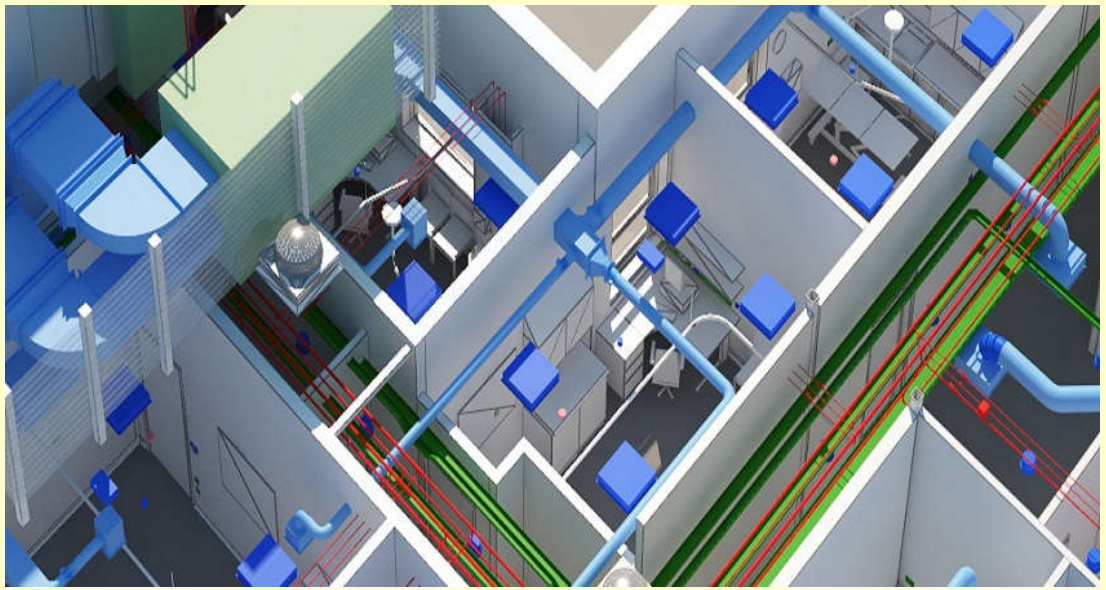

8. Electrical Services Part 1

8.1 Basic principles and practice

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The University of Hong Kong
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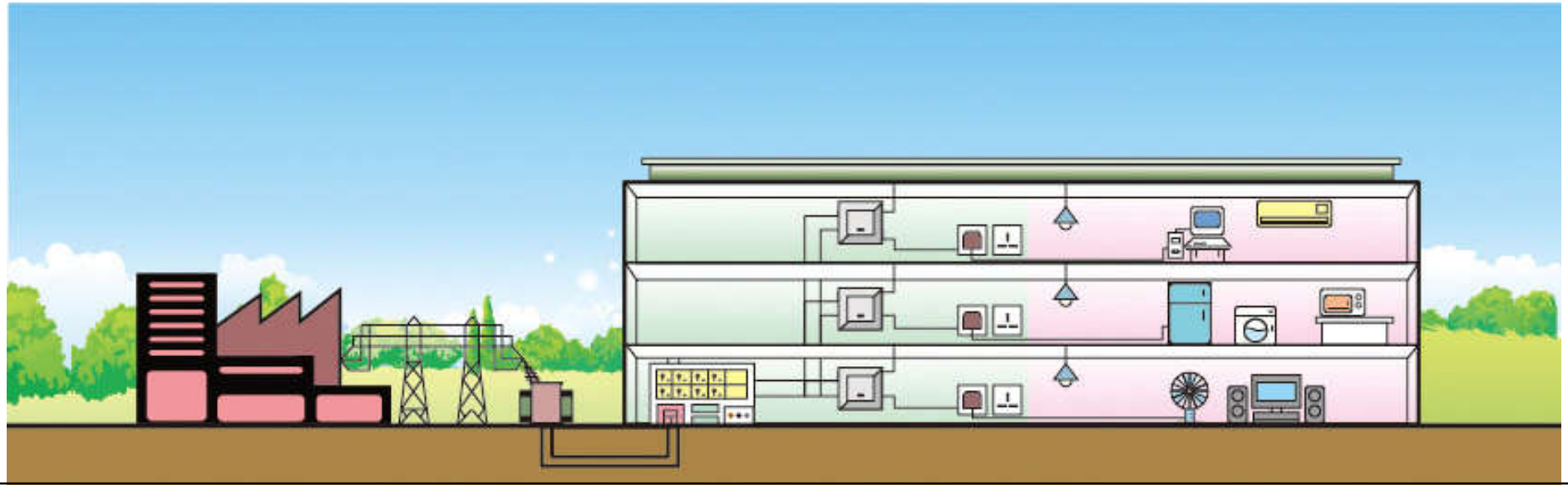
Jun 2021

Contents 內容

- Electricity supply in HK 香港電力供應
- Tariffs & load estimation 電費和負荷估算
- Electrical plantrooms 電氣機房
- Electrical distribution 配電設備

