Code of Practice for Energy Efficiency of Building Services Installation

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EMSD

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Code of Practice for Energy Efficiency of Building Services Installation

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1. Introduction

1.1 This Code of Practice titled "Code of Practice for Energy Efficiency of Building Services Installation", hereinafter referred as the "Building Energy Code" or "BEC", is issued under Part 9 of the Buildings Energy Efficiency Ordinance, Chapter 610 (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 building services installations defined in the Ordinance. Building services installations designed, installed and maintained to a design standard 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 and Mechanical Services Department (EMSD) in collaboration 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 also be publicized and given in the homepage of the Ordinance (http://www. emsd.gov.hk/beeo).

2. Interpretations and Abbreviations

2.1 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 motorised drive.

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

'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.

'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.

'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.

Examples of central building services installation		
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	on the incoming side of an electricity supplier's electricity meter for an individual unit	located anywhere in that building unless it is on the outgoing side of an electricity supplier's electricity meter for an individual unit which responsible person is not the owner of that building
Lift and 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 associated chilled/heated water pumps and if applicable associated condenser water pumps, cooling towers and/or 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 and the loss from dimmer/driver/step-down transformer, of a lamp. Circuit wattage is equal to the sum of nominal lamp wattage and lamp controlgear loss and the loss in the dimmer or driver and for a lamp operating on low voltage the step-down transformer should the dimmer or driver or transformer not be integral to the controlgear.

'**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, if any, 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.

'**conditioned floor area**' means the internal floor area of a 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.

'**direct digital control (DDC)**' means a type of control where controlled and monitored data, in analog or binary form, is converted to digital format for manipulations and calculations by a micro-processer and then converted back to analog or binary form to control physical devices.

'**Director**' means the Director of Electrical and Mechanical Services.

'**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.

'**effective current-carrying capacity**' **in the context of electrical installation** 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 utilization 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 Ordinance (Cap. 618).

'**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 Fire Safety in Buildings, Buildings Department.

'**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.

'**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 building, a space or a unit, means the floor area of all enclosed spaces measured to the internal faces of enclosing external and/or party walls.

'**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 Ordinance (Cap. 618), 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 an escalator as defined in section 2(1) of the Lifts and Escalators Ordinance (Cap. 618); 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 only the specific zone.

'**lift decoration load**' means the loads of the materials used 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 include the floor tiles, additional ceiling panels, additional car wall decorative panels and their corresponding materials for backing and/or fixing, but however exclude the 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 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 maximum circuit wattage consumed by fixed lighting installations per unit floor area of an illuminated space.

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

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

,where the total circuit wattage should be taken at the full lighting output condition.)

'**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 if applicable, 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**' in the context of electrical power 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**' in the context of lift and escalator installation means the mechanism of a set of speed reduction gears transferring the power from the motor shaft to the drive sheave in a traction drive 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 \ Ordinance (Cap. 618).

'**meter**' means a measuring instrument to measure, register or indicate the value of voltage, current, power factor, electrical consumption or demand, water flow, energy input/output 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, operating 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.

'**passenger conveyor**' should have the same meaning assigned by section 2 of the Lifts and Escalators Ordinance (Cap. 618).

'**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 (P), in Watts, to the total apparent power (S) that contains the fundamental and all harmonic components, in Volt-Amperes. S is derived based on

$$S = |V_1||I_1| + |V_2||I_2| + |V_3||I_3|$$

where : I_1, I_2 and I_3 stand for the measured line currents;

V_1, V_2 and V_3 stand for the measured phase voltages of three-phase four-wire power supply system.

For three-phase three-wire power supply system, the phase voltages are derived in accordance with the procedures as given in Appendix B of this BEC; and

$|V_z|$ and $|I_z|$ (with sub-script z = 1, 2 or 3) are the magnitudes of the phase voltages and the line currents respectively.

'**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 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 Ordinance (Cap. 618).

'**rated speed**' of a lift or escalator should have the same meaning as in the Lifts and Escalators Ordinance (Cap. 618).

'**recooling**' means lowering the temperature of a medium such as 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 a medium such as air that has been previously cooled by a refrigeration/cooling 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 Ordinance (Cap. 618).

'**shading coefficient** (SC)' of a glazing means the ratio of solar heat gain at normal incidence through the glazing to that through 3 mm thick clear double-strength glass, and should not include the shading from interior or exterior 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 that is illuminated by artificial lighting installation, and is bounded by a physical floor, a physical ceiling and physical walls.

'**stairlift**' means a kind of lift for transporting an ambulant disabled person or person in a wheelchair between two or more levels by means of a guided carriage/platform moving substantially in the direction of a flight of stairs and travelling in the same path in both upward and downward directions.

'**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; the zones for combination to form a single thermal block need not be contiguous.

'**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**' in the context of the performance-based approach means the sum of the energy consumption of the building services installations of a building and its energy consuming equipment, 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**' when not referring to dimensions (of length, area, volume, mass, time, power, energy etc.) 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 with one or more factory-made assemblies that includes evaporator, compressor, condenser, cooling or heating coil, air re-circulation fan section, and regulator controls, with single or multiple indoor units, 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) **system**' means an engineered direct expansion multi-split system incorporating at least one variable capacity compressor distributing refrigerant through a piping network to multiple indoor units, each capable of individual zone temperature control, where the cooling or heating supply to the conditioned spaces are adjusted by modulating the flow of refrigerant through integral zone temperature control devices and common communications network. Variable refrigerant flow utilizes three or more steps of control on common, interconnecting piping.

'**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 whose car is dimensioned and designed for carrying 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.

2.2 Abbreviations

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

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

'**CIBSE**' refers to the Chartered Institution of Building Services Engineers

'**DW143**' refers to "Guide to Good Practice Ductwork Leakage Testing, Sixth Edition (2013)", Buildings & Engineering Services Association, UK.

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

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

'**NEMA**' refers to National Electrical Manufacturers Association (USA).

'**OTTV**' refers to 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.

3. Application

3.1 Scope of Application

This BEC is applicable to the prescribed building services installations of a building or a unit in that building, belonging to one of the categories of buildings prescribed in Schedule 1 of the Ordinance, irrespective of the form of the electrical power supply for these installations.

3.2 Limit of Scope of Application

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 Installations in a Prescribed Building in respect of which a Consent to the Commencement of Building Works for Superstructure Construction is given after the commencement of Part 2 and Part 3 of the Ordinance

4.1.1 To satisfy the relevant requirements of the Ordinance, the building services installations in a prescribed building in respect of which a consent to the commencement of building works (as defined in section 2 of the Ordinance) for superstructure construction is given after the commencement of Part 2 and Part 3 of the Ordinance, save for exclusion or exemption under the Ordinance, should in any circumstances comply with the requirements in either -

(a) Sections 5 to 8 of this BEC (prescriptive approach), or

(b) Section 9 of this BEC (performance-based approach)

for system design, unless otherwise specified.

4.1.2 The requirement in clause 4.1.1 should be applicable to the building services installations covered by new construction of a building and all subsequent retrofitting works irrespective of whether the retrofitting works are regarded as major retrofitting works defined in Schedule 3 of the Ordinance or not.

4.2 Building Services Installations in a Prescribed Building in respect of which a Consent to the Commencement of Building Works for Superstructure Construction is given on or before the commencement of Part 2 and Part 3 of the Ordinance

To satisfy the relevant requirements of the Ordinance, when major retrofitting works defined in the Ordinance are carried out in a prescribed building in respect of which a consent to the commencement of building works (as defined in section 2 of the Ordinance) for superstructure construction is given on or before the commencement of Parts 2 and Part 3 of the Ordinance, the involved building services installations, save for exclusion or exemption under the Ordinance, should in any circumstances comply with the requirements in Section 10 of this BEC for system design, unless otherwise specified.

4.3 Energy Efficiency Requirements at Design Conditions

The energy efficiency requirements in this BEC refer to the standards at the corresponding design conditions.

4.4 Requirements on Maintaining of Design Standard

The building services installations in clause 4.1 and 4.2, save for exclusion or exemption under the Ordinance, should be maintained to a design standard as required in sections 12(3) and 18(2) of the Ordinance. The standard to be maintained refers to the version of BEC declared in the relevant Certificate of Compliance Registration or Form of Compliance (respectively defined in section 2 of the Ordinance, with relevant requirements prescribed in Part 2 and Part 3 of the Ordinance).

4.5 Demonstration of Compliance

The specified forms under the Ordinance, accompanied by the documents specified in the forms, should be submitted to the Director to demonstrate compliance with the BEC requirements.

5. Energy Efficiency Requirements for Lighting Installation

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 For the avoidance of doubt, the following lighting installations in a building are not regarded as lighting installations to which the Ordinance is applicable –

(a) lighting installation exterior to a building such as façade lighting installation, outdoor lighting installation, and lighting installation underneath canopy over a pavement or road;

(b) lighting installation not of fixed type, and connected to power supply via flexible cable with plug and socket;

(c) lighting installation integral to an equipment or instrumentation that is not a luminaire and with separate control switch;

(d) lighting installation integral to a signage;

(e) lighting installation owned by the electricity supplier and installed in a consumer's substation; and

(f) lighting installation included in the installations specified in Schedule 2 of the Ordinance.

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 a space of a type 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 70W.

