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Code of Practice for Energy Efficiency of Building Services Installations in Building

NOTE: This version of the Code is for reference only and not the official version to be gazetted by the Director of Electrical and Mechanical Services under section 40(3) of the Ordinance

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Electrical & Mechanical Services Department

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Code of Practice for Energy Efficiency of Building Services Installations in Buildings

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1. Introduction

1.1 This Code of Practice should be titled “Code of Practice for Energy Efficiency of Building Services Installations in Buildings”, hereinafter referred as the “Building Energy Code” or “BEC”, is approved and issued under the Building Energy Efficiency Ordinance, Chapter xxx (hereinafter referred as “the Ordinance”).

1.2 This BEC sets out the technical guidance and details in respect of the minimum energy efficiency requirements governing the prescribed building services installations under the Ordinance. Building services installations designed, installed and maintained in accordance with this BEC are deemed to have satisfied the relevant requirements of the Ordinance in the technical aspects.

1.3 This BEC is developed by the Electrical & Mechanical Services Department (EMSD) in conjunction with various professional institutions, trade associations, academia and government departments.

1.4 This BEC may be updated from time to time by appropriate notices to cope with technological advancement and prevalent trade practices, and the update will be publicized and given in EMSD’s web-site (http://www.emsd.gov.hk).

2. Interpretations

'air-conditioning' means the process of cooling, heating, dehumidification, humidification, air distribution or air purification.

'air-conditioning installation' has the same meaning in the Ordinance, which in relation to a building, means fixed equipment, distribution network or control devices that cool down, heat up, humidify, dehumidify, purify or distribute air within the building.

'air handling unit (AHU)' means an equipment that includes a fan or blower, cooling and/or heating coils, and provisions for air filtering and condensate drain etc.

'air-conditioning system' means the fixed equipment, distribution network and terminals that provide either collectively or individually the processes of cooling, dehumidification, heating, humidification, air distribution or air-purification or any other associated processes to a conditioned space.

'appliance' means an item of current using equipment other than a luminaire or an independent motor or motor drive.

'area of a space (unit : m^2)' in the context of lighting installation is measured based on the space's internal dimensions excluding thickness of wall and column.

'ASHRAE' refers to American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

'bed passenger lift' means a lift used for transportation of passenger and bed including stretcher.

'brake load' should have the same meaning as in the Code of Practice on the Design and Construction of Lifts and Escalators, EMSD.

'BS EN' – BS refers to British Standards Institution and EN refers to European Committee for Standardization.

'builder's lift' means a lifting machine -

(a) that has a cage;
(b) the operating controls for which are located inside the cage;
(c) the cage of which is raised and lowered by means of a rack and pinion suspension system or rope suspension system; and
(d) the direction of movement of which is restricted by guide or guides, and is used for construction work, and includes the supports, liftway and enclosures and the whole of the mechanical and electrical apparatus required in connection with the operation and safety of the builder's lift.

'building envelope' means the ensemble of the building's external walls.

'building services installation' has the same meaning in the Ordinance, which means - (a) an air-conditioning installation; (b) an electrical installation; (c) a lift and escalator installation; or (d) a lighting installation.

'CEMEP' refers to The European Commission and the Committee of Manufacturers of Electrical Machines and Power Electronics.

'**central building services installation**' has the same meaning in the Ordinance, which means –

(a) a building services installation in a prescribed building that does not solely serve a unit of that building; or

(b) a building services installation in a prescribed building that has no common area except an installation that –

(i) solely serves a unit of that building; and

(ii) is owned by a person who is not the owner of that building.

The technical demarcation as **central building services installation** for corresponding individual installations is -

Building / Individual installation	Building with designated common area	Building without designated common area
Lighting installation	located in the common area	located anywhere in that building unless it is in an individual unit and is separately owned by the responsible person of the unit who is not the owner of that building
Air-conditioning installation	not separately owned by the responsible person of an individual unit	located anywhere in that building, unless it is separately owned by the responsible person of an individual unit who is not the owner of that building
Electrical installation	not on the customer's side of an electricity supplier's electricity meter for an individual unit	located anywhere in that building unless it is on the customer's side of an electricity supplier's separate electricity meter for an individual unit which responsible person is not the owner of that building
Lift & escalator installation	located in the common area, unless solely serving an individual unit	located anywhere in that building, unless it is solely serving an individual unit and is separately owned by the responsible person of that unit who is not the owner of that building

'**chilled/heated water plant**' means a system of chillers/heat pumps, with corresponding matching chilled/heated water pumps and as appropriate condenser water pumps, cooling towers and radiators.

'**chiller**' means an air conditioning equipment that includes evaporator, compressor, condenser, and regulator controls, which serves to supply chilled water.

'**circuit wattage** (unit : W)' in a lighting circuit means the power consumption, including lamp controlgear loss, of a lamp; circuit wattage is equal to the sum of nominal lamp wattage and lamp controlgear loss.

'**circuit, feeder**' means a circuit connected directly from the main LV switchboard or from the isolator just downstream of the main fuse of the electricity supplier to the major current-using equipment.

'**circuit, final**' means a circuit connected from a local distribution board to a current-using equipment, or to socket-outlets or other outlet points for the connection of such equipment or appliances.

'**circuit, main**' means a circuit connected from a distribution transformer to the main LV switchboard downstream of it.

'**circuit, sub-main** (sub-circuit)' means a circuit connected from the main LV switchboard, including the portion through the rising mains as appropriate, or from the isolator just downstream of the main fuse of the electricity supplier, to a local distribution board.

'**coefficient of performance** (COP) **- cooling**' means the ratio of the rate of heat removal to the rate of energy input, in consistent units, for an air-conditioning equipment.

'**coefficient of performance** (COP)**, heat pump - heating**' means the ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a heat pump type air conditioning equipment.

'**common area**' has the same meaning in the Ordinance, which, in relation to a prescribed building –
(a) means any area of the building other than the parts that have been specified in an instrument registered in the Land Registry as being for the exclusive use, occupation or enjoyment of an owner; and
(b) without limiting paragraph (a), includes car parks, entrance lobbies, lift lobbies, corridors, staircases, common toilets, common store rooms, plant rooms, switch rooms, pipe ducts, cable ducts, refuse rooms, material recovery chambers, covered podia, covered playgrounds, occupants' clubhouses and building management offices.

'**conditioned floor area**' means the floor area of conditioned space, as measured at the floor level within the interior surfaces of walls enclosing the conditioned space.

'**conditioned space**' means a space within boundaries maintained to operate at desired temperature through cooling, heating, dehumidification or humidification, using means other than only natural or forced fan ventilation.

'**constant air volume** (CAV) **air distribution system**' means a system that controls the dry-bulb temperature within a space by varying the temperature of supply air that is maintained at constant volume flow to the space.

'**control valve**' in an air-conditioning installation means a valve that controls the flow of chilled or heated water supply to AHU or heat exchanger in response to the cooling or heating load.

'**current unbalance**' in three-phase 4-wire installation is given by:

$I_u = (I_d \times 100) / I_a$

where I_u = percentage current unbalance

I_d = maximum current deviation from the average current

I_a = average current among three phases

'**dead band**' means the range of values within which an input variable can be varied without initiating any noticeable change in the output variable.

'**design energy**' means the total energy consumption of the designed building modelled in accordance with the requirements given in Section 9 of this BEC.

'**designed building**' means the building or unit for which compliance with this BEC based on the performance-based approach in Section 9 of this BEC is being sought, and includes its building envelope, building services installations, and energy consuming equipment.

'**designed circuit current**' means the magnitude of the maximum design current (root mean square (r.m.s.) value for alternating current (a.c.)) to be carried by the circuit at its design load condition in normal service.

'**design documents**' means the documents for describing the building design or building system design, such as drawings and specifications.

'**distribution transformer**' means an electromagnetic device used to step down electric voltage from high voltage distribution levels (e.g. 11kV or 22kV) to the low voltage levels (e.g. 380V), rated from 200kVA, for power distribution in buildings.

'**driving controller**' means the power electronics mechanism to control the output performance including speed, rotation, torque etc. of the controlling motor.

'**dumb-waiter**' means a small service lift usually for transporting prepared meals and the like in a unit serving food.

'**DW143**' refers to "A Practical Guide to Ductwork Leakage Testing (2000)", Heating and Ventilating Contractors' Association (HVCA), UK.

'**effective current-carrying capacity**' means the maximum current-carrying capacity of a cable that can be carried in specified conditions without the conductors exceeding the permissible limit of steady state temperature for the type of insulation concerned.

'**electrical installation**' has the same meaning in the Ordinance, which in relation to a building, means fixed equipment, distribution network or accessories for electricity distribution or utilization in the building.

'**emergency lighting of non-maintained type**' means a kind of emergency lighting that remains off until failure of normal power supply.

'**energy budget**' means the total energy consumption of the reference building modelled in accordance with the requirements given in Section 9 of this BEC.

'**equipment**' means any item for such purposes as conversion, distribution, measurement or utilisation of electrical energy, such as luminaires, air conditioning equipment, motors, motor drives, machines, transformers, apparatus, meters, protective devices, wiring materials, accessories and appliances.

'**escalator**' should have the same meaning assigned by Section 2 of the Lifts and Escalators (Safety) Ordinance (Cap. 327).

'**fan motor power** (unit : Watt)' means the actual electrical power drawn by the motor, calculated by dividing fan shaft power/fan brake power by motor efficiency and mechanical drive efficiency.

'**fireman's lift**' should have the same meaning in the Code of Practice for the Provision of Means of Access for Firefighting and Rescue Purposes, Building Authority.

'**freight lift**' means a lift mainly intended for the transport of goods, which are generally accompanied by persons handling the goods. A general freight lift is one which:-

- the loading in the lift will normally be evenly distributed over the floor of the car;
- the weight of any single piece of freight, or the weight of any single truck, which may be used in the loading of the lift, and the load therein, will be not more than a quarter of the rated load of the lift; and
- the lift will be loaded only manually or by means of trucks which are not driven by any form of power.

'**harmonics**' means a component frequency of the periodic oscillations of an electromagnetic wave that is an integral multiple of the fundamental frequency, being 50 Hz for the power distribution system in Hong Kong.

'**heat pump**' means an air conditioning equipment that includes evaporator, compressor, condenser, and regulator controls, which serves to supply heated water or heated air.

'**hydraulic lift**' means a lift which the lifting power is derived from an electrically driven pump transmitting hydraulic fluid to a jack, acting directly or indirectly on the lift car.

'**IEC**' refers to International Electrotechnical Commission.

'**IEEE**' refers to The Institute of Electrical and Electronics Engineers, Inc.

'**industrial truck loaded freight lift**' is a lift which will be loaded and unloaded by industrial truck, and the loading is not necessarily evenly distributed over the floor, and the weight of any single piece of freight and its truck can exceed a quarter of the rated load of the lift.

'**internal floor area**', in relation to a space or a unit, means the floor area of all enclosed space measured to the internal faces of enclosing external walls, party walls or virtual side planes to distinguish the space or unit in question from adjoining spaces or units.

'**lamp controlgear**' is a device used for starting and maintaining the operation of a lamp.

'**lamp controlgear loss** (unit : W)' means the power consumption of a lamp controlgear operating under the design voltage, frequency and temperature of a lighting installation, excluding the power consumption in the dimmer and for a lamp operating on low voltage the step-down transformer should the dimmer or transformer not be integral to the controlgear.

'**lift**' should have the same meaning assigned by Section 2 of the Lifts and Escalators (Safety) Ordinance (Cap. 327), but for purpose of this BEC excluding mechanized vehicle parking system.

'**lift and escalator installation**' has the same meaning in the Ordinance, which means a system of equipment comprising –

(a) a lift or escalator as defined in section 2(1) of the Lifts and Escalators (Safety) Ordinance (Cap. 327); and

(b) any associated installation specified in a code of practice that is used for the operation of the lift or escalator.

'**lift bank**' means a lift system with two or more lift cars serving a zone, including lifts that may serve more than one zone but for the time in question serving the specific zone.

'**lift decoration load**' means the loads in a lift car for decorative purpose and not essential to lift operative functions delineated in the Code of Practice on the Design and Construction of Lifts and Escalators, EMSD, which should however exclude balancing weights in association with provision of air-conditioning to the lift car.

'**lift in a performance stage**' means a lift at the backstage designated to serve the performers of a show on a stage.

'**lighting control point**' means a lighting control device controlling the on, off or lighting level setting of a lighting installation.

'**lighting, decorative**' means lighting that is purely ornamental and installed for aesthetic effect, and should not include general lighting.

'**lighting installation**' has the same meaning in the Ordinance, which in relation to a building, means a fixed electrical lighting system in the building including –

(a) general lighting that provides a substantially uniform level of illumination throughout an area; or

(b) maintained type emergency lighting;

but does not include non-maintained type emergency lighting.

'**lighting power density** (LPD) (unit : W/m^2)' means the electrical power consumed by fixed lighting installations per unit floor area of an illuminated space.

(In equation form, the definition of LPD is given by:

$$LPD = \frac{\text{Total wattage of the fixed lighting installations}}{\text{Internal floor area of that space}}$$)

'**local distribution board**' means the distribution board for final circuits to current-using equipment, luminaires, or socket-outlets.

'**luminaire**' means a lighting device, which distributes light from a single lamp or a group of lamps; a luminaire should include controlgears and all necessary components for fixing and mechanical protection of lamps.

'**main fuse**' has the meaning in the supply rules of the electricity supplier.

'**maximum demand**' means the maximum power demand registered by a consumer in a stated period of time such as a month; the value is the average load over a designated interval of 30 minutes in kVA.

'**mechanical drive**' means the mechanism of a set of speed reduction gears transferring the power from the motor shaft to the drive sheave in a traction lift system or to the chain or drum drive for the pallets or steps in an escalator or conveyor system.

'**mechanized vehicle parking system**' should have the same meaning as in the Lifts and Escalators (Safety) Ordinance (Cap. 327).

'**meter**' means a measuring instrument and connected equipment designed to measure, register or indicate the value of voltage, current, power factor, electrical consumption or demand with respect of time, etc.

'modelling assumptions' in the context of the performance-based approach (Section 9 of this BEC) means the conditions (such as weather conditions, thermostat settings and schedules, internal heat gain, operation schedules, etc.) that are used for calculating a building's annual energy consumption.

'motor control centre (MCC)' means a device or group of devices in a cubicle assembly that serves to control the operation and performance of the corresponding electric motor greater than 5kW, or group of motors with at least one greater than 5kW,.including starting and stopping, selecting mode of rotation, speed, torque etc., which may or may not incorporate protective devices against overloads and faults.

'motor drive' of a lift, escalator or passenger conveyor means the electrical motor driving the equipment plus the driving controller.

'multi-functional space' in the context of lighting installation means a space in which

- its different functional activities classified in terms of the various space types (listed in Table 5.4) are performed at different times, and
- the illumination for each space type is provided by a specific combination of different groups of luminaires in the space.

'nominal lamp wattage (unit : W)' means the power consumption of a lamp, excluding the lamp controlgear loss, given by the lamp manufacturer.

'non-linear load' means any type of equipment that draws a non-sinusoidal current waveform when supplied by a sinusoidal voltage source.

'off-hour' means a time beyond normal occupancy hours.

'OTTV' means the OTTV in the Code of Practice for Overall Thermal Transfer Value in Buildings, Building Authority, promulgated under Building (Energy Efficiency) Regulation (Cap. 123M) and the subsequent amendments.

'passenger conveyor' should have the same meaning assigned by Section 2 of the Lifts and Escalators (Safety) Ordinance (Cap. 327).

'passenger lift' means a lift which is wholly or mainly used to carry persons.

'power factor, displacement' of a circuit means the ratio of the active power of the fundamental wave, in Watts, to the apparent power of the fundamental wave, in Volt-Amperes, its value in the absence of harmonics coinciding with the cosine of the phase angle between voltage and current.

'power factor, total' of a circuit means the ratio of total active power of the fundamental wave, in Watts, to the total apparent power that contains the fundamental and all harmonic components, in Volt-Amperes.

