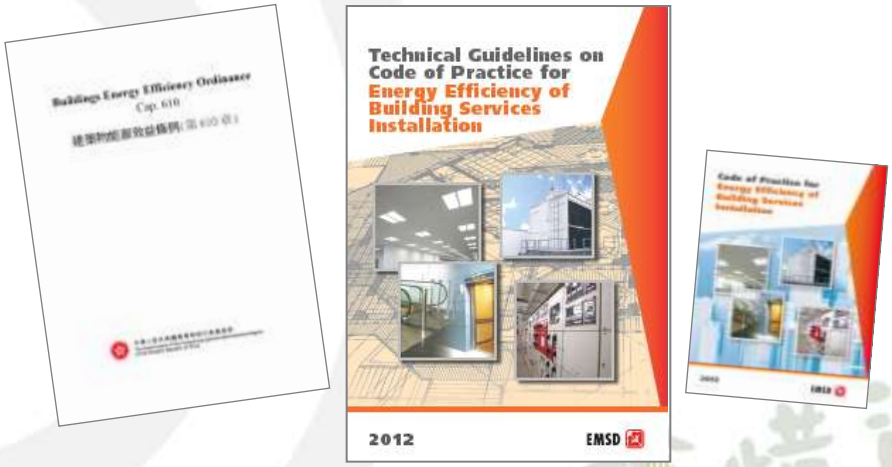
Technical Guidelines on Code of Practice for Energy Efficiency of Building Services Installation (TG-BEC)



Briefing Session for Registered Energy Assessors

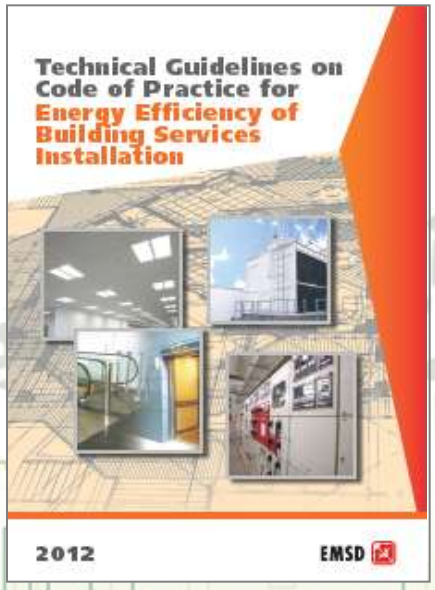
機電工程署 EMSD

Buildings Energy Efficiency Ordinance

- Buildings Energy Efficiency Ordinance (BEEO) fully implemented on 21 Sep 2012 - combat climate change

- Require 4 key types of building services installations (BSI) to comply with Code of Practice for Energy Efficiency of Building Services Installation (BEC) issued by EMSD in Feb 2012

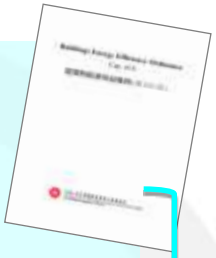
- **Technical Guidelines on Code of Practice for Energy Efficiency of Building Services Installation** (**TG-BEC or TG**) issued by EMSD on 3 Sep 2013 – explains BEEO & BEC contents
- Good Practice – to exceed min requirements in BEC



機電工程署 EMSD

TG Contents

- 10 sections

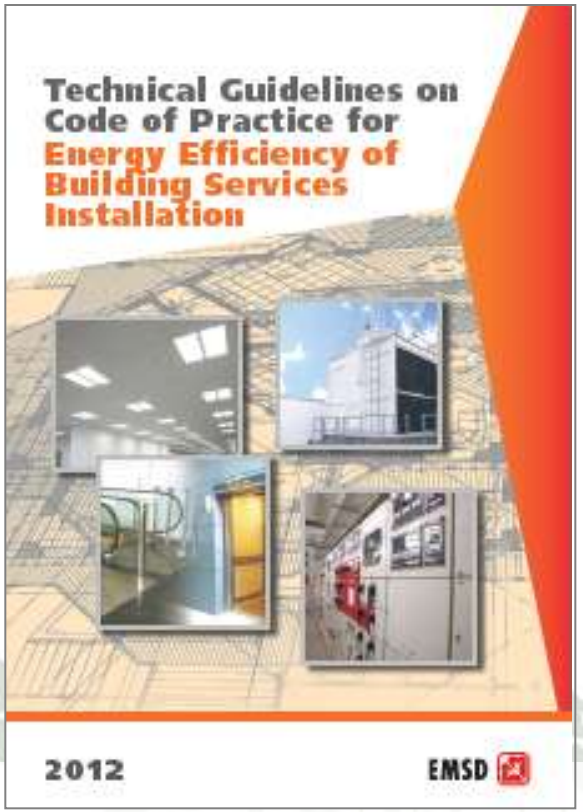


1 - Introduction
2 - Interpretations & Abbreviations
3 - Application
4 - Technical Compliance with BEEO

Overview & explanation of BEEO compliance process

5 - Lighting
6 - Air-conditioning
7 - Electrical
8 - Lift & Escalator
9 - Performance-based Approach
10 - Major Retrofitting Works (MRW)

Explanations of BEC's technical requirements with examples



TG – Compliance Process

Prescribed Buildings and Exemptions

BEEO & BEC governs (BEEO Sch 1)

Prescribed buildings

- Hotel & guesthouse
- Educational building
- Community building
- Municipal services
- Hospital & clinic
- Government building
- Airport passenger building
- Railway station
- Commercial building
- Industrial building **common area**
- Residential building **common area**
- Composite building
  - commercial portion
  - **common area** of portion for residential or industrial use

BEEO does not govern (BEEO sec 4 & Sch 2)

- Small building (3-storey each $\leqq$ 65 m^2)

- Building with approved electrical load $\leqq$100A

- Historical or Monument building

- Building to be demolished in 12 months

- BS installations, with specific operational & technical natures such as fire protection, life safety, industrial undertaking etc.

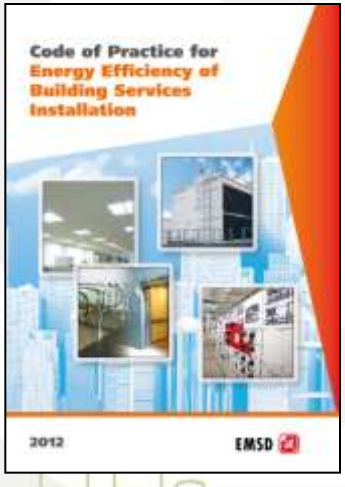
TG – Compliance Process

"**NEWLY CONSTRUCTED**" building –

Having obtained the consent to the commencement of building works for superstructure construction from Building Authority after BEEO comes into full operation i.e. after **21 Sep 2012**

"**EXISTING**" building –

Having obtained the consent on or before **21 Sep 2012**



NEWLY CONSTRUCTED BUILDINGS

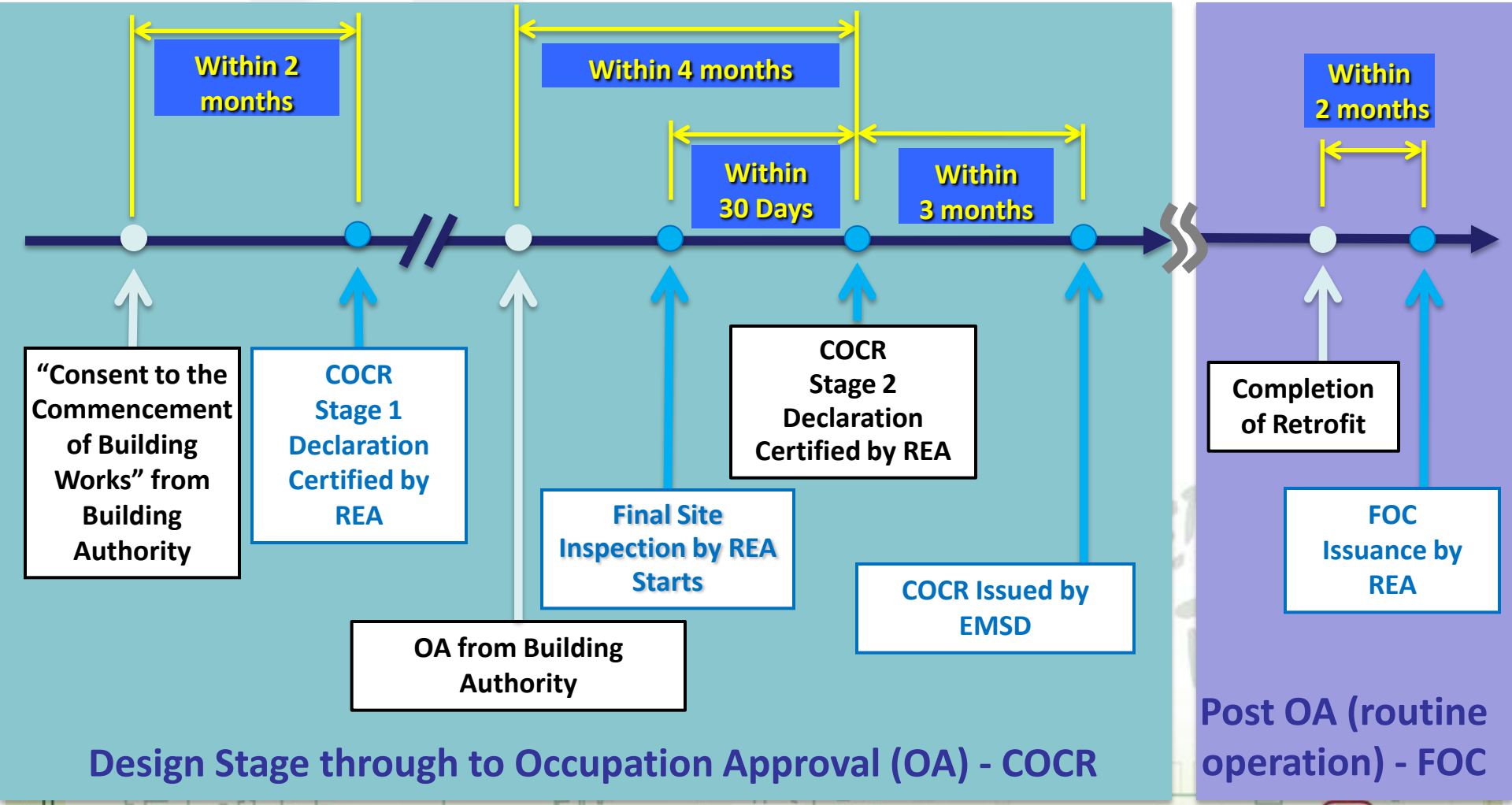
- Building owner to engage a Registered Energy Assessor (REA) to certify BEC compliance
- Building owner to obtain a **Certificate of Compliance Registration (COCR)** from EMSD

Major retrofitting works in units or common areas in both **NEWLY CONSTRUCTED** & **EXISTING** buildings

- Building owner / Responsible person to engage a REA to certify BEC compliance
- Obtain **Form of Compliance (FOC)** from the REA

TG – Compliance Process

Timeline for Newly Constructed Buildings



機電工程署 EMSD

TG – Compliance Process

CBSI & Non-CBSI

Building type	Common area or unit served by concerned BSI	Ownership of BSI	CBSI or non-CBSI	Justification based on BEEO interpretation
Building with common area (i.e. with deed of mutual covenant or DMC)	Entrance lobby, common corridor, staircase etc. (i.e. the common area interpreted in BEEO)	Building owner	CBSI	BSI not solely serving a unit
	Building owner occupied unit	Building owner	Non-CBSI	BSI solely serving a unit
	Occupier owned unit	Building owner		
		Unit occupier		
	Leased unit	Building owner		
		Unit lessee		
Building without common area (without DMC)	Entrance lobby, common corridor, common staircase etc.	Building owner	CBSI	BSI owned by the building owner (and not solely serving a unit)
	Building owner occupied unit	Building owner	CBSI	BSI owned by the building owner
	Leased unit			
	Leased unit	Unit lessee	Non-CBSI	BSI solely serving a unit and owned by a person who is not the building owner

TG – Compliance Process

Major Retrofitting Works (MRW) (BEEO Sch 3)

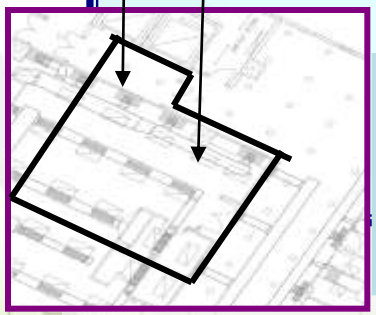
500 m² Works Area

Addition/replacement of BSI

conducted at one or more places in **a unit** or **a common area**

a total floor area covered by the works under the **same series of works** within **12 months**

≥ 500 m²



OR

CBSI Main Component

Central Building Services Installation (CBSI) – e.g. serving common area, central chilled water plant *(see later slide)*