Table 5.4 : Lighting Power Density and Automatic Lighting Control for Various Types of Space

Type of Space	Maximum Allowable LPD (W/m²)	Automatic Lighting Control Required (Yes / No)
Atrium / Foyer with headroom over 5m	17	Yes
Bar / Lounge	13	No
Banquet Room / Function Room / Ball Room	17	No
Canteen	11	No
Car Park	5	Yes, at parking spaces only
Changing Room/ Locker Room	10	Yes
Classroom / Training Room	12	Yes
Clinic	15	No
Common Room/ Break Room	8	Yes
Computer Room / Data Centre	15	Yes
Conference / Seminar Room	14	Yes
Confinement Cell	12	No
Copy/ Printing Room, Photocopy Machine Room	10	Yes
Corridor	8	Yes
Court Room	15	Yes
Covered Playground (underneath building)/ Sky Garden	12	Yes
Dormitory	8	Yes
Entrance Lobby	13	Yes
Exhibition Hall / Gallery	15	No
Fast Food / Food Court	14	No
Guest room in Hotel or Guesthouse	13	No
Gymnasium / Exercise Room	11	Yes
Indoor Swimming Pool, for recreational or leisure purposes	15	No
Kitchen	13	No
Laboratory	15	No
Lecture Theatre	13	Yes
Library – Reading Area or Audio Visual Centre	12	No
Library – Stack Area	15	No
Lift Car	11	Yes
Lift Lobby	10	Yes
Loading & Unloading Area	8	Yes
Long Stay Ward for elderly	15	No
Nurse Station	13	No
Office, enclosed (Internal floor area at or below $15m^2$)	12	Yes
Office, Internal floor area above $15m^2$ and of or below $200m^2$	10	Yes
Office, Internal floor area above $200m^2$	9	Yes
Pantry	12	Yes

Table 5.4 : Lighting Power Density and Automatic Lighting Control for Various Types of Space

Type of Space	Maximum Allowable LPD (W/m^2)	Automatic Lighting Control Required (Yes / No)
Passenger Terminal Building		
● Arrival Hall / Departure Hall, with headroom not exceeding 5m	14	No
● Arrival Hall / Departure Hall, with headroom over 5m	18	No
● Passenger circulation area	13	No
Patient Ward / Day Care	13	No
Plant Room / Machine Room / Switch Room	10	No
Porte Cochere	13	No
Porte Cochere with headroom over 5m	15	No
Public Circulation Area	13	Yes
Railway Station		
• Concourse / Platform / Entrance / Adit / Staircase, with headroom not exceeding 5 m	14	No
• Concourse / Platform / Entrance / Adit / Staircase, with headroom over 5 m	18	No
Refuge Floor	11	Yes
Restaurant	17	No
Retail	16	No
School hall	14	Yes
Seating Area inside Theatre / Cinema / Auditorium / Concert Hall / Arena	10	No
Server Room / Hub Room	10	No
Sports Arena, Indoor, for recreational purpose	17	No
Staircase	7	No
Storeroom / Cleaner	9	Yes
Toilet / Washroom / Shower Room	11	Yes
Workshop	13	No

Table 5.4 : Lighting Power Density and Automatic Lighting Control for Various Types of Space

Type of Space	Maximum Allowable LPD (W/m^2)	Automatic Lighting Control Required (Yes / No)
Multi-functional Space	See below	
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.		

5.4.2 The lighting power of the lighting installations stated in clause 5.1.2 will be excluded in the LPD calculation. The clarification of the Director should be sought in case of uncertainty on whether a lighting installation may be excluded in the LPD calculation.

5.4.3 Two or more neighbouring spaces segregated by floor-to-ceiling height walls should be regarded as separate individual spaces, irrespective of whether or not they serve the same function, and each of these individual spaces is governed by the requirement in clause 5.4.1.

5.5 Lighting Control Point

5.5.1 A single lighting control point in any of the spaces that is not classified as an office should control no more than $500m^2$, unless the total electrical power consumed by the complete fixed lighting installations in the space does not exceed 70W. The minimum number of lighting control points for 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 x (N -1) < A ≤ 15 x N	0 < N ≤ 10
30 x (N-6) < A ≤ 30 x (N – 5)	10 < N ≤ 20
50 x (N -12) < A ≤ 50 x (N-11)	N > 20

5.5.2 In an office 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, separate lighting control points should be provided to operate the luminaires for that activity, such that the operation of these luminaires should be independent of the operation of the luminaires not for the activity.

5.5.4 Lighting control points for the lighting installations to which the Ordinance is applicable should be independent from those for the other lighting installations to which the Ordinance is not applicable, such that these two categories of lighting installation may be switched on/off independently.

5.5.5 For any space, other than carpark, with lighting installation designed for 24 hours a day and 7 days a week operation, the requirements in clause 5.5.1 should not be applicable.

5.6 Automatic Lighting Control

5.6.1 The Basic Provision

5.6.1.1 Automatic lighting control should be provided to the space given in Table 5.4 unless the total electrical power consumed by the complete fixed lighting installations in the space does not exceed 150 W. The control should be able to shut off or reduce the general lighting power by at least 50% automatically of the lighting zone being controlled.

5.6.1.2 For any space requiring automatic lighting control, the requirements on daylight responsive control are applicable when the space is provided with fenestrations on exterior wall or overhead skylight.

5.6.1.3 The control devices or system should provide independent control which –

(a) control the lighting for an area of no more than 2000 m^2;

(b) include no more than one floor except for spaces at multiple floors with similar configurations, lighting layouts and the lighting installations are under the same ownership; and

(c) cater for weekend and holidays operation pattern except the lighting installation designed for such a space is required of 24 hours a day and 7 days a week operation.

5.6.1.4 Any manual control installed to provide override of the automatic lighting control by the occupant of the space should not turn the lighting on for more than two hours per activation and should not control more than 500 m^2.

5.6.1.5 For space deploying occupant sensors, the reduced lighting power control should activate within 15 minutes of all occupants leaving the space.

5.6.1.6 The requirement on automatic lighting control should not be applicable to any space to be occupied in the manner of 24 hours a day and 7 days a week.

5.6.1.7 The exception on automatic lighting control as given in clause 5.6.1.1 should not be applicable to the lighting installation in lift car.

5.6.2 Daylight responsive control for daylight through fenestrations on exterior wall

5.6.2.1 A space having one or more side window fenestrations, of or adding up to 5 m^2 or above, should have one or more portions within the space assigned as a lighting zone or lighting zones. Each lighting zone should be provided with daylight responsive control under a separate control device. The control should be able to shut off or reduce the lighting zone's lighting power automatically to 50% or less of the lighting zone being controlled in response to available daylight.

5.6.2.2 The area of a lighting zone, in fulfilling the requirement under daylight responsive control through fenestrations on exterior wall, should be:

(a) not less than twice the fenestration area for a discrete fenestration;

(b) not less than twice the sum of the areas of the fenestrations for a series of fenestrations; or

(c) the lighting space's internal floor area if such is so exceeded based on the computed area of the fenestration or the series of fenestrations.

5.6.2.3 A discrete fenestration may cater for a single lighting zone.

5.6.2.4 Fenestrations on the same orientation of the building when being separated by opaque wall section of 2m wide or less should be regarded as a series of fenestrations and to cater for a single lighting zone.

5.6.2.5 The requirement on daylight responsive control as given in clause 5.6.2.1 to clause 5.6.2.4 should not be applicable -

(a) when the glazing in the fenestration is of non-see-through type;

(b) when the general lighting completely or partially within a lighting zone does not exceed 150W; or

(c) to any of the lighting zone's overlapped area which is already assigned under other lighting zone using daylight responsive control through overhead skylight.

5.6.2.6 A single daylight responsive control device is permissible to serve the lighting zones at multiple floors provided that the concerned spaces are with similar configuration, lighting layout, daylight factor and the lighting installations are under the same ownership.

5.6.3 Daylight responsive control for daylight through overhead skylight

5.6.3.1 A space having one or more skylight fenestrations, of or adding up to 5 m^2 or above, should have one or more portions within the space assigned as a lighting zone or lighting zones. Each lighting zone should be provided with daylight responsive control under a separated control device. The control should be able to shut off or reduce the lighting zone's lighting power automatically to 50% or less in response to the available daylight.

5.6.3.2 The area of a lighting zone, in fulfilling the requirement under daylight responsive control through overhead skylight, should be:

(a) not less than 5 times the fenestration area for a discrete fenestration;

(b) not less than 5 times the sum of the areas of the fenestrations for a series of fenestrations; or

(c) the lighting space's internal floor area if such is so exceeded based on the computed area of the fenestration or the series of fenestrations.

5.6.3.3 A discrete fenestration of skylight may cater for a single lighting zone.

5.6.3.4 Fenestrations on the same skylight when being separated by opaque roof section of 2m wide or less should be regarded as a series of fenestrations and to cater for a single lighting zone.

5.6.3.5 The requirement on daylight responsive control as given in clause 5.6.3.1 to clause 5.6.3.4 should not be applicable -

(a) when the glazing in the fenestration is of non-see-through type;

(b) when the general lighting completely or partially within a lighting zone does not exceed 150W; or

(c) to any of the lighting zone's overlapped area which is already assigned under other lighting zone using daylight responsive control through fenestration on exterior wall.

6. Energy Efficiency Requirements for Air-conditioning Installation

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 For the avoidance of doubt, the following air-conditioning installations in a building are regarded as air-conditioning installations to which the Ordinance is applicable, unless otherwise specified in clause 6.1.3 -

(a) air moving equipment being part of a fire service installation but also providing normal air-conditioning to a space;
(b) unitary air-conditioner for lift car; and
(c) equipment/component not located within the building, but owned by the owner or responsible person of a space within the building, to provide or assist to provide air-conditioning to that space.

6.1.3 For the avoidance of doubt, the following air-conditioning installations in a building are not regarded as air-conditioning installations to which the Ordinance is applicable –

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

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 and fan motor performance;
(e) reducing conduction losses in pipework, ductwork and AHU casing through minimum allowable thickness on insulation thereto;

(f) reducing the use of energy through efficient controls of air-conditioning equipment and systems in respect of demand control; and

(g) reducing the use of energy through 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:

Table 6.4 : Air-conditioning System Load Design Conditions

Condition	Season	Applications	Temperature / Relative Humidity	
Indoor, for human comfort applications	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 of 35^{0}C with wet bulb temperature lower than 29^{0}C, or Maximum wet bulb temperature of 29^{0}C with dry bulb temperature lower than 35^{0}C	
	Winter	All applications	Minimum dry bulb temperature	7^{0}C

6.5 Separate Air Distribution System for Process Zone

6.5.1 A process zone refers to a zone meeting a process requirement or serving as a computer/data centre with special temperature and/or humidity requirements, and its serving air distribution system should be dedicated to serve the process 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 should not be applicable 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	$0.009 \times p^{0.65}$
II	above 1000 to 2000	$0.003 \times p^{0.65}$
III	above 2000	$0.001 \times p^{0.65}$
Remark: 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 clean condition, 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 at the clean condition is deductible from the system fan motor power.

6.7.4 An air-conditioning system with fan motor power of 1.0 kW or above should be designed to vary the airflow as a function of load.

6.7.4.1 A CAV air distribution system should be provided with low-speed operation. At the low-speed operation, the fan speed should not exceed 66% of the full speed and the fan motor should draw no more than 40% of the full speed power.

6.7.4.2 A VAV air distribution system should be provided with minimum fan speed not exceeding 50% of the full speed. At the minimum fan speed, the fan motor should draw no more than 30% of the full speed power.

6.7.4.3 If the air volume flow rate at the reduced speed operation failed to meet the fresh air requirement of the conditioned space, the low-speed operation of the CAV air distribution system or the minimum fan speed of the VAV air distribution system should be selected to provide the required fresh air rate.

