Green Mark 2021

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Energy Modelling Guideline

Green Mark 2021

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Energy Efficiency

Revision Log

Revision	Description	Effective Date
R1	1st Version	1/11/2021
R1.1	Minor update	1/11/2021

Energy Modelling Guideline

General

The energy modelling for evaluating the energy performance of a building shall be carried out in a prescribed manner to quantify the potential savings based on energy efficiency measures and improvements that reduce cooling load requirement over the Reference Model. The energy savings shall be measured by comparing the annual energy consumption of the Proposed Model (designed building) against the Reference Model (baseline building).

Simulation Software

The simulation software used for energy modelling shall 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 recognised institution in accordance with ANSI/ASHRAE Standard 140 – Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs (or other equivalent standards).

Reference Model

(i) Baseline Standards

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 on Baseline Standards. The requirements are applicable to all buildings.

<table>
<tr><th>S/N</th><th>Component</th><th>Baseline Standard</th><th>Minimum Requirement</th></tr>
<tr><td>1</td><td colspan="3">Building Description</td></tr>
<tr><td>1.1</td><td>Building Envelope Design</td><td>BCA Approved Document
Code on Envelope Thermal Performance for buildings

SS 212: 2007 – Specification for Aluminum Alloy Windows</td><td>(a) ETTV shall not exceed 45W/m^2
(b) For roof with skylight, RTTV shall not exceed 50 W/m^2
(c) For roof without skylight, the average U value of the gross area of the roof shall not exceed the limits below:
<table><tr><th>Weight Group</th><th>Weight range (kg/m^2)</th><th>Max Thermal Transmittance (W/m^{2}k)</th></tr><tr><td>Light</td><td>Under 50</td><td>0.5</td></tr><tr><td>Medium</td><td>50 to 230</td><td>0.8</td></tr><tr><td>Heavy</td><td>Over 230</td><td>1.2</td></tr></table>(d) All windows and curtain walls are designed to ensure air leakage rates do not exceed the limits specified in SS 212 – Specification for Aluminium Alloy Windows and SS654 – Code of Practice for Curtain Walls.
(e) Building entrances and door openings to building exterior or non-air-conditioned spaces and the like shall
(i) be provided with doors that are equipped with automated technology or
(ii) self-closing devices. Where door opening of any commercial units located along the perimeter of the building envelope, that unit shall be equipped with the addition of pressure independent control valve and energy meters to measure the consumption of fan coiled units (FCUs) within the unit; and</td></tr>
</table>

S/N	Component	Baseline Standard	Minimum Requirement
			(iii) be equipped with vestibules or other appropriate measures for the doorway with high pedestrian traffic flow. In the case of vestibules, the interior and exterior door must have a minimum distance of not less than 2.5 m apart and should be interlocked to avoid being opened at the same time. ***Note:*** Doorway with high pedestrian traffic flow refers to building main entrances and those leading to transport nodes or other commercial buildings. (f) Cool paint and/or other similar materials that are used in the building to reduce heat gain could be included in the propose model. The team shall provide the product specification of Thermal Conductivity Values (K-Values) and emissivity value of the materials, values to be incorporated to the propose model.
1.2	Building Shape, Size and Configuration		Reference Model to be the same as Proposed Model
1.3	Building Zoning & Thermal Block		Reference Model to be the same as Proposed Model. Zoning of air-conditioned and non-air-conditioned areas shall be modelled based on the approved building plan except for floor areas that conform to the provisions for *Passive Design Features* under Para 3.9 to reduce air-conditioned spaces. Where ACMV zones are defined on the ACMV design drawings, each ACMV zone shall be modelled as a separate thermal block.
2	**System Description**		
2.1	Air-conditioning System Types	*SS 530: 2014 – Code of Practice for Energy efficiency Standard for Building Services and Equipment* *ASHRAE 90.1: 2013 – Energy Standard for Buildings Except Low-Rise Residential Buildings*	(a) Based on the peak building cooling load, the reference system shall be as follows: (i) Peak building cooling load ≥ 500RT: Centrifugal chiller. - Peak cooling load ≤ 800 RT: 1 number of centrifugal chiller - Peak cooling load > 800 RT: N numbers of centrifugal chillers equally sized with each chiller ≤ 800 RT (ii) Peak building cooling load < 500RT and air-conditioned area ≥ 5,000m^2: Screw chiller - Peak cooling load ≤ 300 RT: 1 number of screw chiller - Peak cooling load > 300 RT: 2 numbers of screw chillers sized equally sized with each chiller ≤ 300 RT (iii) Peak building cooling load < 500RT and air-conditioned area < 5,000m^2: The reference system shall be of the same type as the proposed system. (iv) For VRF systems, the baseline of constant COP of 3.28, 3.22 and 2.93 shall be adopted, with reference to *SS 530: 2014, Table 1B*. (b) Additional chiller or other air conditioning configuration may be considered if the reference chiller(s) operate at less than 50% of its capacity for more than 20% of the time. (c) The energy consumption contribution from the District Cooling System (DCS) shall be excluded from the energy modelling. Note: Requirements on energy savings shall be as defined in GM 2021, Section 1 - Energy Efficiency.
2.2	Chiller Efficiency	SS 530: 2014	Minimum energy efficiency standard stated in *SS 530: 2014*. Please refer below for the default chiller efficiency curve.

<table>
<tr><th>S/N</th><th>Component</th><th>Baseline Standard</th><th>Minimum Requirement</th></tr>
<tr><td>2.3</td><td>Air-Conditioning Hydronic Systems</td><td>SS 553: 2016 - Code of Practice for Air-conditioning and Mechanical Ventilation in Buildings

California Energy Commission Non-Residential Alternative Calculation Method Reference Manual 2013 Appendix 5.7</td><td>(a) Pumping system design criteria
(b) 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 $kW/m^3/s$.
(ii) For motors > 3.7 kW: The chilled water pump shall have VSD and the motor shall have controls and/ or devices (such as variable speed control) that will result in pump motor demand of no more than 30% of design wattage at 50% of design water flow.
(iii) For motors ≤ 3.7 kW: The chilled water pump shall be the equivalent of a constant speed pump if motor is less than 3.7 kW.
(iv) Condenser water pump shall be the equivalent of a constant speed pump.
(v) Buildings served by DCS, code-compliance chilled water pump efficiency will be 0.0586 kW/RT.
(c) Calculation for part load performance of chilled water pump with VSD and the minimum operating load shall be capped at 50% (25 Hz) of the equipment capacity.

Pump power ratio = $0.0205x + 0.4101x^2 + 0.5753x^3$
where x is the part load ratio

Values in table below are for reference only
(projects are advised to use actual value and formula for computation)
<table>
<tr><th>x</th><th>0.2</th><th>0.3</th><th>0.4</th><th>0.5</th><th>0.6</th><th>0.7</th><th>0.8</th><th>0.9</th><th>1</th></tr>
<tr><td>Pump ratio</td><td>0.025</td><td>0.059</td><td>0.111</td><td>0.185</td><td>0.284</td><td>0.413</td><td>0.573</td><td>0.770</td><td>1.00</td></tr>
</table>
Other equivalent methodology can be considered but affinity law is not recommended as it does not account for the loss in actual operating conditions.</td></tr>
<tr><td>2.4</td><td>Cooling Tower</td><td>SS 530: 2014

California Energy Commission Non-Residential Alternative Calculation Method Reference Manual 2013 Appendix 5.7</td><td>Performance requirement for heat rejection equipment:
a) Propeller or axial fan cooling towers: Cooling tower performance shall not be less than 3.23 L/s/kW.
b) Centrifugal fan cooling towers: Cooling tower performance shall not be less than 1.7 L/s/kW.
c) Calculation for part load performance of Cooling tower with VSD and the minimum operating load shall be capped at 50% (25 Hz) of the equipment capacity.
Cooling tower fan power ratio = $0.331629 - 0.885676x + 0.605565x^2 + 0.948482x^3$
where x is the part load ratio
Values in table below are for reference only
(projects are advised to use actual value and formula for computation)
<table>
<tr><th>x</th><th>0.2</th><th>0.3</th><th>0.4</th><th>0.5</th><th>0.6</th><th>0.7</th><th>0.8</th><th>0.9</th><th>1</th></tr>
<tr><td>CT ratio</td><td>0.186</td><td>0.146</td><td>0.135</td><td>0.159</td><td>0.223</td><td>0.334</td><td>0.496</td><td>0.716</td><td>1.000</td></tr>
</table>
Other equivalent methodology can be considered but affinity law is not recommended as it does not account for the loss in actual operating conditions.</td></tr>
<tr><td>2.5</td><td>Air Conditioning Fan Systems</td><td>SS 553: 2016
ASHRAE 90.1: 2013
Non-domestic Building Services Compliance Guide 2013 Edition</td><td>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 the allowable fan system power.