Addition/replacement of CBSI **main component** –

a complete electrical circuit at rating **≥ 400A**

or

a chiller or **a unitary air-conditioner** at rating **≥ 350kW** capacity (cooling or heating)

or

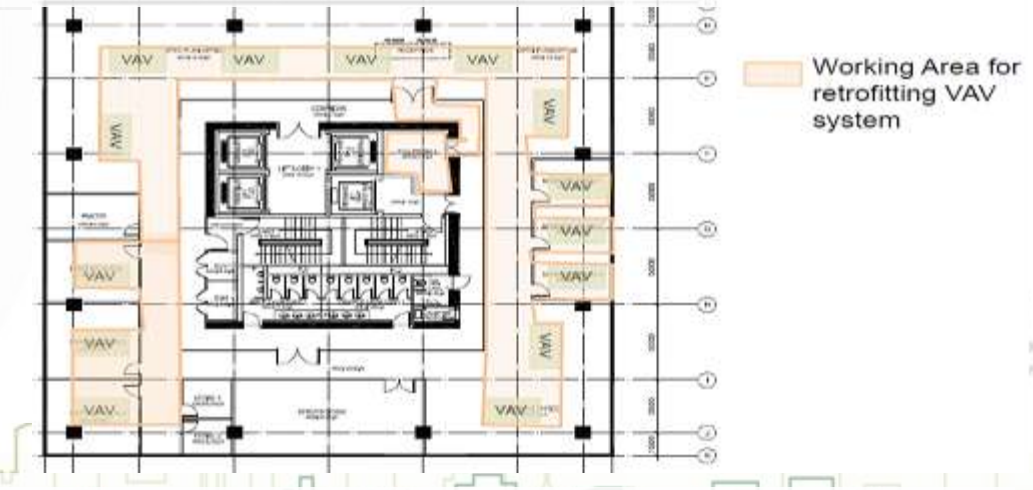
motor drive + mechanical drive of a lift, escalator or passenger conveyor

TG – Compliance Process

MRW (Cont'd)

- Completion of MRW (e.g. cert of completion) – when all involved BSIs are ready to be used for their principal function as designed (BEEO sec 17(3))
- Application threshold is the rating at works completion (BEEO sec 5)

  e.g. Replacement of CBSI 360kW chiller with one at **340kW** - **NOT MRW**
- The common area (corridor, lift lobby, staircase etc.) of a building, the building's occupants' clubhouse and the building's car park – each has its 500 m^2 MRW threshold (BEEO Sch3 notes)
- Works area –
  - internal floor area measured to the internal faces of enclosing external and/or party walls
  - may include areas NOT served by the concerned BSI e.g. duct route area, wiring route area etc.

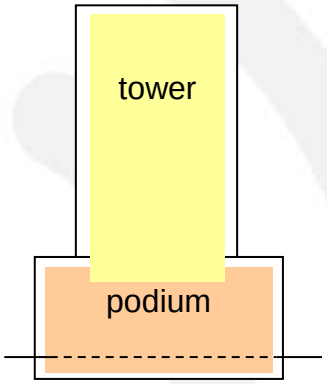


- Good Practice – compliance with BEC for non-MRW in existing buildings

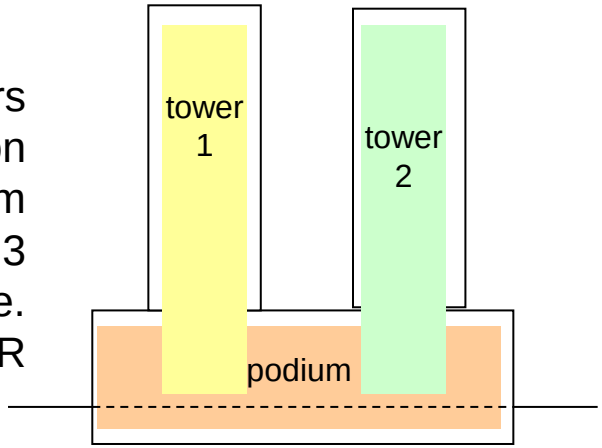
TG – Compliance Process

Building Blocks Concept (COCR preferable)

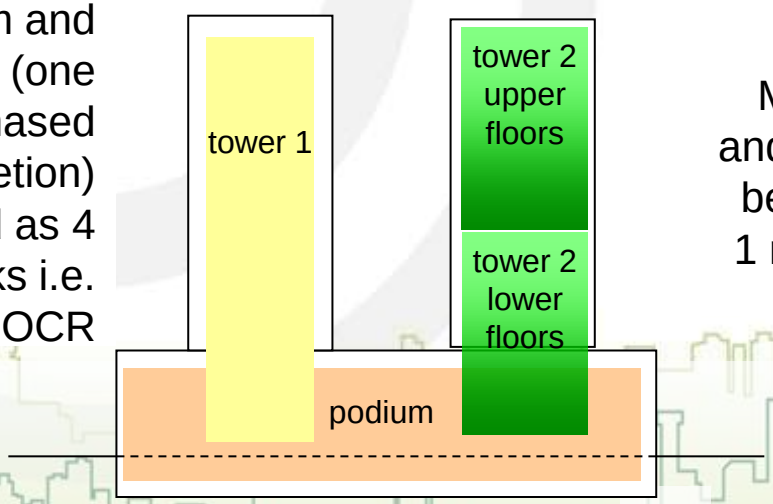
Podium and tower counted as 1 no. block i.e. 1 COCR



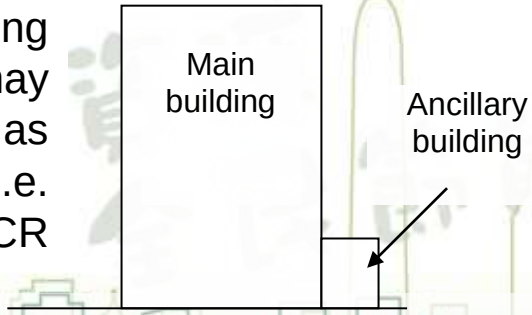
Two towers with common podium counted as 3 nos. blocks i.e. 3 nos. COCR



Podium and two towers (one with phased completion) counted as 4 nos. blocks i.e. 4 nos. COCR



Main building and annex may be counted as 1 no. block i.e. 1 no. COCR



TG – Compliance Process

Maintaining of Design Standard

- BEC performance standard (e.g. chiller COP) refers to the condition as at design

  BEC specified condition ≠ fluctuating operating condition

- Maintaining of design standard = Maintaining of standard of applicable BEC version (BEEO s12(3), 12(4) & 18(2))

  e.g.

	BEC Ver at Stage 1 Declaration	Current BEC Ver	MRW in 2015 and onward	Non-MRW in 2015 and onward
Building with COCR issued in 2013	BEC 2012	BEC 2012 Rev.1	Follow current BEC version, i.e. BEC 2012 Rev.1	Follow BEC version at Stage 1 Declaration, i.e. BEC 2012

- Repairs & retrofits - not to change BEC compliance to non-compliance

  e.g. replacing with a lower efficiency motor

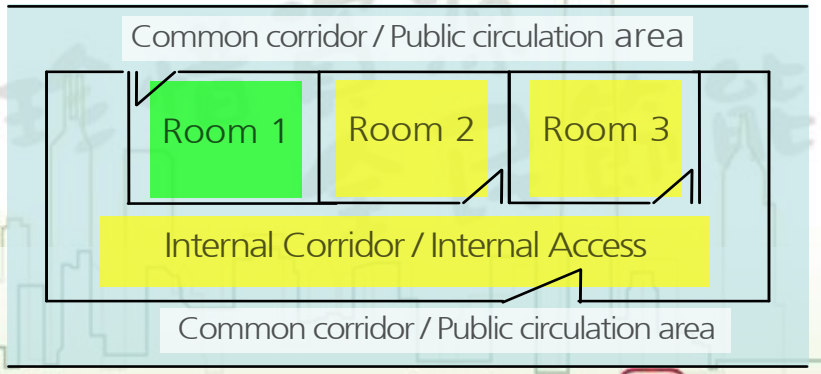
- Good Practice – always follow latest BEC version

TG – Compliance Process

Other Explanations/Remarks

- Prescribed building identification –
  - OA (occupation permit) usage categorization
  - instrument or land record maintained with the Land Registry or Lands Department (in the form of land register, memorial, government lease, conditions of grant/sale/exchange etc.)
- BEEO not applicable to fire services installation, security system, broadcast reception etc.
- Change of use of a space may trigger BEC non-compliance

  e.g. Office (LPD 15 W/m^2) → Store room (LPD 11 W/m^2)
- A unit may consist of multiple rooms
- Specified forms and technical forms



TG – Requirements on Lighting

BEC Non-applicable Installations (examples)

External building facade

Signage

Non-maintained

Signage (advertisement)

Display

Decoration

Stage

Festival

Non fixed type

TG – Requirements on Lighting

BEC Non-applicable Installations (examples)

Research
(illuminating testing in fume cupboard)

Surgical

Plant growth

Luminaires for sale in a shop

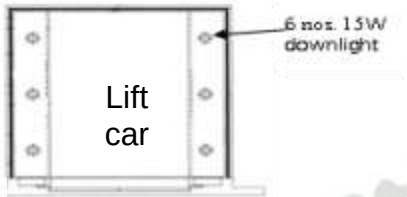
Lighting Power Density (LPD)

- Lighting serving both decoration and as general lighting – LPD requirement applicable

TG – Requirements on Lighting

Lighting Power Density (LPD) (Cont'd)

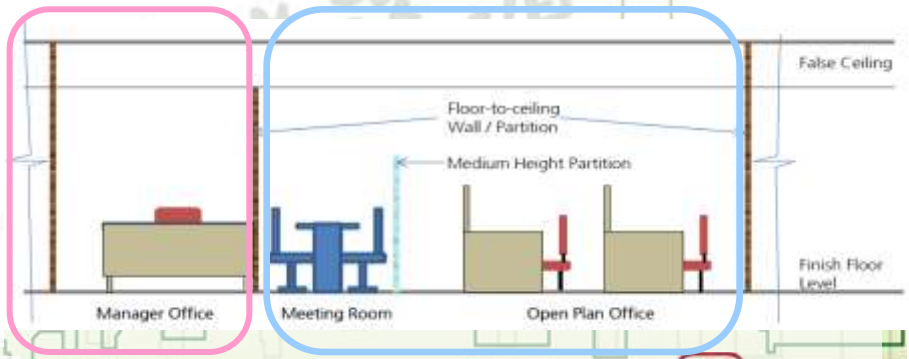
- LPD design approach
  - Internal floor area – measuring from the internal surfaces of enclosing walls and include thickness of columns and party walls
  - To classify a space as a type of space in BEC Table 5.4
  - Reference to surrounding - e.g. reception area for an office set-up to be classified as "office', and reception area for a gymnasium set-up as "gymnasium"
  - Demarcation based on function and nature –
    e.g. in-house staff passage → "corridor"; passage for public → "public circulation area"
  - Space with less than 100 W lighting –
    Not governed by LPD (BEC c5.4.1)



  - Separation between spaces

    Meeting Room + Open Plan Office regarded as a space (medium height partition)

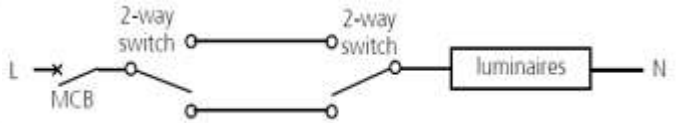
    Manager Office as a space (floor to ceiling height partition)