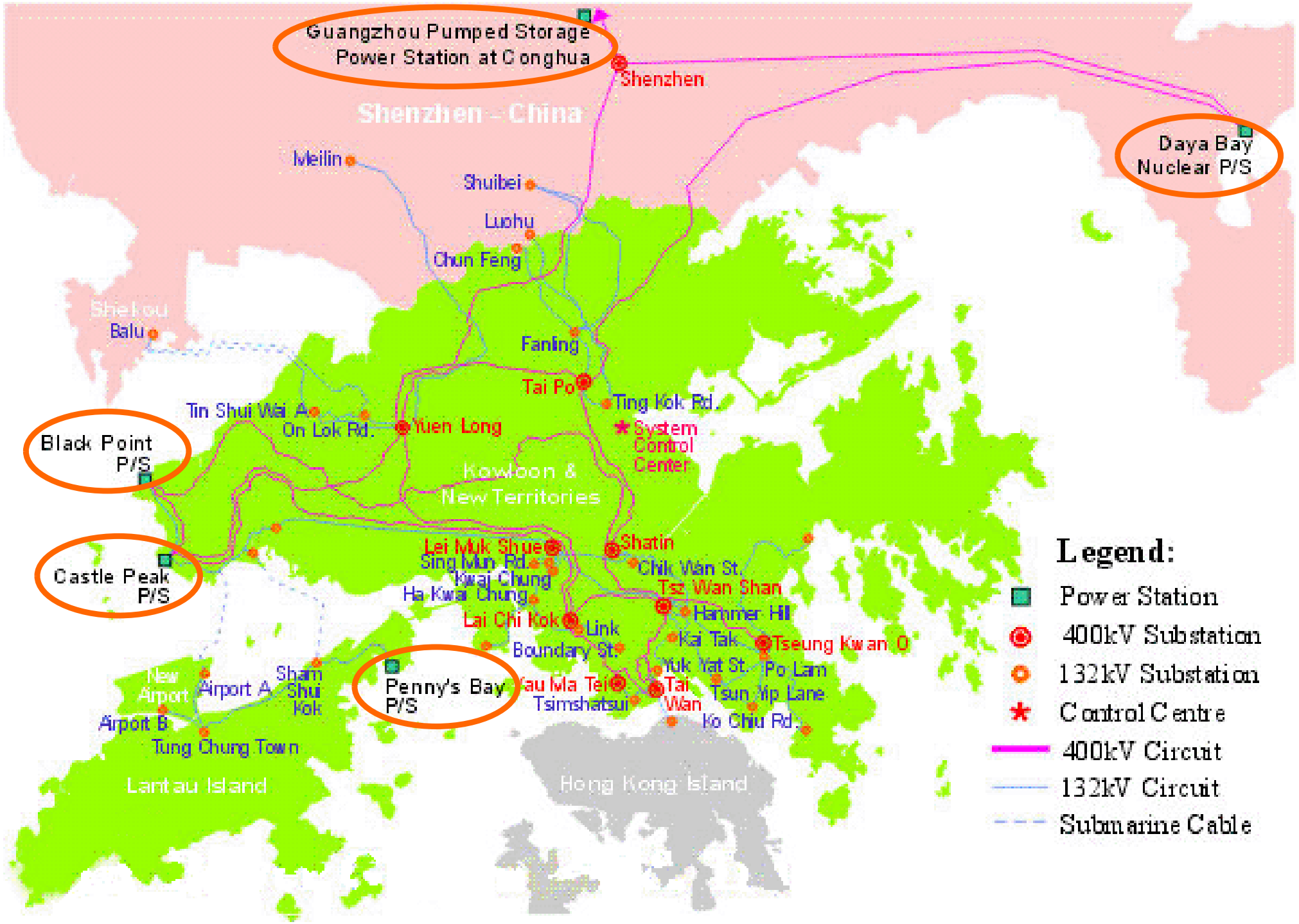


Electricity supply in HK

- Power companies in Hong Kong
  - CLP Power (CLP) 中華電力有限公司
    - http://www.clpgroup.com/
  - HK Electric Investments Limited (HEC) 港燈電力投資有限公司
    - http://www.hkelectric.com/
  - Both are investor-owned, publicly listed
  - Government monitors through the “Scheme of Control Agreements” (SCA) 管制計劃協議

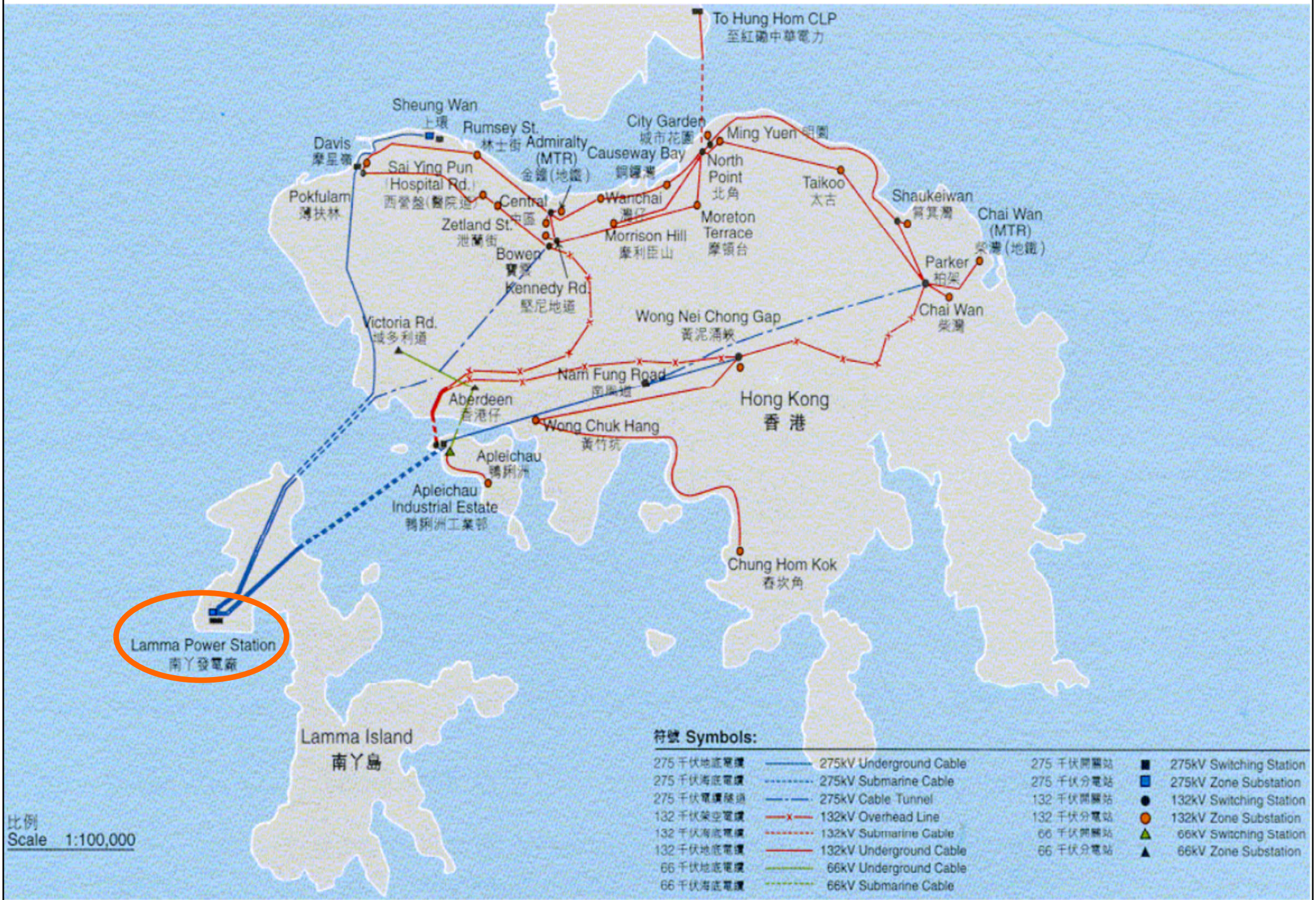
(See also: Hong Kong: the Facts: Power and Gas Supplies https://www.gov.hk/en/about/abouthk/factsheets/docs/power_gas_supplies.pdf)