'powered lifting platform' means a platform not being a lift car that can be moved up or down through a powered mechanism

'process requirement' in air-conditioning means the requirement in the provision of air-conditioning for a manufacturing or industrial process other than for human comfort purpose.

'public service escalator or passenger conveyor' means an escalator or passenger conveyor that is part of a public traffic system including entrance and exit points (for example for connecting a traffic station and a building), and is suitable for operating regularly for not less than 140 hours/week with a load reaching 100% of the brake load during periods lasting for at least 0.5 hour during any time interval of 3 hours.

'rated load' of a lift or escalator should have the same meaning as in the Lifts and Escalators (Safety) Ordinance (Cap. 327).

'rated speed' of a lift or escalator should have the same meaning as in the Lifts and Escalators (Safety) Ordinance (Cap. 327).

'recooling' means lowering the temperature of air that has been previously heated by a heating system.

'**reference building**' means a building design of the same size and shape as the designed building or unit, modelled in accordance with the requirements given in Section 9 of this BEC and with corresponding building services installations fully satisfying the energy efficiency requirements given in Sections 5 to 8 of this BEC.

'**reheating**' means raising the temperature of air that has been previously cooled by a refrigeration system.

'**rising mains**' means the part of a circuit for distribution of electricity throughout a building for multiple occupation and any tee-off there from for each occupation will be provided a meter of an electricity supplier.

'**service lift**' should have the same meaning as in the Lifts and Escalators (Safety) Ordinance (Cap. 327).

'**shading coefficient** (SC)' means the ratio of solar heat gain at normal incidence through glazing to that through 3 mm thick clear, double-strength glass. Shading coefficient, as used herein, does not include interior, exterior, or integral shading devices.

'**skylight-roof ratio**' means the ratio of skylight area to gross roof area.

'**space**' in the context of lighting installation means a region in a building or unit that is illuminated by artificial lighting and is bounded by a physical floor, a physical ceiling and physical walls or virtual side planes to distinguish the space in question from adjoining spaces.

'**stairlift**' should have the same meaning as in the Code of Practice on the Design and Construction of Lifts and Escalators, EMSD.

'**supply water temperature reset control**' means the control in an air-conditioning installation where the chilled or heated water supply to AHU or fan coil unit can automatically change at a certain part load condition to a temperature setting demanding less energy consumption, and can, upon resumption of the full load condition, automatically return to the original setting.

'**surface coefficient** (symbol : h), (unit : W/m^2-°C)' means the rate of heat loss by a unit area of a given surface divided by the temperature difference in degree Celsius between the surface and the ambient air.

'**thermal block**' means a collection of one or more air-conditioning zones grouped together for simulation purposes. Spaces need not be contiguous to be combined within a single thermal block.

'**thermal conductivity** (symbol : λ), (unit : W/m-°C)' means the quantity of heat that passes in unit time through unit area of a homogeneous flat slab of infinite extent and of unit thickness when unit difference of temperature in degree Celsius is established between its faces.

'**total energy consumption**' means the sum of the energy consumption of the building services installations of a building or unit, calculated over a period of one year with numerical method for building energy analysis, with calculation in accordance with Section 9 of this BEC.

'**total harmonic distortion** (THD)' in the presence of several harmonics, means a ratio of the root mean square (r.m.s.) value of the harmonics to the r.m.s. value of the fundamental expressed in percentage.

(In equation form, the definition of %THD for current is given by:

$$\%THD = \frac{\sqrt{\sum_{h=2}^{\infty}(I_h)^2}}{I_1} \times 100$$

where : I_1 = r.m.s. value of fundamental current

I_h = r.m.s. value of current of the hth harmonic order)

'**trade-off**' in the performance-based approach in Section 9 of this BEC means the compensation of the shortcoming of energy performance in an installation by an alternative design with better energy performance in the building.

'**unconditioned space**' means the enclosed space within a building that is not a conditioned space.

'**unit**' has the same meaning in the Ordinance, which in relation to a building, means –
(a) a unit or a part of the building; or
(b) 2 or more units or parts of the building that are –
(i) occupied by the same occupier for the purpose of the same undertaking; and
(ii) interconnected by an internal corridor, internal staircase or other internal access;
but does not include a common area of the building.

'**unitary air-conditioner**' means an air conditioning equipment that includes evaporator, compressor, condenser, cooling or heating coil, air re-circulation fan section, and regulator controls, which serves to supply cooled or heated air.

'**variable air volume** (VAV) **air distribution system**' means a system that controls the dry-bulb temperature within a space by varying the volume of supply air to the space automatically as a function of the air-conditioning load.

'**variable refrigerant flow** (VRF)' means variable refrigerant volume flow in a unitary air-conditioner where the cooling supply to the air-conditioned space is adjusted by modulating the flow of refrigerant.

'**variable speed drive** (VSD)' of a motor means a motor drive that controls the motor speed over a continuous range.

'**vehicle lift**' means a lift which is suitably dimensioned and designed for carrying motor vehicles.

'**voltage**' means voltage by which an installation (or part of an installation) is designated. The following ranges of voltage (root mean square (r.m.s.) values for alternating current (a.c.)) are defined:

- low voltage (LV) : normally exceeding extra low voltage but normally not exceeding: between conductors, 1000V r.m.s. a.c. or 1500V direct current (d.c.), or between a conductor and earth, 600V r.m.s. a.c. or 900V d.c.;
- extra low voltage : normally not exceeding 50V r.m.s. a.c. or 120V d.c., between conductors or between a conductor and earth;
- high voltage (HV) : normally exceeding low voltage.

'**window-wall ratio**' means the ratio of vertical fenestration area to gross exterior wall area.

'**zone**' in the context of air-conditioning means a space or group of spaces within a building with similar air-conditioning requirements which are considered to behave as one space for the purpose of design and control of air-conditioning system.

3. Application

3.1 Prescribed Buildings

This BEC is applicable to the prescribed building services installations in the categories of buildings prescribed in Schedule 1 of the Ordinance.

3.2 Exemption

This BEC is not applicable to –

(a) the categories of buildings not prescribed in Schedule 1 of the Ordinance;

(b) the categories of buildings specified in Section 4 of the Ordinance; and

(c) the categories of building services installations specified in Schedule 2 of the Ordinance.

4. Technical Compliance with the Ordinance

4.1 Building Services Installation in Post-enactment Buildings

4.1.1 Post-enactment buildings refer to buildings that obtain the "consent to the commencement of building works" (as defined in Section 2 of the Ordinance) for superstructure construction after the commencement of Part 2 of the Ordinance.

4.1.2 To satisfy the relevant requirements of the Ordinance, the building services installations in post-enactment buildings, save for exemption under the Ordinance, should in any circumstances comply with the requirements in -

(a) either Sections 5 to 8 of this BEC as appropriate (prescriptive approach) or Section 9 of this BEC (performance-based approach) for system design, and

(b) Section 11 of this BEC for maintenance,

unless otherwise specified.

4.2 Building Services Installation Covered by Major Retrofitting Works

4.2.1 When major retrofitting works prescribed in Schedule 3 of the Ordinance and Section 10 of this BEC are carried out in post-enactment buildings or pre-enactment buildings, to satisfy the relevant requirements of the Ordinance, the involved building services installations, save for exemption under the Ordinance, should comply with the requirements in -

(a) Section 10 of this BEC for system design, and

(b) Section 11 of this BEC for maintenance,

unless otherwise specified.

4.2.2 Pre-enactment buildings refer to buildings that obtain the "consent to the commencement of building works" (as defined in Section 2 of the Ordinance) for superstructure construction on or before the commencement of Part 2 of the Ordinance.

4.2.3 Notwithstanding requirements on major retrofitting works in clause 4.2.1, retrofitting works not falling within the scope of major retrofitting works in post-enactment buildings should still be governed by clause 4.1.2 where appropriate.

5. Energy Efficiency Requirements for Lighting Installations

5.1 Scope of Application

5.1.1 All lighting installations, unless otherwise specified, in a prescribed building should be in accordance with the energy efficiency requirements of this Section.

5.1.2 The following installations are not governed by the energy efficiency requirements of this Section –

(a) lighting exterior to a building including façade lighting, outdoor lighting, signage lighting and lighting underneath canopy over a pavement or road;
(b) lighting not of fixed type, and connected to power supply via flexible cable with plug and socket;
(c) lighting integral to an equipment or instrumentation that is not a luminaire and with separate control switch;
(d) lighting integral to a signage; and
(e) a lighting installation included in the installations specified in Schedule 2 of the Ordinance.

5.1.3 For the avoidance of doubt, a lighting installation should also include -

(a) all maintained type lighting installation fed by essential power supply.

5.2 General Approach

The requirements for energy efficient design of lighting installations are for the purposes of -

(a) reducing lighting power through imposing maximum allowable lighting power density in a space; and
(b) reducing energy use through proper lighting control.

5.3 Definitions

The definitions of terms applicable to lighting installations are given in Section 2 of this BEC.

5.4 Lighting Power Density

5.4.1 The lighting power density (LPD) of an individual space classified in Table 5.4 should not exceed the corresponding maximum allowable value given in Table 5.4, unless the total electrical power consumed by the complete fixed lighting installations in the space does not exceed 100W.

Table 5.4 : Lighting Power Density for Various Types of Space

Type of Space	Maximum Allowable Lighting Power Density (W/m^2)
Atrium / Foyer with headroom over 5m	20
Bar / Lounge	15
Banquet Room / Function Room / Ball Room in Hotel or Guesthouse	23
Canteen	15
Carpark	6
Classroom / Lecture Theatre / Training Room	17
Clinic	20
Conference / Seminar Room	18
Corridor	12
Dormitory / Quarters / Barrack	13
Entrance Lobby	17
Exhibition Hall / Gallery	23
Guest room in Hotel or Guesthouse	17
Gymnasium / Exercise Room	15
Kitchen	17
Laboratory	17
Library - Reading Area, Stack Area or Audio Visual Centre	17
Lift Car	15
Lift Lobby	15
Loading & Unloading Area	11
Multi-functional Space LPD of each combination of function-specific luminaires should not exceed the maximum allowable value corresponding to the type of space illuminated by that combination of luminaires, detailed as follows: LPD_{F1} not to exceed LPD_{S1} , LPD_{F2} not to exceed LPD_{S2} ,………., LPD_{Fn} not to exceed LPD_{Sn} where LPD_{F1} , LPD_{F2} .,…., LPD_{Fn} respectively refers to the lighting power density corresponding to function F1, F2, …., Fn, and LPD_{S1} , LPD_{S2} .,…., LPD_{Sn} respectively refers to the maximum allowable value of lighting power density corresponding to the classified Space S1, S2,….., Sn based on the respective function F1, F2, ……, Fn.	See below
Office, Drawing	20
Office, Open Plan / Cellular	17
Patient Ward / Day Care	15
Plant Room / Machine Room / Switch Room	13
Public Circulation Area	15

Table 5.4 : Lighting Power Density for Various Types of Space	
Type of Space	Maximum Allowable Lighting Power Density (W/m^2)
Railway Station • Concourse / Platform / Entrance / Adit / Staircase, with headroom not exceeding 5m • Concourse / Platform / Entrance / Adit / Staircase, with headroom over 5m	15 20
Restaurant	23
Retails	20
Seating Area inside Theatre / Cinema / Auditorium / Concert Hall / Arena	17
Sports Arena, Indoor, for recreational purpose	17
Staircase	8
Storeroom / Cleaner	11
Toilet / Washroom / Shower Room	13
Workshop	15

5.4.2 The lighting power of the installations specified in Schedule 2 of the Ordinance may be excluded in the calculation of lighting power density.

5.5 Lighting Control

5.5.1 The minimum number of lighting control points for any space that is classified as an office should comply with requirements given in Table 5.5.

Table 5.5 : Minimum Number of Lighting Control Points for Office Space	
Space Area A (m^2)	Minimum No. of Lighting Control Points (N : integer)
$15 \times (N - 1) < A \leq 15 \times N$	$0 < N \leq 10$
$30 \times (N-6) < A \leq 30 \times (N - 5)$	$10 < N \leq 20$
$50 \times (N - 12) < A \leq 50 \times (N-11)$	$N > 20$

5.5.2 In a space with actual lighting power density value lower than the corresponding value in Table 5.4, fewer no. of control points can be provided, the percentage reduction of which should not be more than the ratio given by the difference between allowable LPD and actual LPD to the allowable LPD.

5.5.3 For each functional activity in a multi-functional space, suitable lighting control point(s) should be provided for the specific combination of luminaires for the activity in question, and the operation of these luminaires for the specific activity should be independent of the operation of the luminaires not for the activity.

5.5.4 Switching for general lighting and other non-general lighting (including lighting of the installations specified in Schedule 2 of the Ordinance) should be separated from each other in order to allow separate switching off when not in use.

6. Energy Efficiency Requirements for Air-conditioning Installations

6.1 Scope of Application

6.1.1 All air-conditioning installations, unless otherwise specified, in a prescribed building should be in accordance with the energy efficiency requirements of this Section.

6.1.2 The following installations are not governed by the energy efficiency requirements of this Section –

(a) an air-conditioning installation included in the installations specified in Schedule 2 of the Ordinance; and
(b) equipment operating on high voltage.

6.1.3 For the avoidance of doubt, the energy efficiency requirements of this Section should also apply to -

(a) all air moving equipment being part of a fire service installation but also providing normal air-conditioning or ventilation to a space; and
(b) unitary air-conditioner for lift car.

6.2 General Approach

The requirements for energy efficient design of air-conditioning installations are for the purposes of –

(a) encouraging proper sizing of air-conditioning equipment and systems by setting design conditions and imposing load estimation procedures;
(b) reducing air side distribution losses through imposing limits on air distribution system fan motor power and ductwork leakage, and conditions warranting separate distribution systems;
(c) reducing water side distribution losses through imposing limits on pipe friction loss and conditions warranting variable flow;
(d) reducing energy consumption in air-conditioning equipment through minimum allowable coefficients of performance;
(e) reducing conduction losses in pipework, ductwork and AHU casing through minimum allowable thickness on insulation thereto; and
(f) reducing the use of energy through efficient controls and monitoring facilities for power and energy consumption.

6.3 Definitions

The definitions of terms applicable to air-conditioning installations are given in Section 2 of this BEC.

6.4 System Load Calculation

6.4.1 The air-conditioning cooling and heating load calculations should be in accordance with established internationally recognised procedures and methods.

6.4.2 The following design conditions should be used for load calculations for sizing system and equipment:

Table 6.4 : Air-conditioning System Load Design Conditions

Condition	Season	Applications	Temperature / Relative Humidity	
Indoor, for human comfort applications, except for the installations specified in Schedule 2 of the Ordinance	Summer	Office and Classroom	Minimum dry bulb temperature	23^{0}C
			Minimum relative humidity	50%
		Other applications	Minimum dry bulb temperature	22^{0}C
			Minimum relative humidity	50%
	Winter	Hotel	Maximum dry bulb temperature	24^{0}C
			Maximum relative humidity	50%
		Other applications	Maximum dry bulb temperature	22^{0}C
			Maximum relative humidity	50%
Outdoor	Summer	All applications	Maximum dry bulb temperature	35^{0}C #
			#: at coincident wet bulb temperature of 26.4^{0}C	
			Maximum wet bulb temperature	29^{0}C
	Winter	All applications	Minimum dry bulb temperature	7^{0}C

6.5 Separate Air Distribution System for Process Zone

6.5.1 An air distribution system serving a process zone for process requirement or computer/data centre with special process temperature and/or humidity requirements should be dedicated to serve the zone only and be separate from other system serving comfort only zone.

6.5.2 A process zone in clause 6.5.1 can share a common air distribution system with comfort only zone and the requirement in clause 6.5.1 needs not apply if

(a) the supply air to the comfort zone is no more than 25% of the total air flow of the common air distribution system; or
(b) the total conditioned floor area of the comfort zone served by the common system is smaller than 100m^2; or
(c) the process zone has separate room temperature control and requires no reheat of the common system supply air, and the supply air to the process zone is no more than 25% of the total air flow of the common system.