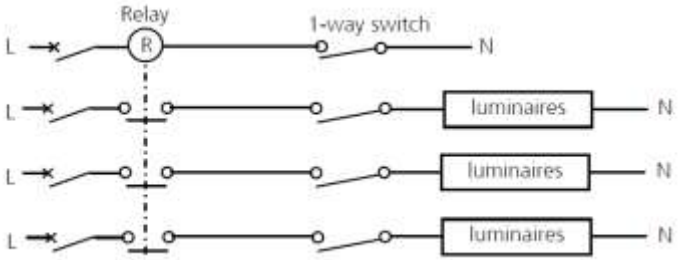


TG – Requirements on Lighting

Lighting Control

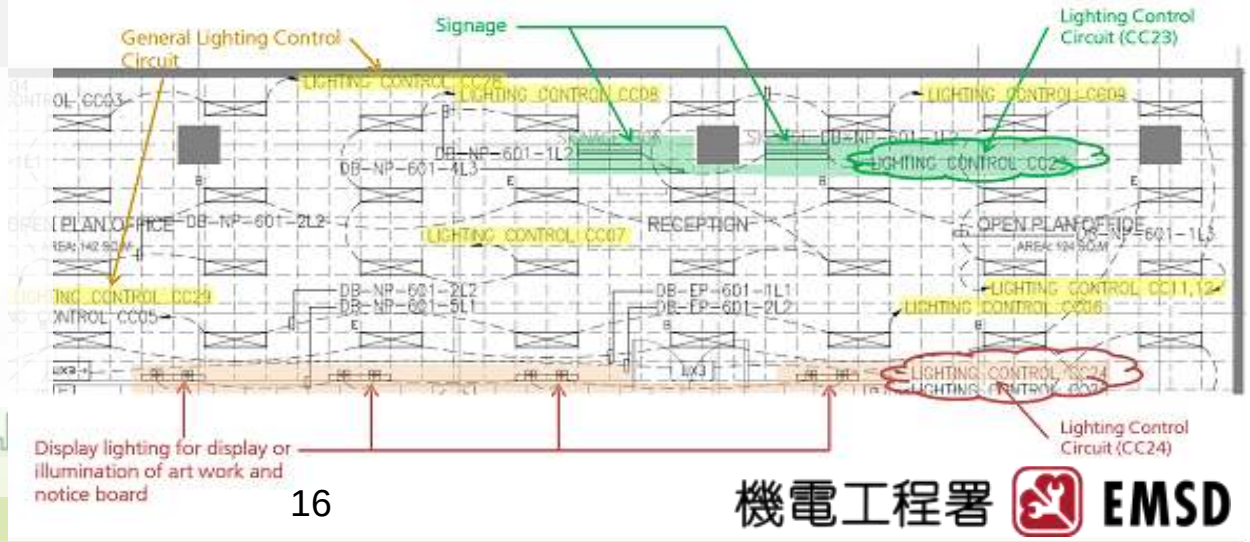
- Control points for office
  - 2 nos. Control points
  - 4 nos control points
  - lower LPD – reduced no. of control points





Area (m^2)	Min no. of lighting control points	Area (m^2)	Min no. of lighting control points
> 0 - 15	1	> 180 - 210	12
> 15 - 30	2	> 210 - 240	13
> 30 - 45	3	> 240 - 270	14
> 45 - 60	4	> 270 - 300	15
> 60 - 75	5	> 300 - 330	16
> 75 - 90	6	> 330 - 360	17
> 90 - 105	7	> 360 - 390	18
> 105 - 120	8	> 390 - 420	19
> 120 - 135	9	> 420 - 450	20
> 135 - 150	10	> 450 - 500	21
> 150 - 180	11		

- Control of BEEO applicable lighting to be independent from BEEO non-applicable lighting

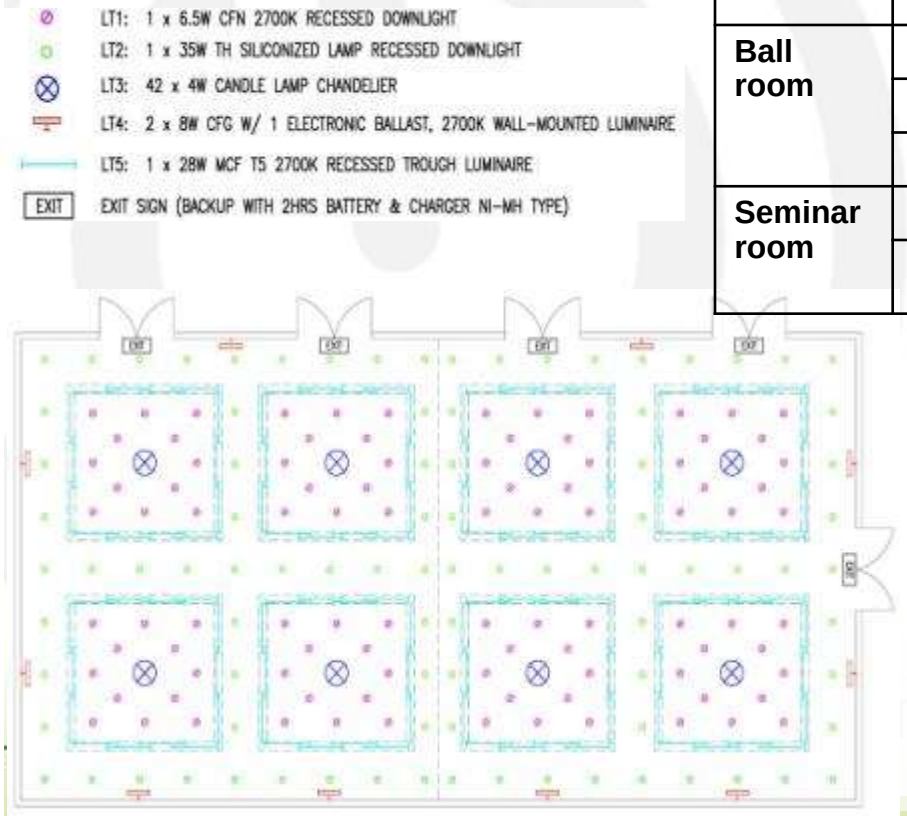


TG – Requirements on Lighting

Multi-functional Space

Serve different lighting scenes

Space Function	Function-specific Luminaires			LPD (W/m²)	
	Luminaire Designation	Qty	Total Circuit Watt	Calculated	Max Allowable
Banquet room	LT1	96	720	[720 + 3330 + 1344] / 264 = **20.4**	**23**
	LT2	90	3330		
	LT3	8	1344		
	LT4	Excluded in LPD			
Ball room	LT2	90	3330	[3330 + 1344] / 264 = **17.7**	**23**
	LT3	8	1344		
	LT4	Excluded in LPD			
Seminar room	LT1	96	720	[720 + 3360] / 264 = **15.5**	**16**
	LT5	112	3360		



Ball Room / Banquet Room arrangement - LPD of combination of luminaires < 23 W/m²

Seminar room arrangement - LPD of combination of luminaires < 16 W/m²

TG – Requirements on Air-conditioning

BEC Non-applicable Installations (examples)

- Chiller operating at high electrical voltage of 3.3 kV
- AHU solely for surgical operation
- Fan solely for smoke extract
- Exhaust fan for fume cupboard for research

System Load

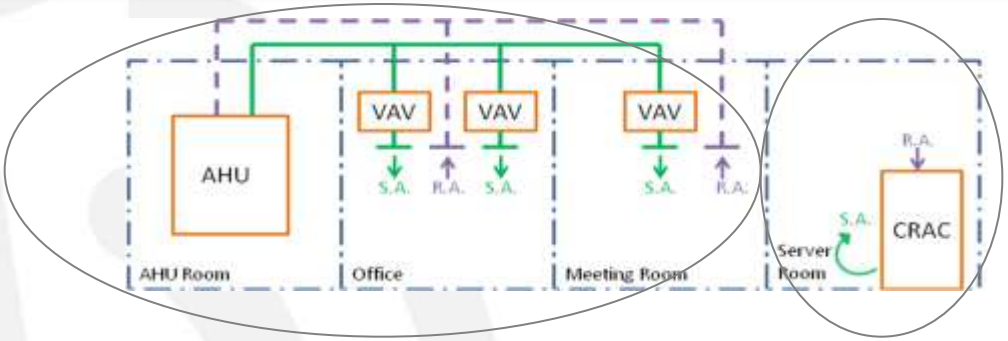
- Load calculations - internationally recognised procedures & methods
  - ASHRAE Handbook Fundamentals,
  - CIBSE Guide A, etc.
- BEC Table 6.4 indoor conditions – for human comfort application only
- Non-human comfort applications – data centre, wine cellar, pathology room
- Outdoor conditions
  - Sensible heat intensive loads – max 35°C DB & < 29°C WB
  - Latent heat intensive loads – max 29°C WB & < 35°C DB

BEC Table 6.4 : Air-conditioning System Load Design Conditions

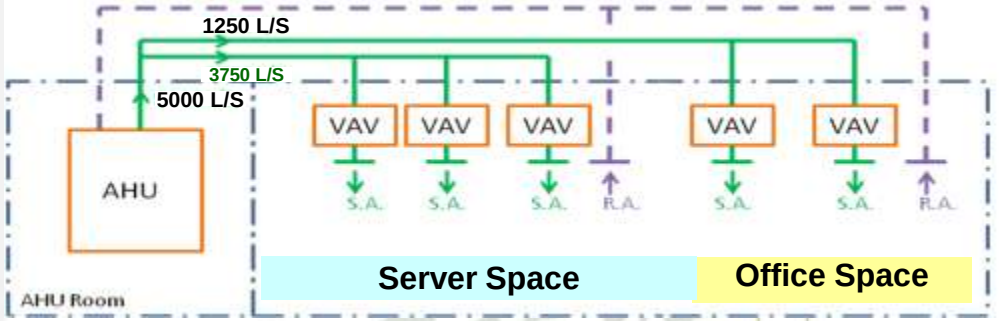
Condition	Season	Applications	Temperature / Relative Humidity	
Indoor, for human comfort applications	Summer	Office and Classroom	Minimum dry bulb temperature	23°C
			Minimum relative humidity	50%
		Other applications	Minimum dry bulb temperature	22°C
			Minimum relative humidity	50%
	Winter	Hotel	Maximum dry bulb temperature	24°C
			Maximum relative humidity	50%
		Other applications	Maximum dry bulb temperature	22°C
			Maximum relative humidity	50%
Outdoor	Summer	All applications	Maximum dry bulb temperature of 35°C with wet bulb temperature lower than 29°C, or Maximum wet bulb temperature of 29°C with dry bulb temperature lower than 35°C	
	Winter	All applications	Minimum dry bulb temperature	7°C

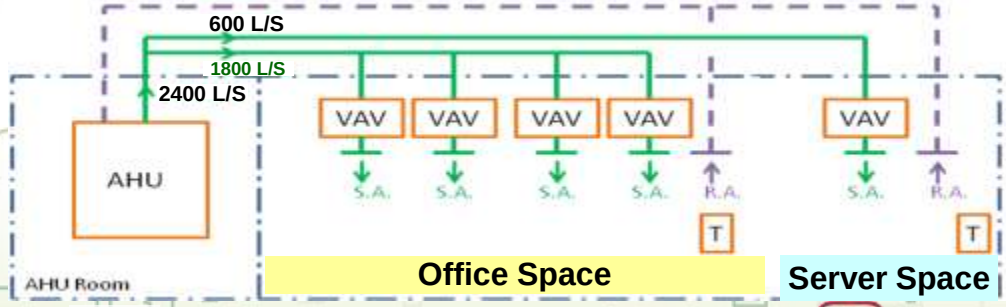
TG – Requirements on Air-conditioning

Separate Air Distribution System for Process Zone



- Exemptions
  - Supply air to comfort zone (Office Space) no more than 25% of total air flow
  - comfort only zone has a small conditioned area of smaller than 100 m^2,
  - Supply air to process zone (Server Space) no more than 25% of total air flow





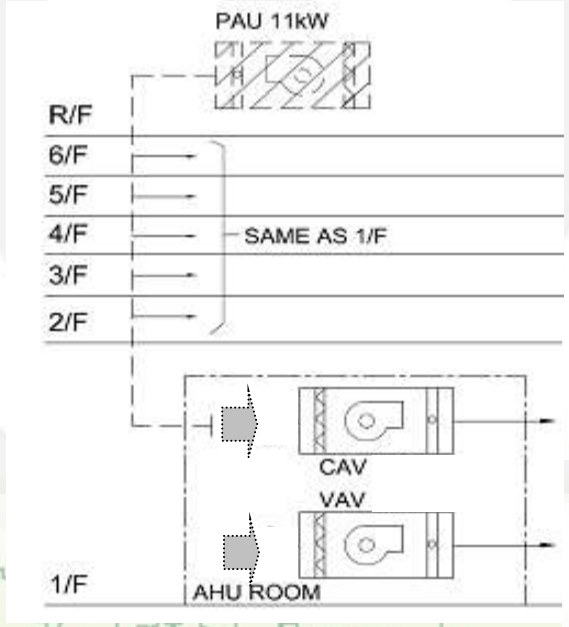
TG – Requirements on Air-conditioning

Ductwork Leakage Limit

- Based on DW143
- Lower L/s per m^2 for higher pressure

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	$0.001 \times p^{0.65}$

Max System Fan Motor Power (P_T) – CAV 1.6 and VAV 2.1 W / L/s



- PAU fan to be excluded
- Return air fan (if in place) to be included
- Fan motor power can be based on flow/shaft power curve (and efficiency of motor & mechanical drive)
- Exemption for P_T < 5kW # and FCUs