CLP Power Generation & Transmission Network



(Source: http://www.chinalightandpower.com.hk/)

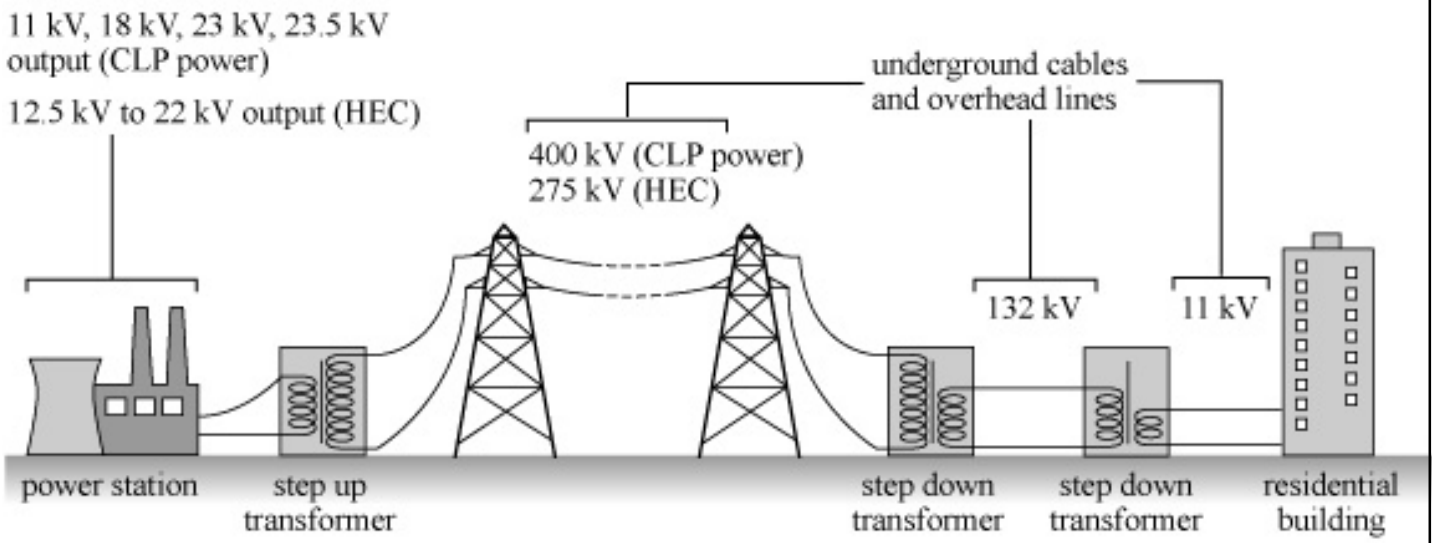
HEC Power Generation & Transmission Network



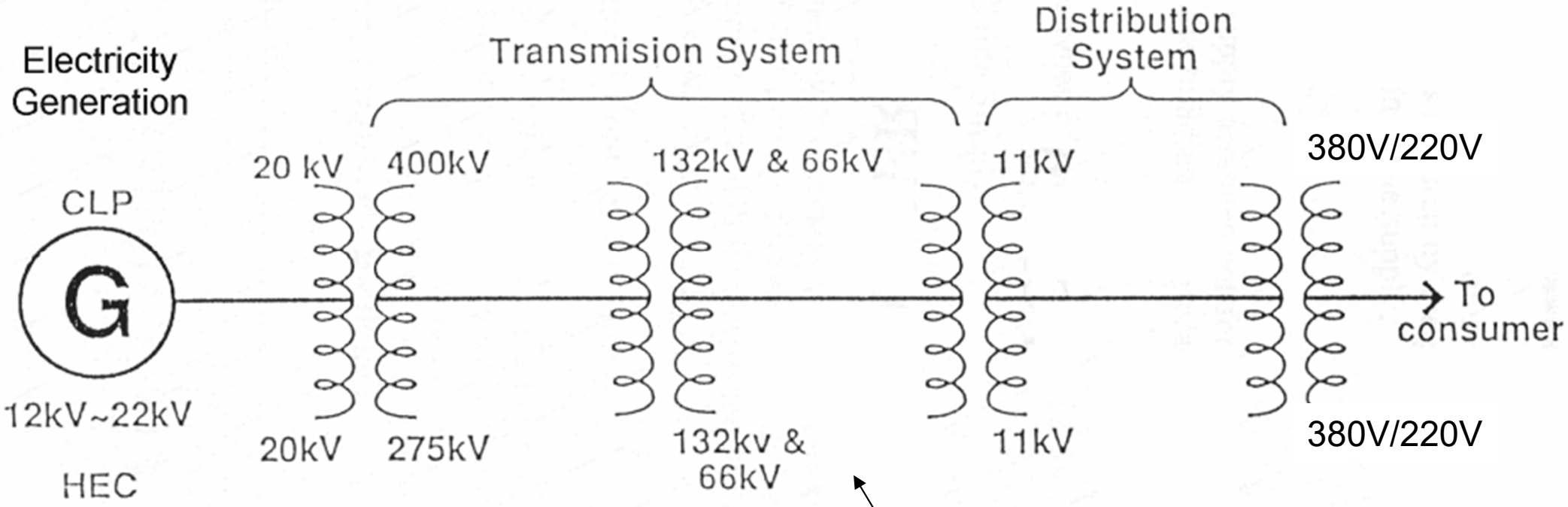
(Source: http://www.hec.com.hk/)

Electricity supply in HK

- Electricity supply process
  - Fuels – imported from overseas
  - Generation – power generation at power plants
  - Transmission – through high voltage lines
  - Distribution – consumer supply (lower voltage)
- CLP's transmission system is also connected to Guangdong (export & import of electricity)
  - Export to some Shenzhen industrial areas
  - Import from Nuclear Power Station at Daya Bay & pumped Storage Power Station at Conghua



CLP's power stations:
- Black Point (2,500 MW)
- Castle Peak (4,108 MW)
- Penny's Bay (300 MW)



HEC's power station:
- Lamma Island (3,757 MW)

Q: Do you know why the transmission system is at higher voltages?