6.6 Air Distribution Ductwork Leakage Limit

6.6.1 At least 25% in area of ductwork designed to operate at operating static pressure in excess of 750 Pa should be leakage-tested in accordance with DW143 and meet the corresponding maximum allowable air leakage limit given in Table 6.6.

Table 6.6 : Air Leakage Limit of Ductwork

Leakage Class	Operating Static Pressure (Pa)	Air Leakage Limit (L/s per m^2 of duct surface)
I	above 750 to 1000	0.009 x $p^{0.65}$
II	above 1000 to 2000	0.003 x $p^{0.65}$
III	above 2000	0.001 x $p^{0.65}$
p is the operating static pressure in Pascal		

6.7 Air Distribution System Fan Power

6.7.1 The system fan motor power required for a constant air volume air distribution system for a conditioned space should not exceed a limit of 1.6 W per litre per second (L/s) of supply system air flow.

6.7.2 The system fan motor power required for a variable air volume air distribution system for a conditioned space should not exceed a limit of 2.1 W per L/s of supply system air flow.

6.7.3 The system fan motor power limit specified in clauses 6.7.1 and 6.7.2 refers to the sum of fan motor power of the supply air fan and return air fan of the air distribution system. The system fan motor power limit is based on the assumption that the pressure drop across air filters, any other air treatment devices and heat wheels/exchangers in the air distribution system will not exceed 250 Pa in total, and the portion of fan power consumed due to pressure drop in excess of 250 Pa is deductible from the system fan motor power.

The portion of deductible fan motor power should be calculated as follows:

$P_f = V \times (P_d - 250) / (\eta_m \times \eta_f \times \eta_d)$

where

P_f = Deductible fan motor power for air treatment/filtering (W) in excess of 250 Pa

V = Air volume flow rate (m^3/s)

P_d = Air pressure drop (Pa) of the treatment/filtering system and/or heat wheel/exchanger system in clean condition

η_m = Motor efficiency

η_f = Fan efficiency

η_d = Drive/belt efficiency

6.7.4 Any individual supply or return air fan in a variable air volume air distribution system with a fan motor power of 5 kW or greater should incorporate controls and devices such that the fan motor demands no more than 55 % of design input power at 50% of design air volume.

6.7.5 The requirements in clauses 6.7.1 and 6.7.2 should not apply to

(a) a system with system fan motor power less than 5 kW; or

(b) a system only with air handling units with individual fan motor power less than 1 kW; or

(c) an installation specified in Schedule 2 of the Ordinance.

6.8 Pumping System Variable Flow

6.8.1 A water side pumping system should be designed for variable flow if its control valves are designed to modulate or step open and close as a function of load, and it should be capable of reducing system flow to 50% of design flow or less, except -

(a) where a minimum flow greater than 50% of the design flow is required for the proper operation of the equipment it serves, such as chiller, or

(b) it has no more than one control valve, or

(c) it incorporates supply water temperature reset control.

6.8.2 A variable speed pump with motor power of 5kW or greater should demand no more than 55% of design input power at 50% of design water volume.

6.9 Frictional Loss of Water Piping System

Water piping with diameter larger than 50 mm should be sized for frictional loss not exceeding 400 Pa/m and water flow velocity not exceeding 3 m/s. Water piping with diameter 50 mm or below should be sized for flow velocity not exceeding 1.2 m/s.

6.10 System Control

6.10.1 Temperature Control

6.10.1.1 Each air-conditioning system for cooling or heating should be provided with at least one automatic temperature control device for regulation of space temperature.

6.10.1.2 A temperature control device for comfort cooling should be capable of adjusting the set point temperature of the space it serves up to 29^{0}C or higher.

6.10.1.3 A temperature control device for comfort heating should be capable of adjusting the set point temperature of the space it serves down to 16^{0}C or lower.

6.10.1.4 A temperature control device for both comfort cooling and heating should be capable of providing a dead band of at least 2^{0}C within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum, except for a temperature control device that requires manual changeover between heating and cooling modes.

6.10.2 Humidity Control

6.10.2.1 Each air-conditioning system for removing or adding moisture to maintain specific humidity levels should be provided with at least one automatic humidity control device for regulation of humidity.

6.10.2.2 A humidity control device for comfort humidification should be capable of adjusting the set point relative humidity of the space it serves down to 30%.

6.10.2.3 A humidity control device for comfort dehumidification should be capable of adjusting the set point relative humidity of the space it serves up to 60%.

6.10.3 Zone Control

6.10.3.1 Each air-conditioned zone should be controlled by a separate temperature control device for controlling the temperature within the zone.

6.10.3.2 For the purpose of clause 6.10.3.1 a zone should not include spaces on different floors, except for an independent perimeter system that is designed to offset only envelope heat gain or loss or both, where

(a) the perimeter system includes at least one temperature control zone for each building exposure having exterior walls facing only one orientation for contiguous distance of 15 m or more, and
(b) the cooling and/or heating supply of the perimeter system is controlled by a temperature control device located within the zone served by the system.

6.10.3.3 Where both heating and cooling are provided to a zone for human comfort application, the controls should not permit the heating of previously cooled air, and the cooling of previously heated air, and should not permit both heating and cooling operating at the same time, except

(a) for a variable air volume system which, during periods of occupancy, is designed to reduce the supply air to each zone to a minimum before reheating, recooling, or mixing of previously cooled/heated air, and the minimum volume should be no greater than 30% of the peak supply volume; or
(b) for the reheating or recooling of outdoor air which has been previously pre-cooled or pre-heated by a primary air handling unit; or
(c) at least 75% of the energy for reheating or for providing heated air in mixing is provided from a site-recovered or renewable energy source; or
(d) the zone has a peak supply air flow rate of 140 L/s or less; or
(e) where specific humidity levels are required to satisfy process requirements; or
(f) for the installations specified in Schedule 2 of the Ordinance.

6.10.4 Off-hours Control

6.10.4.1 Each air-conditioning system with cooling or heating capacity more than 10kW should be equipped with automatic controls capable of accomplishing a reduction of energy use in the corresponding cooling or heating mode of operation through control setback or equipment shutdown during periods of non-use of the spaces served by the system.

6.10.4.2 Each air-conditioning system with cooling or heating capacity not more than 10kW may be controlled by readily accessible manual off-hour control to achieve a reduction of energy use in the corresponding cooling or heating mode of operation.

6.10.4.3 Guest Rooms in Hotel, Guest House and Hostel

Each guest room or suite with multiple rooms should be provided with a single master control device to reduce energy use during un-occupied periods. The master control device should be able to -

(a) turn off or reduce the conditioned air supply to a minimum; or
(b) reset the temperature setting to reduce energy use; or
(c) reset the temperature setting together with reduction of fan speed.

6.11 Thermal Insulation

6.11.1 All chilled water pipework, suction refrigerant pipework, and ductwork carrying cooled air, and casing of air handling unit handling cooled air should be insulated with a minimum thickness calculated in accordance with the respective equation and approach in clauses 6.11.1.1 and 6.11.1.2, for given surrounding condition and thermal conductivity of insulation of the installation.

6.11.1.1 Calculation of Insulation Thickness for Pipework

(a) Calculate using Equation 6.11(a) the provisional thickness χ (unit – mm) based on known values of the variables in Equation 6.11(a).

$\chi = 10^3 \times \lambda/h \times \{(\theta_d - \theta_l)/(\theta_m - \theta_d)\}$ ………………………………... Equation 6.11(a)

where h = Surface coefficient of external surface of insulation - W/m^2-^{o}C

λ = Thermal conductivity of insulating material - W/m-^{o}C

θ_d = Dew point temperature - ^{o}C

θ_l = Temperature of the cold surface (line temperature) - ^{o}C

θ_m = Temperature of the ambient still air - ^{o}C

(b) Roughly estimate the value of L_a based on general engineering practice, and calculate using Equation 6.11(b) the provisional thickness χ (unit – mm) based on known values of the variables in Equation 6.11(b).

$\chi = 0.5\,(d_o + 2L_a) \times \ln\,[1 + 2L_a/d_o]$ ………………………………Equation 6.11(b)

where L_a = Estimated minimum thickness – mm, which will converge to become the actual value through iterations

d_o = Outside diameter of pipe or tube – mm

(c) Compare the two calculated values of thickness in (a) and (b). The estimated L_a value will be deemed to be the actual thickness if the two χ values are reasonably close to each other. Should the two values not be reasonably close, conduct an iteration of Equation 6.11(b) with another estimated likely converging value of L_a.

6.11.1.2 Calculation of Insulation Thickness for Ductwork and AHU Casing

Calculate using Equation 6.11(a) the thickness χ (unit – mm) based on known values of the variables in Equation 6.11(a).

6.11.2 As an alternative to clause 6.11.1 the insulation thickness should be as given in Tables 6.11a to 6.11c, for the given surrounding condition and thermal conductivity of insulation of the installation.

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Table 6.11a : Minimum Insulation Thickness for Chilled Water Pipework @1

	Outdoor @2				Unconditioned Space @2				Conditioned Space @2	
Thermal conductivity λ @3 (W/m-°C)	0.024		0.04		0.024		0.04		0.024	0.04
Surface coefficient h @4 (W/m²-°C)	9	13.5	9	13.5	5.7	10	5.7	10	not applicable	
Pipe outer diameter d_o @1	Insulation thickness (mm) @1									
21.3 mm	20	15	30	22	29	19	43	28	13	13
26.9 mm	21	15	32	23	31	20	46	29	13	13
33.7 mm	22	16	34	24	32	21	48	31	13	13
42.4 mm	23	17	35	25	34	21	50	32	13	25
48.3 mm	24	17	36	26	35	22	52	33	13	25
60.3 mm	25	18	38	27	36	23	54	35	13	25
76.1 mm	26	18	40	28	38	24	57	36	14	25
88.9 mm	26	19	41	29	39	24	59	37	14	25
114.3 mm	27	19	42	30	41	25	62	39	14	25
139.7 mm	28	20	44	31	42	26	64	40	14	25
168.3 mm	29	20	45	32	43	26	66	41	14	25
219.1 mm	29	20	47	32	44	27	69	42	15	25
273 mm	30	21	48	33	45	27	71	43	15	25
323.9 mm	30	21	49	34	46	28	73	44	15	25
355.6 mm	31	21	49	34	47	28	74	45	15	25
406.4 mm	31	21	50	34	47	28	75	45	15	25

Remarks @ to Tables 6.11a to 6.11c:

1 Pipework : Table 6.11a based on steel pipes of BS EN Standards 10255:2004 / BS EN 10220:2002 at line temp θ_l of 5°C, and table 6.11b based on copper pipes of BS EN Standard 12449:1999. (for other metal pipes, same insulation thickness should be applied to comparable outer diameters).

2 Outdoor or unconditioned space condition : based on 27°C dew point at 90% coincident relative humidity and coincident 28.8°C dry bulb (as recommended in 2009 ASHRAE Handbook – Fundamentals);
Conditioned space : insulation thickness based on recommendation in ASHRAE Standard 90.1-2004, and minimal thickness taken as 13mm.

3 Thermal conductivity λ : based on rating at 20°C mean.

4 Surface coefficient : h is assumed for indoor still air condition to be 5.7 for bright metal surface and to be 10 for cement or black matt surface; h is assumed for outdoor condition with a wind speed of 1m/s to be 9 for bright metal surface and to be 13.5 for black matt surface.

Table 6.11b : Minimum Insulation Thickness for Refrigerant Pipework (suction) @1

	Outdoor @2				Unconditioned Space @2				Conditioned Space @2	
Thermal conductivity λ (W/m-°C) @3	0.024		0.04		0.024		0.04		0.02	0.04
Surface coefficient h (W/m²-°C) @4	9	13.5	9	13.5	5.7	10	5.7	10	not applicable	
Pipe outer diameter d_o @1	Insulation thickness (mm) @1									
Line temperature θ_l	0^0C									
6 mm	18	13	27	19	25	17	38	25	13	13
8 mm	19	14	28	21	27	18	40	26	13	13
10 mm	20	15	30	22	29	19	43	28	13	13
12 mm	21	15	31	23	30	19	44	29	13	13
15 mm	22	16	33	24	31	20	47	30	13	13
22 mm	24	18	36	26	34	22	51	33	13	13
28 mm	25	18	38	28	36	23	54	35	13	25
35 mm	27	19	40	29	38	24	57	37	13	25
42 mm	28	20	41	30	40	25	59	38	13	25
54 mm	29	21	44	31	42	27	62	40	13	25
76 mm	31	22	47	33	45	28	67	43	14	25
Line temperature θ_l	-10^0C									
6 mm	23	17	34	25	33	21	49	31	13	13
8 mm	24	18	36	26	35	23	52	33	13	13
10 mm	26	19	38	28	37	24	54	35	13	13
12 mm	27	20	40	29	38	25	57	37	13	13
15 mm	28	21	42	31	40	26	59	39	13	13
22 mm	31	22	46	33	44	28	65	42	13	13
28 mm	32	24	48	35	46	30	69	44	13	25
35 mm	34	25	51	37	49	31	72	47	13	25
42 mm	35	26	53	38	51	33	75	49	13	25
54 mm	37	27	56	40	54	34	80	51	13	25
76 mm	40	28	60	43	57	36	86	55	14	25
Line temperature θ_l	-20^0C									
6 mm	28	20	41	30	39	25	59	38	13	13
8 mm	29	21	44	32	42	27	62	40	13	13
10 mm	31	23	46	33	44	28	65	42	13	13
12 mm	32	24	48	35	46	30	68	44	13	13
15 mm	34	25	50	37	48	31	72	46	13	13
22 mm	37	27	55	40	53	34	78	51	13	13
28 mm	39	28	58	42	56	36	82	53	13	25
35 mm	41	30	61	45	59	38	87	56	13	25
42 mm	43	31	64	46	61	39	90	59	13	25
54 mm	45	33	67	49	64	41	96	62	13	25
76 mm	48	35	72	53	69	44	104	67	14	25

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Table 6.11c : Minimum Insulation Thickness for Ductwork and AHU Casing [@1]

	Outdoor [@2]				Unconditioned Space [@2]				Conditioned Space [@2]	
Thermal conductivity λ (W/m-^{o}C) [@3]	0.024		0.04		0.024		0.04		0.024	0.04
Surface coefficient h (W/m^2-^{0}C) [@4]	9	13.5	9	13.5	5.7	10	5.7	10	not applicable	
Temperature difference between air inside duct/ casing and surrounding of duct/casing	Insulation thickness (mm) [@1]									
15 ^{0}C	20	13	33	22	31	18	52	30	15	25
20 ^{0}C	27	18	46	30	43	25	72	41	15	25

6.11.3 Insulation for outdoor or unconditioned space should be water vapour retardant such as of closed cell type, to prevent degradation due to moisture ingress.

6.12 Air-conditioning Equipment Efficiency

6.12.1 A factory-designed and pre-fabricated electrically-driven equipment shown in Tables 6.12a or 6.12b should have the corresponding minimum coefficient of performance at the specified rating condition given in the table.

6.12.2 A room air conditioner of the types under the scope of The Hong Kong Voluntary Energy Efficiency Labelling Scheme for Room Coolers launched by EMSD as at January 2009, or governed by the Code of Practice on Energy Labelling of Products, May 2008 Edition, published by EMSD should fulfill the requirements of Energy Efficiency Grade 3 or above.