CAV fan motor drawing 3 kW # at 2.5 m^3/s

Office

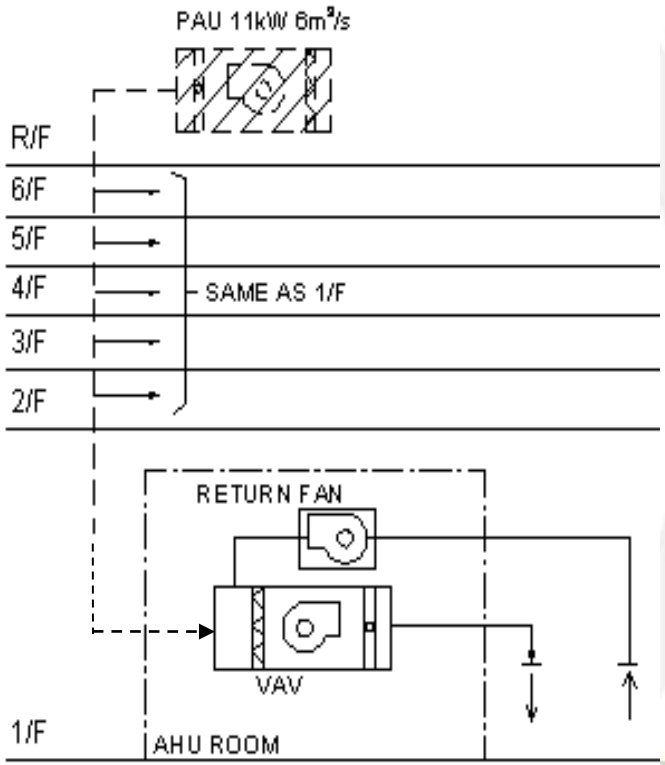
System fan motor power for CAV = 3 kW # / 2.5 m^3/s = 1.2 W/ L/s

VAV fan motor drawing 7 kW at 4 m^3/s

System fan motor power for VAV = 7 kW / 4 m^3/s = 1.75 W/ L/s

TG – Requirements on Air-conditioning

System Fan Motor Power – Deductible Fan Motor Power



Deductible fan motor power P_f

total filter pressure drop p_d = 450 Pa V = 5.5m³/s

η_m = 0.92 η_d = 0.97 η_f = 0.8

$P_f = V \times (p_d - 250) / (\eta_m \times \eta_d \times \eta_f)$ ***[$p_d \geq 250$: deductible]***

$= 5.5 \times (450 - 250) / (0.92 \times 0.97 \times 0.8)$

= 1,541 W or 1.54 kW

System fan motor power (P_T) for a VAV system with supply & return air fans and deductible fan motor power

$P_T = FSP_S / (\eta_m \times \eta_d) - P_f + FSP_R / (\eta_m \times \eta_d)$

$= [7 / (0.92 \times 0.97)] - 1.54 + [4 / (0.9 \times 0.97)]$ kW

= 7.84 – 1.54 + 4.58 kW

= 10.9 kW

System fan motor power = P_T / V = 10.9 / 5.5 kW/m³/s

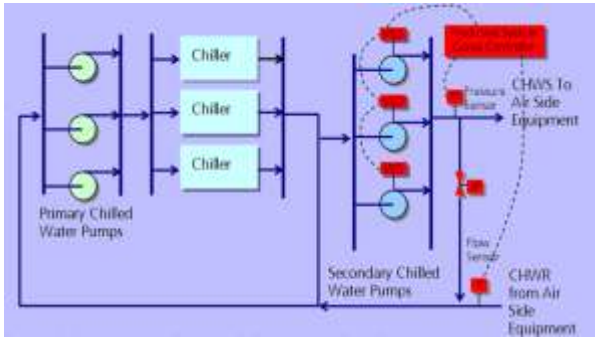
= 1.98 W/L/s

which fulfils the 2.1 W/L/s requirement

TG – Requirements on Air-conditioning

Pumping System Variable Flow

- System capable of operating at ≤ 50% of design flow
- Flow reduction by
  - Chiller & pump sequencing
  - Valves on/off/modulation
  - Reduced speed of variable/multi-speed pumps



- Manual operation to achieve flow reduction NOT acceptable
- Exemptions
  - Applicable to small system or system with supply water temperature reset

Water Piping Frictional Loss

- Applicable to chilled water, heated water and condenser water piping

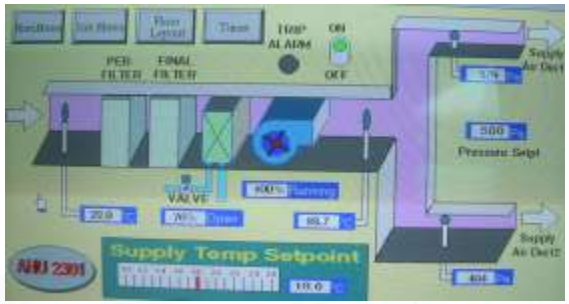
Piping Diameter (mm)	Greater than 50mm	50mm
Frictional loss (Pa/m)	≤ 400 Pa/m	Not applicable
Water flow velocity (m/s)	≤ 3 m/s	≤ 1.2 m/s

TG – Requirements on Air-conditioning

System Control

- Provision in thermostat/humidistat of wide range temperature setting
  - Allows higher operation setting flexibility
  - Not applicable to a unitary air-conditioner's thermostat/humidistat that is
    - integral to the air-conditioner, and
    - supplied by manufacturer as standard ancillary

- Off-hours control
  - System > 10 kW capacity
    - automatic shut down or control setback (e.g. room temp (cooling) 23°C →28°C)
    - timer, occupancy sensor etc.
  - Hotel guest room master control device – card key



- Spaces forming a zone to be on same floor

TG – Requirements on Air-conditioning

Thermal Insulation

- "Outdoor", "Unconditioned", "Conditioned" – each at uniformity temp and humidity
- False ceiling void – regarded as unconditioned, unless a return air plenum or of perforated type
- The requirement of insulation thickness is only applicable to
  - site-installed pipework and ductwork
  - site assembled AHU/FCU casing
- Tabulated thickness based on heat transfer equations -

a) Calculate the provisional thickness χ (unit – mm)

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

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

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

θ_d = Dew point temperature °C θ_i = Temperature of the cold surface °C

θ_m = Temperature of the ambient still air - °C

b) Estimate the value of L_a based on general engineering practice, and calculate using Equation (b) the provisional thickness χ (unit – mm)

$\chi = 0.5\ (d_o + 2L_a) \times \ln\ [1 + 2L_a/d_o]$ ..... Equation (**b**)

Where L_a = Estimated min thickness mm (will converge to the actual value through iterations)

d_o = Outside diameter of pipe or tube mm

TG – Requirements on Air-conditioning

Thermal Insulation (Cont'd)

- Supplement of tabulated thickness for ductwork for 10°C temperature difference

Ambient Condition	Outdoor				Unconditioned Space				Conditioned Space	
Thermal conductivity λ (W/m-°C)	0.024		0.04		0.024		0.04		0.024	0.04
Surface coefficient h (W/m^2-°C)	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)									
10 °C	13	13	21	14	20	13	33	19	13	18

- Water vapour retardant type insulation –
  - closed cell type
  - fibreglass with multi-layer double-side reinforced aluminium foil
  - insulation coated with heavy mastic etc.
- Good Practice – metal cladding

TG – Requirements on Air-conditioning

Unitary Air Conditioner

- Single package window type and wall mounted split type room air conditioner under the Labelling Scheme (Cap 598) - to fulfill Energy Label Grade 1 or 2
- Room air conditioners other than single package window type and wall mounted split type - to fulfill BEC min coefficient of performance (COP)
- Equivalent COP range of Energy Label Grade 1 & 2 – TG Table 6.12.2(a)

Table 6.12.2 (a) : Equivalent COP Range of Mandatory Energy Efficiency Labelling Scheme (MEELS) Grade 1 and Grade 2

Grade of MEELS	Type of Air Conditioner	Allowable Energy Consumption Index in MEELS	Equivalent COP Range at Rating Condition
1	Window Type	≤ 85%	≥ 2.66
	Split Type		≥ 3.04
2	Window Type	95% to > 85%	2.38 to < 2.66
	Split Type		2.72 to < 3.04

TG – Requirements on Air-conditioning

Other Explanations/Remarks

- VAV fan motor and variable speed pump

  motor (5kW) operating power "≤ 55% of design input power at 50% flow"

  ⇒ adoption of variable speed drive

- COP (coefficient of performance) requirements

  not applicable to absorption chiller, heat recovery chiller, ice making chiller, evaporatively-cooled chiller

- Good practice
  - Automatic controls to integrate with building's BMS with energy management function
  - Data logging & transmission to BMS

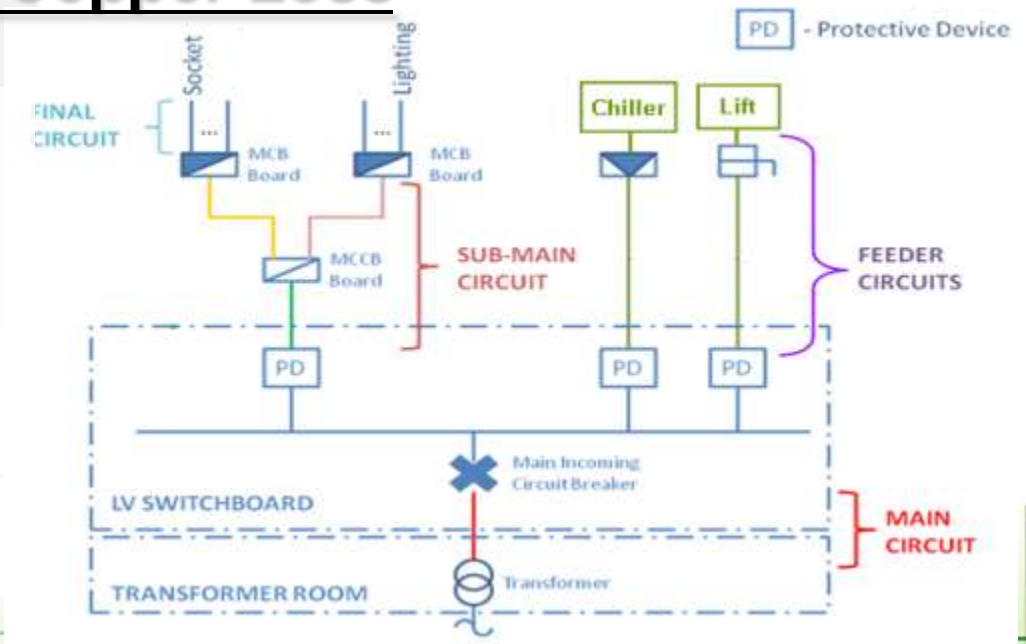
TG – Requirements on Electrical

BEC Non-applicable Installations (examples)

- Equipment or cabling at high voltage or extra low voltage
- Generator set and outgoing cabling
- Motor of fire services pump and cabling solely for the pump
- Appliances not fixed in position such as task lighting

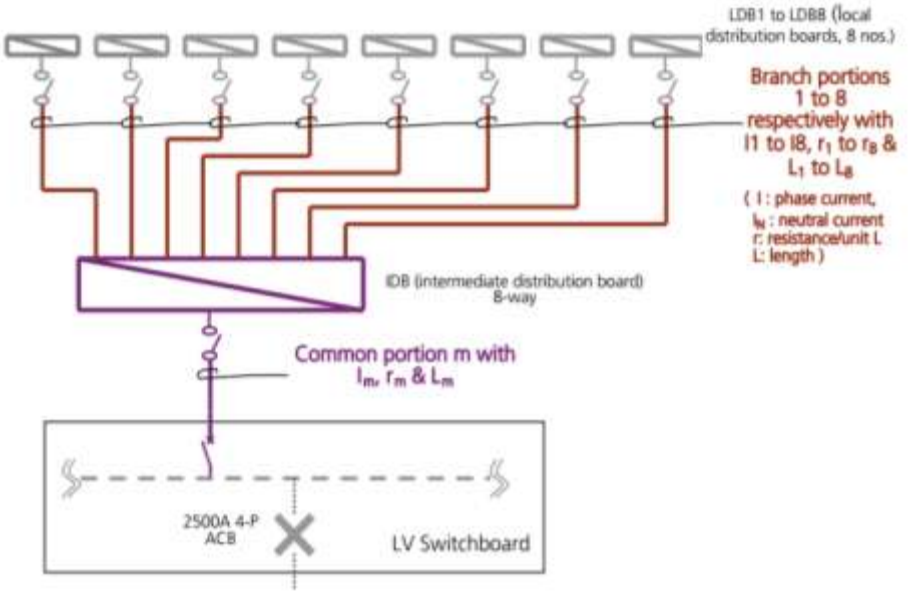
Circuit Copper Loss

- Sub-circuit may consist of a common portion with branch-offs from an intermediate distribution board
- Approach in calculating the percentage of copper loss for such sub-circuit - TG Table 7.4(b)iii)



TG – Requirements on Electrical

Circuit Copper Loss (Cont'd)



- All branch portions and common portion to be included
- I_N to account for triplen harmonics or unbalanced 1-phase loads
- Diversity factor may be applied :

$$Diversity\ Factor\ (df) = \frac{\text{RMS Design Current of Common Portion}}{\sum \text{RMS Design Current of All Branch Portions}}$$