<u>Airflow Rate for Reference Model</u>
a) The airflow rate for the Reference Model shall be based on the auto-sizing function of the energy modelling software used.</td></tr>
</table>

S/N	Component	Baseline Standard	Minimum Requirement
			b) The Reference Model for spaces served by fan coil units (FCUs) shall be of constant flow system, and the airflow rate shall be auto sized by the energy modelling software. In instances where, airflow rate simulated is less than that of the smallest FCU available in the market (e.g FCUs in hotel guest rooms), the airflow rate of the proposed FCU can be adopted for the Reference Model. Fan System Design Criteria (a) For fan systems with a motor nameplate power ≥ 4 kW, the fan power limitation in air-conditioning system (the allowable fan system input power) shall be referenced to SS 553, Table 2a- Fan power limitation. (b) For fan system having a motor nameplate power < 4 kW, the allowable fan system input power shall be ≤ 0.6 kW/m^3/s (0.17 W/CMH) of supply air. For cases where the proposed fan power exceeds the reference power limitation, the energy consumption of the reference model is to be the same as that of the proposed fan systems. (c) Constant volume shall not exceed 1.5 kW/m3/s (or 0.42 W/CMH + A) of supply air. Reference control strategy for CAV system shall be constant speed. (d) Variable volume shall not exceed 2.1 kW/m3/s (or 0.58 W/CMH + A) of supply air. (e) Fan power limitation pressure drop adjustment (A) can be considered and shall be based on SS 553, Table 2b - Fan power limitation pressure drop adjustment. Pressure drop adjustment is applicable to particulate filtration credit MERV 14, MERV 15 and filters with higher MERV ratings, but not appliable to particulate filtration credit MERV 9 to MERV 13. (f) Fan power limitation pressure drop adjustment can be considered for activities where higher fan power is expected to overcome the high static pressure of the specialized hardware such as kitchen exhaust, heap filter or high-pressure exhaust system used in clean room, laboratories and hospitals. There is no exception to the reference for cases when the proposed fan power exceeds the reference power limitation in Table 2b of SS 553: 2016. (g) Transit Station and Underground Structures / Spaces - Pressure adjustment can be considered for horizontal long duct of 70m or more at 2 Pa/m run. Part load fan power limitation a) The reference control strategy for VAV system shall come with VSD without exemption, applicable to all fans including small fan motors ≤ 7.4 kW. b) Individual VAV fans with motors of ≥ 7.4 kW shall meet one of the following requirements: • Be driven by an electrical variable speed drive. • 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 set point equals one-third of the total design static pressure based on manufacturer's certified fan data. • Calculation for part load performance of VAV fan with VSD and the minimum operating load shall be capped at 50% (25 Hz) of the equipment capacity. The part load fan power calculator may be referenced from 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. Fraction of full-load fan power = $0.0013 + 0.1470x + 0.9506x^2 - 0.0998x^3$ where x is the part load ratio (Ratio of current L/s against design L/s)

<table>
<tr><th>S/N</th><th>Component</th><th>Baseline Standard</th><th>Minimum Requirement</th></tr>
<tr><td></td><td></td><td></td><td>
The values indicated in table below are for reference only. It is advisable to use formula and actual value for computation.
<table>
<tr><th>x</th><th>0.2</th><th>0.3</th><th>0.4</th><th>0.5</th><th>0.6</th><th>0.7</th><th>0.8</th><th>0.9</th><th>1</th></tr>
<tr><td>Fan ratio</td><td>0.068</td><td>0.128</td><td>0.206</td><td>0.300</td><td>0.410</td><td>0.536</td><td>0.676</td><td>0.831</td><td>1.000</td></tr>
</table>
For laboratories, ACH baseline will reference to existing laboratory with similar function and there shall be setback ACH during non-occupancy. Where information is not readily available, the following baseline can be considered after discussion with assessors. Projects shall design for minimum flowrate to reduce energy consumption within safety limit.
<table>
<tr><th>Laboratories</th><th>ACH* for unoccupied hours</th><th>ACH* for occupied hours</th></tr>
<tr><td>BSL1</td><td>3</td><td>4</td></tr>
<tr><td>BSL2 & 3 (Sprinkled)</td><td>4</td><td>8</td></tr>
<tr><td>BSL2 & 3 (Non-Sprinkled)</td><td>6</td><td>12</td></tr>
<tr><td>CDSL 1, 2, 3</td><td>Minimum opening for fume hood(s)</td><td>Maintain minimum 0.5m/s airf for fume hood(s) at working position. Reasonable diversity be considered.</td></tr>
</table>
*ACH baseline for BSL4 / CDSL4 to be discussed with assessor(s) on case-by-case basis if baseline for BSL3/CDSL3 are not suitable.
</td></tr>
<tr><td>2.6</td><td>Mechanical Ventilation Fan Systems</td><td>SS 553: 2016

ASHRAE 90.1: 2013

Non-domestic Building Services Compliance Guide 2013 Edition</td><td>
The ratio of fan system power to the supply fan air flow rate (main fan) of each ventilation system at design conditions shall not exceed the allowable fan system power.

<u>Fan system design criteria</u>
(a) Mechanical ventilation systems having a total fan system power ≥ 4kW shall refer to SS 553: 2016, Table 8 – Fan Power Limitation in Mechanical Ventilation Systems.
(b) For fan system with a motor nameplate power < 4 kW, the allowable fan system input power shall not exceed 0.6 kW/m^3/s (or 0.17 W/CMH) of supply air. For cases where the proposed fan power exceeds the reference power limitation, the energy consumption of the reference model is to be the same as that of the proposed fan.
(c) Reference fan power limitation for mechanical ventilation system shall be considered to be of constant volume type and the fan system input shall not exceed 0.3 W/CMH + A.
(d) Fan power limitation pressure drop adjustment (A) shall refer to SS 553: 2016, Table 2b- Fan power limitation pressure drop adjustment. Pressure drop adjustment is applicable to particulate filtration credit MERV 14, MERV 15 and filters with higher MERV ratings, but not appliable to particulate filtration credit MERV 9 to MERV 13.
(e) Exceptions can be considered for activities where higher fan power are expected to overcome the high static pressure of the specialized hardware such as kitchen exhaust, heap filter or high-pressure exhaust system used in clean room, and hospital. There is no exception to the Reference Model for cases when proposed fan power exceeds the baseline power limitation.
</td></tr>
</table>