6.7.5 The requirements in clauses 6.7.1 and 6.7.2 should not be applicable to

(a) a system with system fan motor power less than 2.5 kW; or
(b) a system with air handling units (AHUs) and for each AHU the motor power of an individual fan is less than 1 kW; or
(c) an installation specified in Schedule 2 of the Ordinance.

6.7.6 The system fan motor power required for an air distribution system of a mechanical ventilation system for a space should not exceed a limit of 1.1 W per L/s of exhaust air flow rate or fresh air flow rate whichever the larger unless the system is with system fan motor power less than 2.5 kW.

6.7.6.1 In fulfilling clause 6.7.6, the portion of fan power consumed due to pressure drop across the following listed air treatment or filtration device is deductible from the system fan motor power. This is based on the understanding that the listed devices are of significant air pressure drop typically.

(a) Grease filter;
(b) Hydrovent and air washer;
(c) Baffle filter
(d) Activated carbon filter; and
(e) Venturi scrubber.

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 by sequencing on and off of multiple chillers and pumps or by reduced speed operation of variable speed pump, 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 three control valves, or
(c) it incorporates supply water temperature reset control, or
(d) where the chiller plant design capacity is of 350 kW or less.

6.8.2 A chilled water pump, with motor output power exceeding 3.7kW, serving a variable flow system as prescribed in clause 6.8.1 should incorporate controls and devices such that the pump motor demands no more than 30% of design input power at 50% of design water volume flow.

6.8.3 A chilled water plant consisting of multiple chillers should be designed in such a way that the chilled water flow through a chiller should be automatically shut off when the chiller is shut down. The requirement should be applicable to the condenser water flow of water cooled chillers.

6.9 Frictional Loss of Water Piping System

6.9.1 Water piping with diameter 50 mm or below should be sized for water flow velocity not exceeding 1.2 m/s.

6.9.2 Water piping with diameter larger than 50 mm should be sized for frictional loss not exceeding 400 Pa/m and –

(a) water flow velocity not exceeding 2.5 m/s for system that operates under non-variable flow condition; or

(b) water flow velocity not exceeding 3.0 m/s for system that operates under variable flow condition.

6.9.3 In fulfilling clause 6.9.2(b), the system that operates under variable flow condition should deploy variable-speed pump motors or deploy multiple duty fixed-speed pump motors that operate in stages in accordance with demand.

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 The requirement in clause 6.10.1.2 and clause 6.10.1.3 should not be applicable to an unitary air-conditioner with the control device –

(a) that forms an integral part of the unitary air-conditioner; or

(b) that is offered by the manufacturer as a standard ancillary to the unitary air-conditioner with the device being available ex-factory in the same package of the unitary air-conditioner.

6.10.1.5 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 to its serving space 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 space 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 up to 60%.

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 down to 30%.

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 an 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, unless otherwise specified in clause 6.10.4.2, 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.

(a) When deploying control setback, the air-conditioning system –

i. under the cooling mode operation, should be equipped with controls capable of and configured to automatically restart and temporarily operate the air-conditioning system as required to maintain the space temperatures below an adjustable cooling set point at least 5°C above the occupied cooling set point.

ii. under the heating mode operation, should be equipped with controls capable of and configured to automatically restart and temporarily operate the air-conditioning system as required to maintain the space temperatures above an adjustable heating set point at least 6°C below the occupied heating set point.

(b) When deploying equipment shutdown, the air-conditioning system should be equipped with at least one of the following:

i. Controls that can start and stop the system under different time schedules for seven different day types per week, are capable of retaining programming and time setting during loss of power for period of at least ten hours, and include an accessible manual control for override that allows temporary operation of the air-conditioning system for up to two hours.

ii. Occupant sensor that is capable of shutting the air-conditioning system off when no occupant is sensed for a period of up to 30 minutes.

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.

6.10.4.4 The fresh air intake and exhaust air discharge for a conditioned space should be equipped with automatic dampers which shutoff when the conditioned space is not in use. The dampers should be kept at the shutoff position during preoccupancy cool-down and during off-hour setback if the air-conditioning system is provided with preoccupancy cool-down and/or off-hour setback mode.

6.10.5 Isolation of Zones

6.10.5.1 The air-conditioning systems serving zones intended to operate or be occupied non-simultaneously should be divided into isolation areas where -

(a) an isolation area, consisting of zones of similar characteristics, should not exceed 2300 m^2 of air-conditioned floor area nor include more than one floor; and
(b) each isolation area should be equipped with controls and isolation devices capable of automatic shutoff of conditioned supply air and fresh air to and exhaust air from the area.

6.10.5.2 For the purpose of fulfilling clause 6.10.5.1, the central systems and chilled water plant should be provided with controls and devices to allow stable operation for any length of time while serving only the smallest isolation area served by the system or plant.

6.10.5.3 Isolation devices and controls should not be required for-

(a) exhaust air and fresh air connections to isolation areas when the fan system to which they connect is 2400 L/s or smaller;
(b) exhaust airflow from a single isolation area of less than 10% of the design airflow of the exhaust system to which it connects;
(c) isolation areas intended to operate continuously; or
(d) isolation areas intended to be inoperative only when all other isolation areas are inoperative.

6.10.6 Control of VAV Air Distribution System

6.10.6.1 The static pressure sensor should be located such that the controller set point should not be greater than 300 Pa. If this results in the sensor being located downstream of major duct split, sensors should be installed in each major branch.

6.10.6.2 The set point of the static pressure sensor should be reset based on the actual demand load of the conditioned space.

6.10.7 Demand Control Ventilation

6.10.7.1 A carpark ventilation system should be designed to operate with staging or modulation of fans, based on the detected contaminant level, to provide down to 50% or less of the design capacity. For carpark on basement floor, additional control in response to temperature is permissible.

6.10.7.2 The requirement in clause 6.10.7.1 should be applicable to

(a) the exhaust air fans and the fresh air fans in respect of staging or modulation of fans, where jet fans, if any, should be exempted from the fan staging or modulation; and

(b) the carpark ventilation system with the total fan motors' nameplate power, including the fresh air fans, exhaust air fans and jet fans, of 11 kW or above.

6.10.7.3 An air-conditioning system serving a conditioned space with design fresh airflow rate of 1400 L/s or above should be provided with demand control ventilation unless the system is provided with exhaust air energy recovery.

6.10.7.4 In fulfilling clause 6.10.7.3, the fresh air dampers connecting to the air handling unit or fresh air fan should be designed to modulate in accordance with the CO_2 level of the conditioned space served by the air-conditioning system unless the system is operated at free cooling mode if provided.

6.11 Thermal Insulation

6.11.1 Chilled water pipework, suction refrigerant pipework, ductwork carrying cooled air, and casing of air handling unit handling cooled air should be insulated with a minimum thickness determined in accordance with Tables 6.11a, 6.11b and 6.11c for given ambient condition and thermal conductivity of insulation of the installation.

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

Ambient Condition	Outdoor @2				Unconditioned Space @2				Conditioned Space @2	
Thermal conductivity λ (W/m-°C) @3	0.024		0.04		0.024		0.04		0.024	0.04
Surface coefficient h (W/m²-°C) @4	9	13.5	9	13.5	5.7	10	5.7	10	any value	
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 insulation thickness in Table 6.11a based on steel pipes of diameters to BS EN Standards 10255:2004 / BS EN 10220:2002 and at line temperature θ_l of 5°C;

Pipework insulation thickness in Table 6.11b based on copper pipes of diameters to BS EN Standard 1057:2006;

For metal pipes of other standards, same insulation thickness should be applied to comparable outer diameters.

@2 Outdoor or unconditioned space ambient condition : Insulation thickness based on 27°C dew point at 90% coincident relative humidity (app. coincident 28.8°C dry bulb), as recommended in 2009 ASHRAE Handbook – Fundamentals;

Conditioned space ambient condition: Insulation thickness based on recommendation in ASHRAE Standard 90.1-2007, with minimum thickness taken as 13 mm for recommended values below 13 mm.

The design outdoor or unconditioned space ambient conditions above are accepted as the most extreme conditions for calculating minimum insulation thickness for compliance with this BEC.

@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										
Ambient Condition	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	any value	
Pipe outer diameter d_o @1	Insulation thickness (mm) @1									
Line temperature θ_l	0°C									
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
76.1 mm	31	22	47	33	45	28	67	43	14	25
Line temperature θ_l	-10°C									
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
76.1 mm	40	28	60	43	57	36	86	55	14	25
Line temperature θ_l	-20°C									
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
76.1 mm	48	35	72	53	69	44	104	67	14	25

Table 6.11c : Minimum Insulation Thickness for Ductwork and AHU Casing @1										
Ambient Condition	Outdoor @2				Unconditioned Space @2				Conditioned Space @2	
Thermal conductivity λ (W/m-°C) @3	0.024		0.04		0.024		0.04		0.024	0.04
Surface coefficient h (W/m²-°C) @4	9	13.5	9	13.5	5.7	10	5.7	10	any value	
Temperature difference between air inside duct/ casing and surrounding of duct/casing	Insulation thickness (mm) @1									
15 °C	20	13	33	22	31	18	52	30	15	25
20 °C	27	18	46	30	43	25	72	41	15	25

6.11.2 Insulation for outdoor or unconditioned space should be water vapour retardant such as of closed cell type, fiberglass insulation with multi-layer double-side reinforced aluminium foil and sealed at joints using aluminium foil adhesive tape, insulation coated with heavy duty mastic over reinforcing membrane, 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, 6.12b or 6.12c should have the corresponding minimum coefficient of performance at full load at the specified standard rating condition given in the table. A chiller deploying variable speed drive should also have the minimum coefficient of performance at the 75% of full load fulfilling the corresponding value given in Table 6.12b.

6.12.2 A room air conditioner under the scope of the Mandatory Energy Efficiency Labelling Scheme under Energy Efficiency (Labelling of Products) Ordinance (Cap. 598) should fulfill the requirements of Energy Efficiency Grade 1 or Grade 2 specified in the Scheme.