Table 7.4 (b) iii) : Calculation of % Copper Loss of Sub-circuit with Intermediate Distribution Board

(j standing for m, 1, 2, 3, 4, 5, 6, 7 or 8)	Root Mean Square (rms) Design Current I_{jb} (A)	Resistance r_j (mΩ/metre)	Length L_j (metre)	Copper Loss P_{copper} (W)	Sub-circuit Active Power (W)
Common portion m	I_m	r_m	L_m	$(3 \times I_m^2 + I_{mN}^2) \times r_m \times L_m \times 1/1000$	$\sqrt{3} \times 380 \times I_{m1} \times \cos\theta$
Branch portion 1	I1	r_1	L_1	$(3 \times I1^2 + I1_N^2) \times r_1 \times L_1 \times 1/1000$	(I_{m1} is the value of the fundamental component, and $I_{m1} \neq I_m$; I_m is the root mean square value of the fundamental and all harmonic components; and cosθ is the displacement power factor.)
Branch portion 2	I2	r_2	L_2	$(3 \times I2^2 + I2_N^2) \times r_2 \times L_2 \times 1/1000$	
Branch portion 3	I3	r_3	L_3	$(3 \times I3^2 + I3_N^2) \times r_3 \times L_3 \times 1/1000$	
Branch portion 4	I4	r_4	L_4	$(3 \times I4^2 + I4_N^2) \times r_4 \times L_4 \times 1/1000$	
Branch portion 5	I5	r_5	L_5	$(3 \times I5^2 + I5_N^2) \times r_5 \times L_5 \times 1/1000$	
Branch portion 6	I6	r_6	L_6	$(3 \times I6^2 + I6_N^2) \times r_6 \times L_6 \times 1/1000$	
Branch portion 7	I7	r_7	L_7	$(3 \times I7^2 + I7_N^2) \times r_7 \times L_7 \times 1/1000$	
Branch portion 8	I8	r_8	L_8	$(3 \times I8^2 + I8_N^2) \times r_8 \times L_8 \times 1/1000$	

Sub-circuit copper loss = $\sum P_{copper}$ (sum of above 9 portions)

$= 1/1000 \times \{ [(3 \times I_m^2 + I_{mN}^2) \times r_m \times L_m] + \sum [3 \times (I_{jb} \times df)^2 + (I_{jN} \times df)^2] \times r_j \times L_j) \}$ where j = 1 to 8

Sub-circuit % copper loss = $\sum P_{copper}$ ÷ sub-circuit active power

$= 1/1000 \times \{ [(3 \times I_m^2 + I_{mN}^2) \times r_m \times L_m] + \sum [3 \times (I_{jb} \times df)^2 + (I_{jN} \times df)^2] \times r_j \times L_j) \}$

$\div \{ (\sqrt{3} \times 380 \times I_{m1} \times \cos\theta) \}$

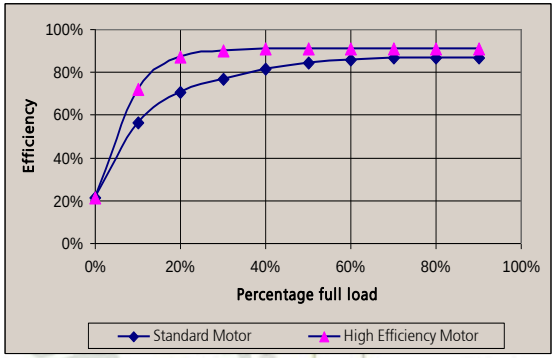
TG – Requirements on Electrical

Circuit Copper Loss (Cont'd)

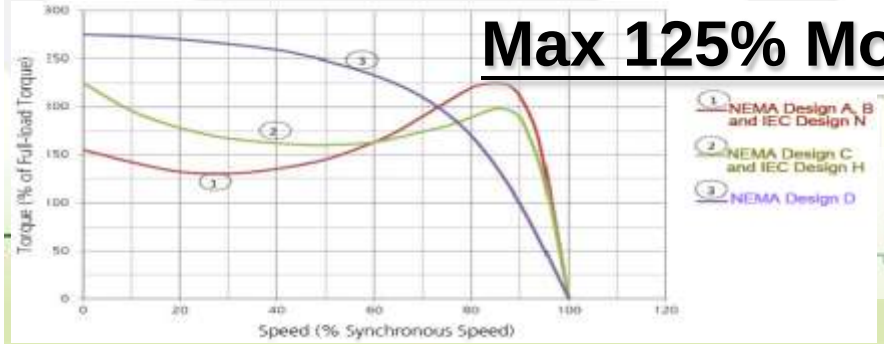
- Electricity supplier metering point may be a point to differentiate CBSI (e.g. in common area, the switch room) from non-CBSI
- Circuit under responsibilities of two parties
  - Calculation of upstream circuit copper loss to account for downstream (future) portion
  - Maintain proper record of sizing

Min Motor Efficiency

Governed	Not Governed
Motor of telescopic gondola	Submersible pump
Motor of plumbing water pump	Motor rated output power <0.75kW
Motor of water feature pump	2-speed motor
	Motor operating above 40°C



Max 125% Motor (>5kW) Sizing

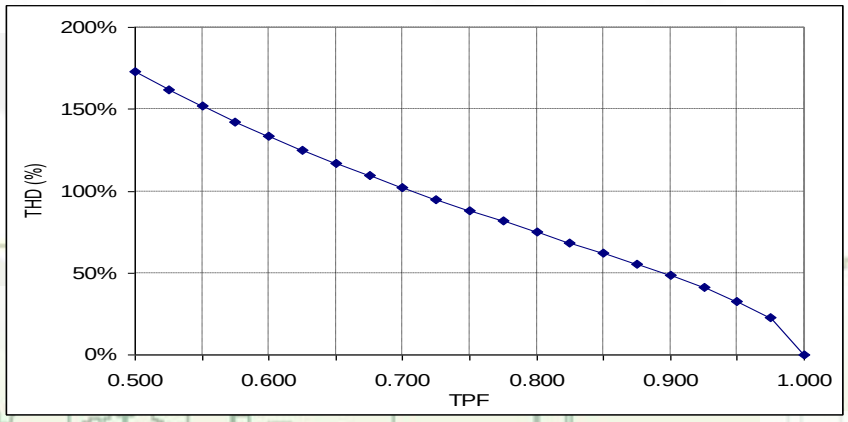


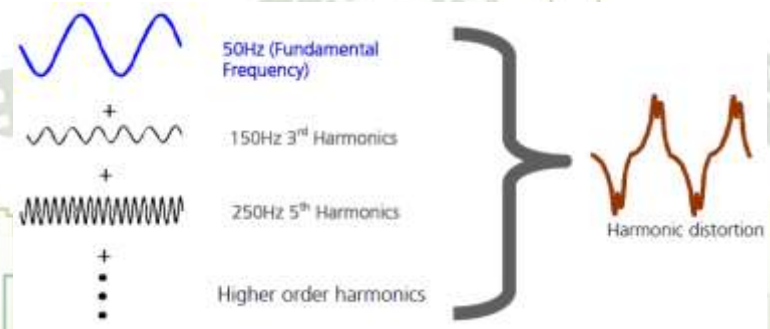
- Not govern motor for high starting torque
  e.g. NEMA Design C & D and IEC Design H

TG – Requirements on Electrical

Power Quality

- Assume voltage distortion negligible, which is also reduced with better THD
- 1-phase equipment (PC, electronic ballast etc.) – triplen harmonics (3rd, 9th, 15th, 21st etc.)
- Rectifier : $h = kq \pm 1$ h: harmonic order, k: integer, q: pulse no. (nos. of rectifiers)
  - 6-pulse VSD : THD = $\sqrt{I_5^2 + I_7^2 + I_{11}^2}$ x 100% = 26.2%
  - 3-phase I_b=100A, DPF=0.85, THD=38.6%, 40m, 35mm^{2}4/C/PVC/SWA/PVC
    Circuit copper loss = 1.14 kW (which is app 60% higher than a linear load)
- TPF = $\frac{DPF}{\sqrt{1+THD^2}} \Rightarrow$ THD ↑ TPF ↓

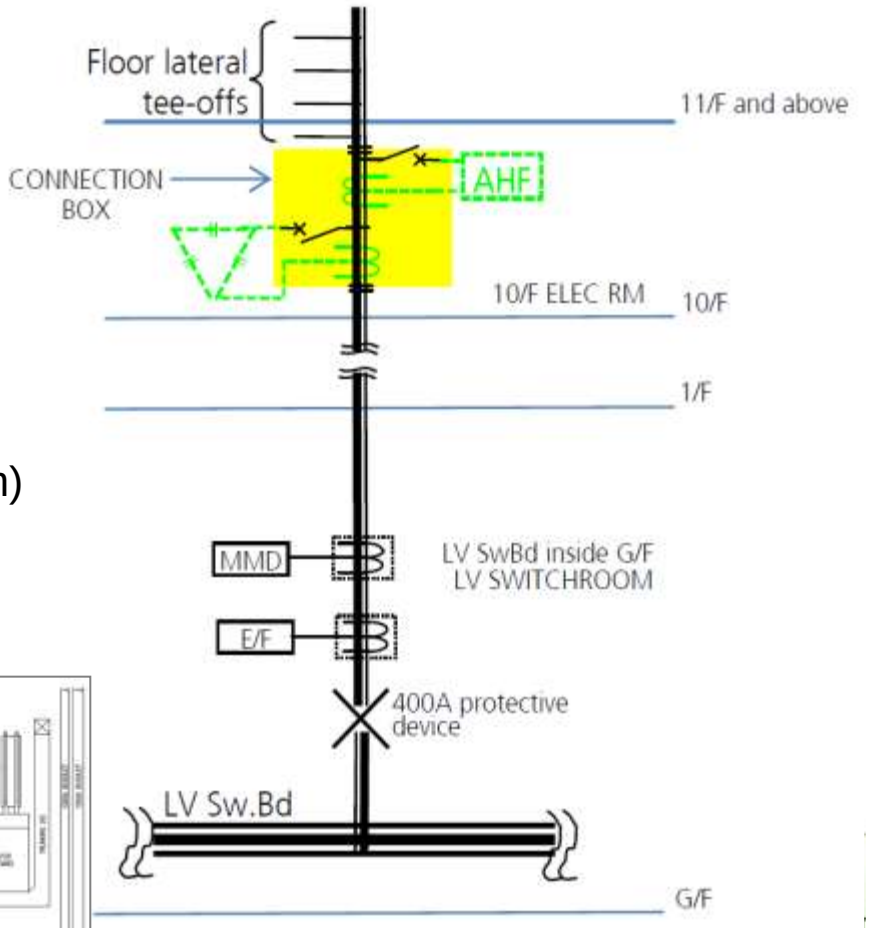


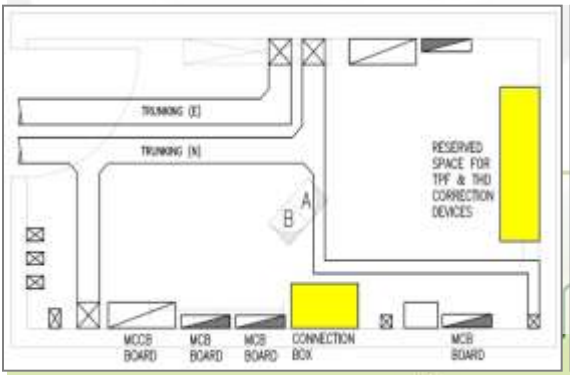


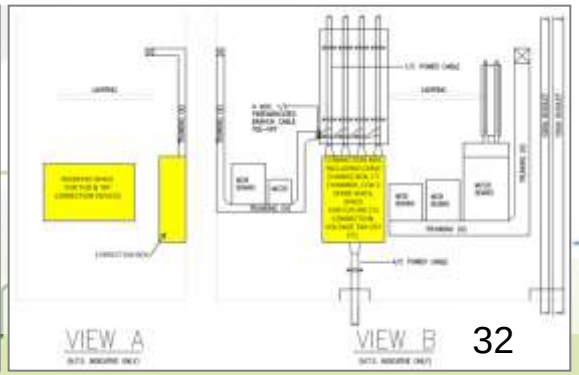
TG – Requirements on Electrical

Connection Points for TPF & THD Correction Devices

- Circuit at or above 400A (protective device rating) (
  3-phrase circuit to electricity supplier meter
- To allow flexibility for future connection in fulfillir
  allowable min TPF & max THD
- **Connection points – spare ways**
- Adequate spacing
  - CT chamber, correction device
- Alternative spare ways provision –
  - just before first lateral tee-off (right diagram)
  - at each of the floor lateral tee-offs
  - at each of the DB downstream of the tee-off
- Connection points to be shown on drawings