Electricity supply in HK

- Supply voltage & frequency 供電電壓及頻率
  - Alternating current (A.C.) system at 50 Hz
    - Single phase 單相: 220 volts
    - Three phase 三相:
      - Low voltage (LV):- 220/380 volts (3 phase 4 wire) 三相四線
      - High voltage (HV):- 11 kV, 22kV, 132 kV
  - Limits of fluctuation
    - Voltage:
      - 220 volts and 220/380 volts: plus or minus 6%
      - 11 kV, 22kV and 132 kV: plus 10% or minus 2.5%
    - Frequency: 50 Hz – plus or minus 2%

Electricity supply in HK

- Three types of incoming supply
  - Low voltage cable supply
    - When the demand is low (< 240 kVA or < 400 A, 3-phase) & nearby network has adequate capacity
    - Normally, a 4-core aluminum LV cable of 400 A
  - 11 kV high voltage cable & LV supply
    - 11 kV/380 V transformer(s) & HV panels are needed
  - 11 kV incoming supply
    - When load is extremely high and/or security of supply is desirable; require HV switch room

Electricity supply in HK

- Active power (useful or real power) 有功功率
  - Time average of instantaneous power when the average is taken over a complete cycle of an A/C waveform, expressed in Watt (W)
  - For single phase, $P = V\ I \cos \phi$
  - For balanced three-phase, $P = \sqrt{3}\ V_{ph\text{-}ph}\ I \cos \phi$
- Apparent power 視在功率
  - For single phase, $AP = V\ I$
  - For three phase, $AP = \sqrt{3}\ V_{ph\text{-}ph}\ I$

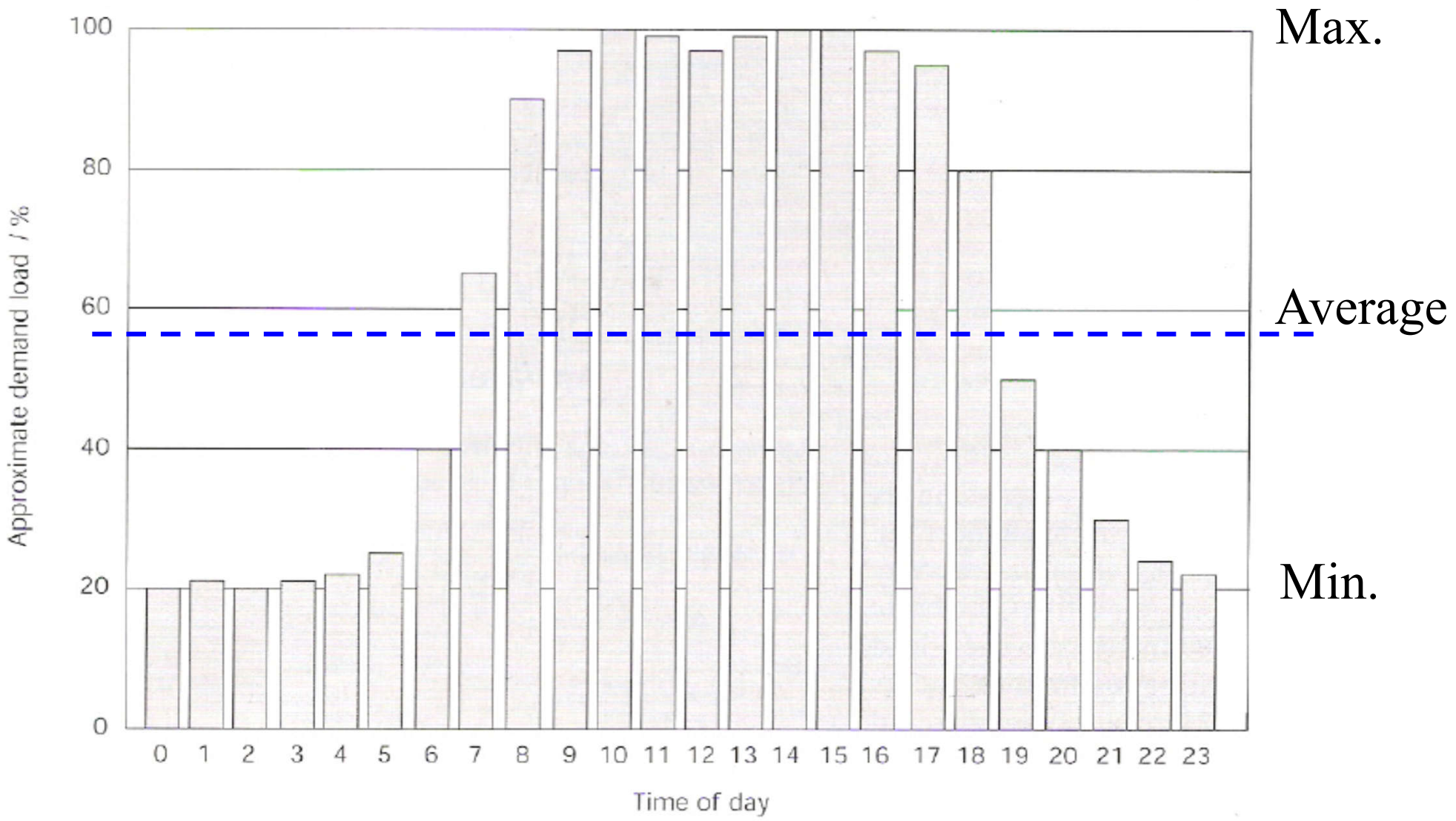
Electricity supply in HK

- Power factor 功率因數
  - The ratio of the apparent power in a circuit (V.A) to the useful power (W) if the voltage and current are sinusoidal
  - Power factor = kW/ kV.A
- Connected load 連接負載
  - Sum of all the loads connected to the electrical system, usually expressed in watts

Tariffs & load estimation

- Electricity tariffs = costing systems that a power company follows to bill the consumers
- Basic terms
  - Maximum demand (in kVA or kW) 最大需求
    - Max. load requirements of the system attained over a specified interval (e.g. 15 min, 30 min., 60 min.)
  - Average demand (in kW) 平均需求
    - Power consumed (kWh) during a period (day, month, year) and then averaged by the duration

Typical load profile for an office building



Q: Do you know how the load profiles affect the operation of power companies?