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<table>
<tr><th colspan="6"><u>Table 6.12a : Minimum Coefficient of Performance for Unitary Air-conditioner</u></th></tr>
<tr><td>Type of Cooling</td><td colspan="4">Air-cooled</td><td>Water-cooled</td></tr>
<tr><td>Capacity range (kW)</td><td>7.5 kW & below, of types outside the scope of Room Air Conditioners in the labelling schemes in Clause 6.12.2</td><td>Above 7.5 kW & below 40 kW</td><td>40 to 200 kW</td><td>Above 200 kW</td><td>All Ratings</td></tr>
<tr><td rowspan="2">Minimum COP at cooling mode (free air flow)</td><td rowspan="2">2.4 for split type
2.1 for non-split type</td><td colspan="2">2.4</td><td>2.6</td><td rowspan="2">3</td></tr>
<tr><td>3 for VRF</td><td colspan="2">2.9 for VRF</td></tr>
<tr><td>Minimum COP at heat pump mode (free air flow)</td><td>2.4</td><td>2.7</td><td>2.8</td><td>2.9</td><td>not applicable</td></tr>
</table>

<table>
<tr><th colspan="5">Standard rating conditions</th></tr>
<tr><td rowspan="2">Mode</td><td colspan="2">Air-cooled</td><td colspan="2">Water-cooled</td></tr>
<tr><td>Condenser ambient</td><td>Room air entering equipment</td><td>Entering water temperature</td><td>Room air entering equipment</td></tr>
<tr><td>Cooling</td><td>35^{o}C dry bulb</td><td>26.7^{o}C dry bulb/
19.4^{o}C wet bulb</td><td>29.5^{o}C</td><td>26.7^{o}C dry bulb/
19.4^{o}C wet bulb</td></tr>
<tr><td>Heating</td><td>7^{o}C dry bulb /
6^{o}C wet bulb</td><td>21^{o}C dry bulb</td><td colspan="2">(not applicable)</td></tr>
<tr><td>Water side fouling factor</td><td colspan="4">0.000018m^{2}-^{0}C/W for evaporator; 0.000044m^{2}-^{0}C/W for condenser</td></tr>
</table>

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Table 6.12b : Minimum Coefficient of Performance for Chiller

Air-cooled

	Reciprocating		Scroll	Screw	Centrifugal
Capacity Range (kW)	Below 400 kW	400 kW & above	All Ratings	All Ratings	All Ratings
Minimum COP at cooling (free air flow)	2.6	2.8	2.7	2.9	2.8

Water-cooled

	Reciprocating			Scroll			Screw			Centrifugal		
Capacity Range (kW)	Below 500 kW	500 to 1000 kW	Above 1000 kW	Below 500 kW	500 to 1000 kW	Above 1000 kW	Below 500 kW	500 to 1000 kW	Above 1000 kW	Below 500 kW	500 to 1000 kW	Above 1000 kW
Minimum COP (Cooling)	3.4	3.9	4.1	4	4.5	5.2	4.6	4.6	5.5	4	4.5	5.7

Standard rating conditions

Mode	Air-cooled			Water-cooled					
	Condenser ambient temperature	Chilled water temperature		Condenser water temperature				Chilled water temperature	
				Fresh water		Sea water			
		In	Out	In	Out	In	Out	In	Out
Cooling	$35^{o}C$	$12.5^{o}C$	$7^{o}C$	$32^{0}C$	$37^{0}C$	$28^{0}C$	$33^{0}C$	$12.5^{0}C$	$7^{0}C$

Water side fouling factor			
	Evaporator	$0.000018m^{2}\text{-}^{0}C/W$	
	Condenser	Fresh water	$0.000044m^{2}\text{-}^{0}C/W$
		Sea water	$0.000088m^{2}\text{-}^{0}C/W$

6.12.3 When components from more than one manufacturer are used as parts of an air-conditioning equipment with a rating above 10 kW of cooling/heating capacity, the overall system coefficient of performance, based on component efficiencies provided by the component manufacturers, should also satisfy the requirements of clause 6.12.1.

6.13 Energy Metering

6.13.1 A chiller, heat pump or unitary air-conditioner, of 350 kW or above cooling/heating capacity, should be equipped with continuous monitoring facilities to measure or calculate its power & energy input, cooling/heating power & energy output and coefficient of performance.

6.13.2 A chilled/heated water plant, of 350kW or above cooling/heating capacity, should be equipped with continuous monitoring facilities to measure or calculate its power & energy input, cooling/heating power & energy output, and coefficient of performance.

6.13.3 It is acceptable to make use of the manufacturer's curve or data indicating the chiller's flow rate and pressure drop relationship to obtain the chilled water flow rate based on its pressure drop through the evaporator, and likewise to obtain the heated water flow rate based on the flow's pressure drop through the heat pump's condenser.

6.13.4 In calculating a chilled water plant's power & energy input, the inputs to all equipment for producing the cooling output, such as chiller compressors, circulation pumps of condensers or cooling towers, condenser fans, cooling tower fans, radiator fans etc. should be included. Likewise for a heated water plant, the inputs to all equipment for producing the heating output, such as heat pump compressors, circulation pumps on heat input side of water source heat pumps, fans of air source heat pumps, boilers or hot water heaters etc. should be included.

7. Energy Efficiency Requirements for Electrical Installations

7.1 Scope of Application

7.1.1 All electrical installations, unless otherwise specified, in a prescribed building should be in accordance with the energy efficiency requirements of this Section.

7.1.2 The following installations are not governed by the energy efficiency requirements of this Section –

(a) an electrical installation which is operated at high voltage or extra low voltage;

(b) an electrical installation of which the equipment is owned by the electricity supplier and installed in a consumer's substation; and

(c) an electrical installation included in the installations specified in Schedule 2 of the Ordinance;

7.1.3 For the avoidance of doubt, the energy efficiency requirements of this Section should also apply to -

(a) all circuits in lighting installation, in air-conditioning installation, or in lift & escalator installation, or all circuits with fixed motors such as for plumbing or drainage; and

(b) all circuits fed by essential power supply and provide supply to routine operating equipment or installation such as maintained type emergency lighting, fireman's lift etc.

7.2 General Approach

The approach on energy efficiency is through both design and monitoring. The approach on design aims to select energy efficient components to be integrated into the electrical installation, and the approach on monitoring aims to provide required information for better energy utilization and management.

7.2.1 The requirements for energy efficient design of electrical installations are for the purposes of -

(a) minimizing losses such as iron losses, copper losses, losses due to phase current unbalance and harmonics, and indirect losses due to rise of temperature in the power distribution system; and

(b) reducing losses and energy wastage in the utilization of electrical power;

7.2.2 The requirements for energy efficient monitoring facilities of the electrical installations are for the purposes of -

(a) getting required energy consumption data for better energy utilization and management;
(b) identifying possible power quality problems so that appropriate solution can be taken to reduce the losses; and
(c) facilitating energy audits.

7.3 Definitions

The definitions of terms applicable to Electrical Installations are given in Section 2 of this BEC.

7.4 Power Distribution Loss

7.4.1 Distribution Transformer

A distribution transformer other than that owned by the electricity supplier should have a minimum efficiency given in Table 7.4.1 and be tested in accordance with IEC Standard 60076-1 Ed. 2.1, at the test conditions of full load, free of harmonics and at unity displacement power factor.

<u>Table 7.4.1 : Minimum Transformer Efficiency</u>

Transformer Capacity	Efficiency
< 1000kVA	98%
≥ 1000kVA	99%

7.4.2 Main Circuit

7.4.2.1 The copper loss of a main circuit connecting the distribution transformer and the main incoming circuit breaker of a LV switchboard should not exceed 0.5% of the total active power transmitted along the circuit conductors at designed circuit current.

7.4.2.2 As an alternative to clause 7.4.2.1 the transformer room and the corresponding main switch room should be right beside, above or below each other.

7.4.2.3 The effective current-carrying capacity of the neutral conductor in a main circuit should have a rating not less than that for the corresponding phase conductors.

7.4.3 Feeder Circuit

The maximum copper loss in a feeder circuit, single or three phase, should not exceed 2.5% of the total active power transmitted along the circuit conductors at designed circuit current. This requirement does not apply to circuits used for compensation of reactive and distortion power.

7.4.4 Sub-main Circuit

7.4.4.1 The maximum copper loss for non-residential buildings in a sub-main circuit, single or three phase, not exceeding 100 m length should not exceed 1.5% of the total active power transmitted along the circuit conductors at designed circuit current.

7.4.4.2 The maximum copper loss for non-residential buildings in a sub-main circuit, single or three phase, exceeding 100 m length should not exceed 2.5% of the total active power transmitted along the circuit conductors at designed circuit current, subject to the sum of losses in sub-main circuit and final circuit over 32A (based on circuit protective device rating) not exceeding 2.5%.

7.4.4.3 The maximum copper loss for residential buildings in a sub-main circuit, single or three phase, should not exceed 2.5% of the total active power transmitted along the circuit conductors at designed circuit current.

7.4.5 Final Circuit

The maximum copper loss for a final circuit over 32A (based on circuit protective device rating), single or three phase, should not exceed 1% of the total active power transmitted along the circuit conductors at designed circuit current.

7.4.6 The calculation of copper loss in clauses 7.4.2 to 7.4.5 should be based on the approach given in Appendix A, which should include the effects of total power factor and total harmonic distortion of current in case of a non-linear load.

7.5 Motor Installation

7.5.1 Motor Efficiency

A polyphase induction motor should have a nominal full-load motor efficiency fulfilling the corresponding value given in Table 7.5.1.

Table 7.5.1 : Minimum Nominal Full-Load Motor Efficiency for Single-Speed Polyphase Motor and Mult-Speed Polyphase Motor at High Speed	
Motor Rated Output (P, in kW)	Minimum Rated Efficiency (%)
1.1 kW ≤ P < 1.5 kW	76.2 %
1.5 kW ≤ P < 2.2 kW	78.5 %
2.2 kW ≤ P < 3 kW	81 %
3 kW ≤ P < 4 kW	82.6 %
4 kW ≤ P < 5.5 kW	84.2 %
5.5 kW ≤ P < 7.5 kW	85.7 %
7.5 kW ≤ P < 11 kW	87 %
11 kW ≤ P < 15 kW	88.4 %
15 kW ≤ P < 18.5 kW	89.4 %
18.5 kW ≤ P < 22 kW	90 %
22 kW ≤ P < 30 kW	90.5 %
30 kW ≤ P < 37 kW	91.4 %
37 kW ≤ P < 45 kW	92 %
45 kW ≤ P < 55 kW	92.5 %
55 kW ≤ P < 75 kW	93 %
75 kW ≤ P < 90 kW	93.6 %
P ≥ 90 kW	93.9 %

Note:
- Minimum efficiency levels based on standard of CEMEP Eff 2.
- Compliance to above should be based on testing to relevant international standards such as IEEE 112-B:2004, or IEC 60034-2-1 (Ed.1.0).

7.5.2 Motor Sizing

For a motor above 5 kW output power rating, the ratio of its output power to the power demand of the system it drives should not exceed 125% of the anticipated system load unless the load characteristic requires a specially high starting torque. If the calculated 125% of system load does not fall in the rating of a standard rated motor, the next higher rating standard motor may be used.

7.5.3 Motor for Air-conditioning Equipment, Distribution Transformer and Lift & Escalator

The requirements in clauses 7.5.1 and 7.5.2 do not apply to -

(a) a motor of a chiller or unitary air-conditioner fulfilling the air-conditioning equipment efficiency requirement in clause 6.12;

(b) a motor of a ventilation fan integrated with a distribution transformer fulfilling the transformer efficiency requirement in clause 7.4.1; and

(c) a motor of a lift and escalator installation fulfilling the electrical power requirement in clause 8.4.

7.6 Power Quality

7.6.1 Total Power Factor

7.6.1.1 The design total power factor for a circuit at or above 400A, single or three phase, (based on circuit protective device rating) or a circuit connecting to the meter of the electricity supplier at designed circuit current should not be less than 0.85. Design calculations are required to demonstrate adequate provision of power factor correction device to achieve the minimum power factor of 0.85.

7.6.1.2 In fulfilling clause 7.6.1.1 for a circuit with total power factor less than 0.85, a suitable power factor correction device, if provided, should be installed at the source motor control centre or local distribution board.

7.6.1.3 The requirement in clause 7.6.1.1 does not apply to a circuit serving a lift & escalator installation that has fulfilled the power factor requirement in clause 8.5.1.

7.6.2 Total Harmonic Distortion

7.6.2.1 The design total harmonic distortion of current for a circuit connecting to the meter of the electricity supplier at designed circuit current should not exceed the corresponding figures in Table 7.6.2.

7.6.2.2 The design total harmonic distortion of current for a circuit at or above 400A, single or three phase, (based on circuit protective device rating) at designed circuit current should not exceed the corresponding figures in Table 7.6.2.

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Table 7.6.2 : Maximum Total Harmonic Distortion of Current

Designed Circuit Current (I, in A)	Maximum Total Harmonic Distortion (THD) in Percentage of Fundamental Current
I < 40A	20.0 %
40A ≤ I < 400A	15.0 %
400A ≤ I < 800A	12.0 %
800A ≤ I < 2000A	8.0 %
I ≥ 2000A	5.0 %

7.6.2.3 In fulfilling clauses 7.6.2.1 and 7.6.2.2, a suitable harmonic reduction device should be provided at the source motor control centre or local distribution board.

7.6.2.4 In fulfilling clause 7.6.2.3 in respect of harmonic reduction device for a circuit principally for motors with variable speed drives, a group compensation at the motor control centre or local distribution board is allowed, provided that the maximum fifth harmonic current distortion at the VSD input terminals during normal operation within the variable speed range is less than 35%.

7.6.2.5 The requirements in clauses 7.6.2.1 and 7.6.2.2 does not apply to a circuit serving a lift & escalator installation that has fulfilled the harmonics distortion requirement in clause 8.6.

7.6.3 Balancing of Single-phase Loads

For all three-phase 4-wire circuits at or above 400A (based on circuit protective device rating) with single-phase loads, the maximum unbalanced single-phase loads distribution should not exceed 10% in terms of percentage unbalance.

7.7 Metering and Monitoring Facilities

7.7.1 Main Circuit

A main incoming circuit at or above 400A current rating, single or three phase, (based on circuit protective device rating) should be incorporated with metering devices for measuring voltages (all phase-to-phase and phase-to-neutral), currents (three phases and neutral currents) and power factor, and for recording total energy consumption (kWh), maximum demand (kVA) and total harmonic distortion.

7.7.2 Feeder and Sub-main Circuit

7.7.2.1 A feeder or sub-main circuit exceeding 200A and below 400A current rating, single or three phase, (based on circuit protective device), except for compensation of reactive and distortion power purpose, should be incorporated with metering devices, to measure currents (three phases and neutral) and record energy consumption in kWh for energy monitoring and audit purposes.

7.7.2.2 A feeder or sub-main circuit at or above 400A current rating, single or three phase, (based on circuit protective device rating), except for compensation of reactive and distortion power purpose, should be incorporated with metering devices for measuring voltages (all phase-to-phase and phase-to-neutral), currents (three phases and neutral currents) and power factor, and for recording total energy consumption (kWh), maximum demand (kVA) and total harmonic distortion.

8. Energy Efficiency Requirements for Lift & Escalator Installations

8.1 Scope of Application

8.1.1 All lift & escalator installations, unless otherwise specified, in a prescribed building should be in accordance with the energy efficiency requirements of this Section.

8.1.2 The following installations are not governed by the energy efficiency requirements of this Section –

(a) mechanized vehicle parking system;
(b) service lift, dumb-waiter, or stairlift;
(c) industrial truck loaded freight lift;
(d) lift in a performance stage;
(e) powered lifting platform;
(f) lift that is not operated on a traction drive by suspension ropes or not operated by a hydraulic piston; and
(g) a lift & escalator installation included in the installations specified in Schedule 2 of the Ordinance.

8.1.3 For the avoidance of doubt, the energy efficiency requirements of this Section should also apply to -

(a) all passenger lifts, bed passenger lifts, freight lifts, vehicle lifts, escalators and passenger conveyors; and
(b) fireman's lifts that operate under normal condition (i.e. Fireman's Switch is off).

8.2 General Approach

The requirements for energy efficient design of lift and escalator installations are for the purposes of –

(a) reducing power consumption through imposing maximum allowable electrical power of motor drive;
(b) reducing losses in the utilization of power through imposing minimum allowable total power factor, limiting the lift decoration load, and requiring a standby mode in lift operation;
(c) reducing losses due to the associated power quality problems; and
(d) providing appropriate metering and energy monitoring facilities for better energy efficiency management.

8.3 Definitions

The definitions of terms applicable to Lift & Escalator Installations are given in Section 2 of this BEC.