<table>
<tr><th colspan="6"><u>Table 6.12a (Part 1):</u>
<u>Minimum Coefficient of Performance for Unitary Air-conditioner at Full Load</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 (@4)</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@1)</td><td rowspan="2">2.6 for split type
2.3 for non-split type</td><td colspan="2">2.5</td><td>2.6</td><td rowspan="2">3.3</td></tr>
<tr><td>3 (@2)</td><td colspan="2">3.1 (@2)</td></tr>
<tr><td>Minimum COP at heating mode (heat pump) (free air flow@1)</td><td>2.7</td><td>3.1</td><td>3.1</td><td>3.1</td><td>3.4</td></tr>
</table>

<table>
<tr><th colspan="6"><u>Table 6.12a (Part 2):</u>
<u>Minimum Coefficient of Performance for Variable Refrigerant Flow System at Full Load</u></th></tr>
<tr><td>Type of Cooling</td><td colspan="4">Air-cooled (@3)</td><td>Water-cooled (@3)</td></tr>
<tr><td>Capacity range (kW)</td><td>20 kW or below</td><td>Above 20 kW to 40 kW</td><td>Above 40 kW to 200 kW</td><td>Above 200 kW</td><td>All Ratings</td></tr>
<tr><td>Minimum COP at cooling mode (free air flow@1)</td><td>3.6</td><td>3.6</td><td>3.45</td><td>3.3</td><td>4.5</td></tr>
<tr><td>Minimum COP at heating mode (heat pump) (free air flow@1)</td><td>4.0</td><td>3.8</td><td>3.8</td><td>3.6</td><td>4.8</td></tr>
</table>

<table>
<tr><th colspan="5">Standard rating conditions</th></tr>
<tr><td>Type of Cooling</td><td colspan="2">Air-cooled</td><td colspan="2">Water-cooled</td></tr>
<tr><td>Operation condition</td><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°C dry bulb</td><td>27°C dry bulb/
19°C wet bulb</td><td>29.5°C</td><td>27°C dry bulb/
19°C wet bulb</td></tr>
<tr><td>Heating</td><td>7°C dry bulb /
6°C wet bulb</td><td>20°C dry bulb</td><td>20°C</td><td>20°C dry bulb/
15°C wet bulb</td></tr>
<tr><td>Water side fouling factor</td><td colspan="4">0.000018 m^2-^{0}C/W for evaporator; 0.000044 m^2-^{0}C/W for condenser</td></tr>
</table>

Remarks @ to Table 6.12a (Part 1) & (Part 2):

@1: without connection of ductwork at condenser (likewise at evaporator for heat pump); the COP for equipment with high static fans (for connecting ductwork) can be determined based on the fan power of normal fans for free air flow (and not the fan power of the high static fans)

@2: for making use of varying the refrigerant volume flow to cope with the loading demand of conditioned space

@3: Equivalent refrigerant piping of 5.0m; level difference 0m

@4: For types outside the scope of Room Air Conditioners in the labelling scheme specified in clause 6.12.2

Table 6.12b : Minimum Coefficient of Performance for Chiller[@2] at Full Load

Air-cooled

Type of compressor	Reciprocating		Scroll		Screw		VSD Screw		Centrifugal	VSD Centrifugal
Capacity Range (kW)	Below 400 kW	400 kW & above	Below 400 kW	400 kW & above	Below 500 kW	500 kW & above	Below 500 kW	500 kW & above	All Ratings	All Ratings
Minimum COP at cooling (free air flow[@1])	2.8	2.9	2.8	2.9	3.0	3.1	3.0 (3.8)[@5]	3.1 (3.9)[@5]	3.2	3.2 (4.2)[@5]

Water-cooled

Type of compressor	Reciprocating / Scroll			Screw			VSD Screw			Centrifugal			VSD 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 1000 kW	1000 kW to 3000 kW	Above 3000 kW	Below 1000 kW	1000 kW to 3000 kW	Above 3000 kW
Minimum COP (Cooling)	4.2	4.7	5.3	4.8	5.0	5.5	4.7 (6.4)[@5]	4.9 (6.7)[@5]	5.3 (7.0)[@5]	5.4[@3] 5.6[@4]	5.8	5.8	5.3 (7.0)[@5]	5.6 (7.5)[@5]	5.8 (7.6)[@5]

<table>
<tr><th colspan="10"><u>Table 6.12b : Minimum Coefficient of Performance for Chiller@2 at Full Load</u></th></tr>
<tr><th colspan="10"><u>Standard rating conditions</u></th></tr>
<tr><td>Type of Cooling</td><td colspan="3">Air-cooled</td><td colspan="6">Water-cooled</td></tr>
<tr><td rowspan="4">Operation condition</td><td rowspan="3">Condenser ambient temperature</td><td colspan="2" rowspan="2">Chilled water temperature</td><td colspan="4">Condenser water temperature</td><td colspan="2" rowspan="2">Chilled water temperature</td></tr>
<tr><td colspan="2">Fresh water</td><td colspan="2">Sea water</td></tr>
<tr><td>In</td><td>Out</td><td>In</td><td>Out</td><td>In</td><td>Out</td><td>In</td><td>Out</td></tr>
<tr><td>35°C</td><td>12.5°C</td><td>7°C</td><td>32°C</td><td>37°C</td><td>28°C</td><td>33°C</td><td>12.5°C</td><td>7°C</td></tr>
<tr><td rowspan="3">Water side fouling factor</td><td colspan="3">Evaporator</td><td colspan="6">0.000018m^{2}-^{0}C/W</td></tr>
<tr><td colspan="3" rowspan="2">Condenser</td><td colspan="3">Fresh water</td><td colspan="3">0.000044m^{2}-^{0}C/W</td></tr>
<tr><td colspan="3">Sea water</td><td colspan="3">0.000088m^{2}-^{0}C/W</td></tr>
</table>

Remarks @ to Table 6.12b:

@1 : without connection of ductwork at condenser; the COP for equipment with high static fans (for connecting ductwork) can be determined based on the fan power of normal fans for free air flow (and not the fan power of the high static fans)

@2 : including chiller with remote condenser;
not including heat recovery chiller;
not including chiller for low temperature application with design leaving fluid temperature below 4.4°C

@3 : min. COP for rated capacity below 500 kW;

@4 : min. COP for rated capacity between 500 to below 1000 kW;

@5 : min. COP at 75% of the full load with 24°C water-cooled condenser water temperature in or 27°C air-cooled condenser ambient temperature

<table>
<tr><th colspan="6">Table 6.12c : Minimum Coefficient of Performance for Heat Pump at Full Load</th></tr>
<tr><td>Type of Heat Extract</td><td colspan="3">Air-to-water</td><td colspan="2">Water-to-water</td></tr>
<tr><td>Capacity range (kW)</td><td>100 kW or below</td><td>Above 100kW & 500kW or below</td><td>Above 500 kW</td><td>500kW or below</td><td>Above 500 kW</td></tr>
<tr><td>Minimum COP at heating mode (free air flow[@1])</td><td>2.8</td><td>2.8</td><td>3.1</td><td>4.4</td><td>4.5</td></tr>
<tr><td colspan="6">Standard rating conditions</td></tr>
<tr><td>Type of Heat Extract</td><td colspan="3">Air-to-water</td><td colspan="2">Water-to-water</td></tr>
<tr><td>Heated water temperature</td><td colspan="5">40 °C In / 45 °C Out</td></tr>
<tr><td rowspan="3">Operating condition</td><td colspan="3" rowspan="3">Ambient 7 °C db & 90 % RH</td><td colspan="2">Chilled water temperature</td></tr>
<tr><td>In</td><td>Out</td></tr>
<tr><td>12.5 °C</td><td>7 °C</td></tr>
<tr><td>Water side fouling factor</td><td colspan="5">Closed loop system: 0.000018m²-°C/W
Open loop system (Fresh water): 0.000044m²-°C/W</td></tr>
<tr><td colspan="6">@1: without connection of ductwork at evaporator; the COP for equipment with high static fans (for connecting ductwork) can be determined based on the fan power of normal fans for free air flow (and not the fan power of the high static fans)</td></tr>
</table>

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

6.12.4 Open-circuit cooling tower should meet the following requirement on minimum water flow per unit tower fan motor nameplate power –

(a) 1.7 L/s per kW for centrifugal fans; and

(b) 3.4 L/s per kW for propeller or axial fans,

at 37^{o}C entering condenser water, 32^{o}C leaving condenser water and 28^{o}C entering air wet-bulb temperature

6.12.5 The fan(s) of an open-circuit cooling tower served by an individual motor or an array of motors with the rated motor power totaling 3.7 kW or above should incorporate control and devices that should result in the fan motor demand no more than 30% of design input power at 50% of design air flow and that should automatically control the fan speed to control the leaving condenser water temperature of the cooling tower.

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 its power (kW) & energy (kWh) input, cooling/heating power (kW) & energy (kWh) 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 its power (kW) & energy (kWh) input, and cooling/heating power (kW) & energy (kWh) output, such that the plant's coefficient of performance can be determined.

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 determining 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, whereas the inputs to chilled water pumps should be excluded. 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, whereas the inputs to heated water pumps should be excluded.

6.13.5 The measurement parameters as stated in clause 6.13.1 and 6.13.2 should be trended every 15 minutes and include hourly, daily, monthly, and annual data. The monitoring facilities should be capable of maintaining all data collected for a minimum of 36 months.

6.13.6 For each of an air handling unit, with an individual motor or an array of motors with the rated motor power totaling 5 kW or above, being accommodated in plant room, metering devices or the provision of measurement should be provided for measurement of power (kW) consumption of the air handling unit.

6.14 Direct Digital Control (DDC)

6.14.1 DDC should be provided for -

(a) a chilled/heated water plant and all the coils and terminal units served by the plant when the plant is of 350 kW or above cooling/heating capacity serving more than three zones; and
(b) an air distribution system for a conditioned space with system fan motor power of 7.45 kW or above.

6.14.2 The DDC should be capable of –

(a) monitoring zone and system demand for fan pressure, pump pressure, heating and cooling;
(b) transferring the zone and system demand to air distribution system controllers and from air distribution systems to plant controllers; and
(c) trending and graphically displaying input and output points.

7. Energy Efficiency Requirements for Electrical Installation

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 For the avoidance of doubt, the following electrical installations in a building are regarded as electrical installations to which the Ordinance is applicable, unless otherwise specified in clause 7.1.3 -

(a) circuit for lighting installation, for air-conditioning installation, for lift and escalator installation, or for fixed motor; and

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

7.1.3 For the avoidance of doubt, the following electrical installations in a building are not regarded as electrical installations to which the Ordinance is applicable –

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

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

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

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 devised 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 based on test in accordance with IEC Standard 60076-1 Ed. 2.1, at the test condition of full load, free of harmonics and at unity displacement power factor.

Table 7.4.1 : Minimum Transformer Efficiency

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 directly beside, directly above or directly 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 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 is not applicable to circuits solely used for correction 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 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 three-phase totally enclosed induction motor should have a nominal full-load motor efficiency fulfilling the corresponding value given in Table 7.5.1, except for a motor integrated into a machine such that it cannot be tested separately from the machine, or a motor specifically designed to operate at ambient air temperature exceeding 40^{o}C.