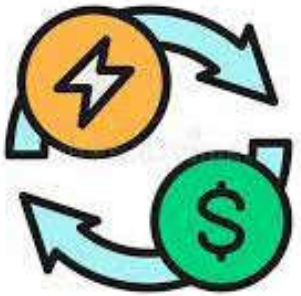
Tariffs & load estimation

- Basic terms (cont'd)
  - Load factor = ratio of average demand to the max. demand during a period 負載係數
    - **Example**: A household has a max. demand of 2 kW on a typical day. During the 24-hour period, the energy consumed is 12 kWh, calculate the load factor.
    - Average demand = 12 kWh/24 hour = 0.5 kW
    - Therefore, load factor = 0.5 / 2 = **0.25**
  - Typical load factors: Office = 0.35; Hospital = 0.7; Domestic = 0.3; Airport = 0.7; Playground = 0.25

Tariffs & load estimation

- Basic terms (cont'd)
  - Diversity/Demand factor 差異/需求因素
    - Ratio of the max. demand of the combined loads of the whole system to the sum of the individual max. demands of various subdivisions of the system (total connected load)
  - Off-peak and on-peak periods 非高峰期和高峰期
    - Off-peak: 09:00pm to 09:00am + all day Sundays & public holidays
    - On-peak: all other hours

Tariffs & load estimation



- Elements of electricity tariffs
  - Demand and energy charges 需求和能源費用
    - Maximum demand charge ($/kVA)
      - Apply to large commercial & industrial customers
    - Energy consumption charge (cents/kWh)
  - Fuel clause/cost adjustment 燃料價格/成本調整
    - Actual cost of fuel less or more than $700 per 44 gigajoules shall be credited or debited
  - Other charges or rebates 其他收費或回扣
    - Such as energy saving rebate, business relief rebate

Do you know how to read the electricity bill?

香港電燈有限公司
The Hongkong Electric Co., Ltd.

港燈 HK Electric

1 **CHAN TAI MAN**
FLAT 2 5/F BLOCK A
HONG KAM COURT
100 SASSOON ROAD POK FU LAM

2 Service Address: ROOM 801, LOK YEE TERRACE, 128 BONHAM ROAD

Account Number: **0123456789**

Date of Bill: 30/06/2015

Domestic Tariff

3 From 01/06/2015 to 30/06/2015 for 30 days of consumption

Meter No.	Present Reading 4	Previous Reading	Units 5	Scheduled Next Meter Reading Date 31/07/2015
3033845	19735	19102	633	

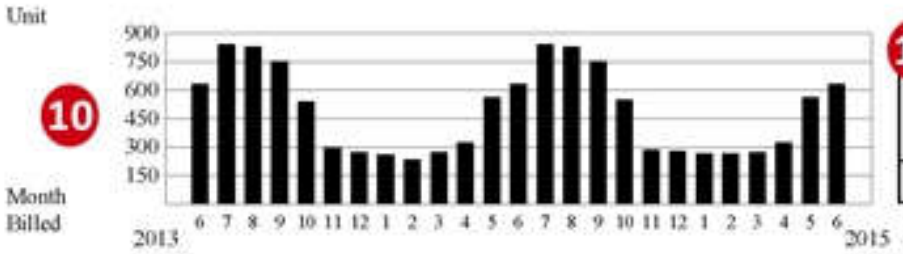
6		
Basic Charge		$530.94
Fuel Clause Adjustment	32.3 ¢/unit 7	204.46
Current Month Charge	8	735.40
Previous Balance		0.94
Balance Carried Forward		-0.34

Last payment of $629.00 on 15/06/2015. Thank you.
Deposit Amount $1000.00

Please Pay This Amount: 9 **$736.00**

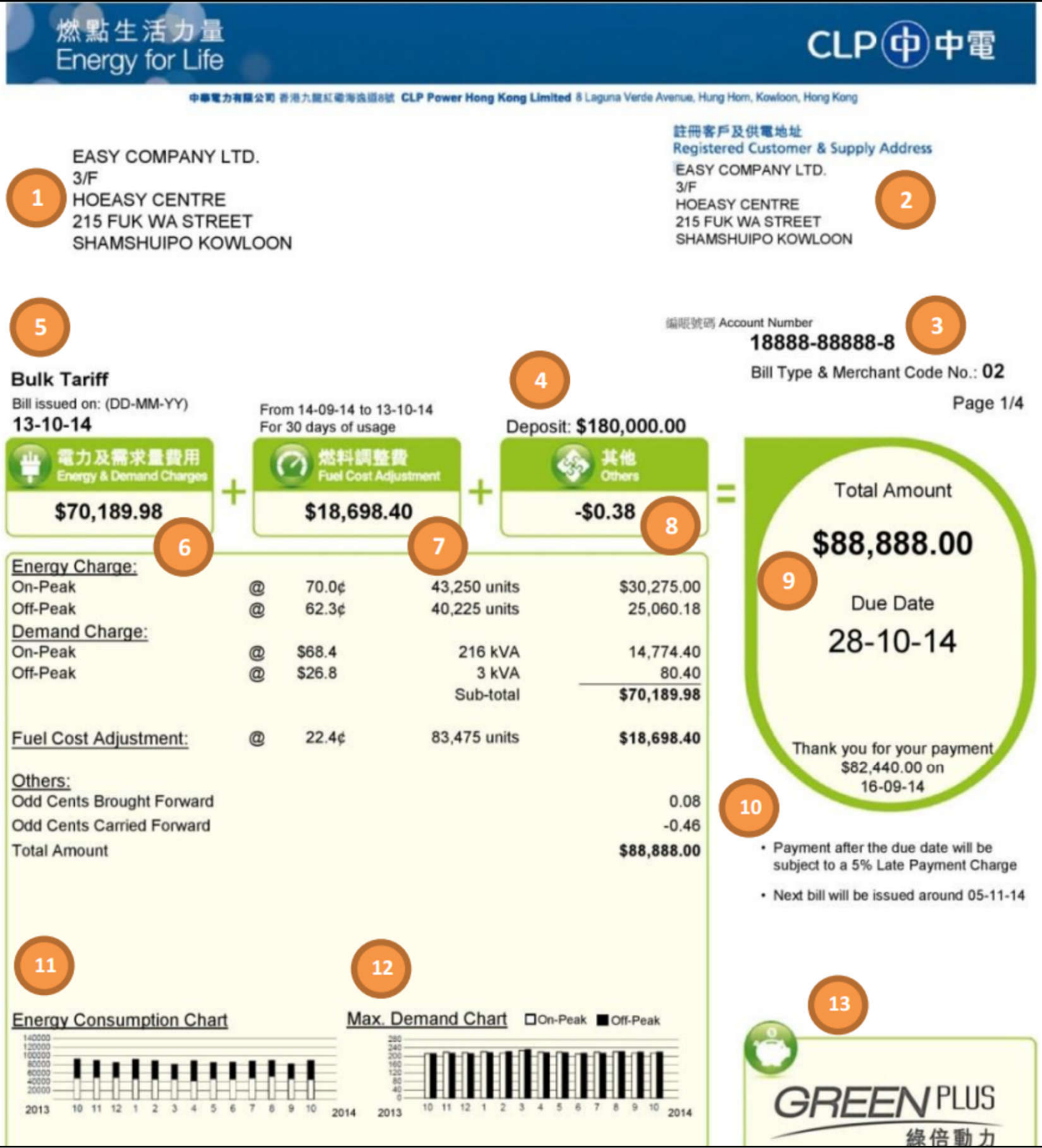
PPS Merchant Code: 03

10



11 CO2 emission per unit of electricity consumed	12 Per capita consumption for HK Electric domestic customers
0.79 kg	170 units / month

Do you know how to read the electricity bill?