S/N	Component	Baseline Standard	Minimum Requirement
			(f) Transit Station and Underground Structures / Spaces - Pressure adjustment can be considered for horizontal long duct of 70m or more at 2 Pa/m run.
2.7	Design Airflow Rates	*ASHRAE 90.1:2013 Section G3.1.2.9.1*	For systems serving laboratory spaces, use a supply-air-to-room-air temperature difference of 9°C or the required ventilation air or makeup air, whichever is greater.
2.8	Exhaust Air	*ASHRAE 90.1:2013 Section 6.5.7.2*	Buildings with laboratory exhaust systems having a total exhaust rate greater than 2360 L/s shall adopt at least one of the energy efficient features as stated in *ASHRAE 90.1 Section 6.5.7.2*.
2.9	Lighting Systems	*SS 530: 2014* *ASHRAE 90.1:2013*	(a) The maximum design lighting power (including ballast loss) for a building's interior lighting shall not exceed the sum of maximal power for various areas calculated in accordance with SS 530: 2014, Table 7A- *Maximum Building Interior Lighting Power Density for Compliance (Space-By Space Method).* Particularly, the maximum design lighting power (including ballast loss) for laboratories shall be 16W/m^2. The allowable lighting power density stated in ASHRAE 90.1:2013 can be considered if the lighting power budget for the types of usage is not available in SS 530. (b) The allowable building exterior and outdoor (uncovered area) lighting power shall be the combined total of the sum of the general hardscape lighting allowance determined in according to SS 530, Table 7D and the sum of the additional lighting power allowance for specific applications determined in accordance with Table 7E. The maximal power density requirements specified in Table 7D are tradable but those specified in Table 7E are not, unless stated otherwise.
2.10	Hot Water generation	*SS 530: 2014* *SS 553: 2016*	(a) For generation of hot water ≤ 60°C, the baseline shall be a heat pump with COP of 3.2. (b) Control of indoor thermal environment via reheat of the air shall not be allowed except for energy source from site-recovered energy (including condenser heat) or site-solar energy, referring to *SS 553, Section 8.14*. The baseline for this case will be heat pump with COP of 3.2.
2.11	Energy Recovery Systems	*SS 553: 2016*	(a) Exhaust air of 2.5 m^3/s or greater from conditioned space in a single location shall have energy recovery system with at least 60% recovery effectiveness. 60% recovery effectiveness shall mean a change of enthalpy of the outdoor air supply equal to 60% of the difference between the outdoor air and return air at design conditions when tested under AHRI standard 1060. (b) Control of indoor thermal environment by reheating the air shall not be allowed except for energy source from site-recovered energy (including condenser heat) or site-solar energy, refer to SS553, Section 8.14. The baseline for this case will be heat pump with COP of 3.2
3	**Others**		

<table>
<tr><th>S/N</th><th>Component</th><th>Baseline Standard</th><th>Minimum Requirement</th></tr>
<tr><td>3.1</td><td>Receptacle & Process loads</td><td>ASHRAE
2013 ASHRAE Fundamentals Handbook (SI)

90.4 2016: 2019 Energy Standards for Data Centers</td><td>In general, the default figures of receptacle value for Reference Model are as below:
<table>
<tr><th>Receptacle Loads</th><th>Standard</th><th>Nominal Values</th></tr>
<tr><td>a. Computer intensive offices
b. General office areas
c. Large conference areas
d. Schools (Tertiary/IHLs)
e. Schools (Primary/Secondary)</td><td>Source:
ASHRAE
90.1.2013</td><td>22.0 W/m²
16.0 W/m²
11 W/m²
8 W/m²
5 W/m²</td></tr>
<tr><td>a. Computer rooms (Information Technology Equipment (ITE):</td><td>Source:
ASHARE
90.4 2016</td><td>215W/m²</td></tr>
</table>
Receptable load not mentioned in the above table is to be the same value as proposed.</td></tr>
<tr><td>3.2</td><td>Occupancy Load</td><td></td><td>For office building, the occupancy load provided in Table 1 under Schedules for Office Building shall be used in both reference and proposed model.

For other building categories, the occupancy load provided will be the same as proposed design.</td></tr>
<tr><td>3.3</td><td>Operation Schedules</td><td></td><td>For office building, the operation schedules for the different spaces within the building provided in Table 2 to 11 under Schedules for Office Building shall be used in both reference and proposed model.

For other building categories, the baseline operation schedules will be the same as proposed design.

Note that for carpark areas that are equipped with Carbon Monoxide (CO) sensors, jet fans if provided shall be considered to operate at 100% at all time in both reference and proposed model.</td></tr>
<tr><td>3.4</td><td>Indoor Thermal Comfort Conditions</td><td>SS554 :2016 – Code of Practice for Indoor Air Quality for Air-conditioned Buildings</td><td>Same as proposed design</td></tr>
<tr><td>3.5</td><td>Minimum Ventilation Rates</td><td>SS 553: 2016</td><td>Same as proposed design. The ventilation rates for specific usages based on international/ Singapore recognised guidelines can be considered.

For Carpark, the baseline air change rate shall refer to SS 553- Section 14.1 Carparks. The ventilation rates for proposed model shall also comply to the requirement in the same standard unless waiver is obtained from relevant authorities.
Exception: This section is not applicable for laboratories</td></tr>
<tr><td>3.6</td><td>Heat Exchanger</td><td></td><td>Same as proposed design</td></tr>
</table>

S/N	Component	Baseline Standard	Minimum Requirement
3.7	Lift & Escalator without Regenerative Drive	*ASHRAE 90.1:2016 – Energy Standard for Buildings Except Low-Rise Residential Buildings*	Same as proposed design

Both the reference and proposed lift design shall incorporate with A/C VVVF features.
Energy consumption of the lift motor, ventilation fans, and lights shall be included in reference and proposed model where the ventilation fans and lights shall be modelled with the same schedule as the lift motor.
If the lift car ventilation fans and lighting power density are unknown, default figures may be used. The default lift car ventilation fan shall be 0.69 W/L·s and the lighting power density shall be 33.79 W/m^2; both operate continuously.

The lift peak motor power shall be calculated as follows:
kW = (weight of lift car + rated load – counterweight) × speed of lift car × 0.00981/hmechanical)

Pm = kW/h motor

Where:
Weight of Lift Car = the proposed design lift car weight, kg
Rated Load = the proposed design lift load at which to operate, kg
Counterweight of Lift Car = the lift car counterweight, from Table G3.9.2, kg
Speed of Lift Car = the speed of the proposed elevator, m/s
hmechanical = the mechanical efficiency of the lift from Table, Lift Motor
hmotor = the motor efficiency from Table, Hydraulic Lift Motor Efficiency
Pm = peak lift motor power, kW

Lift Motor

Number of Stories (Including Basement)	Motor Type	Counterweight	Mechanical Efficiency	Motor Efficiency [a]
< 4	Hydraulic	None	58%	Hydraulic Lift Motor Efficiency
> 4	Traction	Proposed design counterweight, if not specified use weight of the car plus 40% of the rated load	64%	Traction Lift Motor Efficiency

[a] Use the efficiency for the next motor size greater than the calculated kW

Hydraulic Lift Motor Efficiency

Motor (KW)	**7.5**	**15**	**22**	**30**	**75**
Full-Load Efficiency (%)	72	75	78	78	80

Traction Lift Motor Efficiency

Motor (KW)	0.8	1.1	1.5	2.2	3.7	5.6	7.5	11.1	14.9	18.7
Full-Load Efficiency (%)	82.5	84.0	84.0	87.5	87.5	89.5	89.5	91.0	91.0	92.4
Motor (KW)	22.4	29.8	37.3	44.8	56	74.6	93.3	111.9	149.2	

S/N	Component	Baseline Standard	Minimum Requirement									
			Full-Load Efficiency (%)	92.4	93.0	93.0	93.6	94.1	94.5	94.5	95.0	95.0
3.8	Modelling Limitation or Simulation Program		Same as proposed design									

S/N	Component	Baseline Standard	Minimum Requirement
3.9	Passive Design Features		The energy saving contribution from passive design features that could reduce the energy consumption of air conditioning system can be considered. For example, the introduction of air well or slopes to facilitate the provision of natural ventilated carparks which otherwise would have to be mechanically ventilated. Similarly, in the case of circulation spaces such as atria, plaza and corridor spaces where naturally ventilated design is adopted instead of having to air-condition these spaces can be considered as part of passive design strategies. This does not apply to features that would normally be regarded as common such as non-airconditioned spaces for warehouses, carparks, school classrooms and pantries. A written justification detailing the design strategies with due consideration for ventilation requirements and thermal comfort of the designated non air-conditioned spaces provided is to be submitted for evaluation. Justification includes detail calculation, CFD simulation and/or EM simulation of the energy consumption of the reference air-conditioned space and the propose designated non air-conditioned spaces including energy consumption of fan to deliver good thermal comfort. This section does not have a limit on energy savings.
4.0	Renewable Energy		On-site generation of renewable energy such as solar photovoltaic (PV) systems could be adopted to reduce the proposed building's energy consumption. No limit on the energy savings claimable in this section. Refer to GM 2021, Energy Efficiency section on the applicability of Renewable Energy.