Table 7.5.1 : Minimum Nominal Full-Load Motor Efficiency for Single-Speed Three-phase Totally Enclosed Motor

Motor Rated Output (P, in kW)	Minimum Rated Efficiency (%)	
	2-pole	4-pole
0.75 kW ≤ P < 1.1 kW	80.7%	82.5%
1.1 kW ≤ P < 1.5 kW	82.7%	84.1%
1.5 kW ≤ P < 2.2 kW	84.2%	85.3%
2.2 kW ≤ P < 3 kW	85.9%	86.7%
3 kW ≤ P < 4 kW	87.1%	87.7%
4 kW ≤ P < 5.5 kW	88.1%	88.6%
5.5 kW ≤ P < 7.5 kW	89.2%	89.6%
7.5 kW ≤ P < 11 kW	90.1%	90.4%
11 kW ≤ P < 15 kW	91.2%	91.4%
15 kW ≤ P < 18.5 kW	91.9%	92.1%
18.5 kW ≤ P < 22 kW	92.4%	92.6%
22 kW ≤ P < 30 kW	92.7%	93%
30 kW ≤ P < 37 kW	93.3%	93.6%
37 kW ≤ P < 45 kW	93.7%	93.9%
45 kW ≤ P < 55 kW	94%	94.2%
55 kW ≤ P < 75 kW	94.3%	94.6%
75 kW ≤ P < 90 kW	94.7%	95%
90 kW ≤ P < 110 kW	95%	95.2%
110 kW ≤ P < 132 kW	95.2%	95.4%
132 kW ≤ P < 160 kW	95.4%	95.6%
160 kW ≤ P < 200 kW	95.6%	95.8%
P ≥ 200 kW	95.8%	96%

Remarks:
Compliance to above should be based on testing to relevant international standards such as IEEE 112-B:2004, or IEC 60034-2-1 : 2007.

7.5.2 Motor Sizing

(a) For a motor above 5 kW output power rating, its output power should not exceed 125% of the anticipated system load. 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.

(b) The requirement in (a) above should not be applicable to a motor having a load characteristic that requires a high starting torque. A load characteristic that requires a high starting torque refers to a load requiring a motor of IEC Design H, NEMA Design C, NEMA Design D or of a higher standard in terms of starting torque, and the load characteristic should be substantiated with a load calculation indicating the torque profile.

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

The requirements in clauses 7.5.1 and 7.5.2 should not be applicable to -

(a) a motor of a chiller, a heat pump, VRF system or unitary air-conditioner fulfilling the air-conditioning equipment efficiency requirement in clause 6.12 of this BEC;

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

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

(d) a motor of a cooling tower fan fulfilling the energy efficiency requirement in clause 6.12.4 and clause 6.12.5 of this BEC.

7.6 Power Quality

7.6.1 Total Power Factor

7.6.1.1 The design total power factor for a three-phase circuit connecting to the meter of the electricity supplier at designed circuit current should not be less than 0.85.

7.6.1.2 The design total power factor for a circuit at or above 400A (based on circuit protective device rating), single or three phase, at designed circuit current should not be less than 0.85.

7.6.1.3 In fulfilling clause 7.6.1.1 and clause 7.6.1.2, a power factor correction device or a connection point for the correction device should be incorporated at the source motor control centre or local distribution board. The connection point should constitute a spare way at the source motor control centre or local distribution board, and the spare way should be reserved solely for supplying power to the correction device.

7.6.1.4 The requirements in clause 7.6.1.1 and clause 7.6.1.2 should not be applicable to a circuit serving a lift and escalator installation that has fulfilled the power factor requirement in clause 8.5.1 of this BEC.

7.6.2 Total Harmonic Distortion

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

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 harmonic correction device, or a connection point for the correction device, should be incorporated at the source motor control centre or local distribution board. The connection point should constitute a spare way at the source motor control centre or local distribution board, and the spare way should be reserved solely for supplying power to the correction device.

7.6.2.4 In fulfilling clause 7.6.2.3 in respect of harmonic correction 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 should not be applicable to a circuit serving a lift and escalator installation that has fulfilled the harmonics distortion requirement in clause 8.6 of this BEC.

7.6.3 Balancing of Single-phase Loads

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

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), total power factor, 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 correction of reactive or distortion power purpose, should be incorporated with metering devices, for measuring currents (three phases and neutral) and total energy consumption (kWh).

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 correction 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), total power factor, total energy consumption (kWh), maximum demand (kVA) and total harmonic distortion.

7.7.3 Circuits for Central Building Services Installations

7.7.3.1 Circuit serving each of the following installation should be incorporated with metering devices separately,

(a) entire chilled water plant,
(b) entire heated water plant,
(c) all lifts, and
(d) all escalators or passenger conveyors.

7.7.3.2 In fulfilling clause 7.7.3.1, the metering devices should be able to provide the measurement parameters as stated in clause 7.7.2. For the circuit at or below 200A, the metering devices should be able to provide the measurement parameters as stated in clause 7.7.2.1.

7.7.4 In fulfilling clause 7.7.1 and 7.7.2.2 in respect of total harmonic distortion measurement, the metering devices should be capable of measuring at least up to 31st harmonic order.

7.7.5 The measurement parameters as stated in clause 7.7.1 to 7.7.3 should be trended every 15 minutes and include hourly, daily, monthly and annual data. The metering devices and the associated monitoring facilities should be capable of maintaining all data collected for a minimum of 36 months.

8. Energy Efficiency Requirements for Lift and Escalator Installation

8.1 Scope of Application

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

8.1.2 For the avoidance of doubt, the following lift and escalator installations in a building are regarded as lift and escalator installations to which the Ordinance is applicable, unless otherwise specified in clause 8.1.3 -

(a) passenger lift, bed passenger lift, freight lift, vehicle lift, escalator and passenger conveyor;
(b) fireman's lift that operates under normal condition (i.e. Fireman's Switch is off); and
(c) lift and escalator installation attached to the façade of the building and owned by the building owner.

8.1.3 For the avoidance of doubt, the following lift and escalator installations in a building are not regarded as lift and escalator installations to which the Ordinance is applicable –

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

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 and provisioning of regenerative braking;
(b) reducing losses in the utilization of power through imposing requirements of minimum allowable total power factor, limit on lift decoration load, and standby mode in lift operation;

(c) reducing losses due to 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 and Escalator Installations are given in Section 2 of this BEC.

8.4 Electrical Power

8.4.1 Traction Drive Lift

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

8.4.1.2 The requirement in clause 8.4.1.1 should not be applicable 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; or

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

Table 8.4.1a : Maximum Electrical Power (kW) of Traction Drive Lift at Rated Load for Various Ranges of Rated Speed (applicable to new building)

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	6.2	8.7	10.5	14.0	15.8
750 ≤ L < 1000	8.7	10.5	14.9	18.4	21.0
1000 ≤ L < 1350	10.5	14.9	19.3	23.7	28.0
1350 ≤ L < 1600	13.2	17.5	23.7	28.0	33.3
1600 ≤ L < 2000	14.6	21.5	27.5	33.4	39.4
2000 ≤ L < 3000	21.5	31.7	40.4	50.6	60.0
3000 ≤ L < 4000	28.3	41.1	54.1	66.9	78.9
4000 ≤ L < 5000	36.0	51.5	66.9	83.2	98.6
L ≥ 5000	0.00713L+ 0.429	0.0101L + 0.857	0.0134L + 0.433	0.0162L + 1.715	0.0196L + 0.429

Rated Load L (kg)	3 ≤ Vc < 3.5	3.5 ≤ Vc < 4	4 ≤ Vc < 5	5 ≤ Vc < 6	6 ≤ Vc < 7
L < 750	18.4	19.8	21.5	25.7	29.2
750 ≤ L < 1000	23.7	26.6	27.5	33.4	39.4
1000 ≤ L < 1350	31.5	34.3	38.7	44.6	51.5
1350 ≤ L < 1600	37.7	42.1	44.6	53.2	61.8
1600 ≤ L < 2000	45.5	51.5	55.8	64.3	75.4
2000 ≤ L < 3000	67.7	77.1	81.5	98.6	113.1
3000 ≤ L < 4000	89.2	102.9	111.4	128.6	150.1
4000 ≤ L < 5000	111.4	128.6	137.2	162.9	188.7

Rated Load L (kg)	7 ≤ Vc < 8	8 ≤ Vc < 9	Vc ≥ 9
L < 750	33.4	38.7	$4.190Vc + 0.0012Vc^3$
750 ≤ L < 1000	44.6	51.5	$5.588Vc + 0.0018Vc^3$
1000 ≤ L < 1350	60.0	68.6	$7.542Vc + 0.0018Vc^3$
1350 ≤ L < 1600	71.3	81.5	$8.939Vc + 0.0023Vc^3$
1600 ≤ L < 2000	90.1	102.9	$11.174Vc + 0.0012Vc^3$
2000 ≤ L < 3000	132.9	150.1	$16.761Vc + 0.0026Vc^3$
3000 ≤ L < 4000	175.8	201.5	$22.348Vc + 0.0032Vc^3$
4000 ≤ L < 5000	218.7	248.6	$27.935Vc + 0.0042Vc^3$

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

(applicable to major retrofitting works in an existing building)