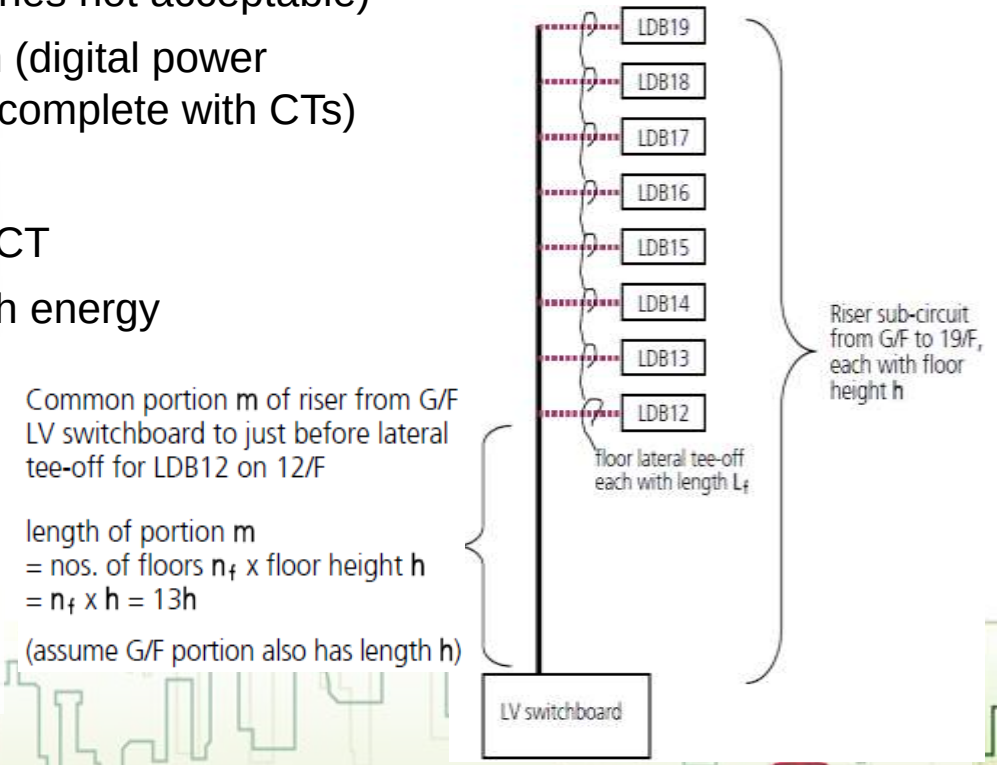




TG – Requirements on Electrical

Other Explanations/Remarks

- Careful planning of 1-phase loads among the three phases
- Metering
  - installation required (hand-held ones not acceptable)
  - data-logging & analytical function (digital power analyzer or multi-function meter, complete with CTs)
  - measuring 31st order harmonics
  - 4-CT configuration better than 3-CT
  - Good Practice – data to BMS with energy management function
- TG Table 7.8 on conductor resistance
- Theory and approach on calculation of circuit copper loss, with illustrative example



TG – Requirements on Electrical

Other Explanations/Remarks (Cont'd)

Table 7.9.1 (a) : Illustration of Conductor Design Considerations

DESIGN CONSIDERATIONS	Abbrev.	Equation described in TG clause 7.8.3 / Relevant TG paragraphs	Floor tee-off	Riser
Floor height (metre)	h	Not applicable (NA)	NA	3
Nos. of floors from G/F to floor of first lateral tee-off	n_f		NA	13
Length of floor lateral tee-off (metre)	L_f		10	NA
Nos. of tee-offs, one per floor, for all the eight floors from 12/F to 19/F	n_t		NA	8
Conductor ambient temperature (°C)	t_a	TG clause 7.8.3	30	
Allowable copper loss (%)	%loss	TG Table 7.4 (b) ii)	1.5%	
Diversity factor	df	TG Table 7.4(b) iii)	NA	0.85
Fundamental current (A)	I_1	TG clause 7.8.3	45	306
Total harmonic distortion (%)	THD	$THD = \frac{\sqrt{\sum_{h=2}^{\infty}(I_h)^2}}{I_1}$ TG clauses 7.8.3 & 7.8.4	15%	NA
Neutral current	I_N	$I_N = 3 \times \sqrt{I_3^2 + I_6^2 + I_9^2 + ...}$ TG clause 7.8.3	0	0
Design root mean square phase current (A)	I_b	$I_b = I_1 \times \sqrt{(1+THD^2)}$	45.5	309.4
Protective device rating (A)	I_n	$I_b \le I_n$	55	320
Total power factor	TPF	TG clauses 7.8.3 & 7.8.4	0.85	NA
Displacement power factor	DPF cosθ	$\cos\theta = TPF \times \sqrt{(1+THD^2)}$	0.86	NA
Effective length of whole sub-circuit (metre) (for purpose of quick estimation of **Max r** only, equation alongside does not appear in TG clause 7.8.3)	EL	$EL = h \times (n_f + 7/8 + 6/8 + 5/8 + 4/8 + 3/8 + 2/8 + 1/8) + L_f$	59.5	
Max resistance (mΩ per metre) of conductor	Max r	$\frac{\%loss \times \sqrt{3} \times 380 \times I_1 \times \cos\theta \times 1000}{(3 \times I_b^2 + I_N) \times L}$	1.0332	0.1519

Table 7.9.1 (b) : Illustration of Cable Selection (4/C PVC/SWA)

CABLE SELECTION	Abbrev.	Equation described in TG clause 7.8.3 / Relevant TG paragraphs	# Tee-off 16 mm²	Riser 150 mm²
Conductor resistance (mΩ per metre)	r	TG Table 7.8 and Wiring Code	1.4	0.15
Permitted conductor temperature (°C)	t_p	TG clause 7.8.3 and Wiring Code	70	70
Conductor tabulated current carrying capacity (A)	I_t		83	332
Conductor operating temperature (°C) at I_b	t_1	$t_1 = t_a + \frac{(3I_b + I_N)^2}{(3I_t)^2}(t_p - 30)$	42.02	64.74
Ratio of conductor resistance at t_1 to t_p	R_1/R_p	$\frac{R_1}{R_p} = \frac{230 + t_1}{230 + t_p}$	0.907	0.982

Remark# to 16 mm² cable selection

A cable of smaller size having a r value greater than **Max r** is selected as a trial, as the actual current with the application of diversity factor **df** would be lower than I_b, the cable can be upgraded if needed based on actual P_{copper} calculated in TG Table 7.9.1(c). (Later calculations in TG Table 7.9.1(c) justify the trial selection of 16mm².)

Table 7.9.1 (c) : Illustration of Copper Loss Calculations

COPPER LOSS CALCULATIONS	Current I_b (*df applied*) (A)	Resistance r (R_t/R_p *applied*) at t_1 (mΩ per metre)	Length L (metre)		Copper loss P_{copper} (Watt)		Sub-circuit active power P (Watt)	
common portion m (G/F to 12/F of 13 floors)	309.4	0.147	$n_t \times h$	39	($[3 \times I_b^2$ (*df applied*) $+ I_N^2] \times r \times L$) / 1000	1650.9	$\sqrt{3} \times 380 \times I_m \times \cos\theta$	173,108
12/F lateral tee-off	38.7	1.269	L_f	10		57.0		
13/F riser portion	270.7	0.147	h	3		97.2		
13/F lateral tee-off	38.7	1.269	L_f	10		57.0		
14/F riser portion	232.1	0.147	h	3		71.4		
14/F lateral tee-off	38.7	1.269	L_f	10		57.0		
15/F riser portion	193.4	0.147	h	3		49.6		
15/F lateral tee-off	38.7	1.269	L_f	10		57.0		
16/F riser portion	154.7	0.147	h	3		31.7		
16/F lateral tee-off	38.7	1.269	L_f	10		57.0		
17/F riser portion	116.0	0.147	h	3		17.9		
17/F lateral tee-off	38.7	1.269	L_f	10		57.0		
18/F riser portion	77.4	0.147	h	3		7.9		
18/F lateral tee-off	38.7	1.269	L_f	10		57.0		
19/F riser portion	38.7	0.147	h	3		2.0		
19/F lateral tee-off	38.7	1.269	L_f	10		57.0		
					Total	2,384		
					% Copper Loss =	1.38%		

TG – Requirements on Lift & Escalator

BEC Non-applicable Installations (examples)

- Service lift (food transportation)
- Stairlift at stairway
- Lift in performance stage
- Lifting platform for wheelchair
- Temporary construction hoist lift
- Industrial truck load freight lift

Max Allowable Electrical Power

- Discourage over-sizing of driving motor & encourage low loss driving controller
- Applicable to lift (rated load & rated speed) and escalator/conveyor (no load & rated speed)
- “Rated load”, “rated speed”, “rise”, “nominal width”, etc. to share meanings in Cap 618
- Not applicable to certain shuttle lift
- Values obtainable from suppliers
- Hydraulic lift – irrespective of direct acting (bottom), side acting, or indirect acting
- Multi-speed escalator/conveyor : allowable value based on top speed
- Public service escalator/conveyor – a system connecting a building to a traffic station or public transport interchange
- Heavy duty escalator – found in railway station
- Passenger conveyor between 1200 mm and 1400 mm width – interpolation to arrive at max allowable value

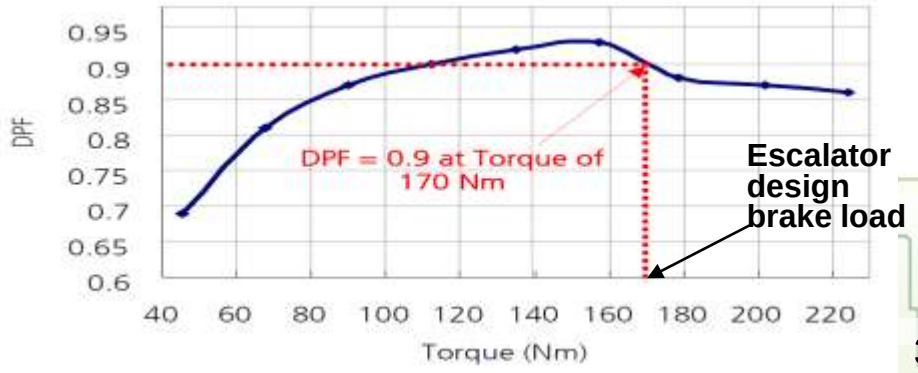
TG – Requirements on Lift & Escalator

Min Allowable TPF

- TPF to account for the combined effect of the DPF of the motor and its driving controller's THD, ∴ TPF < DPF

Lift	• **rated load** • **rated speed upward**	• **TPF ≥ 0.85** **(of the motor drive circuit at the isolator connecting to the building's electrical supply circuit; motor drive = motor + driving controller)** • **A correction device if needed can be installed at the motor control centre of the motor drive**
Escalator	• **brake load** • **rated speed**	
Passenger Conveyor		

- Lift TPF at rated load rated speed upward – may be site-test verified
- Escalator/Passenger conveyor TPF -
  - DPF of driving motor can be identified from its Motor data sheet (usually available from motor manufacturer)
  - Motor data sheet records its testing parameters and typically gives a range of values of DPF and load or torque (Newton-metre)



Running test - (Rated torque = 112.4)

Load Nm	Voltage V	Current A	RPM	Input power KW	Outp. Power KW	Effic.	Power factor	Slip %
1.6	380	14.7	1499	1.616	0.247	0.15	0.17	0.1
23.0	380	16.1	1487	5.117	3.582	0.70	0.48	0.9
45.0	380	19.3	1475	8.759	6.944	0.79	0.69	1.7
67.4	380	23.7	1461	12.575	10.318	0.82	0.81	2.6
89.9	380	29.0	1445	16.573	13.610	0.82	0.87	3.7
112.4	380	34.9	1427	20.758	16.795	0.81	0.90	4.9
134.9	380	41.4	1405	25.083	19.842	0.79	0.92	6.4
157.4	380	48.2	1378	29.485	22.711	0.77	0.93	8.1
178.9	380	54.6	1359	31.488	25.458	0.81	0.88	9.4
201.9	380	62.5	1332	35.830	28.167	0.79	0.87	11.2
224.1	380	71.0	1301	40.200	30.529	0.76	0.86	13.3
246.5	380	80.9	1261	44.919	32.547	0.72	0.84	15.9
269.0	380	93.9	1201	50.270	33.829	0.67	0.81	19.9