8.4 Electrical Power

8.4.1 Traction Lift

8.4.1.1 The running active electrical power of the motor drive of a traction lift system carrying a rated load at its rated speed in an upward direction should not exceed the maximum allowable value given in Table 8.4.1.

8.4.1.2 The requirement in clause 8.4.1.1 does not apply to –

(a) a lift

i. with rated speed not less than 9 m/s serving a zone of over 50-storey or over 175m between top/bottom-most landing and principal/ground landing, and

ii. designated as fireman's lift or sky lobby shuttle serving two principal stops

(b) a lift with rated load above 5000 kg at rated speed of 3 m/s or above.

Table 8.4.1 : Maximum Electrical Power (kW) of Traction Lift System at Rated Load for Various Ranges of Rated Speed

Rated Load L (kg)	Rated Speed Vc (m/s)				
	Vc < 1	1 ≤ Vc < 1.5	1.5 ≤ Vc < 2	2 ≤ Vc < 2.5	2.5 ≤ Vc < 3
L < 750	6.7	9.5	11.4	15.2	17.1
750 ≤ L < 1000	9.5	11.4	16.2	20	22.8
1000 ≤ L < 1350	11.4	16.2	20.9	25.7	30.4
1350 ≤ L < 1600	14.3	19	25.7	30.4	36.1
1600 ≤ L < 2000	16.2	23.8	30.4	37.1	43.7
2000 ≤ L < 3000	23.8	35.2	44.7	56.1	66.5
3000 ≤ L < 4000	31.4	45.6	59.9	74.1	87.4
4000 ≤ L < 5000	39.9	57	74.1	92.2	109.3
L ≥ 5000	0.0079L + 0.475	0.0112L + 0.95	0.0148L + 0.48	0.018L + 1.9	0.0217L+ 0.475
	3 ≤ Vc < 3.5	3.5 ≤ Vc < 4	4 ≤ Vc < 5	5 ≤ Vc < 6	6 ≤ Vc < 7
L < 750	20	21.9	23.8	28.5	32.3
750 ≤ L < 1000	25.7	29.5	30.4	37.1	43.7
1000 ≤ L < 1350	34.2	38	42.8	49.4	57
1350 ≤ L < 1600	40.9	46.6	49.4	58.9	68.4
1600 ≤ L < 2000	50.4	57	61.8	71.3	83.6
2000 ≤ L < 3000	75.1	85.5	90.3	109.3	125.4
3000 ≤ L < 4000	98.8	114	123.5	142.5	166.3
4000 ≤ L < 5000	123.5	142.5	152	180.5	209
	7 ≤ Vc < 8	8 ≤ Vc < 9	Vc ≥ 9		
L < 750	37.1	42.8	$4.643Vc + 0.0013Vc^3$		
750 ≤ L < 1000	49.4	57	$6.192Vc + 0.002 Vc^3$		
1000 ≤ L < 1350	66.5	76	$8.357Vc + 0.002Vc^3$		
1350 ≤ L < 1600	78.9	90.3	$9.905Vc + 0.0025 Vc^3$		
1600 ≤ L < 2000	99.8	114	$12.381Vc + 0.0013Vc^3$		
2000 ≤ L < 3000	147.3	166.3	$18.572Vc + 0.0029Vc^3$		
3000 ≤ L < 4000	194.8	223.3	$24.762Vc + 0.0036Vc^3$		
4000 ≤ L < 5000	242.3	275.5	$30.953Vc + 0.0046Vc^3$		

8.4.2 Hydraulic Lift

The running active electrical power of the hydraulic oil pump motor of a hydraulic lift system carrying a rated load at its rated speed in an upward direction should not exceed the maximum allowable value given in Table 8.4.2.

Table 8.4.2 : Maximum Electrical Power (kW) of Hydraulic Lift System at Rated Load

Rated Load L (kg)	Power (kW)
L < 1000 kg	26.6
1000 kg ≤ L < 2000 kg	50.4
2000 kg ≤ L < 3000 kg	71.3
3000 kg ≤ L < 4000 kg	92.2
4000 kg ≤ L < 5000 kg	115
L ≥ 5000 kg	0.023L

8.4.3 Escalator

The running active electrical power of the steps driving motor of an escalator with nominal width W and rise R when operating under no-load condition at rated speed Vr should not exceed the corresponding maximum allowable value given in Table 8.4.3.

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Table 8.4.3 : Maximum Electrical Power of Escalator at Designated Width and Rise for Various Ranges of Rated Speed Operating under No Load

Nominal Width W (mm)	Rise R (m)	Electrical Power (W) at Rated Speed Vr (m/s)					
		Non-Public Service Escalator			Public Service Escalator		
		Vr < 0.5	0.5 ≤ Vr < 0.6	0.6 ≤ Vr < 0.75	Vr < 0.5	0.5 ≤ Vr < 0.6	0.6 ≤ Vr < 0.75
600	R < 3.5	1283	1473	1853	Not Applicable		
	3.5 ≤ R < 5	1520	1805	2233			
	5 ≤ R < 6.5	1758	2138	2613			
	R ≥ 6.5	209R + 432	247R + 530	302R + 652			
800	R < 3.5	1425	1615	1948	1995	2375	2945
	3.5 ≤ R < 5	1710	1995	2423	2375	2850	3515
	5 ≤ R < 6.5	1995	2375	2898	2755	3278	4085
	6.5 ≤ R < 8	2328	2755	3373	3135	3705	4608
	R ≥ 8	230R + 588	253.6R + 694	312.5R + 853	291.6R + 795	347.7R + 952	433R + 1183
1000	R < 3.5	1520	1805	2185	2138	2518	3135
	3.5 ≤ R < 5	1900	2185	2708	2518	3230	3705
	5 ≤ R < 6.5	2214	2660	3230	2898	3468	4275
	6.5 ≤ R < 8	2613	3040	3753	3278	3895	4893
	R ≥ 8	268R + 653	349.6R + 771	346.7R + 997	305.6R + 837	346.7R + 1109	456.9R + 1251

Nominal Width W (mm)	Rise R (m)	Heavy Duty Escalator @		
		Vr = 0.5	0.5 < Vr ≤ 0.65	0.65 < Vr ≤ 0.75
1000	R ≤ 5	3822	4127	4328
	5 < R ≤ 6.5	4746	5074	5292
	6.5 < R ≤ 10	7034	7454	7742
	10 < R ≤ 13	8994	9502	9840
	13 < R ≤ 16	10864	11425	11801
	16 < R ≤ 17.5	11797	12388	12780
	17.5 < R ≤ 20	13355	13991	14425
	R > 20	622.9R + 896	641.3R + 1165	654R + 1345

@ escalator with the following characteristics can be regarded as heavy duty escalator :

- designed to perform or operate continuously for a period of not less than 20 hours per day, seven days per week, with an alternating passenger load of 100% brake load for one hour and 50% brake load for the following hour;
- not less than 4 no. of flat steps at each landing;
- maximum calculated or measured deflection of supporting structure of escalator not exceeding 1/1500 of the distance between supports;
- brake load given by multiplying the number of visible steps by 120 kg; and
- diameter of chain wheel not less than 100 mm.

8.4.4 Passenger Conveyor

The running active electrical power of the steps driving motor of a passenger conveyor with length L and nominal width W at an inclination up to 6^0 from horizontal when operating under no-load condition at rated speed Vr should not exceed the corresponding maximum allowable value given in Table 8.4.4.

Table 8.4.4 : Maximum Electrical Power of Passenger Conveyor at Designated Width and Length at Inclination up to 6^0 from Horizontal for Various Ranges of Rated Speed Operating under No Load

Nominal Width (mm)	Nominal Length L (m)	Electrical Power (W) at Rated Speed Vr (m/s)							
		Non-Public Service Passenger Conveyor				Public Service Passenger Conveyor			
		Vr < 0.5	0.5 ≤ Vr < 0.6	0.6 ≤ Vr < 0.75	0.75 ≤ Vr < 0.90	Vr < 0.5	0.5 ≤ Vr < 0.6	0.6 ≤ Vr < 0.75	0.75 ≤ Vr < 0.90
800	L < 8	1093	1450	1900	2138	1283	1663	1900	2233
	8 ≤ L < 12	1568	2100	2750	3088	1568	1995	2612	3088
	12 ≤ L < 16	2043	2750	3500	4085	2043	2613	3325	4085
	16 ≤ L < 20	2518	3900	4400	5035	2518	3705	4180	5035
	L ≥ 20	120.6L + 97	186L + 149	211L + 169	240L + 192	120.6L + 96	176.7L + 141	200.4L + 160	240.3L + 192
1000	L < 8	1235	1650	1900	2138	1378	1758	1995	2328
	8 ≤ L < 12	1995	2700	3050	3468	1995	2565	2898	3468
	12 ≤ L < 16	2660	3550	4000	4560	2660	3373	3800	4560
	16 ≤ L < 20	3278	4400	4950	5653	3278	4180	4703	5653
	L ≥ 20	155.8L + 124	209L + 168	237L + 190	270.7L + 216	155.8L + 124	198.5L + 159	225L + 180	270.7L + 216
1400 & above	L < 8	1544	2063	2375	2673	1723	2198	2494	2910
	8 ≤ L < 12	2494	3375	3813	4335	2494	3206	3623	4335
	12 ≤ L < 16	3325	4438	5000	5700	3325	4216	4750	5700
	16 ≤ L < 20	4098	5500	6188	7066	4098	5225	5879	7066
	L ≥ 20	195L + 155	261L + 210	296L + 238	338L + 270	195L + 155	248L + 199	281L + 225	338L + 270

Note: the maximum allowable electrical power for passenger conveyors with Nominal Width above 1000 mm and below 1400 mm is given by interpolation of the control figures for equipment at Nominal Width 1000 mm and equipment at Nominal Width 1400 mm, respectively at the corresponding Rated Speed and Nominal Length.

8.5 Utilization of Power

8.5.1 Total Power Factor

8.5.1.1 The total power factor of the motor drive of a lift at the isolator connecting the lift to the building's electrical supply circuit should not be less than 0.85 when the lift car is carrying a rated load at its rated speed and traveling in an upward direction.

8.5.1.2 The total power factor of the motor drive of an escalator or passenger conveyor at the isolator connecting the escalator or conveyor to the building's electrical supply circuit should not be less than 0.85 when the motor drive is operating under its brake load condition at rated speed, and for escalator or conveyor with a rise with the equipment moving in an upward direction.

8.5.1.3 For purpose of fulfilling clauses 8.5.1.1 or 8.5.1.2, a suitable power factor correction device can be installed at the motor control centre of the motor drive to provide the compensation to the corresponding level in clauses 8.5.1.1 or 8.5.1.2.

8.5.2 Lift Decoration Load

The maximum decoration load in a lift car should not be more than 50% of the lift's rated load with a limitation of 600kg.

8.5.3 Lift Parking Mode

8.5.3.1 Under normal operating status, at least one lift car of a lift bank should operate under a parking mode during low traffic period when the traffic demand on the vertical transportation system is low.

8.5.3.2 Under a parking mode of operation, a lift car should not respond to passenger calls until it returns to the normal operation mode.

8.5.3.3 The ventilation and air-conditioning of a lift car, except for observation lift with solar heat gain through glazing, within a lift bank, during parking mode and after idling for 2 minutes with the lift doors closed, should be shut off automatically until the lift car is activated again by passenger call.

8.6 Total Harmonic Distortion

8.6.1 When a lift car is moving up with rated load at its rated speed, the total harmonic distortion produced by the motor drive system at the isolator connecting the lift to the building's electrical supply circuit should be limited to the corresponding maximum allowable value given in Table 8.6.1.

Table 8.6.1 : Maximum Total Harmonic Distortion of Motor Drive System for Lift

Circuit Fundamental Current of Motor Drive, I (A), Moving Up with Rated Load at Rated Speed	Maximum Total Harmonic Distortion (%) in Each Phase
I < 40A	40%
40A ≤ I < 80A	35%
80A ≤ I < 400A	22.5%
400A ≤ I < 800A	15%

8.6.2 When an escalator or passenger conveyor is operating with no load at its rated speed, the total harmonic distortion produced by the motor drive system at the isolator connecting the escalator or passenger conveyor to the building's electrical supply circuit should be limited to the corresponding maximum allowable value given in Table 8.6.2.

Table 8.6.2 : Maximum Total Harmonic Distortion of Motor Drive System for Escalator and Passenger Conveyor

Circuit Fundamental Current of Motor Drive, I (A), with No Load at Rated Speed	Maximum Total Harmonic Distortion (%) in Each Phase	
I < 40A	35%, for electrical supply direct from building's feeder circuit	40%, for electrical supply not direct from building's feeder circuit
40A ≤ I < 80A	35%	
80A ≤ I < 400A	22.5%	

8.6.3 For purpose of fulfilling clauses 8.6.1 or 8.6.2, a suitable harmonic reduction device can be installed at the motor control centre of the motor drive to reduce the overall total harmonic distortion to the corresponding level in clauses 8.6.1 or 8.6.2.

8.7 Metering and Monitoring Facilities

8.7.1 Metering devices or the provision for measurement should be provided for the electrical supply circuit for the motor drive of each lift, escalator or passenger conveyor, for measurement of voltages (phase-to-phase and phase-to-neutral), currents (line currents and neutral currents), total power factor, energy consumption (kWh), power (kW) and maximum demand (kVA).

8.7.2 In fulfilling clause 8.7.1 the provision for measurement should include the provision of suitable accessibility and sufficient space, with appropriate connecting ancillaries, for the ready connection and subsequent removal of such devices not entailing a stoppage or disruption to the operation of the lift, escalator or passenger conveyor.

9. Performance-based Approach

9.1 Scope of Application

9.1.1 The requirements in this Section should be satisfied for buildings using the performance-based approach, which is regarded as an alternative approach for meeting the prescriptive requirements given in Sections 5 to 8 of this BEC, in fulfilling the energy efficiency requirements under the Ordinance.

9.2 General Approach

The requirements in the performance-based approach are for the purposes of -

(a) reducing energy consumption in the designed building through the focus on its total energy consumption and the adoption of basic energy efficiency requirements; and

(b) providing an alternative approach to full compliance with the energy efficiency requirements given in Sections 5 to 8 of this BEC.

9.3 Definitions

The definitions of terms applicable to performance-based approach are given in Section 2 of this BEC.

9.4 Basic Requirements

9.4.1 Under the performance-based approach, the designed building is governed by the basic requirements given in Table 9.4.

Table 9.4 : Basic Requirements for Performance-based Approach
Energy efficiency requirements on building services installations: Lighting installations, given in Section 5 of this BEC (clause no.) Lighting control (5.5) Air-conditioning installations, given in Section 6 of this BEC (clause no.) System load calculation (6.4) Separate air distribution system for process zone (6.5) Air distribution ductwork leakage limit (6.6) Pumping system variable flow (6.8) Frictional loss of water piping system (6.9) System control (6.10) Thermal insulation (6.11) Energy metering (6.13) Electrical installations, given in Section 7 of this BEC (clause no.) Power distribution loss (7.4) Motor installation (7.5) Power quality (7.6) Metering and monitoring facilities (7.7) Lift & escalator installations, given in Section 8 of this BEC (clause no.) Electrical power (8.4) Utilization of power (8.5) Total harmonic distortion (8.6) Metering and monitoring facilities (8.7)
Energy efficiency requirements on building envelope: Overall thermal transfer value, requirements same as given in Building (Energy Efficiency) Regulation (Cap.123M)

9.4.2 The energy efficiency requirements given in Sections 5 to 8 of this BEC not forming the basic requirements in Table 9.4 are deemed as the trade-off allowable requirements, by which the designed building is not governed.

9.5 Comparison of Design Energy and Energy Budget

9.5.1 A hypothetical design - the reference building, should be –

(a) developed based on the designed building, in accordance with the procedure given in Appendix B, and

(b) governed by all the energy efficiency requirements given in Sections 5 to 8 of this BEC, irrespective of whether or not such are listed in Table 9.4.

9.5.2 The design energy and energy budget, respectively of the designed building and reference building, should be calculated -

(a) using the same consistent numerical method for building energy analysis; and
(b) in accordance with the procedure given in Appendix B.