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	6.4	9.0	10.8	14.4	16.2
750 ≤ L < 1000	9.0	10.8	15.4	19.0	21.7
1000 ≤ L < 1350	10.8	15.4	19.9	24.4	28.9
1350 ≤ L < 1600	13.6	18.1	24.4	28.9	34.3
1600 ≤ L < 2000	15.4	22.6	28.9	35.3	41.5
2000 ≤ L < 3000	22.6	33.5	42.5	53.3	63.2
3000 ≤ L < 4000	29.8	43.3	56.9	70.4	83.0
4000 ≤ L < 5000	37.9	54.2	70.4	87.6	103.8
L ≥ 5000	0.0075L + 0.451	0.0106L + 0.903	0.0141L + 0.456	0.017L + 1.805	0.0206L+ 0.451
Rated Load L (kg)	3 ≤ Vc < 3.5	3.5 ≤ Vc < 4	4 ≤ Vc < 5	5 ≤ Vc < 6	6 ≤ Vc < 7
L < 750	19.0	20.8	22.6	27.1	30.7
750 ≤ L < 1000	24.4	28.0	28.9	35.3	41.5
1000 ≤ L < 1350	32.5	36.1	40.7	46.9	54.2
1350 ≤ L < 1600	38.9	44.3	46.9	56.0	65.0
1600 ≤ L < 2000	47.9	54.2	58.7	67.7	79.4
2000 ≤ L < 3000	71.3	81.2	85.8	103.8	119.1
3000 ≤ L < 4000	93.9	108.3	117.3	135.4	158.0
4000 ≤ L < 5000	117.3	135.4	144.4	171.5	198.6
Rated Load L (kg)	7 ≤ Vc < 8	8 ≤ Vc < 9	Vc ≥ 9		
L < 750	35.3	40.7	$4.411Vc + 0.0012Vc^3$		
750 ≤ L < 1000	46.9	54.2	$5.882Vc + 0.0019 Vc^3$		
1000 ≤ L < 1350	63.2	72.2	$7.939Vc + 0.0019Vc^3$		
1350 ≤ L < 1600	75.0	85.8	$9.410Vc + 0.0024 Vc^3$		
1600 ≤ L < 2000	94.8	108.3	$11.762Vc + 0.0012Vc^3$		
2000 ≤ L < 3000	140.0	158.0	$17.643Vc + 0.0028Vc^3$		
3000 ≤ L < 4000	185.1	212.1	$23.524Vc + 0.0034Vc^3$		
4000 ≤ L < 5000	230.2	261.7	$29.405Vc + 0.0044Vc^3$		

8.4.2 Hydraulic Lift

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

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

Rated Load L (kg)	Power (kW)
L < 1000 kg	25.3
1000 kg ≤ L < 2000 kg	47.9
2000 kg ≤ L < 3000 kg	67.7
3000 kg ≤ L < 4000 kg	87.6
4000 kg ≤ L < 5000 kg	109.3
L ≥ 5000 kg	0.022L

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.

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	1257	1444	1816	Not Applicable		
	3.5 ≤ R < 5	1490	1769	2188			
	5 ≤ R < 6.5	1723	2095	2561			
	R ≥ 6.5	205R + 423	242R + 519	296R + 639			
800	R < 3.5	1397	1583	1909	1955	2328	2886
	3.5 ≤ R < 5	1676	1955	2375	2328	2793	3445
	5 ≤ R < 6.5	1955	2328	2840	2700	3212	4003
	6.5 ≤ R < 8	2281	2700	3306	3072	3631	4516
	R ≥ 8	225.4R + 576	248.5R + 680	306.3R + 836	285.8R + 779	340.7R + 933	424.3R + 1159
1000	R < 3.5	1490	1769	2141	2095	2468	3072
	3.5 ≤ R < 5	1862	2141	2654	2468	3165	3631
	5 ≤ R < 6.5	2170	2607	3165	2840	3399	4190
	6.5 ≤ R < 8	2561	2979	3678	3212	3817	4795
	R ≥ 8	262.6R + 640	342.6R + 756	339.8R + 977	299.5R + 820	339.8R + 1087	447.8R + 1226

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	3746	4044	4241
	5 < R ≤ 6.5	4651	4973	5186
	6.5 < R ≤ 10	6893	7305	7587
	10 < R ≤ 13	8814	9312	9643
	13 < R ≤ 16	10647	11197	11565
	16 < R ≤ 17.5	11561	12140	12524
	17.5 < R ≤ 20	13088	13711	14137
	R > 20	610.4R + 878	628.5R + 1142	640.9R + 1318

Remarks:

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

- designed to 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)	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	1071	1350	1769	2095	1257	1630	1862	2188
	8 ≤ L < 12	1537	1955	2560	3026	1537	1955	2560	3026
	12 ≤ L < 16	2002	2561	3259	4003	2002	2561	3259	4003
	16 ≤ L < 20	2468	3631	4096	4934	2468	3631	4096	4934
	L ≥ 20	118.2L + 94	173.2L + 138	196.4L + 157	235.5L + 188	118.2L + 94	173.2L + 138	196.4L + 157	235.5L + 188
1000	L < 8	1210	1537	1769	2095	1350	1723	1955	2281
	8 ≤ L < 12	1955	2514	2840	3399	1955	2514	2840	3399
	12 ≤ L < 16	2607	3306	3724	4469	2607	3306	3724	4469
	16 ≤ L < 20	3212	4096	4609	5540	3212	4096	4609	5540
	L ≥ 20	152.7L + 122	194.5L + 156	220.5L + 176	265.3L + 212	152.7L + 122	194.5L + 156	220.5L + 176	265.3L + 212
1400 & above	L < 8	1513	1921	2211	2620	1689	2154	2444	2852
	8 ≤ L < 12	2444	3142	3551	4248	2444	3142	3551	4248
	12 ≤ L < 16	3259	4132	4655	5586	3259	4132	4655	5586
	16 ≤ L < 20	4016	5121	5761	6925	4016	5121	5761	6925
	L ≥ 20	191L + 152	243L + 195	275L + 221	331L + 265	191L + 152	243L + 195	275L + 221	331L + 265

Remarks:
The maximum allowable electrical power for a passenger conveyor with Nominal Width above 1000 mm and below 1400 mm is given by interpolation of the control value for equipment at Nominal Width 1000 mm and the control value for equipment at Nominal Width 1400 mm.

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 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 either-

(a) the isolator connecting the escalator or passenger conveyor to the building's electrical supply circuit; or
(b) the circuit protective device serving the escalator or the passenger conveyor

should not be less than 0.85 when the motor drive is operating under its brake load condition at rated speed, with the steps or pallets moving in an upward direction for escalator or conveyor with a rise.

8.5.1.3 In fulfilling clauses 8.5.1.1 or 8.5.1.2, a 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.

8.5.1.4 As part of the compliance demonstration, the total apparent power S through the evaluation of the phase voltages of a three-phase three-wire system and hence the total power factor should also be computed in accordance with the procedures given in Appendix B of this BEC.

8.5.2 Lift Decoration Load

The decoration load in a lift should not exceed the corresponding maximum allowable value given in Table 8.5.2.

Table 8.5.2 : Maximum Lift Decoration Load	
Lift Rated Load L (kg)	Allowable Decoration Load D (kg)
L < 1800	D = 0.45 x L, or 490 whichever is smaller
L ≥ 1800	D = 0.3080 x L – 0.00002110 x L^2, or 1015 whichever is smaller

8.5.3 Lift Parking Mode

8.5.3.1 Under normal operating status, at least one lift 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 should not respond to passenger calls until it returns to the normal operation mode.

8.5.4 Lift Ventilation and Air-conditioning

8.5.4.1 Except for observation lift with itself travelling through or its lift well located in unconditioned space, the ventilation of a lift car after idling for 2 minutes should be shut off automatically until the lift is activated again by passenger call.

8.5.4.2 Except for observation lift with itself travelling through or its lift well located in unconditioned space, the air-conditioning of a lift car after idling for 10 minutes should

- be shut off automatically until the lift is activated again by passenger call, and
- resume operation no earlier than 5 minutes after the shut-off.

8.5.4.3 Power consumption of lift car ventilation fan at design air flow condition should not exceed 0.7 W per litre per second (L/s).

8.5.5 Lift Regenerative Braking

Regenerative braking should be provided for each of a lift -

(a) with rated speed of 2.5 m/s or above, and

(b) rated load at 1000 kg or above.

The power from the regenerative braking should be fed towards the incoming source of the driving controller.

8.5.6 Lift Car Lighting

(a) The lighting power density of lift car should not exceed the maximum allowable value given in Table 5.4 of this BEC unless the total electrical power consumed by the complete fixed lighting installation of the lift car does not exceed 70W.

(b) The requirement given in clause 5.5.1 about lighting control point should not be applicable to the lighting installation of the lift car.

(c) The exception on automatic lighting control as given in clause 5.6.1.1 should not be applicable to the lighting installation of the lift car.

(d) After idling for 10 minutes, the lift car lighting should reduce to 50% or less of the total lighting power consumption automatically.

8.5.7 Automatic Speed Reduction of Escalator

Switching provision should be made for each escalator to operate under automatic speed reduction mode when the traffic demand is low. Further consideration in respect of safety, operation and riding quality should be conducted when deploying automatic stop at low traffic demand period.

8.6 Total Harmonic Distortion

8.6.1 When a lift is moving up with rated load at its rated speed, the total harmonic distortion produced by the motor drive 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 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 at either-

(a) the isolator connecting the escalator or passenger conveyor to the building's electrical supply circuit; or
(b) the circuit protective device serving the escalator or the passenger conveyor

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 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 In fulfilling clauses 8.6.1 or 8.6.2, a harmonic correction 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 should be provided for the electrical supply circuit for the motor drive of each lift, escalator or passenger conveyor, for measurement of voltages (all phase-to-phase and phase-to-neutral), currents (three phases and neutral), total power factor, total harmonic distortion, energy consumption (kWh), power (kW) and maximum demand (kVA).

8.7.2 In fulfilling clause 8.7.1, a metering device or a set of metering device should be provided for each lift, escalator or passenger conveyor. In respect of total harmonic distortion measurement, the metering device should be capable of measuring at least up to 31^{st} harmonic order.

8.7.3 The measurement parameters stated in clause 8.7.1 should be trended every 15 minutes and include hourly, daily, monthly, and annual data. The monitoring facilities should be capable of maintaining all data collected for a minimum of 36 months.

9. Performance-based Approach

9.1 Scope of Application

9.1.1 The requirements in this Section should be complied with 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.

9.1.2 For the avoidance of doubt, the following clauses in Sections 5 to 8 should also be applicable to the performance-based approach, in addition to the requirements specified in clauses 9.2 to 9.5 of this Section –

- clauses 5.1 to 5.3, clauses 6.1 to 6.3, clauses 7.1 to 7.3 and clauses 8.1 to 8.3.

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 requirements given in Table 9.4 should be the trade-off allowable.

Table 9.4 : Trade-off for Performance-based Approach
Energy efficiency requirements on building services installations: Lighting installations, given in Section 5 of this BEC (clause no.) Lighting power density (5.4) Automatic lighting control (5.6) Air-conditioning installations, given in Section 6 of this BEC (clause no.) Air distribution system fan power (6.7) Pumping system variable flow (6.8) Frictional loss of water piping system (6.9) System control (6.10) Air-conditioning equipment efficiency (6.12) Electrical installations, given in Section 7 of this BEC (clause no.) Power distribution loss (7.4) Motor installation (7.5) Power quality (7.6) Lift and 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)
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 performance of the trade-off should not exceed 15% lower than the corresponding prescriptive requirement given in Section 5 to 8 of this BEC.

9.4.3 For the trade-off on lighting power density and air distribution system fan power, the energy efficiency performance should not exceed 20% lower than the corresponding prescriptive requirement given in Section 5 and 6 of this BEC.