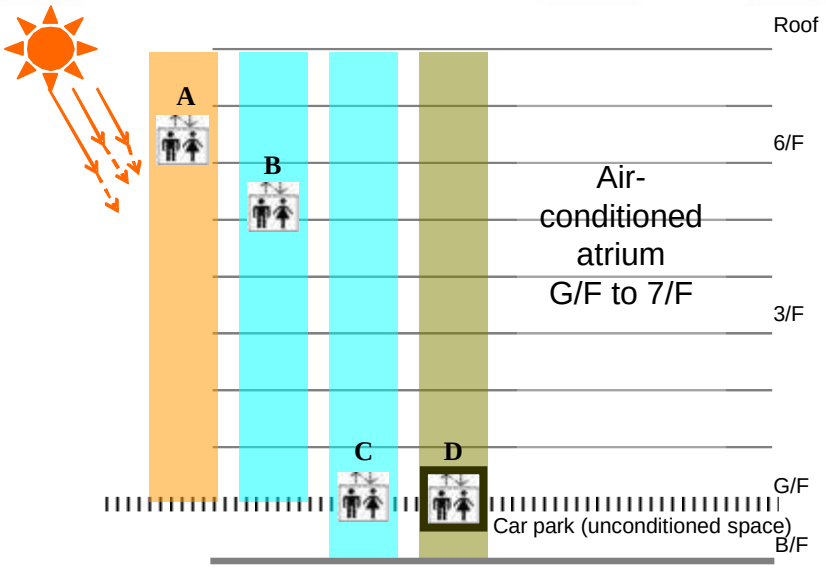
TG – Requirements on Lift & Escalator

Lift Decoration Load

- Consideration of lighter alternative – slightly thinner stone panel, light-weight stone panel (with aluminium backing) or vinyl tiling (floor)
- REA/designer and architect/owner collaboration

Lift Parking Mode

- Applicable to lift bank
- Lift idling – actuation (at low traffic) by auto programming or manual switching at supervisory panel or control switch at lift lobby (Low traffic – traffic demand falling to say 20%)
- Automatic shutting-off of ventilation or air-conditioning (AC) at idling, with exemptions (below)
- Delayed stopping of AC and delayed restart – energy saving Vs AC compressor sustaining



Lift designation	**Exemption** applicable	Justifications / Remarks
Observation lift A (glazed car wall)	Yes	Travelling through outdoor space
Observation lift B (glazed car wall)	No	Not travelling through outdoor or unconditioned space
Observation lift C (glazed car wall)	Yes	Travelling through un-conditioned space, the carpark
Ordinary lift D (NO glazed car wall)	No	Not an observation lift

TG – Requirements on Lift & Escalator

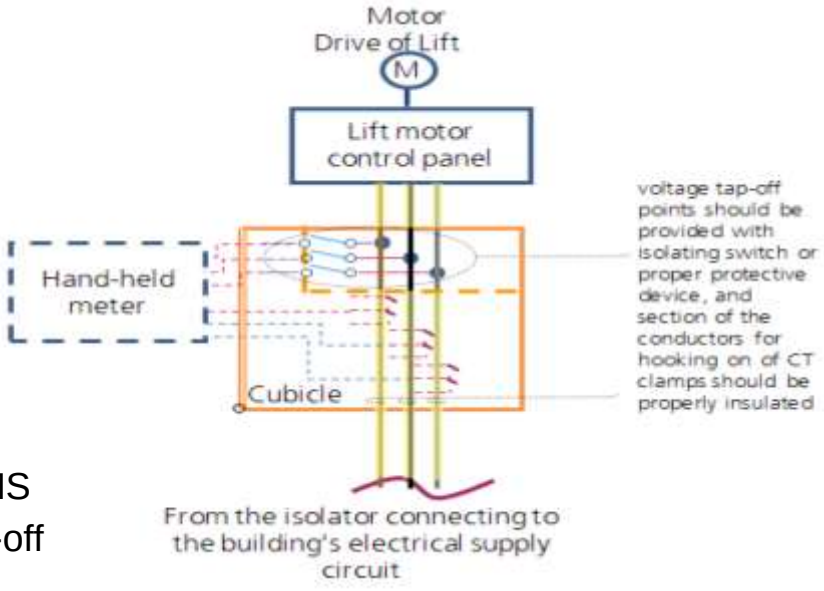
Max Allowable THD

Lift	• **rated load** • **rated speed upward**	• **THD ≤ values given in BEC Tables 8.6.1 & 8.6.2 15% to 40%) (in each phase, of the motor drive circuit at the isolator connecting to the building's electrical supply circuit; motor drive = motor + driving controller)** • **A correction device if needed can be installed at the motor control centre of the motor drive**
Escalator	• **no load** • **rated speed**	
Passenger Conveyor		

- May be site verified
- THD contributes to TPF

Metering & Monitoring Facilities

- Permanent fixed metering devices or provision for measurement
- Data-logging & analytical function (digital power analyzer or multi-function meter, complete with CTs)
- Measuring 31st order harmonics
- Total kVA to base on average line voltage and average line current
- Good Practice
  - Permanent metering - transmit measured data to BMS
  - Provision for measurement - Proper provision of tap-off points (isolation switches) & proper insulation



TG – Requirements on Lift & Escalator

Good Engineering Practice – Normalization of Lift Energy Consumption

- Normalize lift energy consumption based on its **energy consumed per unit load per unit distance travelled**
- Benchmarking parameter, **J/kg-m** -

  Reflects the energy performance of a lift or a bank of lifts accounting for both the power consumption of the motor drive as well as the intelligence of the supervisory controls

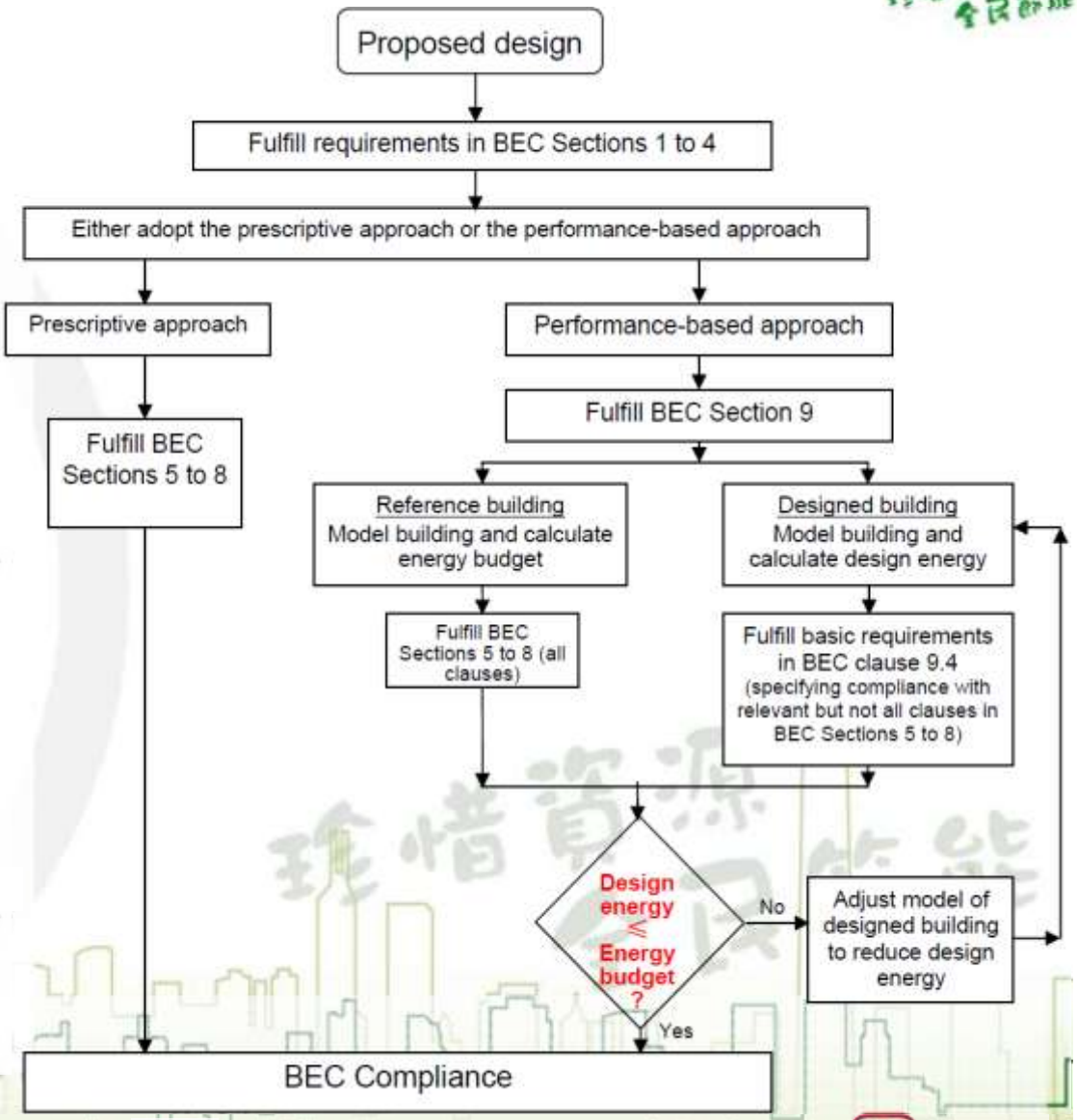
$$J/kg\text{-}m = \frac{E_T}{\sum_{i=1}^{n} W_i D_i}$$

- The lower the J/kg-m value, the lower would be the energy consumption

[@] Lam D.C.M., So A.T.P., Ng T.K., "Energy conservation solutions for lifts and escalators of Hong Kong Housing Authority", *Elevator Technology 16, Proceedings of 16th World Congress on Elevator Technologies*, The International Association of Elevator Engineers, Helsinki, June, 2006, pp. 190-199

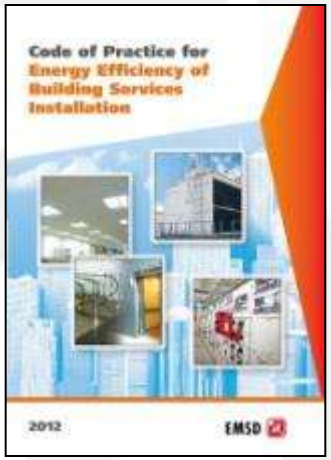
TG – Performance Based Approach

- Provides design flexibility to encourage energy efficient innovative features
- Lists building energy simulation programs commonly used locally
- Justifiable examples
  - lighting having higher LPD but lower energy consumption as a result of its energy efficient control using daylight measuring head, look out sensor & look down sensor
  - chiller having lower full load COP but lower energy consumption as a result of its higher part load COP
  - adoption of photovoltaic



TG – Performance Based Approach

TG - Major Retrofitting Works



(a) Works area ≥ 500 m^2

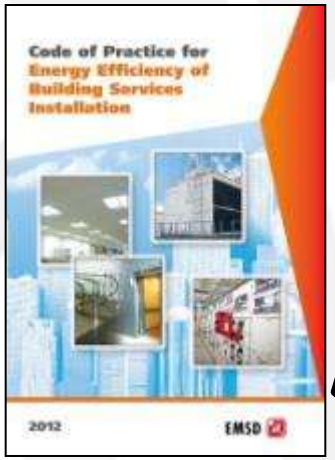
① ② ③ ④

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.
(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