Note: *Refer to ASHRAE 90.1:2013 Appendix G when there is no baseline standard for energy related features such as chilled beams, underfloor air distribution systems, receptacle loads, lifts and escalators, hot water systems and etc. If baseline is unavailable for building with special requirements, reference could be made to similar building type completed after 2005. Detailed calculations shall be provided to justify energy savings from the use of salient energy efficient features /equipment. Where justification cannot be provided, same input parameters for good design practice shall apply to both the Reference and Proposed Model.*

(ii) Default Chiller Efficiency Curve

The default Chiller Curve and Chiller Configuration, references to *SS 530: 2014, AHRI 551/591, Full Load Conditions*. The standard rating conditions are based on chilled water supply temperature at 7.0°C, chilled water return temperature at 12.0°C, condenser water entering temperature at 30.0°C and condenser water leaving temperature at 35.0°C. The default part load performance curves below are provided in DOE 2.2 and IESVE software 2014 which are compliant with California's TM24 requirement:

Equipment Type	Size Category	COP									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Rotary Screw and Scroll	< 263kW	3.125	3.581	3.809	3.970	4.105	4.228	4.345	4.461	4.576	4.694
	≥ 264 kW and < 528 kW	3.255	3.730	3.967	4.135	4.276	4.403	4.526	4.646	4.767	4.889
	≥ 528 kW and < 1055 kW	3.551	4.069	4.328	4.511	4.665	4.804	4.938	5.069	5.200	5.334
	≥ 1,055 kW and < 2110 kW	3.842	4.403	4.683	4.881	5.047	5.198	5.342	5.484	5.626	5.771
	≥ 2,110 kW	4.185	4.796	5.100	5.317	5.497	5.662	5.819	5.974	6.129	6.286
Centrifugal	< 1,055 kW	1.676	2.914	3.821	4.478	4.949	5.279	5.504	5.648	5.732	5.771
	≥ 1,055kW and < 1,407 kW	1.826	3.174	4.162	4.878	5.391	5.750	5.995	6.152	6.244	6.286
	≥ 1,407kW	1.826	3.174	4.162	4.878	5.391	5.750	5.995	6.152	6.244	6.286

Energy Modelling Methodology

1. The 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, controls and other associated components selected for use in the building.

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

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

   (i) the same software
   (ii) the same appropriate up-to-date weather data set shall be used for energy modeling such as ASHRAE's International Weather for Energy Calculation data for Singapore.
   (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. If there is 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.
   (viii) the same internal illuminance levels (lux) for space lightings

4. The overall energy consumption of the Reference Model and Proposed Model are 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 (for 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 (for e.g. photo-copiers, printers, fax machines, Computer rooms (Information Technology Equipment - ITE), computers, laptops, fridges, projectors, audio-cum video systems, water heaters, dryers, washers, etc).

5. The basis for deriving the overall energy consumption and potential energy savings must be spelled out and justified by way of the calculation for consideration. Notwithstanding this, the potential energy savings for the following systems/devices shall be capped as follows:

List of Systems/Devices	Applications and Descriptions	Cap on Energy Savings Devices
Escalator	Application to escalator with sleep mode or 2 speed function.	30%
Lift with regenerative features	Application to lifts with regenerative features.	18% Project team shall provide simulation results of the energy saving from the regenerative features. Simulation shall be based on the travel distance and the expected occupancy corresponding to the building activities.
Auto-dimming systems with occupancy sensors	Applicable to lighting at office space, meeting rooms, staircase, toilets and corridors. Device integrated to the lighting system to lower the output of the lighting system when the office desk is unoccupied.	10%
Occupancy sensors / Motion sensors	Applicable to lighting at staircases, toilets and corridors	15%
	Applicable to lighting at carpark areas.	30%
Photosensors	Applicable to transient spaces and corridors of office space. Device integrated to the lighting system to adjust the output of the lighting system based on the amount of light it senses when the office desk is unoccupied.	No cap on energy savings. Project team shall provide daylight simulation to demonstrate the energy savings achievable from photosensor. Refer to GM 2021- Daylighting simulation guideline.
Carbon Monoxide Detectors (CO Sensors)	Applicable to mechanical ventilation fans only. Not applicable to carparks with jet fans that are required to be in full operating conditions, 24/7 to ensure good air circulation within the carpark. The energy savings consideration for the provision of CO sensors can be found in the guidance note and Worked Example 1 of Guidance Notes.	30% No Cap on energy savings. Project team shall provide CO simulation to demonstrate the energy savings from the use of CO sensors by way of Computational Fluid Dynamics (CFD) simulation. Refer to GM 2021- CFD simulation guideline.

6. **<u>Receptacle load cap:</u>** For projects with receptable loads that take up more than 25% of the total building consumption in the reference model, the receptacle load shall be capped at 25% of the reference consumption. The same load/value shall be applied to the proposed model. However, additional energy saving from receptable load reduction can be accorded. Details are provided in the following, item 7. The methodology to accord the energy savings for receptacle load reduction is provided in the guidance notes and Worked Example 2 of Guidance Notes for clarity.

7. **Energy saving considerations for projects with receptacle load cap**: Energy savings of receptable load reduction can be accorded if there are provisions to measure and monitor the receptable load during operation. Energy monitoring devices such as dedicated energy meters to measure receptable load must be in place so that the actual receptacle load density can be determined for verification purpose. Refer to the table below on specific consideration for different building typologies/functions.

Building Type/Function	Specific Considerations
Offices	Energy savings can be considered if the proposed receptacle load density is lower than that of the reference model (16 W/m^2). There must be commitment made to deliver lower receptacle density during operation, green lease and tenant/user engagement programmes.
Data Centres	Energy consumption from data centre operation is to be included for both reference and proposed model and based on the methodology under the guidance provided in BCA-IMDA Green Mark for New Data Centre GM NDC: 2019. Energy savings cannot be considered for the energy consumption from data centre, server rooms and computer rooms (ITE). The building owner shall apply for the BCA-IMDA Green Mark for New Data Centre scheme if the energy consumption of the Data Centre is 1 MW or more. Green Mark rating of DC shall be the same or higher than the Green Mark rating of the building.
Laboratories	Reference can be made to the receptacle load values stated in the ASHRAE Handbook – Fundamentals or other international recognised guides with diversity. Existing measured data shall be considered.
Industrial Buildings	Energy consumption from process load/equipment and services dedicated (e.g air-conditioned system, supply and exhaust air fan system) for manufacturing process shall be excluded. Energy consumption of receptable load such as lighting, ventilation system, air conditioning system and relevant system provided for these spaces shall be included in the Energy Modelling. The energy consumption of shared systems serving process load and the space shall be accounted based on the weighted consumption, with the provision of adequate meters or equipment to measure and determine the respective energy consumption for verification purpose.
Schools	Energy savings can be considered if the proposed receptacle load density is lower than that of the reference model. There must be commitment made to deliver lower receptacle density during operation and student engagement programmes must be in place.
Transit Stations	Receptacle loads from train operation such as train traction load and transfer loss can be excluded.

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.