9.5.3 The design energy should not exceed the energy budget.

9.5.4 Trade-off in Design Energy

9.5.4.1 In fulfilling clause 9.5.3, the increase in design energy as a result of not satisfying the trade-off allowable requirements in clause 9.4.2, can be off-set with reduction in design energy as a result of -

(a) an improvement over the corresponding minimum allowable levels of performance in any one or more of the items listed with energy efficiency requirements in Sections 5 to 8 of this BEC, and/or
(b) a better OTTV, on condition that the energy reduction counted towards the off-set should be limited to not more than 5% of the energy budget, and/or
(c) having recovered energy or renewable energy captured or generated on site.

9.5.4.2 For buildings not governed by the Building (Energy Efficiency) Regulation, clause 9.5.4.1 (b) should not apply.

9.5.4.3 The items or installations involved in the trade-off process should be under the same ownership.

9.5.4.4 The subsequent alteration or replacement of items or installations in the trade-off should not result in the non-compliance of clause 9.5.3.

10. Energy Efficiency Requirements for Major Retrofitting Works

10.1 Whenever major retrofitting works are carried out in a prescribed building, the involved building services installations, save for exemption under the Ordinance, should meet the energy efficiency requirements as stipulated in this Section.

10.2 The major retrofitting works are basically prescribed in Schedule 3 of the Ordinance. The technical elaboration of the works and the associated energy efficiency requirements applicable to them are given in Table 10.

Table 10

Major Retrofitting Works and Energy Efficiency Requirements

Category of Major Retrofitting Work	Condition for Applicability of BEC Requirement		Applicable BEC Requirement	BEC Clause No.
(a) Works involving addition or replacement of a building services installation that covers one or more places with a floor area or total floor area of not less than 500 m^2 under the same series of works within 12 months in a unit or a common area should include item (i), item (ii) and/or item (iii) as described below (please also see the remarks at the end of this table) –				
(i) addition or replacement of luminaire(s)	total circuit wattage of the additional or replacing luminaires at or exceeding 3kW	no existing luminaires in the area, or the sum of circuit wattage of additional or replacing luminaires more than that of 50% of the original luminaires in the area	lighting power density	5.4
		the area has no existing luminaires, or the work involves a complete rewiring of the existing lighting circuits in the area	lighting control	5.5

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Table 10
Major Retrofitting Works and Energy Efficiency Requirements

Category of Major Retrofitting Work	Condition for Applicability of BEC Requirement		Applicable BEC Requirement	BEC Clause No.
(ii) addition or replacement of air handling unit(s), unitary air-conditioner(s) and/or chiller(s)	total cooling/heating capacity of the additional or replacing air handling unit(s), unitary air-conditioner(s) and/or chiller(s) at or exceeding 60kW	applicable in any conditions	air- conditioning equipment efficiency	6.12
		the additional or replacing air handling unit(s) forming a complete air distribution system in the context of clause 6.7	separate air distribution system for process requirements	6.5
			air distribution system fan power	6.7
		the work involving additional water pipework	frictional loss of water piping system	6.9
		the work involving a complete replacement of corresponding water side pumping system		
		the work involving additional or replacing pipework, ductwork or AHU	thermal insulation	6.11
		the work involving additional or replacing water pump with new motor, AHU with new motor, or fan with new motor	motor efficiency	7.5.1
(iii) addition or replacement of motor drive and mechanical drive, of a lift, an escalator, or a passenger conveyor	the work involving a traction lift with machine above and with 1:1 or 2:1 suspension roping system, a hydraulic lift, an escalator or a passenger conveyor		corresponding electrical power	8.4
	the work involving a traction lift, a hydraulic lift, an escalator or a passenger conveyor		total power factor	8.5.1
			lift parking mode	8.5.3
			total harmonic distortion	8.6
			metering & monitoring facilities	8.7
	the work involving the addition of a lift		lift decoration load	8.5.2

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<table>
<tr><th colspan="5">Table 10
Major Retrofitting Works and Energy Efficiency Requirements</th></tr>
<tr><th>Category of Major Retrofitting Work</th><th colspan="2">Condition for Applicability of BEC Requirement</th><th>Applicable BEC Requirement</th><th>BEC Clause No.</th></tr>
<tr><td colspan="5">(b) Addition or replacement of a main component of a central building services installation should include item (i), item (ii) and/or item (iii) as described below (please also see the remarks at the end of this table) –</td></tr>
<tr><td rowspan="10">(i) addition or replacement of a complete electrical circuit at rating of 400A or above</td><td colspan="2">the work involving a complete main circuit, except for cable route between existing transformer room and associated LV switch room with length exceeding 20 m</td><td rowspan="4">circuit copper loss in power distribution in buildings</td><td>7.4.2</td></tr>
<tr><td colspan="2">the work involving a complete feeder</td><td>7.4.3</td></tr>
<tr><td colspan="2">the work involving a complete sub-main</td><td>7.4.4</td></tr>
<tr><td colspan="2">the work involving a complete final circuit</td><td>7.4.5</td></tr>
<tr><td colspan="2" rowspan="3">the work involving a complete feeder, or involving a complete sub-main and all its downstream final circuits</td><td>total power factor</td><td>7.6.1</td></tr>
<tr><td>total harmonic distortion</td><td>7.6.2</td></tr>
<tr><td>balancing of single-phase loads</td><td>7.6.3</td></tr>
<tr><td colspan="2">the work involving a main circuit, a feeder or a sub-main, with addition of corresponding switch cubicle for the circuit termination at the main LV switchboard</td><td>metering & monitoring facilities</td><td>7.7</td></tr>
<tr><td rowspan="2">in addition to the addition or replacement of the complete electrical circuit at rating 400A or above</td><td>the work involving an addition or replacement of luminaires with a total circuit wattage at or exceeding 3kW</td><td colspan="2">requirements as for (a) (i)</td></tr>
<tr><td>the work involving an addition or replacement of air handling unit(s), unitary air-conditioner(s) and/or chiller(s) with a total cooling/heating capacity at or exceeding 60kW</td><td colspan="2">requirements as for (a) (ii)</td></tr>
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<table>
<tr><th colspan="5">Table 10
Major Retrofitting Works and Energy Efficiency Requirements</th></tr>
<tr><th>Category of Major Retrofitting Work</th><th colspan="2">Condition for Applicability of BEC Requirement</th><th>Applicable BEC Requirement</th><th>BEC Clause No.</th></tr>
<tr><td rowspan="8">(ii) addition or replacement of a unitary air-conditioner or a chiller of a cooling or heating rating at or exceeding 350kW</td><td colspan="2">applicable in any conditions</td><td>air- conditioning equipment efficiency</td><td>6.12</td></tr>
<tr><td colspan="2" rowspan="2">the work involving for the additional or replacing air-conditioning equipment the addition or complete replacement of corresponding water side pumping system</td><td>frictional loss of water piping system</td><td>6.9</td></tr>
<tr><td>energy metering</td><td>6.13</td></tr>
<tr><td colspan="2">ditto, the corresponding water side pumping system forming an independent system</td><td>pumping system variable flow</td><td>6.8</td></tr>
<tr><td colspan="2">the work involving additional or replacing pipework, ductwork or AHU</td><td>thermal insulation</td><td>6.11</td></tr>
<tr><td colspan="2">the work involving additional or replacing water pump with new motor, AHU with new motor, or fan with new motor</td><td>motor efficiency</td><td>7.5.1</td></tr>
<tr><td rowspan="2">in addition to the addition or replacement of the unitary air-conditioner or chiller at or exceeding 350 kW</td><td>the work involving addition or replacement of luminaires with a total circuit wattage at or exceeding 3kW</td><td colspan="2">requirements as for (a) (i)</td></tr>
<tr><td>the work involving addition or replacement of air handling unit(s) with a total cooling/ heating capacity at or exceeding 60kW</td><td colspan="2">requirements as for (a) (ii)</td></tr>
<tr><td rowspan="6">(iii) addition or replacement of the motor drive and mechanical drive of a lift, an escalator or a passenger conveyor</td><td colspan="2">the work involving a lift with machine above and with 1:1 or 2:1 suspension roping system, a hydraulic lift, an escalator or a passenger conveyor</td><td>corresponding electrical power</td><td>8.4</td></tr>
<tr><td colspan="2" rowspan="4">the work involving a traction lift, a hydraulic lift, an escalator or a passenger conveyor</td><td>total power factor</td><td>8.5.1</td></tr>
<tr><td>lift parking mode</td><td>8.5.3</td></tr>
<tr><td>total harmonic distortion</td><td>8.6</td></tr>
<tr><td>metering & monitoring facilities</td><td>8.7</td></tr>
<tr><td colspan="2">the work involving the addition of a lift</td><td>lift decoration load</td><td>8.5.2</td></tr>
</table>

Table 10
Major Retrofitting Works and Energy Efficiency Requirements

Category of Major Retrofitting Work	Condition for Applicability of BEC Requirement	Applicable BEC Requirement	BEC Clause No.

Remarks

1. Save for the addition or replacement works described above, major retrofitting works should also include enhancement works for existing building services installation of which all ratings refer to the ratings of the newly installed equipment.
2. Attention is drawn to the Notes in Schedule 3 of the Ordinance on identifying "a common area" and "the same series of works" specified in item (a) of this table.
3. The "floor area" stated in item (a) of this table means the works area which is the "internal floor area" (as defined in Section 2 of this BEC) covered by the major retrofitting works but may not be the area served by the concerned building services installations. In practice, such works area may be identified on the relevant layout plans and/or by the fencing-off of the works area on site such as hoarding, canvas, fencing or signs etc.
4. The "12-month" period under a same series of works specified in item (a) of this table may be counted from the commencement date of either one of the works under the same series of works. The floor area covered by any works of the same series of works commenced within this 12-month period (the first day and the last day inclusive) should be counted towards the "total floor area" covered by the same series of works within this 12-month period. If some works under the same series of works have commenced within a 12-month period in a unit or a common area and their works areas aggregate to not less than 500 m^2, then besides these works all other works of the same series of works in the same unit or common area, even not commenced within the said 12-month period, should also comply with the requirements specified above for the item (a).

10.3 Performance-based Approach

10.3.1 The performance-based approach is applicable to major retrofitting works given in the Ordinance.

10.3.2 The items or installations involved in the trade-off process should be under the same ownership..

11. Requirements on Maintenance

11.1 The building services installations should be properly maintained to an energy efficiency standard as required by the Ordinance. For this purpose, upon change of the responsible person of a unit or common area, the current responsible person should provide all Forms of Compliance issued under the Ordinance and all associated documents, if any, to the successor and the new responsible person should obtain such documents from the predecessor as well..

11.2 The subsequent alteration or replacement of items or installations in the trade-off under the performance-based approach should not result in the non-compliance of clause 9.5.3.

11.3 As-built records of the installations, including their subsequent alterations, should be maintained according to good trade practice to facilitate inspections.

11.4 Records on energy consumptions or from which energy consumptions could be derived, obtained through metering facilities required in this BEC, should be kept for regular review of the energy performance of the installations.

11.5 Operation and maintenance documents such as manufacturers' maintenance manuals of the installations should be kept to facilitate planning of maintenance.

11.6 Proper operation and maintenance logs should be kept for regular review of the operating performance of the installations.

11.7 While good engineering and trade practices should be adopted in maintenance of the energy efficiency performance of the installations, due consideration would be allowed for normal wear and tear for degrading of energy efficiency performance of the installations over time gradually, provided that the design standard of such installations has not been lowered in any alteration or replacement works, unless otherwise permitted in this BEC.

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Appendix A
Guidelines on Calculation of Cable Loss

This Appendix provides a guidance on the calculation of copper losses in circuits for fulfilling Section 7 of this BEC.

A1 Resistance of Copper Cable

A1.1 Table A1 below provides resistance values of copper cables, which can be based upon in the selection of appropriate cable sizes for fulfilling the requirements on allowable percentage copper loss in an electrical circuit.

Table A1 : Conductor (copper) Resistance for PVC and XLPE Cable at 50 Hz Single-phase or Three-phase a.c.

Conductor cross-sectional area (mm^2)	Conductor Resistance (mΩ/m)					
	Multicore Armoured & Non-armoured #1		Single-core PVC/XLPE Non-armoured, with or without sheath #2			
	PVC cable at max. conductor operating temperature of 70°C	XLPE cable at max. conductor operating temperature of 90°C	PVC cable at max. conductor operating temperature of 70°C		XLPE cable at max. conductor operating temperature of 90°C	
			Enclosed in conduit/ trunking	Clipped direct or on tray, touching	Enclosed in conduit/ trunking	Clipped direct or on tray, touching
1.5	14.5	15.5	14.5	14.5	15.5	15.5
2.5	9	9.5	9	9	9.5	9.5
4	5.5	6	5.5	5.5	6	6
6	3.65	3.95	3.65	3.65	3.95	3.95
10	2.2	2.35	2.2	2.2	2.35	2.35
16	1.4	1.45	1.4	1.4	1.45	1.45
25	0.875	0.925	0.9	0.875	0.925	0.925
35	0.625	0.675	0.65	0.625	0.675	0.675
50	0.465	0.495	0.475	0.465	0.5	0.495
70	0.315	0.335	0.325	0.315	0.35	0.34
95	0.235	0.25	0.245	0.235	0.255	0.245
120	0.19	0.2	0.195	0.185	0.205	0.195
150	0.15	0.16	0.155	0.15	0.165	0.16
185	0.125	0.13	0.125	0.12	0.135	0.13
240	0.095	0.1	0.0975	0.0925	0.105	0.1
300	0.0775	0.08	0.08	0.075	0.0875	0.08
400	0.0575	0.065	0.065	0.06	0.07	0.065
500	-	-	0.055	0.049	0.06	0.0525
630	-	-	0.047	0.0405	0.05	0.043
800	-	-	-	0.034	--	0.036
1000	-	-	-	0.0295	-	0.0315

#1 Based on Table 4D2B, 4D4B, 4E2B & 4E4B, Standard BS7671, The Regulations for Electrical Installations, British Standards Institution

#2 Based on Table 4D1B & 4E1B, Standard BS7671

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A2 Cable Sizing

The relationship among circuit design current I_b, nominal rating of protective device I_n and effective current-carrying capacity of conductor I_z for an electrical circuit can be expressed as:

$$I_b \leq I_n \leq I_z$$

A2.1 Conventional Method

Assumption: The supply voltages and load currents are sinusoidal and balanced among the three phases in a three-phase 4-wire power distribution system.