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 A, and

(b) governed by all the energy efficiency requirements given in Sections 5 to 8 of this BEC.

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 A of this BEC.

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) an energy efficient feature to improve the energy performance in lighting, air-conditioning, electrical and lift and escalator installations, and/or

(c) a better OTTV resulting in energy reduction counted towards the trade-off , and/or

(d) having recovered energy or renewable energy captured or generated on site

9.5.4.2 Clause 9.5.4.1 (c) should not be applicable to buildings not governed by the Building (Energy Efficiency) Regulation (Cap. 123M).

9.5.4.3 The items or installations involved in the trade-off process should be under the same ownership except for building with the cooling source from a remote plant or a service provider of district cooling system.

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.

9.5.4.5 Trade-off should not be applicable to an item which has not been installed.

9.5.4.6 The equipment or system of energy recovery captured or renewable energy generated on site should be equipped with metering and monitoring facilities such that the performance of such equipment or system can be measured and verified.

(a) For such equipment or system generating electric energy, it should be equipped with metering devices for measuring voltages (all phase-to-phase and phase-to-neutral), currents (three phases and neutral), total power factor, total energy consumption (kWh), maximum demand (kVA) and total harmonic distortion.

(b) For such equipment or system recovering or generating thermal energy, it should be equipped with measuring and monitoring facilities to measure its power (kW) input, energy (kWh) input, cooling/heating power (kW) output and cooling/heating energy (kWh) output.

(c) The measurement parameters should be trended every 15 minutes and include hourly, daily, monthly and annual data. The measuring and monitoring facilities should be capable of maintaining all data collected for a minimum of 36 months.

10. Energy Efficiency Requirements for Major Retrofitting Works

10.1 Scope of Application

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

10.1.2 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 10.1.

Table 10.1

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 replacement luminaires at or exceeding 3kW	no existing luminaires in the area, or the sum of circuit wattage of additional or replacement luminaires is 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 point	5.5
			automatic lighting control	5.6

Table 10.1
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) ,VRF system(s), heat pumps(s) and/or chiller(s)	total cooling/heating capacity of the additional or replacement air handling unit(s), unitary air-conditioner(s), VRF system(s), heat pump(s) and/or chiller(s) at or exceeding 60kW	involving addition or replacement of unitary air-conditioner, VRF system, heat pump, cooling tower and/or chiller	air- conditioning equipment efficiency	6.12
		the additional or replacement 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
			direct digital control	6.14
		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 addition or replacement of pipework, ductwork or AHU	thermal insulation	6.11
		the work involving addition or replacement of water pump with new motor, of AHU with new motor, or of 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 drive lift with machine above and with 1:1 or 2:1 suspension roping system, a hydraulic lift, an escalator or a passenger conveyor		electrical power	8.4
	the work involving a traction drive lift, a hydraulic lift, an escalator or a passenger conveyor		total power factor	8.5.1
			total harmonic distortion	8.6
			metering & monitoring facilities	8.7
			automatic speed reduction of escalator (except public service escalator and heavy duty escalator)	8.5.7
	the work involving addition of a lift or replacement of a lift car		lift decoration load	8.5.2
			lift ventilation & air conditioning	8.5.4

Table 10.1
Major Retrofitting Works and Energy Efficiency Requirements

Category of Major Retrofitting Work	Condition for Applicability of BEC Requirement	Applicable BEC Requirement	BEC Clause No.
		lighting power density	5.4
		automatic lighting control	8.5.6

Table 10.1
Major Retrofitting Works and Energy Efficiency Requirements

<table>
<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">power distribution loss</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-circuit</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-circuit 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-circuit, 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 of 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), of unitary air-conditioner(s), VRF system(s), of heat pump(s) and/or of chiller(s), with a total cooling/heating capacity at or exceeding 60kW</td><td colspan="2">requirements as for (a) (ii)</td></tr>
</table>

Table 10.1

Major Retrofitting Works and Energy Efficiency Requirements

<table>
<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="9">(ii) addition or replacement of a unitary air-conditioner or a chiller of a cooling rating or a heat pump of heating rating at or exceeding 350kW</td><td colspan="2">applicable in any conditions;
the work involving addition or replacement of cooling tower(s)</td><td>air- conditioning equipment efficiency</td><td>6.12</td></tr>
<tr><td colspan="2" rowspan="3">the addition or replacement of air-conditioning equipment involving addition or complete replacement of the 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>direct digital control</td><td>6.14</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 addition or replacement of pipework, ductwork or AHU</td><td>thermal insulation</td><td>6.11</td></tr>
<tr><td colspan="2">the work involving addition or replacement of water pump with new motor, of AHU with new motor, or of 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, chiller or heat pump at or exceeding 350 kW</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), of unitary air-conditioner(s), of VRF system(s), of heat pump(s) and/or of chiller(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="4">(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 traction drive 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>electrical power</td><td>8.4</td></tr>
<tr><td colspan="2" rowspan="3">the work involving a traction drive lift, a hydraulic lift, an escalator or a passenger conveyor</td><td>total power factor</td><td>8.5.1</td></tr>
<tr><td>total harmonic distortion</td><td>8.6</td></tr>
<tr><td>metering & monitoring facilities</td><td>8.7</td></tr>
</table>

Table 10.1
Major Retrofitting Works and Energy Efficiency Requirements

Category of Major Retrofitting Work	Condition for Applicability of BEC Requirement	Applicable BEC Requirement	BEC Clause No.
		automatic speed reduction of escalator (except public service escalator or heavy duty escalator)	8.5.7
	the work involving addition of a lift or replacement of a lift car	lift decoration load	8.5.2
		lift ventilation & air-conditioning	8.5.4
		lighting power density	5.4
		automatic lighting control	8.5.6

Remarks:

1. Save for the addition or replacement works described above, major retrofitting works should also include enhancement works for existing building services installation and all ratings involved refer to the ratings of the newly installed equipment.
2. Attention is drawn to the Notes in Schedule 3 of the Ordinance on identifying "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 item (a).

10.2 Performance-based Approach

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

10.2.2 In adopting the performance-based approach for major retrofitting works, the requirements in Section 9 and Appendix A of this BEC should be satisfied.

Appendix A

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

A1 Introduction

A1.1 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.

A1.2 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.

A1.3 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.

A1.4 Portion of a building
For major retrofitting works involving not an entire building but only a portion of the building, the building energy analysis may not necessarily cover the entire building, but should nevertheless include the systems and components that have impacts in terms of energy consumption on the portion of the building, such as an air-conditioning system serving both the portion and its adjoining areas.

A2 Numerical Method for Building Energy Analysis

A2.1 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.

A2.2 The use of a computer-based hour-by-hour, full-year, multiple-zone numerical analysis for modelling and simulating the design energy and energy budget is required. The simulation program should be capable of modelling :

- effects of thermal mass;
- hourly variations in occupancy, lighting power, air-conditioning system operation including thermostat setpoints, and miscellaneous equipment power, defined separately for each day of a week and each holiday;
- 10 or more thermal zones; and
- air-conditioning equipment part load performances.

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; whenever a simpler tool is used, essential information about its modeling capability, calculation techniques & procedures, and validation results including sensitivity analyses should be available for submission to the Director for approval.

A2.3 The simulation program should use scientifically justifiable techniques and procedures for modelling building loads, systems, and equipment. It should be capable of modeling and simulating the thermal behavior of a building and the interaction of its building fabric, air-conditioning, lighting and other relevant energy consuming equipment and systems.

A2.4 The simulation program should have the ability to either directly determine the design energy and energy budget, or produce simulation reports of energy use for determining the design energy and energy budget using a separate calculation engine.

A2.5 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.

A2.6 When a simulation program is used to verify compliance with this BEC via the performance-based approach in Section 9 of this BEC, the program should meet the requirements of ASHRAE Standard 140 or its modelling capabilities should be provided to the Director, and its calculation techniques and validation results should also be provided upon request by the Director for evaluation and approval.

A2.7 The simulation program should be able to deliver the following printouts, for both designed building and reference building –

(a) breakdown of energy consumption for lighting installation, space cooling and heat rejection equipment, space heating (if provided), fans of AHUs and ventilation fans, pumps for air-conditioning, service water heating equipment, catering, lift and escalator, miscellaneous equipment/appliance loads (e.g. office equipment, server etc); and

(b) monthly building energy consumption profile.

A3 Evaluation of Building Energy Performance

A3.1 General Requirements

A3.1.1 **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.

A3.1.2 **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.

A3.1.3 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.

A3.1.4 Occupant-sensitive Features. Occupant behaviour, unless otherwise specified in this Appendix, 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 should be excluded from the design energy calculation.

A3.1.5 Renewable Energy and recovered energy. Useful energy generated from renewable energy sources or recovered energy sources can be considered in the evaluation of building energy performance, provided that the sources are reliable and the energy generation can be estimated mathematically. 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. 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.

A3.1.6 Professional Judgement. Although certain modelling techniques and compliance assumptions applied to the building design are fixed or restricted, there are other aspects of computer modelling for which professional judgement is necessary. The professional judgement for these aspects should be duly exercised. The Director may accept or not accept a particular modeling input, and may require the submission of substantiations with supporting evidence and documentation.

A3.1.7 Exclusion or exemption. The energy calculation should include all energy uses in the building as far as practicable, rather than just the central plant and equipment. Consumptions/loadings for installations excluded or exempted from the compliance of the Ordinance, such as fire services, and essential health and safety-related installations, could be excluded in the energy calculation, unless these installations contribute to a trade-off of design energy or are put in continuous run under normal operation which have significant energy consumption.

A3.2 Determination of Design Energy for the Designed Building

A3.2.1 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 areas, lighting power and controls, air-conditioning system types, sizes, and controls, and so on. The major building systems including building envelope, lighting installation, air-conditioning installation, ventilating fans, pumps, service water heating equipment, catering, lift and escalator, miscellaneous equipment/appliance loads (e.g. office equipment, server etc); must be included in the energy calculation. Except for items for off-setting of design energy, other building systems' energy consumption should be taken as the same in both designed and reference buildings.

A3.2.2 System Capacities and Data. When air-conditioning, lighting and other 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 professional judgement and all of them should be documented for verification whenever required.

A3.2.3 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 applicable to the building project. All the assumptions should be based on professional judgement and documented for verification whenever required.

A3.2.4 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.

A3.2.5 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;
(d) the lighting schedules in the designed building should reflect the compliance with the automatic lighting control requirements in section 5.6 of this BEC;
(e) automatic lighting control included in the designed building but not required in section 5.6 of this BEC should be modeled in the simulation.