Guidance Notes

Work Example 1 - Calculation of Proposed Carpark Energy Consumption

Example of carpark of office building equipped with a combination of mechanical ventilation system and jet fans with CO sensors. Operation schedule to be based on Table 10 and for the case of jet fans system to be considered 100% in operation, 24/7 to ensure good air circulation within the carpark. Input power of Mechanical Ventilation Fans and Jet Fans shall be based on contractor or supplier's specification for the proposed building.

Default MV Fan Schedule with CO sensors

Day	ACMV Schedule	MV Fans Percentage of Input Power (%) controlled by CO Sensors	Jet Fans Percentage of Input Power (%)
Mon – Fri (peak)	7 AM to 10 PM - 3,900 hours (15 hours* 5 days/week * 52 weeks)	100	100
Mon – Fri (off-peak)	10 PM to 7 AM - 2,340 hours (9 hours * 5 days/week * 52 weeks)	50	100
Sat (off-peak)	1,248 hours (24 hours * 52 weeks)	50	100
Sun (off-peak)	1,248 hours (24 hours * 52 weeks)	50	100

CO sensors to operate during off-peak hours to reduce the MV input power. MV fans shall operate at 50% of the input power with the use of CO sensors.

Carpark Fan - Calculation of Proposed Model Energy Consumption

System Configuration	No of Fans	Motor Input Power (W)	Total Motor Input Power (W)	Annual Energy Consumption (kWh)
Mechanical Ventilation Fans	2 Supply 2 Exhaust	11	44	171,600 (44kW * 100% * 3,900 hours) + 106,392 (44kW * 50% * 4,836 hours
Jet Fans	10	0.15	1.5	13,104 (1.5*100% * 8736 hours)
Total				291,096

Worked Example 2 – Calculation of Energy Savings for Receptable Load Reduction

Energy Savings Considerations for receptable load reduction applicable for projects where the receptacle load is capped at 25% of the total energy consumption in Reference Model.

Example of an office building that is designed with a reduction in the receptacle load density for 50% of the office space from 16 W/m^2 to 13 W/m^2. Assume that these office spaces have the same operating hours. The percentage saving for the overall reduction can be computed based on areas proration.

Step 1: Determine the overall percentage energy savings by reducing the receptacle load density.

Description	Areas (m^2)	Percentage Distribution by Areas	Reference Model Receptacle Load Density (W/m^2)	Proposed Model Receptacle Load Density (W/m^2)	Energy Savings from Receptacle Load Reduction Effort
Office Space 1	1000	50%	16	10	37.5%
Office Space 2	1000	50%	16	16	0%
Average receptacle load density & Overall energy savings:			16	13	18.8%

Step 2: Check on the energy consumption distribution of reference model and receptacle load cap of 25%.

End Use	Reference Model Energy Consumption (MWh)	Proposed Model Energy Consumption (MWh)	Remarks
Receptacle Load (a)	2000 (16 W/m^2)	1625 (13 W/m^2)	Assume receptacle load from reference model to be 2000 MWh. Energy consumption of proposed model – receptable load is derived from reference model with 18.8% reduction in Step 1 Reference model exclude passive design enhancement and renewable energy sources.
Other Energy Consuming System and Equipment (b)	3800	Assume 2350	Assume the proposed energy consumption for other energy consuming system to be 2350 MWh. These systems include chillers, condenser pumps, chilled water pumps, cooling towers, internal and external lights, lift and escalators, domestic water pumps, and so forth.
Total Energy Building Consumption (TBEC) (C)	5800 (a + b)	3975 (a + b)	Overall energy savings for building is 31.5%
Percentage of receptacle load over TBEC (d)	34% (a ÷ c)	41% (a ÷ c)	Reference receptable load is more than 25%
Apply 25% cap to the reference receptable load (e)	3800 => 75% Receptacle load with 25% cap will be 1267	1,625> 1,267 (Apply same reference value)	Propose receptable load is more than reference receptable load after applying 25% cap, 1,267 MWh.

Step 3: Adjustment to the receptable load for reference and proposed model

End Use	Reference Model Energy Consumption (MWh)	Proposed Model Energy Consumption (MWh)	Remarks
Adjusted Receptacle Load (f)	1,267 (Cap at 25%)	1029 1267 x (100%-18.8%) = 1029	The proposed receptacle load is adjusted by apply the percentage of energy savings accorded for receptacle load reduction to the cap receptacle load value.
Other Energy Consuming System and Equipment	3800	2350	Values remain unchanged
Total Building Energy Consumption (TBEC)	5067 (b + e)	3379 (b + f)	Overall energy savings for building is 33.3 %

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Guidance Notes

The name and company of the Energy Modelling consultant, details of software used and its limitations, building type and complexity shall be submitted to BCA. The Energy Modelling Form for Green Mark Scheme (Finalisation of Building Design) following shall be submitted and Form for Energy Modelling Form for Green Mark Scheme (Validation After Project Completion).

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 energy modelling specialist is responsible for the correctness of the modelling including proper usage of relevant software is engaged, the appropriate practitioner shall ensure that the assumptions and inputs used for energy modeling are bona fide.

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 final assessment. They are:

(a) Certification showing that the simulation software is tested and meet the criteria in accordance with the ANSI/ASHRAE Standard 140
(b) Detailed drawings and other necessary information of proposed design
(c) Detailed system design calculation
(d) Summary of Space and Envelope Thermal Transfer Value (ETTV) of the Building Envelope as in Energy Modelling Form for Green Mark Scheme (Finalisation of Building Design)
(e) List of data such as:
    - 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 load, outdoor ventilation rates, misc. loads etc.). Schedules for each individual operating zone (e.g. lighting, occupants, mechanical fans, AHUs, other mechanical and electrical equipment, etc.)
    - Executable input data files used in the generation of the energy estimates for the Proposed and Reference Models
    - 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.)
    - One year simulated hourly cooling load data in the form of the Frequency vs Cooling Load (RT) plot, Cooling Load vs Time, A/C efficiency vs Time
    - Detailed computation of the ETTV for both Reference and Proposed Models
    - Summary printouts of energy modelling software for the Reference Model including summary of weather data results Monthly energy consumption of mechanical and electrical system components such as air-conditioned system, lighting systems, receptacle equipment's, lift and escalator etc.
(f) Executable excel file of the EM simulation for both the Proposed and Reference Models
(g) Similar documentation requirements as above will also be required to reflect the as-built condition upon project completion for validation

To assist in the generation of satisfactory results from the energy modelling simulation, the EM consultant shall adhere to the following self-assessment checklist before the energy modelling assessment.

Checklist Item	Notes
A. Overview	1) Verify if Energy Modelling is required. 2) Verify the key performance indicators (KPI) a. EEI b. W/m^2 c. kW/RT
B. Input Checks (for both proposed and reference model)	1) General Setting a. Weather b. Elevation c. Orientation d. Area summary (discrepancies within 5%) 2) Façade a. Select at least 3 areas to verify façade selection b. Construction c. SC value of glass and U-Value of walls and windows. 3) Thermal Zoning 4) HVAC design a. Typical space W/m^2 and whole building W/m^2 b. Cooling load profile c. Cooling system • Compressor (e.g. chiller if applicable) • Condenser (e.g. cooling tower if applicable) • Pumps (if applicable) • Overall and individual efficiency (kW/RT) d. Air distribution (baseline - provide oversizing factor) • Individual W/CMH • Typical CMH/m^2 and whole building CMH/m^2 • Overall air distribution kW/RT e. Overall – Provide unmet hours (shall not exceed 300 unmet hours) 5) Lighting 6) Receptacle load 7) MV fans 8) Schedule and diversity (including non-A/C areas like car park) 9) Energy saving items, eg heat recovery 10) Non-modelled items by alternative calculation
C. Output checks	1) Indoor thermal parameters for three typical indoor spaces 2) Daily, weekly, and monthly building cooling load 3) Energy breakdown proportion
D. Consistency checks	1) Proposed model and reference model consistency 2) Input data and output data consistency 3) Assumption verification 4) Exception calculation method

Default Operation schedules and Occupancy Schedules for Office Building

Default schedules correspond to a week operation and occupancy for office building to determine the energy savings.