燃點生活力量
Energy for Life

CLP 中 中電

中華電力有限公司 香港九龍紅磡海逸道8號 CLP Power Hong Kong Limited 8 Laguna Verde Avenue, Hung Hom, Kowloon, Hong Kong

1
EASY COMPANY LTD.
3/F
HOEASY CENTRE
215 FUK WA STREET
SHAMSHUIPO KOWLOON

註冊客戶及供電地址
Registered Customer & Supply Address
EASY COMPANY LTD.
3/F
HOEASY CENTRE
215 FUK WA STREET
SHAMSHUIPO KOWLOON
2

5
Bulk Tariff
Bill issued on: (DD-MM-YY)
13-10-14

編賬號碼 Account Number
18888-88888-8
3
Bill Type & Merchant Code No.: 02
Page 1/4

From 14-09-14 to 13-10-14
For 30 days of usage

4
Deposit: $180,000.00

電力及需求量費用 Energy & Demand Charges	+	燃料調整費 Fuel Cost Adjustment	+	其他 Others	=	Total Amount
$70,189.98		$18,698.40		-$0.38		$88,888.00
6		7		8		9

Due Date
28-10-14

Thank you for your payment
$82,440.00 on
16-09-14

Energy Charge:				
On-Peak	@	70.0¢	43,250 units	$30,275.00
Off-Peak	@	62.3¢	40,225 units	25,060.18
Demand Charge:				
On-Peak	@	$68.4	216 kVA	14,774.40
Off-Peak	@	$26.8	3 kVA	80.40
			Sub-total	**$70,189.98**
Fuel Cost Adjustment:	@	22.4¢	83,475 units	**$18,698.40**
Others:				
Odd Cents Brought Forward				0.08
Odd Cents Carried Forward				-0.46
Total Amount				**$88,888.00**

10
- Payment after the due date will be subject to a 5% Late Payment Charge
- Next bill will be issued around 05-11-14

11
Energy Consumption Chart
2013 10 11 12 1 2 3 4 5 6 7 8 9 10 2014

12
Max. Demand Chart ☐On-Peak ■Off-Peak
2013 10 11 12 1 2 3 4 5 6 7 8 9 10 2014

13
GREEN PLUS
綠倍動力

Example Calculation: HEC Maximum Demand Tariff

A commercial building with a low voltage power supply from HEC has these demand/consumption in a month. Calculate the electricity charge.

- Maximum demand = 800 kVA
- Consumption = 200,000 kWh

Demand charge	400 kVA x $48.3 400 kVA x $47.3	$38,240
Basic charge	(200 units x 800 kVA/unit) x $0.947 40,000 kWh x $0.901	$187,560
Fuel adjustment	32.3 cents/kWh x 200,000 kWh	$64,600
Total amount =		**$290,400**

If the maximum demand is reduced to 600 kVA, what will be the total amount of electricity charge? (Ans.: $279,100)

Tariffs & load estimation

- Electrical load within most commercial buildings can be arranged into the following broad categories:
  - 1. Lighting 照明
  - 2. Small power & special user equipment 小功率及特殊用戶設備
  - 3. Heating, ventilating & air-conditioning (HVAC) equipment 暖通空調設備
  - 4. Lifts & escalators 升降機和自動扶梯

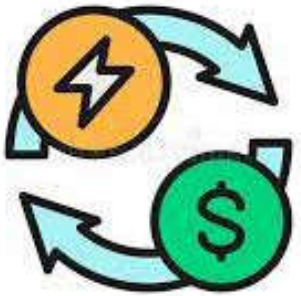
Tariffs & load estimation

- General considerations:
  - Usable floor area (UFA) (m^2)
    - Follow Building (Planning) Regulations
  - Development information
    - Floor area usage, public services, any special loads
    - Load capacity/density (W/m^2 or kVA/m^2)
  - Public services
    - Assessed independently
    - Such as public lighting, lift, water pump, fire services, lobby air conditioning

Minimum design load capacities for lighting and small power requirement for various types of building

Building type	**Minimum load capacity** (W/m^2)
Office	60
School	30
Residential building	30
Hospital	25
Hotel	25
Church	15

