			
[5] Air-Conditioned Plant			
[6] Air System Fans			
Mechanical Ventilation Fans			
Lift			
Escalators			
Receptacle Equipment			
Domestic Water Systems			
Others (excluding renewable energy)			
Total Building Energy Consumption			

Renewable Energy Sources

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

Efficiency Indicators

Efficiency Indicators	Reference Model	Actual Building Model
Energy Efficiency Index, EEI (kWh/m²/yr)		
System Efficiency of Air-Conditioned Plant (ikW/kW)		

[5] Chilled Water System (chillers, water pumps and cooling towers)

[6] Chilled Water Air Handling and Fan Coil Units