Table 1: Occupancy Load for Office Building

Functional Spaces	Occupancy Load (m^2/person)
Reception Areas	3
Lobby/Corridors	0
Waiting Areas/ Visitors Lounge	3
Admin Office	10
Business Centre	10
Meeting/ Seminar Room	1.5
Archive/ Library - Stack Area	10
Archive/ Library - Reading Area	5
Filling Room/ Store	10
Computer Room	5
Design Studio	5
Drafting Office	5
Trading Floor	2
Trading Gallery	1.5
Banking Hall	3
Deposit/ Storage Room	30
Machine/ Printing Room	10
Restaurant	1.5
Canteen	1.5
Staff Canteen	1.5
Shop	5
Toilets	0
Storage Area	30
Mechanical Plant Room	30

Note:

(i) Occupancy load reference from Singapore Fire Code Chapter 1 – Schedule 4

(ii) The default occupancy load density for reference model and proposed model shall be the same.

Table 2: Schedules for Office Space in Office Building (include meeting room, workspaces, waiting areas, business centre, filling room, banking and trading floor)

Hour of Day/Time		Occupancy Schedule Percentage of Maximum load			Lighting Schedule Percentage of Maximum load			Receptacle Schedule Percentage of Maximum load			ACMV Schedule On/Off		
		Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun
1	12 - 1 am	0	0	0	0	0	0	5	5	5	Off	Off	Off
2	1 - 2 am	0	0	0	0	0	0	5	5	5	Off	Off	Off
3	2 - 3 am	0	0	0	0	0	0	5	5	5	Off	Off	Off
4	3 - 4 am	0	0	0	0	0	0	5	5	5	Off	Off	Off
5	4 - 5 am	0	0	0	0	0	0	5	5	5	Off	Off	Off
6	5 - 6 am	0	0	0	0	0	0	5	5	5	Off	Off	Off
7	6 - 7 am	0	0	0	0	0	0	5	5	5	Off	Off	Off
8	7 - 8 am	0	0	0	0	0	0	5	5	5	On	Off	Off
9	8 - 9 am	50	0	0	100	0	0	50	5	5	On	Off	Off
10	9 - 10 am	95	0	0	100	0	0	90	5	5	On	Off	Off
11	10 – 11am	95	0	0	100	0	0	90	5	5	On	Off	Off
12	11 - 12 pm	95	0	0	100	0	0	90	5	5	On	Off	Off
13	12 - 1 pm	50	0	0	50	0	0	50	5	5	On	Off	Off
14	1 - 2 pm	95	0	0	100	0	0	90	5	5	On	Off	Off
15	2 - 3 pm	95	0	0	100	0	0	90	5	5	On	Off	Off
16	3 - 4 pm	95	0	0	100	0	0	90	5	5	On	Off	Off
17	4 -5 pm	95	0	0	100	0	0	90	5	5	On	Off	Off
18	5 - 6 pm	95	0	0	100	0	0	90	5	5	On	Off	Off
19	6 - 7 pm	50	0	0	100	0	0	50	5	5	On	Off	Off
20	7 - 8 pm	0	0	0	0	0	0	5	5	5	Off	Off	Off
21	8 - 9 pm	0	0	0	0	0	0	5	5	5	Off	Off	Off
22	9 - 10 pm	0	0	0	0	0	0	5	5	5	Off	Off	Off
23	10 - 11 pm	0	0	0	0	0	0	5	5	5	Off	Off	Off
24	11 - 12 pm	0	0	0	0	0	0	5	5	5	Off	Off	Off

The above schedules are to be adopted as the default profile of office building for reference model and proposed model. Adjustment to the proposed model to account for the contributing factors from energy efficient systems or devices can be considered.

Table 3: Schedules for Restaurant and Retail in Office Building

Hour of Day/Time		Occupancy Schedule Percentage of Maximum load			Lighting Schedule Percentage of Maximum load			Receptacle Schedule Percentage of Maximum load			ACMV Schedule On/Off		
		Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun
1	12 - 1 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
2	1 - 2 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
3	2 - 3 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
4	3 - 4 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
5	4 - 5 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
6	5 - 6 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
7	6 - 7 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
8	7 - 8 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
9	8 - 9 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
10	9 - 10 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
11	10 – 11am	50	0	0	100	0	0	100	10	10	On	Off	Off
12	11 - 12 pm	90	0	0	100	0	0	100	10	10	On	Off	Off
13	12 - 1 pm	90	0	0	100	0	0	100	10	10	On	Off	Off
14	1 - 2 pm	50	0	0	100	0	0	100	10	10	On	Off	Off
15	2 - 3 pm	50	0	0	100	0	0	100	10	10	On	Off	Off
16	3 - 4 pm	50	0	0	100	0	0	100	10	10	On	Off	Off
17	4 -5 pm	50	0	0	100	0	0	100	10	10	On	Off	Off
18	5 - 6 pm	50	0	0	100	0	0	100	10	10	On	Off	Off
19	6 - 7 pm	90	0	0	100	0	0	100	10	10	On	Off	Off
20	7 - 8 pm	90	0	0	100	0	0	100	10	10	On	Off	Off
21	8 - 9 pm	50	0	0	100	0	0	100	10	10	On	Off	Off
22	9 - 10 pm	20	0	0	100	0	0S	100	10	10	On	Off	Off
23	10 - 11 pm	0	0	0	0	0	0	10	10	10	Off	Off	Off
24	11 - 12 pm	0	0	0	0	0	0	10	10	10	Off	Off	Off

The above schedules are to be adopted as the default profile of Restaurant and Retail for reference model and proposed model. Except for lighting provision, adjustment to the proposed model can be made to account for the contributing factors from energy efficient systems or devices can be considered.

Note that the proposed receptable load density for these spaces must be reasonably expected. For energy modelling, the receptable load density for reference model and proposed model shall be the same.

Table 4: Schedules for Canteen, Staff Canteen, Food court, Café and Pantry in Office Building

Hour of Day/Time		Occupancy Schedule Percentage of Maximum load			Lighting Schedule Percentage of Maximum load			Receptacle Schedule Percentage of Maximum load			ACMV Schedule On/Off		
		Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun
1	12 - 1 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
2	1 - 2 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
3	2 - 3 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
4	3 - 4 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
5	4 - 5 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
6	5 - 6 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
7	6 - 7 am	0	0	0	0	0	0	10	10	10	Off	Off	Off
8	7 - 8 am	20	0	0	100	0	0	100	10	10	On	Off	Off
9	8 - 9 am	50	0	0	100	0	0	100	10	10	On	Off	Off
10	9 - 10 am	40	0	0	100	0	0	100	10	10	On	Off	Off
11	10 – 11am	50	0	0	100	0	0	100	10	10	On	Off	Off
12	11 - 12 pm	90	0	0	100	0	0	100	10	10	On	Off	Off
13	12 - 1 pm	90	0	0	100	0	0	100	10	10	On	Off	Off
14	1 - 2 pm	80	0	0	100	0	0	100	10	10	On	Off	Off
15	2 - 3 pm	50	0	0	100	0	0	100	10	10	On	Off	Off
16	3 - 4 pm	50	0	0	100	0	0	100	10	10	On	Off	Off
17	4 -5 pm	20	0	0	100	0	0	100	10	10	On	Off	Off
18	5 - 6 pm	50	0	0	100	0	0	100	10	10	On	Off	Off
19	6 - 7 pm	80	0	0	100	0	0	100	10	10	On	Off	Off
20	7 - 8 pm	60	0	0	100	0	0	100	10	10	On	Off	Off
21	8 - 9 pm	20	0	0	100	0	0	10	10	10	Off	Off	Off
22	9 - 10 pm	0	0	0	0	0	0	10	10	10	Off	Off	Off
23	10 - 11 pm	0	0	0	0	0	0	10	10	10	Off	Off	Off
24	11 - 12 pm	0	0	0	0	0	0	10	10	10	Off	Off	Off

The above schedules are to be adopted as the default profile of Canteen, Staff Canteen, Food court, Café and Pantry for reference model and proposed model. Except for lighting provision, adjustment to the proposed model can be made to account for the contributing factors from energy efficient systems or devices.