Calculated minimum tabulated value of current: $I_{t\,(min)} = I_n \times \frac{1}{C_a} \times \frac{1}{C_g} \times \frac{1}{C_i}$

Effective current-carrying capacity : $I_z = I_t \times C_a \times C_g \times C_i$

Where I_t = the value of current tabulated in Appendix 4 of BS7671
C_a = Correction factor for ambient temperature
C_g = Correction factor for grouping
C_i = Correction factor for thermal insulation

A2.2 Accounting for Power Factor and Losses due to Harmonic Distortion in Circuits with Non-linear Loads

Displacement Power Factor & Total Power Factor

Consider a circuit with non-linear load current I, which is the r.m.s. value of fundamental I_1 and all harmonic components I_2, I_3, I_4, ..., an expression of the power factor can be given as follows:

Assumption: The circuit is fed from a line voltage U having a low value of distortion and only the fundamental sinusoidal value U_1 is significant:

Apparent Power: $S = UI$

$$S^2 = (UI)^2 = U_1^2(I_1^2 + I_2^2 + I_3^2 + I_4^2 + ...)$$
$$= U_1^2 I_1^2 \cos^2\theta + U_1^2 I_1^2 \sin^2\theta + U_1^2(I_2^2 + I_3^2 + I_4^2 + ...)$$

According to this expression in the distorted circuit, the apparent power contains three major components:

(1) Active Power in kW : $P = U_1 I_1 \cos\theta$
(This is the effective useful power)

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(2) Reactive Power in kVAr : $Q = U_1 I_1 \sin\theta$
(This is the fluctuating power due to the fundamental component and coincides with the conventional concept of reactive power in an inductive circuit consumed and returned to the network during the creation of magnetic fields)

(3) Distortion Power in kVAd $D^2 = U_1^2.(I_2^2 + I_3^2 + I_4^2 + ...)$
$D = U_1\sqrt{(I_2^2 + I_3^2 + I_4^2 + ...)}$(This power appears only in distorted circuits and its physical meaning is that of a fluctuating power due to the presence of harmonic currents)

The relationship among these three power components can be shown in the following power triangles in Figure A2 :

(1) Fundamental Components : $S_1^2 = P^2 + Q_1^2$
with Displacement Power Factor $\cos\theta = P/S_1$)

(2) Fluctuating Power : $Q_T^2 = Q_1^2 + D^2$

(3) Power Triangle in Distorted Circuit : $S^2 = Q_T^2 + P^2$
with Total Power Factor $\cos \gamma = P/S$, which is always smaller than the Displacement Power Factor $\cos\theta$, and can be improved by either reducing the amount of harmonic distortion power (kVAd) or reactive power (kVAr)

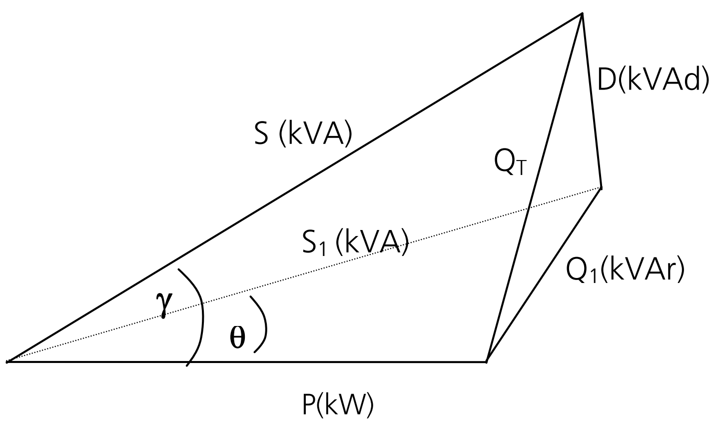

Fig. A2 - Power Triangles for Apparent Power, Active Power, Reactive Power & Distortion Power

A3 Copper Loss Calculation

A3.1 For a Three-phase Balanced and Linear Circuit:

Apparent power transmitted along the circuit conductors in VA, $S = \sqrt{3}U_L I_b$

Active power transmitted along the circuit conductors in W, $P = \sqrt{3}U_L I_b \cos\theta$

Total copper losses in conductors in W, $P_{copper} = 3 \times I_1^2 \times r \times L$

where U_L = Line to line voltage, 380V

$I_b = I_1$ = Design current (with no distortion) of the circuit in ampere

$\cos\theta$ = Power factor of the circuit

r = a.c. resistance per metre at the conductor operating temperature

L = Length of the cable in metre

Percentage copper loss with respect to the total active power transmitted,

$$\% \text{ loss} = \frac{3 \times I_1^2 \times r \times L}{\sqrt{3}U_L I_1 \cos\theta}$$

$$\text{Therefore, max. r (m}\Omega\text{/m)} = \frac{\text{max.}\%\text{loss} \times U_L \times \cos\theta \times 1000}{\sqrt{3} \times I_1 \times L}$$

Appropriate conductor size can then be selected from Table A1 based on calculated value of r.

Correction for copper loss calculation due to various conductor operating temperature can be carried out as follows:

Conductor operating temperature at design current I_b , which = I_1 , is given by:

$$t_1 = t_a + \frac{I_1^2}{I_t^2}\left(t_p - 30\right)$$

where t_a = actual or expected ambient temperature

t_p = maximum permitted conductor operating temperature

ambient temperature = 30°C

The resistance of a copper conductor R_t at temperature t_1 is given by:

$$R_t = R_{20}\left[1 + \alpha_{20}\left(t_1 - 20\right)\right]$$

where R_{20} = conductor resistance at 20°C

α_{20} = temperature coefficient of resistance of copper at 20°C (0.00393/°C)

or alternatively,

$$R_t = R_0\left(1 + \alpha_0 t_1\right)$$

where R_0 = conductor resistance at 0°C

α_0 = temperature coefficient of resistance of copper at 0°C (0.00428/°C)

Therefore ratio, $$\frac{R_t}{R_p} = \frac{1 + \alpha_0 t_1}{1 + \alpha_0 t_p} \approx \frac{230 + t_1}{230 + t_p}$$

A3.2 For a Three-phase Balanced Non-Linear Circuit Having Known Harmonic Current:

Apparent power transmitted along the circuit conductors in VA,

$$S = \sqrt{3} U_L I_b$$

where $$I_b = \sqrt{\sum_{h=1}^{\infty} I_h^2} = \sqrt{I_1^2 + I_2^2 + I_3^2 + \ldots\ldots}$$

From definition: $$THD = \frac{\sqrt{\sum_{h=2}^{\infty} (I_h)^2}}{I_1}$$

Therefore, $$I_b = I_1 \sqrt{1 + THD^2}$$

And, the fundamental current $$I_1 = \frac{I_b}{\sqrt{1 + THD^2}}$$

Assuming voltage distortion is small, $U_L = U_1$, and active power transmitted along the circuit conductors in W is given by:

$$P = \sqrt{3} U_L I_1 \cos\theta$$

where U_L = Supply line voltage at 380V

I_1 = Fundamental phase current of the circuit in ampere

$\cos\theta$ = Displacement power factor of the circuit

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And, Total Power Factor = $\frac{P}{S} = \frac{\cos\theta}{\sqrt{1 + THD^2}}$

Assuming the skin and proximity effects are small, total copper losses in conductors including neutral in W is given by:

$$P_{copper} = (3 \times I_b^{\ 2} + I_N^{\ 2}) \times r \times L$$

where I_N = Neutral current of the circuit in ampere

$$= 3 \times \sqrt{I_3^2 + I_6^2 + I_9^2 + ...}$$

I_b = Design r.m.s. phase current of the circuit in ampere

r = a.c. resistance per metre at the conductor operating temperature

L = Length of the cable in metre

Percentage copper loss with respect to the total active power transmitted,

$$\% \text{ loss} = \frac{(3 \times I_b^{\ 2} + I_N^{\ 2}) \times r \times L}{\sqrt{3} U_L I_1 \cos\theta}$$

Therefore, max. r (mΩ/m) = $\frac{\text{max.}\%\text{loss} \times \sqrt{3} \times U_L \times I_1 \times \cos\theta \times 1000}{(3 \times I_b^{\ 2} + I_N) \times L}$

Appropriate conductor size can then be selected from Table A1 based on calculated value of r.

Correction for copper loss calculation due to various conductor operating temperature can be carried out as follows:

Conductor operating temperature at phase current I_b & neutral current I_N is given by:

$$t_1 = t_a + \frac{(3I_b + I_N)^2}{(3I_t)^2}\left(t_p - 30\right)$$

where t_a = actual or expected ambient temperature

t_p = maximum permitted conductor operating temperature

The resistance of a copper conductor R_t at temperature t_1 is given by:

$$R_t = R_0\left(1 + \alpha_0 t_1\right)$$

where R_0 = conductor resistance at 0°C

α_0 = temperature coefficient of resistance of copper at 0°C (0.00428/°C)

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Therefore ratio, $\frac{R_t}{R_p} = \frac{1+\alpha_0 t_1}{1+\alpha_0 t_p} \approx \frac{230 + t_1}{230 + t_p}$

A3.3 For a Circuit Consisting of Different Components

A circuit such as feeder or sub-circuit may consist of two or more component sections. The percentage copper loss in each component section should be calculated and added up to arrive at the overall percentage copper loss.

Consider a sub-circuit consisting of a riser serving 10 nos. floors with tee-off on each floor and a lateral tee-off on 10/F to a local distribution board. The overall percentage copper loss is given by:

$cl_m / tap_m + cl_{1r} / tap_{1r} + cl_{2r} / tap_{2r} + \ldots\ldots\ldots\ldots\ldots + cl_{10r} / tap_{10r} + cl_t / tap_t$

(summing up for all portions of the rising mains)

where

- cl : copper loss
- tap : total active power
- m : portion of sub-circuit from LV main switch on G/F to rising main
- 1r : 1/F portion of riser from G/F to 1/F
- 2r : 2/F portion of riser from 1/F to 2/F
- : :
- 10r : 10/F portion of riser from 9/F to 10/F
- t : portion of sub-circuit tee-off from riser to local distribution board (in case of a feeder the portion of tee-off to the current-using equipment)

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Appendix B

Calculation of Total Energy Consumption in a Building or Unit Using Numerical Method for Building Energy Analysis

B1 Introduction

B1.1 The calculation of total energy consumption in a building or unit should be based on numerical method for building energy analysis. The purpose of the calculation is to develop fair and consistent evaluations of the energy performance of the effects of deviations from the energy efficiency requirements given in Sections 5 to 8 of this BEC that can be collectively regarded as the prescriptive requirements. Simplifying assumptions if adopted should be aimed to rationalize the modeling or simulation without compromising the intent of energy efficiency.

B1.2 Information of the building design should be translated into building description data required for the energy calculation and simulation. The designed building should be represented in the energy calculation tool using the format required for the building energy analysis and simulation process.

B1.3 The reference building should be developed by modifying the description of the designed building, and should have all the features of the designed building, but be modified as appropriate to meet all the prescriptive requirements in Sections 5 to 8 of this BEC.

B2 Numerical Method for Building Energy Analysis

B2.1 The numerical method for the building energy analysis should be targeted for the estimation of energy consumption in buildings in a comprehensive manner and should include calculation methodologies for the building components or systems being considered.

B2.2 The use of an hour-by-hour, full-year, multiple-zone numerical analysis for modelling and simulating the design energy and energy budget is required. Simpler tools are allowed if they have been shown to produce equivalent results for the type of building and relevant building features and/or systems being considered.

B2.3 The simulation program should use scientifically justifiable techniques and procedures for modelling building loads, systems, and equipment. It should simulate or model the thermal behaviour of buildings and the interaction of their building fabric, air-conditioning, lighting and other relevant energy consuming equipment and systems.

B2.4 The simulation program to be used should have the ability to either directly determine the design energy and energy budget, or produce simulation reports of energy use suitable for determining the design energy and energy budget using a separate calculation engine.

B2.5 The simulation program should be capable of performing design load calculations to determine the required air-conditioning equipment capacities and air and water flow rates for both the designed building and reference building.

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B2.6 When a simulation program is used to verify compliance with this BEC via the performance-based approach in Section 9 of this BEC, essential information about its modelling capabilities, calculation techniques and validation results should be provided for evaluation and approval by EMSD.

B3 Evaluation of Building Energy Performance

B3.1 General Requirements

B3.1.1 *Trade-Offs Limited to Compliance Areas*. When compliance applies to a portion of a building, only the calculation parameters related to the systems for the areas concerned should be allowed to vary. Parameters in relation to unmodified existing conditions or to future building components should be identical for both the energy budget and the design energy calculations.

B3.1.2 *Climatic Data*. Weather data used with the simulation program must be appropriate for the complexity of design features. The climatic data used in the energy analysis should cover a full calendar year of 8,760 hours and should reflect coincident hourly data for temperature, solar radiation, humidity and wind speed based on data from the Hong Kong Observatory. The weather data should be fully verified and justified. The same weather data must be used for the calculation of the designed building and reference building. Weather data of Test Reference Year or weather data in the format of Typical Meteorological Year should preferably be used in the energy calculation.

B3.1.3 *Operating Schedule*. Building operation should be simulated for a full calendar year. Operating schedules should include hourly profiles for daily operation and should account for variation between weekdays, weekends, holidays, and any seasonal operation, where applicable. The schedules should model the time-dependent variations of occupancy, lighting, equipment loads, thermostat settings, mechanical ventilation, air-conditioning equipment availability, and any process loads.

B3.1.4 *Occupant-sensitive Features*. Occupant behaviour should not be relied upon to achieve consistent and permanent reductions in building energy consumption. Design features that depend on the co-operation of the occupants such as the use of blinds should be excluded from the design energy calculation.

B3.1.5 *Renewable Energy and recovered energy*. Useful energy generated from renewable energy sources or recovered from suitable sources can be considered in the evaluation of building energy performance, provided that the sources are reliable and appropriate method is used to estimate the energy generation. To provide credit for these sources in this BEC compliance, renewable energy or recovered energy for routine duty can be excluded from the design energy allowed for the building or unit. Where renewable energy or recovered energy are used, the reference building design should be based on the energy source used as the back-up energy source or electricity if no backup energy source has been specified.

B3.1.6 *Professional Judgement*. Although certain modelling techniques and compliance assumptions applied to the designed building are fixed or restricted, there are other aspects of computer modelling for which professional judgement is necessary. In those instances, it must be exercised properly in evaluating whether a given assumption is appropriate. EMSD has full discretion to accept or not a particular input, especially if the user has not substantiated the value with supporting evidence and documentation.

B3.1.7 *Exclusions*. The energy calculation can exclude such consumptions/loadings for installations exempted from the compliance of the Ordinance, such as fire services, and essential health and safety-related installations.

B3.2 Determination of Design Energy for the Designed Building

B3.2.1 *Simulation Model*. The simulation model of the designed building should be consistent with the design documents, including proper accounting of window and wall types and area; lighting power and controls; air-conditioning system types, sizes, and controls; and so on. The major building systems including building envelope, lighting and air-conditioning must be included in the energy calculation. Except for items for off-setting of design energy, other building systems can be excluded in the building energy simulation or their energy consumption be taken as the same in both designed and reference buildings. But on an exceptional situation (clause B3.4 below), these systems may be included in the energy analysis, provided that an appropriate calculation method is proposed and demonstrated to the satisfaction of EMSD.

B3.2.2 *System Capacities and Data*. When air-conditioning, lighting and other appropriate building systems and equipment are included in the energy calculation, they should be simulated for the designed building using capacities, rated efficiencies, and part-load performance data for the proposed equipment as provided by the equipment manufacturer. If a system or equipment has not been completely determined and specified, its information should be based on reasonable assumptions of the design or construction of such system or equipment. These assumptions should be based on appropriate professional judgement and all of them should be documented for verification whenever required.

B3.2.3 *Yet-to-be-designed Features*. When the method is applied to buildings in which energy-related features have not yet been designed, those yet-to-be-designed features should be described in the designed building so that they minimally comply with applicable requirements of Sections 5 to 8 of this BEC. Where the space classification for a portion of the building is not known, the portion should be assumed a reasonable occupancy appropriate to the building project. All the assumptions should be documented for verification whenever required.

B3.2.4 *Building Envelope*. All components of the building envelope in the designed building should be modelled as shown on architectural drawings or as constructed for the existing building. For buildings where the OTTV is applicable by regulation, the thermal properties and dimensions of these components should be as in the submission for the OTTV.

B3.2.5 *Lighting*. Lighting power in the design should be determined as follows:

(a) where a complete lighting system exists, the actual lighting power should be used in the model;

(b) where a lighting system has been designed, lighting power should be determined in accordance with the design; or

(c) where no lighting system has been specified but it is expected, the lighting power should be determined in accordance with Table 5.4, by identifying for each individual space of the designed building a type of space given in Table 5.4 and use the corresponding maximum allowable LPD value as the LPD for the relevant space.

B3.2.6 *Air-conditioning* The air-conditioning system type and all related performance parameters in the proposed design should be determined as follows:

(a) where a complete air-conditioning system exists, the model should reflect the actual system type using actual component capacities and efficiencies;
(b) where an air-conditioning system has been designed, the air-conditioning model should be consistent with the design; some simulation software might require the efficiencies of mechanical equipment to be adjusted from actual design conditions to the standard rating conditions;
(c) where no cooling system has been specified but it is expected, the cooling system should be modelled as a simple air-cooled single-zone system, one unit per thermal block; the system characteristics should be identical to the system modelled in the reference building; and
(d) where no heating system has been specified but it is expected, the heating system should be modelled as electric; the system characteristics should be identical to the system modelled in the reference building.