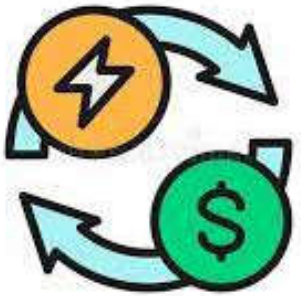
Tariffs & load estimation



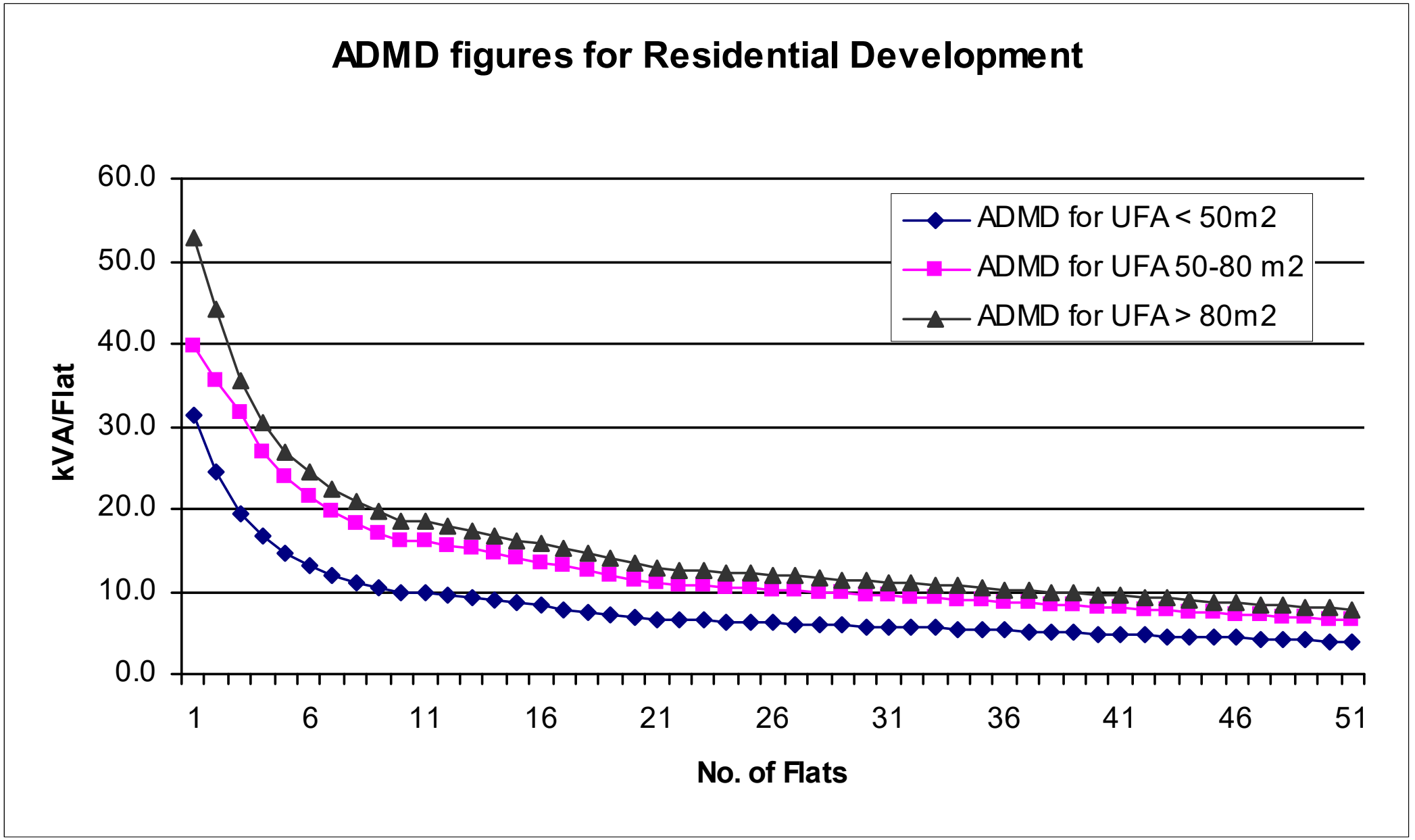
- Code of Practice 215: Load Assessment Procedure (from CLP)
  - Guidelines for load assessment
    - Residential
    - Commercial
    - Industrial
    - Data centre
    - Municipal
    - Mixed development diversity factor (MDDF)
    - Central air conditioning load
    - Other special loads
  - Apply after diversity maximum demand (ADMD) figures

Diversity for mixed usages (e.g. domestic-commercial)

Tariffs & load estimation



- After diversity maximum demand (ADMD)
  - Load densities derived by dividing the aggregate load by the corresponding UFA or flat nos.
  - Cover most typical cases; for special situation, designer/planning engineer may exercise his own discretion to adjust the load estimates
  - ADMD is for planning supply transformer (Tx) capacity, it may not be suitable for designing customer raising mains and lateral mains



What is the effect of load diversity on the kVA/flat data?

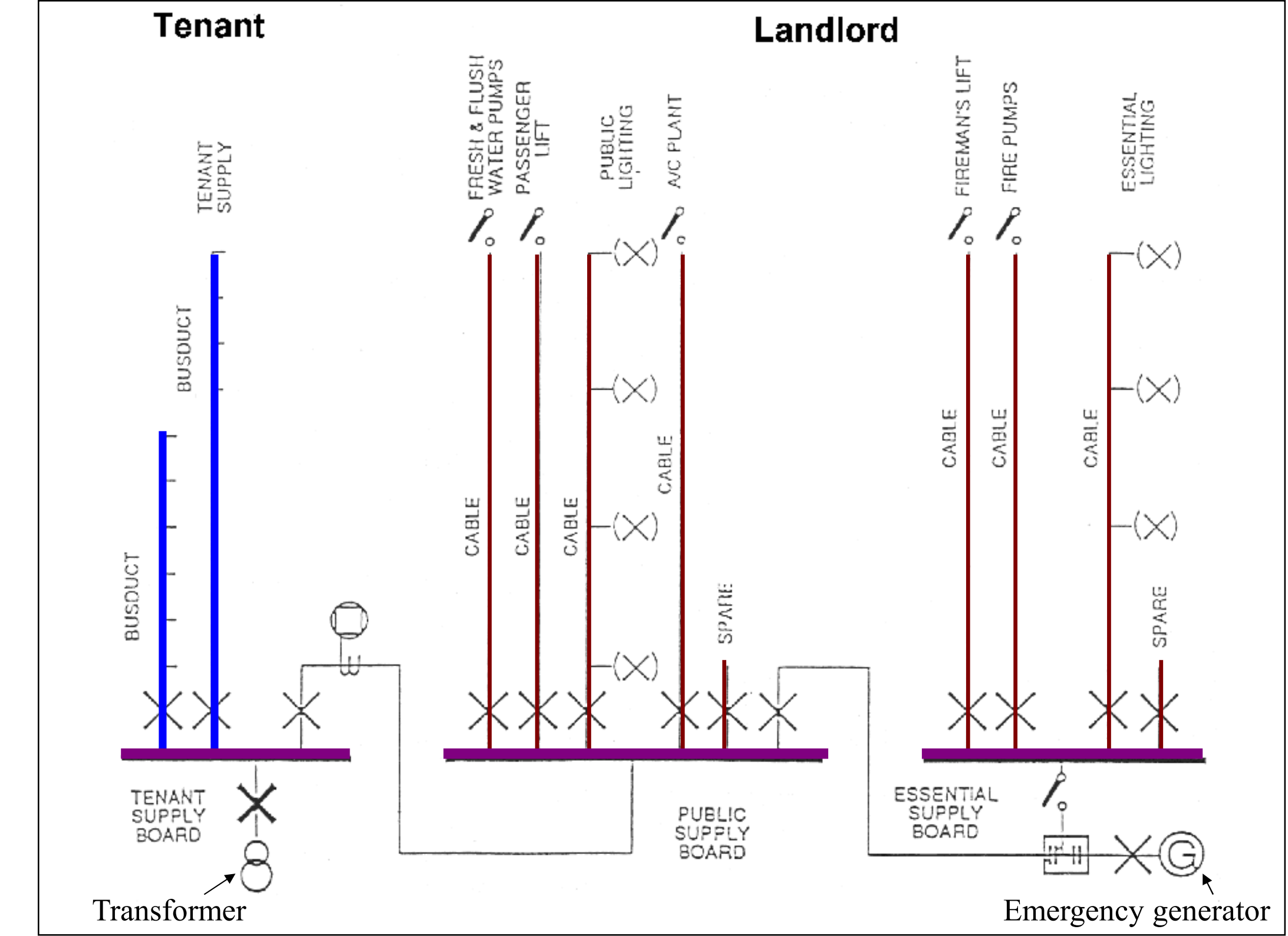
(Source: CLP's COP 215 Load Assessment Procedure)