Note that the proposed receptable load density for these spaces must be reasonably expected. For energy modelling, the receptable load density for reference model and proposed model shall be the same.

Table 5: Schedules for Main Lobby in Office Building

Hour of Day/Time		Occupancy Schedule Percentage of Maximum load			Lighting Schedule Percentage of Maximum load			Receptacle Schedule Percentage of Maximum load			ACMV Schedule On/Off		
		Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun
1	12 - 1 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
2	1 - 2 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
3	2 - 3 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
4	3 - 4 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
5	4 - 5 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
6	5 - 6 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
7	6 - 7 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
8	7 - 8 am	100	0	0	100	0	0	100	0	0	On	Off	Off
9	8 - 9 am	100	0	0	100	0	0	100	0	0	On	Off	Off
10	9 - 10 am	100	0	0	100	0	0	100	0	0	On	Off	Off
11	10 – 11am	100	0	0	100	0	0	100	0	0	On	Off	Off
12	11 - 12 pm	100	0	0	100	0	0	100	0	0	On	Off	Off
13	12 - 1 pm	100	0	0	100	0	0	100	0	0	On	Off	Off
14	1 - 2 pm	100	0	0	100	0	0	100	0	0	On	Off	Off
15	2 - 3 pm	100	0	0	100	0	0	100	0	0	On	Off	Off
16	3 - 4 pm	100	0	0	100	0	0	100	0	0	On	Off	Off
17	4 -5 pm	100	0	0	100	0	0	100	0	0	On	Off	Off
18	5 - 6 pm	100	0	0	100	0	0	100	0	0	On	Off	Off
19	6 - 7 pm	100	0	0	100	0	0	100	0	0	On	Off	Off
20	7 - 8 pm	0	0	0	100	0	0	0	0	0	Off	Off	Off
21	8 - 9 pm	0	0	0	100	0	0	0	0	0	Off	Off	Off
22	9 - 10 pm	0	0	0	100	0	0	0	0	0	Off	Off	Off
23	10 - 11 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
24	11 - 12 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off

The above schedules are to be adopted as default profile of Main Lobby for reference model and proposed model. Adjustment to the proposed model to account for the contributing factors from energy efficient systems or devices can be considered.

Table 6: Schedules for Toilet, Common Corridor in Office Building

Hour of Day/Time		Occupancy Schedule Percentage of Maximum load			Lighting Schedule Percentage of Maximum load			Receptacle Schedule Percentage of Maximum load			ACMV Schedule On/Off		
		Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun
1	12 - 1 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
2	1 - 2 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
3	2 - 3 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
4	3 - 4 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
5	4 - 5 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
6	5 - 6 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
7	6 - 7 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
8	7 - 8 am	0	0	0	100	0	0	0	0	0	On	Off	Off
9	8 - 9 am	0	0	0	100	0	0	0	0	0	On	Off	Off
10	9 - 10 am	0	0	0	100	0	0	0	0	0	On	Off	Off
11	10 – 11am	0	0	0	100	0	0	0	0	0	On	Off	Off
12	11 - 12 pm	0	0	0	100	0	0	0	0	0	On	Off	Off
13	12 - 1 pm	0	0	0	100	0	0	0	0	0	On	Off	Off
14	1 - 2 pm	0	0	0	100	0	0	0	0	0	On	Off	Off
15	2 - 3 pm	0	0	0	100	0	0	0	0	0	On	Off	Off
16	3 - 4 pm	0	0	0	100	0	0	0	0	0	On	Off	Off
17	4 -5 pm	0	0	0	100	0	0	0	0	0	On	Off	Off
18	5 - 6 pm	0	0	0	100	0	0	0	0	0	On	Off	Off
19	6 - 7 pm	0	0	0	100	0	0	0	0	0	On	Off	Off
20	7 - 8 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
21	8 - 9 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
22	9 - 10 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
23	10 - 11 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
24	11 - 12 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off

The above schedules are to be adopted as default profile for Toilet, Common Corridor for reference model and proposed model. Adjustment to the proposed model to account for the contributing factors from energy efficient systems or devices can be considered.

Table 7: Schedules for Server room and Computer Room in Office Building

Hour of Day/Time		Occupancy Schedule Percentage of Maximum load			Lighting Schedule Percentage of Maximum load			Receptacle Schedule Percentage of Maximum load			ACMV Schedule On/Off		
		Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun
1	12 - 1 am	0	0	0	0	0	0	100	100	100	On	On	On
2	1 - 2 am	0	0	0	0	0	0	100	100	100	On	On	On
3	2 - 3 am	0	0	0	0	0	0	100	100	100	On	On	On
4	3 - 4 am	0	0	0	0	0	0	100	100	100	On	On	On
5	4 - 5 am	0	0	0	0	0	0	100	100	100	On	On	On
6	5 - 6 am	0	0	0	0	0	0	100	100	100	On	On	On
7	6 - 7 am	0	0	0	0	0	0	100	100	100	On	On	On
8	7 - 8 am	0	0	0	0	0	0	100	100	100	On	On	On
9	8 - 9 am	0	0	0	0	0	0	100	100	100	On	On	On
10	9 - 10 am	0	0	0	0	0	0	100	100	100	On	On	On
11	10 – 11am	0	0	0	0	0	0	100	100	100	On	On	On
12	11 - 12 pm	0	0	0	0	0	0	100	100	100	On	On	On
13	12 - 1 pm	0	0	0	0	0	0	100	100	100	On	On	On
14	1 - 2 pm	0	0	0	0	0	0	100	100	100	On	On	On
15	2 - 3 pm	0	0	0	0	0	0	100	100	100	On	On	On
16	3 - 4 pm	0	0	0	0	0	0	100	100	100	On	On	On
17	4 -5 pm	0	0	0	0	0	0	100	100	100	On	On	On
18	5 - 6 pm	0	0	0	0	0	0	100	100	100	On	On	On
19	6 - 7 pm	0	0	0	0	0	0	100	100	100	On	On	On
20	7 - 8 pm	0	0	0	0	0	0	100	100	100	On	On	On
21	8 - 9 pm	0	0	0	0	0	0	100	100	100	On	On	On
22	9 - 10 pm	0	0	0	0	0	0	100	100	100	On	On	On
23	10 - 11 pm	0	0	0	0	0	0	100	100	100	On	On	On
24	11 - 12 pm	0	0	0	0	0	0	100	100	100	On	On	On

The above schedules are to be adopted as default profile of Server room and Computer Room for reference model and proposed model. Adjustment to the proposed model to account for the contributing factors from energy efficient systems or devices can be considered.

Note that the proposed receptable load density for these spaces must be reasonably expected. The receptable load density for reference model and proposed model shall be the same.