TG - Major Retrofitting Works



(b) Main CBSI component

① ② ③ ④

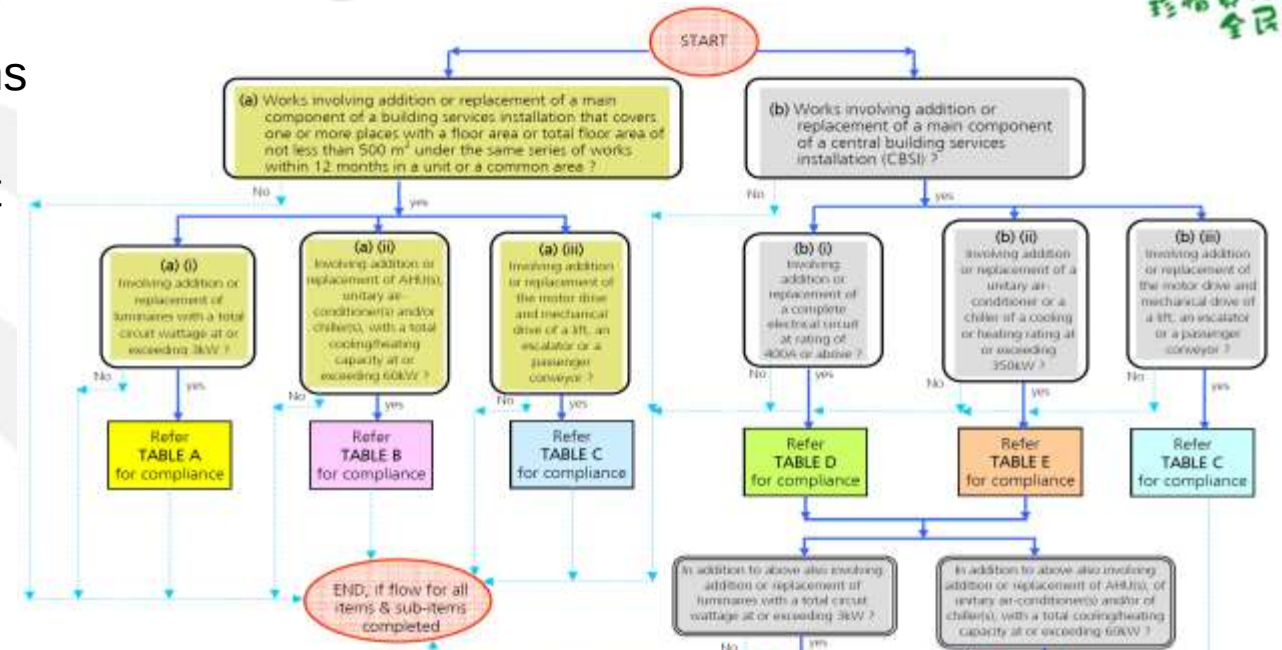
Table 10.1

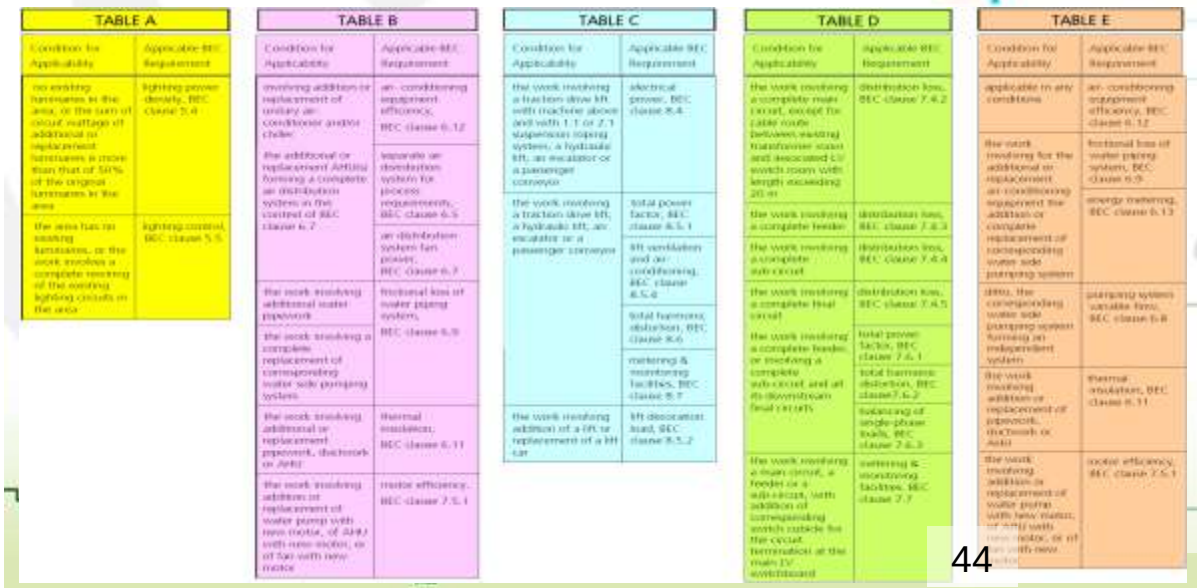
Major Retrofitting Works and Energy Efficiency Requirements

Category of Major Retrofitting Work	Condition for Applicability of BEC Requirement	Applicable BEC Requirement	BEC Clause No.
(ii) addition or replacement of a unitary air-conditioner or a chiller of a cooling or heating rating at or exceeding 350kW	applicable in any conditions	air- conditioning equipment efficiency	6.12
	the work involving for the additional or replacement air-conditioning equipment the addition or complete replacement of corresponding water side pumping system	frictional loss of water piping system	6.9
		energy metering	6.13
	ditto, the corresponding water side pumping system forming an independent system	pumping system variable flow	6.8
	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

TG – Major Retrofitting Works

- Detail explanations on approach to identify if a retrofit falls within the scope of MRW
- Supplements with various examples
- TG Figure 10.1

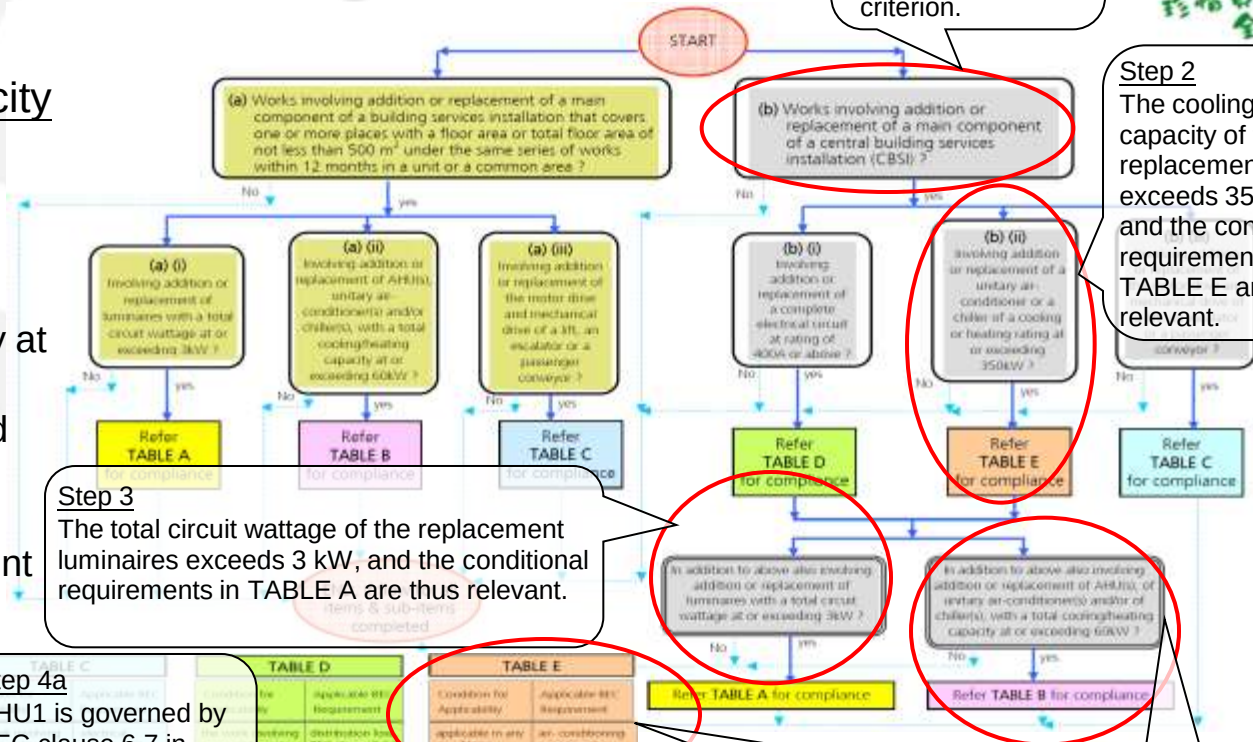




TG – Major Retrofitting Works

Replacement of CBSI chiller of 400 kW capacity

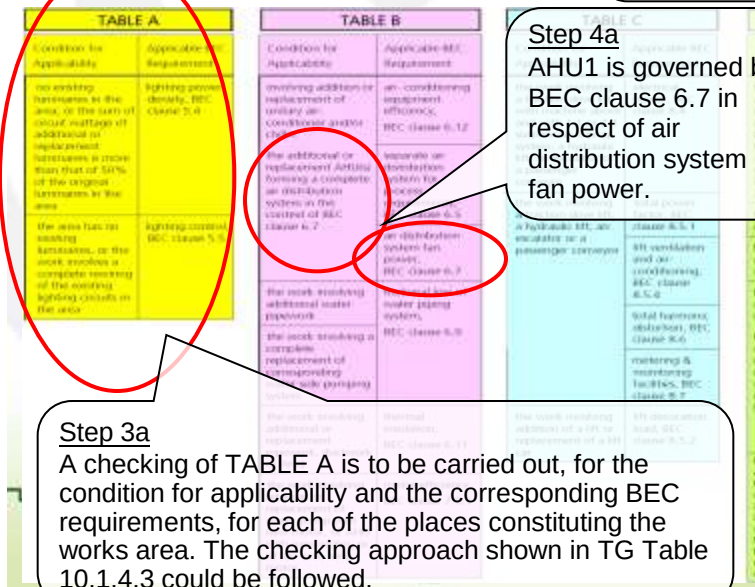
- Replacement of ch.w. pumps (existing motor reused)
- Replacement of a no. of AHUs with total capacity at 100 kW
- AHU1 – all DW replaced
- Other AHUs – DW to remain
- Luminaires – replacement ones at 3.5 kW



Step 1
The retrofit is likely regarded as MRW by the main CBSI component criterion.

Step 2
The cooling capacity of the replacement chiller exceeds 350 kW, and the conditional requirements in TABLE E are thus relevant.

Step 3
The total circuit wattage of the replacement luminaires exceeds 3 kW, and the conditional requirements in TABLE A are thus relevant.



Step 4a
AHU1 is governed by BEC clause 6.7 in respect of air distribution system fan power.

Step 2a
The replacement chiller is governed by the COP requirements in BEC clause 6.12.

Step 2b
The interfacing pipework and ductwork are governed by BEC clause 6.11 in respect of thermal insulation, and the motors of the AHUs are governed by BEC clause 7.5.1 in respect of motor efficiency.

Step 4
The total cooling capacity of the replacement AHUs exceeds 60 kW, and the conditional requirements in TABLE B are thus relevant.

Step 3a
A checking of TABLE A is to be carried out, for the condition for applicability and the corresponding BEC requirements, for each of the places constituting the works area. The checking approach shown in TG Table 10.1.4.3 could be followed.

TG – Major Retrofitting Works

Table 10.1.4.3 : Illustration for a Lighting Retrofit : Checking of Conditions for Applicability, for the Energy Efficiency Requirements

		Place one	Place two	Place three
Space type		Office 1	Office 2	Corridor (internal corridor connecting Office 1 and Office 2)
Works area (internal floor area)		470 m^2	50 m^2	30 m^2
Original luminaires	Circuit wattage	7.8 kW	0.8 kW	0.36 kW
	50% of above	3.9 kW	0.4 kW	0.18 kW
Circuit wattage of replacement or replacing luminaires		4 kW	0.2 kW	0.3 kW
Checking of Condition for applicability	sub item (a)(i)	Condition fulfilled, total circuit wattage of the works area of the three places is 4.5 kW and exceeds 3 kW		
	TABLE A	LPD requirements in BEC clause 5.4		
		4 kW is greater than 50% of original luminaires circuit wattage i.e. 3.9 kW, hence Place one is governed	0.2 kW is not greater than 50% of original luminaires circuit wattage i.e. 0.4 kW, hence Place two is not governed	0.3 kW is greater than 50% of original luminaires circuit wattage i.e. 0.18 kW, hence Place three is governed
		Lighting control requirements in BEC clause 5.5		
		Work does not involve a complete rewiring, hence the lighting control is not governed	Work involves a complete rewiring, hence the lighting control is governed	Control requirement not applicable to "corridor"

TG – Major Retrofitting Works

Same series of works

- Floor area covered by any works commenced within the 12-month period should be counted towards the "500 m^2"
- Works under the same series but not commenced within the 12-month period should also comply with the MRW requirements

Table 10.1.7 (d) : Retrofitting Works Case III

Place	Working period	Works internal floor area	Remarks on same series of works in a 12-month period	Form of Compliance (FOC)
A	1 Jan – 31 Mar 2013	100 m^2	The earliest date of the corresponding places' working period commencement dates should not always be taken as the start of the 500 m^2 counting period (max 12-month) in the counting of the aggregate floor area towards the 500 m^2 criterion. In Case III here, the working period commencement date of 1 May 2013 of place B should be taken as the start date, as the aggregate of place B and those places with works that follow more readily add up to over 500 m^2 (150m^2 (B) + 200m^2 (C) + 200m^2 (D) = 550 m^2). BEC Table 10.1 item (a) governs these places. (Here the 500 m^2 counting period starts on 1 May 2013 and ends on 31 Mar 2014.) Reverting to place A, as it together with places B to D form the series of work, BEC Table 10.1 item (a) also governs works in place A. *Good Practice* *It may be that when the series of works starts (i.e. as at 1 Jan 2013), the works areas of places B to D are yet to be confirmed. Under the situation it is better to have the relevant building services installation in place A to comply with the relevant requirements in BEC Table 10.1 item (a), to avoid the possible non-compliance that can only be known upon confirmation of the works areas.*	The works in all places A to D should be covered by one FOC.
B	1 May – 31 Jul 2013	150 m^2		
C	15 Dec 2013 – 31 Jan 2014	200 m^2		
D	1 Feb – 31 Mar 2014	200 m^2		

Thank You

Energy Efficiency Office
能源效益事務處

Enquiry : 3757 6156

Email : mbec@emsd.gov.hk

Address : 3 Kai Shing Street, Kowloon

Website : http://www.beeo.emsd.gov.hk/