A3.2.6 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;

(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.

A3.2.7 Lift and Escalator. Lift and escalator system power should be determined according to CIBSE Guide D and be included in the energy analysis based on the exceptional calculation methods as shown in clause A3.4.

A3.2.8 Other Systems. Other building systems may be modelled using exceptional calculation methods (clause A3.4 below). If they are modelled, performance should be as indicated on design documents.

A3.2.9 Energy Budget for Designed building. Comparing the design energy of designed building against the energy budget should provide an indication of the likely range of energy use, allow better understanding where and how energy is likely to be used in the building and enable analysis of which measures have the greatest impact on energy use.

A3.2.10 Alterations and Additions. For a design relating to 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 in the excluded parts of the building 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.

A3.2.11 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:
(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. The Director may accept or not accept the method, and may require the submission of substantiations in support of the method's validity.

A3.3 Determination of Energy Budget for the Reference Building

A3.3.1 Simulation Model. The simulation model of the reference building should be developed by modifying the model of the designed building as described in clause A3.2. Except as specifically instructed in this Appendix, all building systems and equipment should be modelled identically for both the reference building and designed building.

A3.3.2 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) shading projections may be excluded from the modeling unless the projections have to be in place for compliance with OTTV requirements; the fenestration of an excluded shading projection should be assumed to be flush with the exterior wall or roof; and
(d) for building not governed by the OTTV requirements, the dimensions of windows, doors and skylights should be same as the designed building.

A3.3.3 OTTV. To determine the envelope parameters for the reference building, the designer should adjust from the envelope model of the designed building its window-wall ratio and skylight-roof ratio, and the shading coefficients of its windows and skylights, so as to meet the OTTV requirements.

A3.3.4 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 of this BEC. Lighting control points should be the minimum required in Section 5 of this BEC. Automatic lighting control should be provided to each of the type of space in accordance with Table 5.4 of this BEC and the control arrangement (e.g. programmable controls or occupancy sensors) should be the same as the designed building. The lighting zone should be arranged to the minimum requirement in section 5.6 of this BEC while the operation schedule or profile should be modeled the same as the designed building.

A3.3.5 Air-conditioning. The air-conditioning systems, zoning and equipment types of the reference building should be identical to the designed building; but the system and equipment of the reference building should exactly meet the relevant requirements in Section 6 of this BEC.

A3.3.6 Lift and Escalator. The lift and escalator equipment types, operation profiles of the reference building should be identical to the designed building; but the system and equipment of the reference building should exactly meet the relevant requirements in Section 8 of this BEC.

A3.3.7 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.

A3.4 Exceptional Calculation Methods

A3.4.1 Where no simulation program is available to model the performance of a design, material, or device, an exceptional calculation method may be used to demonstrate compliance.

A3.4.2 For acceptance by the Director of an exceptional method, its theoretical and empirical information verifying the method's accuracy should be submitted to the Director, 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 the Director's review, and meeting the formatting and content required by the Director;
(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 simulation program.

A3.5 Modelling Assumptions and Methods

A3.5.1 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 designed building and reference building.

A3.5.2 Operation Parameters for Different Types of Space

(a) To systematically present the inputs to the simulation program, the designer should prepare a table summarizing the operation parameters and their corresponding assigned values to the program for all the different spaces in the building, common operation parameters being occupant density, minimum outdoor air, 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 of operation parameters is as shown in Table A3.5a below –

Table A3.5a – 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 (see item (b) below)	Lighting Power Density (W/m^2)	Equipment Power Density (W/m^2)	Service Water Heating Power (W/person)

≈	≈	≈	≈	≈	≈	≈

The values to be assigned to Table A3.5a should be the corresponding design values for the operation parameters. Equipment loads establishing the power densities in W/m^2 should include general service loads that are typical in a building, including additional process electrical usage, but excluding air-conditioning electrical usage.

(b) An operating schedule for each type of space should be prepared. The operating schedule should be a table summarizing for different times of a day the operation densities of occupants, equipment, lighting, AHU/fan, cooling, heating, hot water etc. A description of operation density is given in item (c) below. The operating schedule should reflect the profiles which establish the extent of operation, such as the percentage of the equipment load that is ON by hour of the day. An indicative table of operating schedule is as shown in Table A3.5b below –

Table A3.5b – Operating Schedule showing time profiles of Operation Densities for different Operation Parameters in a Building

Hour	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Occupant																								
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																								

(c) The following indicative Table A3.5c gives the range of values to be assigned as operation densities in Table A3.5b above.

Table A3.5c – Values for Operation Density

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

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

A3.5.3 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.

A3.5.4 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.

A3.5.5 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.

A3.5.6 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 should 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 Interior Shading. 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 OTTV requirements, 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.

A3.5.7 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, and 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 the 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 the 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 supply-air-to-room-air temperature 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 300 hours.

A3.5.8 Service Water Heating

(a) Loads. The same service water heating load assumptions estimated based on CIBSE Guide G 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.

A3.5.9 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 applicable 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.

Appendix B
Calculation of Total Power Factor of Three-Phase Three-Wire Power Supply System

B1 Introduction

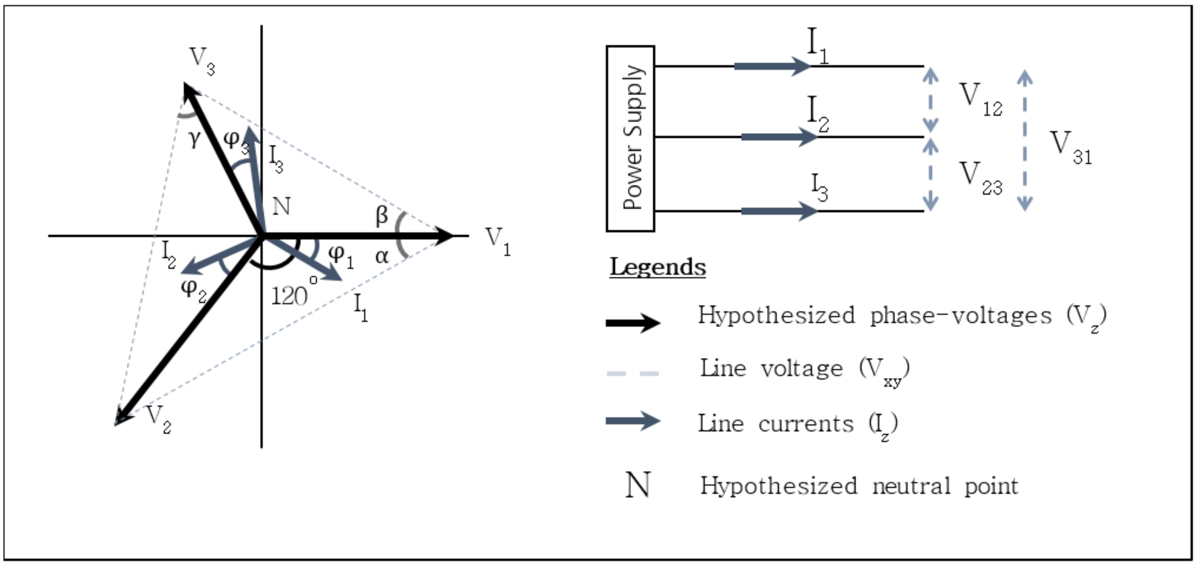
B1.1 This appendix serves as a description of calculation method for the apparent power (S) of three-phase three-wire electrical system without any neutral wire.

B1.2 The calculation of the total power factor of the motor drive of lift and escalator installation should base on calculation method and the data measured on-site. The purpose of the calculation is to develop a consistent evaluations of total power factor of a three-phase supply without a neutral wire.

B2 Calculation Method for Total Power Factor

B2.1 **Line voltages (V_{xy}) and Line currents (I_z).** V_{xy} refers to the line voltage between line x and line y. I_z refers to the line current of line z. Sub-scripts x, y, z = 1, 2, or 3 indicate the respective power lines. V_{xy} (i.e. the V_{12}, V_{23} & V_{31}) and I_z (i.e. the I_1, I_2 & I_3) are obtained by measurement on-site.

B2.2 **Hypothesized phase voltage (V_1, V_2 & V_3) and the neutral point (N).** From the three line voltages (V_{12}, V_{23} and V_{31}) measured, it is possible to determine the three hypothesized phase voltages V_1, V_2 and V_3 having the neutral point N being derived with the three phase voltages (V_1, V_2 & V_3) 120° apart from one another.



B2.3 The total power factor can be obtained by the equation B1. The active power (P) can be read from the metering devices based on two-wattmeter method.

$$\text{Total Power Factor} = \frac{\text{Active Power (P)}}{\text{Apparent Power (S)}} \quad \text{(B1)}$$

B2.4 The apparent power (S) can be obtained by equation B2.

$$S = |V_1||I_1| + |V_2||I_2| + |V_3||I_3| \quad \text{(B2)}$$

Where the hypothesized phase voltages V_1, V_2, V_3 are obtained by equation B3, B4 & B5.

$$|V_1| = |V_{31}| \frac{\sin(\frac{\pi}{3} - \beta)}{\sin(\frac{2\pi}{3})} \quad \text{(B3)}$$

$$|V_2| = |V_{12}| \frac{\sin(\alpha)}{\sin(\frac{2\pi}{3})} \quad \text{(B4)}$$

$$|V_3| = |V_{31}| \frac{\sin(\beta)}{\sin(\frac{2\pi}{3})} \quad \text{(B5)}$$

Denotes $\theta = \alpha + \beta$, then

$$\theta = \cos^{-1}\left[\frac{|V_{12}|^2 + |V_{31}|^2 - |V_{23}|^2}{2|V_{31}||V_{12}|}\right] \quad \text{(B6)}$$

$$\alpha = \tan^{-1}\left[\frac{\sin(\frac{\pi}{3}) - \frac{|V_{31}|}{|V_{12}|}\sin(\frac{\pi}{3} - \theta)}{\cos(\frac{\pi}{3}) + \frac{|V_{31}|}{|V_{12}|}\cos(\frac{\pi}{3} - \theta)}\right] \quad \text{(B7)}$$

$$\beta = \theta - \alpha \quad \text{(B8)}$$

B2.5 Throughout this Appendix, $|V_{xy}|$, $|V_z|$ and $|I_z|$ are the magnitudes of voltages and currents. The measurements on the line voltages (i.e. $|V_{xy}|$) and the line currents (i.e. $|I_z|$) should confine to the magnitudes. V_{xy}, V_z and I_z are all phasors.

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