Table 8: Schedules for FCC room or Security room in Office Building

Hour of Day/Time		Occupancy Schedule Percentage of Maximum load			Lighting Schedule Percentage of Maximum load			Receptacle Schedule Percentage of Maximum load			ACMV Schedule On/Off		
		Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun
1	12 - 1 am	100	100	100	100	100	100	100	100	100	On	On	On
2	1 - 2 am	100	100	100	100	100	100	100	100	100	On	On	On
3	2 - 3 am	100	100	100	100	100	100	100	100	100	On	On	On
4	3 - 4 am	100	100	100	100	100	100	100	100	100	On	On	On
5	4 - 5 am	100	100	100	100	100	100	100	100	100	On	On	On
6	5 - 6 am	100	100	100	100	100	100	100	100	100	On	On	On
7	6 - 7 am	100	100	100	100	100	100	100	100	100	On	On	On
8	7 - 8 am	100	100	100	100	100	100	100	100	100	On	On	On
9	8 - 9 am	100	100	100	100	100	100	100	100	100	On	On	On
10	9 - 10 am	100	100	100	100	100	100	100	100	100	On	On	On
11	10 – 11am	100	100	100	100	100	100	100	100	100	On	On	On
12	11 - 12 pm	100	100	100	100	100	100	100	100	100	On	On	On
13	12 - 1 pm	100	100	100	100	100	100	100	100	100	On	On	On
14	1 - 2 pm	100	100	100	100	100	100	100	100	100	On	On	On
15	2 - 3 pm	100	100	100	100	100	100	100	100	100	On	On	On
16	3 - 4 pm	100	100	100	100	100	100	100	100	100	On	On	On
17	4 -5 pm	100	100	100	100	100	100	100	100	100	On	On	On
18	5 - 6 pm	100	100	100	100	100	100	100	100	100	On	On	On
19	6 - 7 pm	100	100	100	100	100	100	100	100	100	On	On	On
20	7 - 8 pm	100	100	100	100	100	100	100	100	100	On	On	On
21	8 - 9 pm	100	100	100	100	100	100	100	100	100	On	On	On
22	9 - 10 pm	100	100	100	100	100	100	100	100	100	On	On	On
23	10 - 11 pm	100	100	100	100	100	100	100	100	100	On	On	On
24	11 - 12 pm	100	100	100	100	100	100	100	100	100	On	On	On

The above schedules are to be adopted as the default profile of FCC room or Security room for reference model and proposed model. Except for lighting provision, adjustment to the proposed model can be made to account for the contributing factors from energy efficient systems or devices.

Note that the proposed receptable load density for these spaces must be reasonably expected. The receptable load density for reference model and proposed model shall be the same.

Table 9: Schedules for Storeroom, Storage room and Plant room in Office Building

Hour of Day/Time		Occupancy Schedule Percentage of Maximum load			Lighting Schedule Percentage of Maximum load			Receptacle Schedule Percentage of Maximum load			ACMV Schedule On/Off		
		Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun
1	12 - 1 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
2	1 - 2 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
3	2 - 3 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
4	3 - 4 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
5	4 - 5 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
6	5 - 6 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
7	6 - 7 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
8	7 - 8 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
9	8 - 9 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
10	9 - 10 am	0	0	0	0	0	0	0	0	0	Off	Off	Off
11	10 – 11am	0	0	0	0	0	0	0	0	0	Off	Off	Off
12	11 - 12 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
13	12 - 1 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
14	1 - 2 pm	100	0	0	100	0	0	0	0	0	On	On	On
15	2 - 3 pm	100	0	0	100	0	0	0	0	0	On	On	On
16	3 - 4 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
17	4 -5 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
18	5 - 6 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
19	6 - 7 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
20	7 - 8 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
21	8 - 9 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
22	9 - 10 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
23	10 - 11 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off
24	11 - 12 pm	0	0	0	0	0	0	0	0	0	Off	Off	Off

The above schedules are to be adopted as the default profile of Storeroom, Storage room and Plant room for reference model and proposed model. Except for lighting provision, adjustment to the proposed model can be made to account for the contributing factors from energy efficient systems or devices.

Table 10: Schedules for Carpark Lighting and Carpark Mechanical Ventilation System in Office Building

Hour of Day/Time		Lighting Schedule Percentage of Maximum load			Receptacle Schedule Percentage of Maximum load			ACMV Schedule Percentage of Maximum Power			[1]MV Schedule Percentage of Maximum Power (With CO Sensors)		
		Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun	Weekday	Sat	Sun
1	12 - 1 am	50	50	50	0	0	50	100	100	100	50	50	50
2	1 - 2 am	50	50	50	0	0	50	100	100	100	50	50	50
3	2 - 3 am	50	50	50	0	0	50	100	100	100	50	50	50
4	3 - 4 am	50	50	50	0	0	50	100	100	100	50	50	50
5	4 - 5 am	50	50	50	0	0	50	100	100	100	50	50	50
6	5 - 6 am	50	50	50	0	0	50	100	100	100	50	50	50
7	6 - 7 am	50	50	50	0	0	50	100	100	100	50	50	50
8	7 - 8 am	100	50	50	0	0	100	100	100	100	100	50	50
9	8 - 9 am	100	50	50	0	0	100	100	100	100	100	50	50
10	9 - 10 am	100	50	50	0	0	100	100	100	100	100	50	50
11	10 – 11am	100	50	50	0	0	100	100	100	100	100	50	50
12	11 - 12 pm	100	50	50	0	0	100	100	100	100	100	50	50
13	12 - 1 pm	100	50	50	0	0	100	100	100	100	100	50	50
14	1 - 2 pm	100	50	50	0	0	100	100	100	100	100	50	50
15	2 - 3 pm	100	50	50	0	0	100	100	100	100	100	50	50
16	3 - 4 pm	100	50	50	0	0	100	100	100	100	100	50	50
17	4 -5 pm	100	50	50	0	0	100	100	100	100	100	50	50
18	5 - 6 pm	100	50	50	0	0	100	100	100	100	100	50	50
19	6 - 7 pm	100	50	50	0	0	100	100	100	100	100	50	50
20	7 - 8 pm	50	50	50	0	0	50	100	100	100	50	50	50
21	8 - 9 pm	50	50	50	0	0	50	100	100	100	50	50	50
22	9 - 10 pm	50	50	50	0	0	50	100	100	100	50	50	50
23	10 - 11 pm	50	50	50	0	0	50	100	100	100	50	50	50
24	11 - 12 pm	50	50	50	0	0	50	100	100	100	50	50	50

The above schedules are to be adopted as the default profile of Carpark Lighting and Mechanical Ventilation System for reference model and proposed model. Except for jet fan provision, adjustment to the proposed model can be made to account for the contributing factors from energy efficient systems or devices.

Note that the MV schedule will be relevant to mechanical ventilation fans with CO sensors (supply and/or exhaust fans). It does not apply to jet fans system which would need to be in operation at 100%, 24/7 to ensure good air circulation within the carpark for proposed model.

Table 11: Schedules for Escalator and Lift in Office Building

Hour of Day/Time		Escalator Schedule Percentage of Maximum load			Lift Schedule Percentage of Maximum load		
		Weekday	Sat	Sun	Weekday	Sat	Sun
1	12 - 1 am	0	0	0	0	0	0
2	1 - 2 am	0	0	0	0	0	0
3	2 - 3 am	0	0	0	0	0	0
4	3 - 4 am	0	0	0	0	0	0
5	4 - 5 am	0	0	0	0	0	0
6	5 - 6 am	0	0	0	0	0	0
7	6 - 7 am	0	0	0	0	0	0
8	7 - 8 am	100	0	0	35	0	0
9	8 - 9 am	100	0	0	69	0	0
10	9 - 10 am	100	0	0	43	0	0
11	10 – 11am	100	0	0	37	0	0
12	11 - 12 pm	100	0	0	43	0	0
13	12 - 1 pm	100	0	0	58	0	0
14	1 - 2 pm	100	0	0	48	0	0
15	2 - 3 pm	100	0	0	37	0	0
16	3 - 4 pm	100	0	0	37	0	0
17	4 -5 pm	100	0	0	46	0	0
18	5 - 6 pm	100	0	0	62	0	0
19	6 - 7 pm	100	0	0	20	0	0
20	7 - 8 pm	100	0	0	12	0	0
21	8 - 9 pm	0	0	0	0	0	0
22	9 - 10 pm	0	0	0	0	0	0
23	10 - 11 pm	0	0	0	0	0	0
24	11 - 12 pm	0	0	0	0	0	0

The above schedules are to be adopted as the default profile of Escalator and Lift operation for reference model and proposed model. Adjustment to the proposed model can be made to account for the contributing factors from energy efficient systems or devices such as motion sensors, sleep mode, regenerative feature can be considered.

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