B3.2.7 *Lift and Escalator*. Good energy efficient practices of lift and escalator design are specified in the basic requirements and normally no trade-off should be allowed. Under an exceptional situation in clause B3.4, lift and escalator systems may be included in the energy analysis, provided that an appropriate calculation method is proposed and verified.

B3.2.8 *Other Systems*. Other building systems may be modelled using exceptional calculation methods (clause B3.4 below). If they are modelled, performance should be as indicated on design documents. Miscellaneous internal loads, such as those due to office and other equipment, should be estimated with reference to clause B3.5.

B3.2.9 *Exclusion of Building Components and Systems*. To simplify the calculation procedures, some building components and systems in the proposed design may be excluded from the simulation model provided that:

(a) the component energy usage does not affect the energy usage of systems and components that are considered for trade-off; or
(b) the excluded components can meet the relevant requirements of Sections 5 to 8 of this BEC.

B3.2.10 *Alterations and Additions*. For a design relating to major alterations or additions of an existing building, on the building itself or its building services, it is acceptable to demonstrate compliance using building models that exclude parts of the existing building provided all of the following conditions are met:

(a) work to be performed in the excluded parts of the building should meet the requirements of Sections 5 to 8 of this BEC;
(b) the excluded parts of the building are served by air-conditioning systems that are entirely separate from those which are included in the building model; and
(c) design space temperature and air-conditioning system operating set points and schedules, on either side of the boundary between included and excluded parts of the building, are identical.

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B3.2.11 *Limitations to the Simulation Program*. If the simulation program cannot model a component or system included in the designed building, one of the following methods should be used subject to the approval of EMSD:

(a) ignore the component or system if the impact on the trade-offs being considered is not significant;
(b) model the component or system by substituting a thermodynamically similar component or system model; or
(c) model the component or system using the same component or system of the reference building.

Whichever method is selected, the component should be modelled identically for both the designed building and reference building.

B3.3 Determination of Energy Budget for the Reference Building

B3.3.1 *Simulation Model*. The simulation model of the reference building should be developed by modifying the model of the designed building as described in clause B3.2. Except as specifically instructed in B3.2 and in this clause, all appropriate building systems and equipment should be modelled identically for both the reference building and designed building.

B3.3.2 *Building Envelope*.

The reference building should have identical conditioned floor area and identical exterior dimensions and orientations as the designed building. For existing building, the reference building should reflect existing conditions prior to any revisions. For new building, the envelope model of the reference building should be modified from that used in the designed building as follows:

(a) opaque assemblies such as roof, floors, doors, and walls should be modelled as having the same heat capacity as the designed building;
(b) all roof surfaces should be modelled with the same solar absorptivity of the designed building;
(c) no shading projections are to be modelled; fenestration should be assumed to be flush with the exterior wall or roof; and
(d) for building not governed by the OTTV requirements by regulation, the dimensions of windows, doors and skylights should be same as the designed building.

B3.3.3 *OTTV*. To determine the appropriate envelope parameters for the reference building, the designer should adjust from the envelope model of the designed building the combinations of the window-wall ratio and skylight-roof ratio, and the shading coefficients of windows and skylights so as to meet the OTTV requirements.

B3.3.4 *Lighting*. The types of spaces for the individual spaces in the reference building should be same as the designed building. The LPD in each space should be the corresponding maximum allowable value given in Table 5.4. Lighting controls should be the minimum required in Section 5 of this BEC.

B3.3.5 *Air-conditioning*. The air-conditioning system, zoning and equipment type of the reference building should be the same as the designed building, e.g. VAV, if adopted in the

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designed building, should be so adopted in the reference building; but the system and equipment of the reference building should exactly meet the relevant requirements in Section 6 of this BEC.

B3.3.6 *Lift and Escalator*. Lift and escalator systems are usually excluded in the building energy simulation, and under such circumstance if they are considered in the energy analysis, the related systems or components should be the same as those of the designed building. Should a trade-off of lift or escalator energy consumption between the designed building and the reference building be adopted, the procedure in clause A3.4 should apply.

B3.3.7 *Other Systems*. Other systems and miscellaneous loads, if they are considered, should be modelled as identical to those in the designed building. Where there are specific efficiency requirements in Sections 5 to 8 of this BEC, these systems or components should be modelled as having the lowest efficiency allowed by those requirements.

B3.4 Exceptional Calculation Methods

B3.4.1 Where no simulation program is available to adequately model a design, material, or device, EMSD may approve an exceptional calculation method to be used to demonstrate compliance. An application for approval of an exceptional method should be made by the owner/designer.

B3.4.2 For approval of an exceptional method, theoretical and empirical information verifying the method's accuracy should be submitted, which should include the following documentations :

(a) demonstration that the exceptional calculation method and results make no change in any input parameter values specified in Section 9 of this BEC and this Appendix;
(b) input and output documentation facilitating EMSD's review and meeting the formatting and content required by EMSD;
(c) clear and concise instructions for using the technique and method to demonstrate that the requirements in Section 9 of this BEC and this Appendix are met; and
(d) demonstration of reliability and accuracy relative to the appropriate simulation program.

B3.5 Modelling Assumptions and Methods

B3.5.1 In order to maintain consistency between the two sets of calculations, respectively for the design energy and the energy budget, the following input assumptions and methods should be used. Any modification of an assumption applicable to both designed building and reference building should be used in modelling both the the designed building and reference building, unless the designer demonstrates a clear cause to do otherwise.

B3.5.2 Operating Parameters for Different Types of Space

(a) To systematically present the inputs to the simulation software program, the designer should prepare a table summarizing the operation parameters and corresponding assigned values to the program for all the different spaces in the building or unit, common operation parameters being occupant density, minimum outdoor air,

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operating schedule, lighting power density, equipment power density and service water heating power etc. For simplification purpose, spaces with similar functions and operational characteristics, as represented by the operation parameters, may be grouped together as a space type. An indicative table is as shown below –

Table B3.5a – Operation Parameters for Different Types of Space in a Building

Type of Space	Building operation parameters					
	Occupant Density (m^2/person)	Minimum Outdoor Air (L/s/person)	Operating Schedule	Lighting Power Density (W/m^2)	Equipment Power Density (W/m^2)	Service Water Heating Power (W/person)
≈	≈	≈	≈	≈	≈	≈

(b) The values to be assigned to the above table should be the corresponding design values for the operation parameters. Equipment loads establishing the density in W/m^2 should include all general service loads that are typical in a building, including additional process electrical usage, but excluding air-conditioning electrical usage.

(c) The designer should prepare an operating schedule for each type of space, which is a table summarizing for different times of a day the operation densities of occupants, equipment, lighting, AHU/fan, cooling, heating, hot water etc. The operating schedule should reflect the profiles which establish the percentage of the equipment load that is ON by hour of the day. An indicative table is as shown below –

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Table B3.5b – Operation Densities for Different Operation Parameters in a Building

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Occupants																								
Mon – Fri																								
Sat																								
Sun																								
Equipment																								
Mon – Fri																								
Sat																								
Sun																								
Lighting																								
Mon – Fri																								
Sat																								
Sun																								
AHU/Fan																								
Mon – Fri																								
Sat																								
Sun																								
Cooling																								
Mon – Fri																								
Sat																								
Sun																								
Heating																								
Mon – Fri																								
Sat																								
Sun																								
Hot Water																								
Mon – Fri																								
Sat																								
Sun																								

(d) The following gives the range of values to be assigned as operation densities in the above table.

Parameter	Operation density values to be input for different hours of a day
Occupants	**0** for no occupancy, **1** for full occupancy, decimals between **0 to 1** to indicate the intermediate occupancies
Equipment Lighting Hot Water	**0** for not in operation, **1** for full operation, decimals between **0 to 1** to indicate the intermediate operation density
AHU/Fan	**Off** for not in operation, **0n** for in operation
Cooling Heating	actual setting of thermostat dry bulb temperature to be inserted, with **Off** to indicate turning off of cooling/heating

(e) The operating schedule should reflect for the reference building the following –

Parameter	Operation density values to be input for different hours of a day
Lighting	lighting load profile based on the control requirements in Section 5 of this BEC
AHU/Fan Cooling Heating	air-conditioning load profile based on the control requirements in Section 6 of this BEC

(f) Different software programs may demand an input format with variations to that shown in the above indicative tables.

B3.5.3 Orientations and Shape

The reference building should consist of the same number of stories and gross floor area for each story as the designed building. Each floor should be oriented exactly as the designed building. The geometric form should be the same as the designed building. The orientation should be the same as the designed building.

B3.5.4 Operating Schedules

Operating schedules should be identical for the designed building and reference building, except permitted under Section 9 of this BEC or this Appendix as a result of the adoption of an energy efficiency feature. The schedules should well reflect the operating profiles of the energy consuming equipment and systems.

B3.5.5 Internal Loads

(a) *Occupancy*. The value of occupant density for a space in the operating schedule should be identical for both designed and reference buildings.

(b) *Lighting*. The lighting power used to calculate the design energy should be the actual power of the lighting design, with adjustment for energy efficient controls if applicable, in which case the actual installed or designed lighting power should be used along with the operating schedules reflecting the action of the controls to calculate the design energy. In calculating the energy budget, the threshold allowable values in Section 5 of this BEC should be adopted.

(c) *Equipment*. The same assumptions should be made in calculating design energy as are used in calculating the energy budget, except for adjustment for energy efficient controls permitted under Section 9 of this BEC and this Appendix.

B3.5.6 Building Envelope

(a) *Infiltration*. Infiltration should impact only perimeter zones. When the air-conditioning system is ON, no infiltration should be assumed to occur. When the air-conditioning system is OFF, the infiltration rate for exterior walls of the building with entrance doors/revolving doors or with operable windows should be assumed to be: (i) for glazed entrance doors and for revolving doors, 5 litres/second (L/s) per m^2 of door area, and (ii) for operable windows, 2 L/s per m^2 of the respective window area. Tested infiltration values recommended by door/window suppliers may also be used.

(b) *Envelope and Ground Absorptivities*. The solar absorptivity of opaque elements of the building envelope can be assumed to be 70% should the actual or designed data not be available. The solar absorptivity of ground surfaces should be assumed to be 80% should the actual or designed data not be available.

(c) *Window Management*. If the plans and specifications show interior shading devices which perform better than a medium-colored Venetian blind, then those shading devices may be modelled in the designed building, and the reference building can be modelled with medium-colored Venetian blinds. Otherwise, interior shading should be modelled identically in the designed and reference buildings, either with medium-colored Venetian blinds or without interior shades.

(d) *Exterior Shading*. Shading by permanent structures, terrain, and vegetation may be taken into account for computing energy consumption, whether or not these features are located on the building site. A permanent fixture is one that is likely to remain for the life of the designed building.

(e) *Window Areas*. The fraction of total window area in each orientation should be equal for both the reference and designed building. For example, if the designed building has 40% of window area facing north, then the reference building should also have 40% of window area facing north.

(f) *Window Shading Coefficient.* For buildings not governed by the OTTV by regulation, the shading coefficient of windows and skylights in the reference building should be taken as 0.6 or identical to the designed building.

(g) *Thermal Mass*. If no information is available for determining the thermal mass of the building envelope, medium weight construction should be assumed in the modelling.

B3.5.7 Air-conditioning Systems

(a) *Thermal Blocks and Air-conditioning Zones*. Thermal blocks for the reference building and designed building should be identical. Where air-conditioning zones are defined in air-conditioning design documents, each air-conditioning zone should be modelled as a separate thermal block. Different air-conditioning zones may be combined to create a single thermal block or identical thermal blocks to which multipliers are applied, provided all of the following conditions are met:
   i) the space use classification is the same throughout the thermal block;
   ii) all air-conditioning zones in the thermal block that are adjacent to glazed exterior walls face the same orientation or their orientations are within 45 degrees of each other; and
   iii) all of the zones are served by the same air-conditioning system or by the same kind of air-conditioning system.

(b) *Air-conditioning Zones Not Designed*. Where the air-conditioning zones and systems have not yet been designed, thermal blocks should be defined based on similar internal load densities, occupancy, lighting, thermal and space temperature schedules, and in combination with the following guidelines:
   i) separate thermal blocks should be assumed for interior and perimeter spaces. interior spaces should be those located greater than 4 m from an exterior wall; perimeter spaces should be those located closer than 4 m from an exterior wall;
   ii) separate thermal blocks should be assumed for spaces adjacent to glazed exterior walls; a separate zone should be provided for each orientation, except orientations that differ by no more than 45 degrees may be considered to be the same orientation; each zone should include all floor area that is 4 m or less from a glazed perimeter wall, except that floor area within 4 m of glazed perimeter walls

having more than one orientation should be divided proportionately between zones;

iii) separate thermal blocks should be assumed for spaces having floors that are in contact with the ground or exposed to ambient conditions from zones that do not share these features; and

iv) separate thermal blocks should be assumed for spaces having exterior ceiling or roof assemblies from zones that do not share these features.

(c) ***Supply Air Flow Rates***. The design air flow rate for each thermal block of the designed building and reference building should be able to be automatically calculated by the simulation program based on the design cooling supply air temperature and heating supply air temperature.

(d) ***Performance Parameters***. The air-conditioning system's performance parameters for the reference building should be determined from the following rules:

i) components and parameters not specifically addressed in Section 9 of this BEC or this Appendix should be identical to those in the designed building; where there are specific requirements in Section 6 of this BEC, the component efficiency in the reference building should be adjusted to the lowest efficiency level allowed by the requirement for that component type;

ii) all air-conditioning equipment in the reference building should be modelled at the minimum efficiency levels, both part load and full load, in accordance with the requirements in Section 6 of this BEC;

iii) where equipment efficiency ratings include fan energy, the descriptor should be broken down into its components so that supply fan energy can be modelled separately;

iv) minimum outdoor air ventilation rates should be the same for both the reference building and designed building.

v) system design supply air flow rates for the reference building should be based on the actual designed supply-air-to-room-air temperature difference or a difference of 11°C; if return or relief fans are specified in the designed building, the reference building should also be modelled with the same fan type sized for the reference system supply fan air quantity less the minimum outdoor air, or 90% of the supply fan air quantity;

vi) the system fan motor power (kW per L/s of supply air) of the reference building should be up to the limit specified in Section 6 of this BEC; and

vii) the equipment capacities for the reference building design should be sized proportionally to the capacities in the designed building based on sizing runs; i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs should be the same for both the designed building and reference building; unmet load hours for the designed building should not differ from unmet load hours for the reference building design by more than 50 hours.

B3.5.8 Service Water Heating

(a) ***Loads***. The same service water heating load assumptions should be made in calculating design energy as are used in calculating the energy budget.

(b) *Fuels*. The fuel assumed for the service water heating equipment of the reference building should be the same as that for the designed building.

B3.5.9 Controls

(a) *Space Temperature Controls*. Space temperature controls for the reference building should be the same as the designed building. The system should be OFF during off-hours according to the appropriate operating schedules.

(b) *Throttling Range*. The throttling range of room thermostat should be set to no greater than 1°C.

(c) *Outside Air Ventilation*. When providing for outdoor air ventilation when calculating the energy budget, controls should be assumed to close the outside air intake to reduce the flow of outside air to zero during 'setback' and 'unoccupied' periods, unless the design requires an intake of outdoor air to pre-cool or pre-heat the space during the unoccupied periods. Ventilation using inside air may still be required to maintain scheduled setback temperature.

B3.5.10 Speculative Buildings

(a) *Lighting*. The lighting power density for calculating the energy budget should be determined from Tables 5.4. The design energy may be based on an assumed adjusted lighting power for lighting improvements in the near future, the assumption of which and the measures to ensure their adoption should be documented so that the future installed lighting systems can be ensured of compliance with this assumption.

(b) *Air-conditioning Systems and Equipment*. If the air-conditioning system is not completely specified in the plans, the design energy should be based on reasonable assumptions of the construction of air-conditioning systems and equipment in the near future. These assumptions and the measures to ensure their adoption should be documented so that the future air-conditioning systems and equipment can be ensured of compliance with these assumptions.

- End -

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