Tariffs & load estimation

- Load evaluation by power company
  - Architect/Engineer/Developer submit application
  - For typical categories, planning engineer of power company assesses the load estimation using the database Load Assessment Programme (LAST)
  - Compare the declared load with assessed load
    - If declared load > assessed load, justification is needed
  - After finalising the total load, determine the nos. of transformer and transformer bays

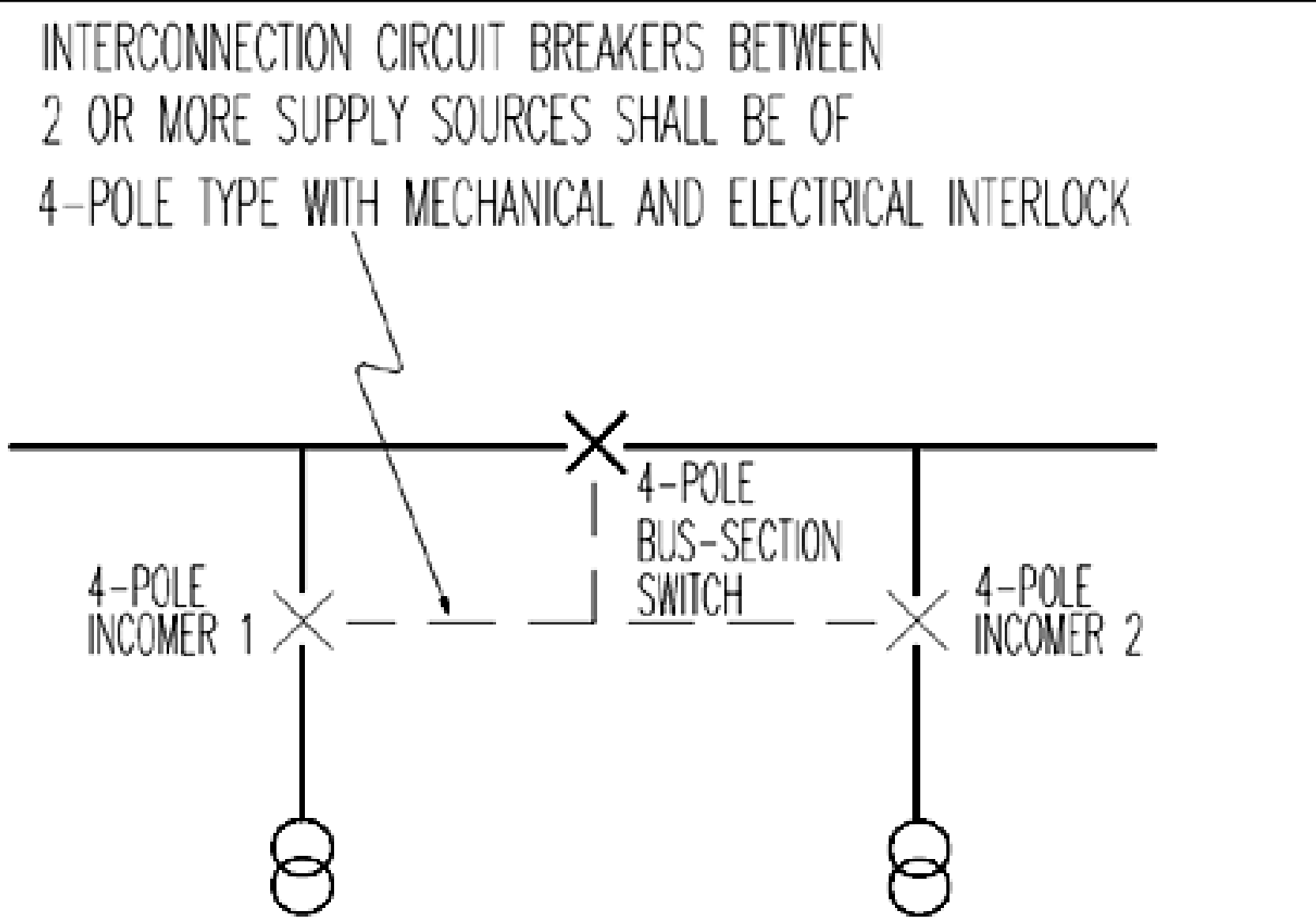
Electrical plantrooms

- Space planning and design for major plants:
  - Transformer (Tx) room (substation) 變壓房/分站
  - Main switch room 總開關掣房
  - Emergency generator room 應急發電機房
- Other plant room space:
  - Meter rooms or space
  - Fuel tank room (fuel for emergency generator)
  - Pipe duct or space for vertical risers
  - Other switch rooms or control rooms


Tenant
Landlord
TENANT SUPPLY
BUSDUCT
BUSDUCT
FRESH & FLUSH WATER PUMPS
PASSENGER LIFT
PUBLIC LIGHTING
A/C PLANT
CABLE
CABLE
CABLE
CABLE
SPARE
FIREMAN'S LIFT
FIRE PUMPS
ESSENTIAL LIGHTING
CABLE
CABLE
CABLE
SPARE
TENANT SUPPLY BOARD
PUBLIC SUPPLY BOARD
ESSENTIAL SUPPLY BOARD
Transformer
Emergency generator

Electrical plantrooms

- Tenant supply – energy consumed by each tenant; monitored by separate energy meter
- Landlord supply:
  - Non-essential supply: plumbing and drainage, passenger lifts, air-conditioning plant, public lighting
  - Essential supply: fire protection/detection system, fireman's lifts, essential lighting, PABX system, building management system, important computer room



Drg. No. GCS/6/05

ARRANGEMENT OF INTERCONNECTION CIRCUIT BREAKERS BETWEEN TWO OR MORE SUPPLY SOURCES

Source: HEC's Guide to Connection of Supply

Electrical plantrooms

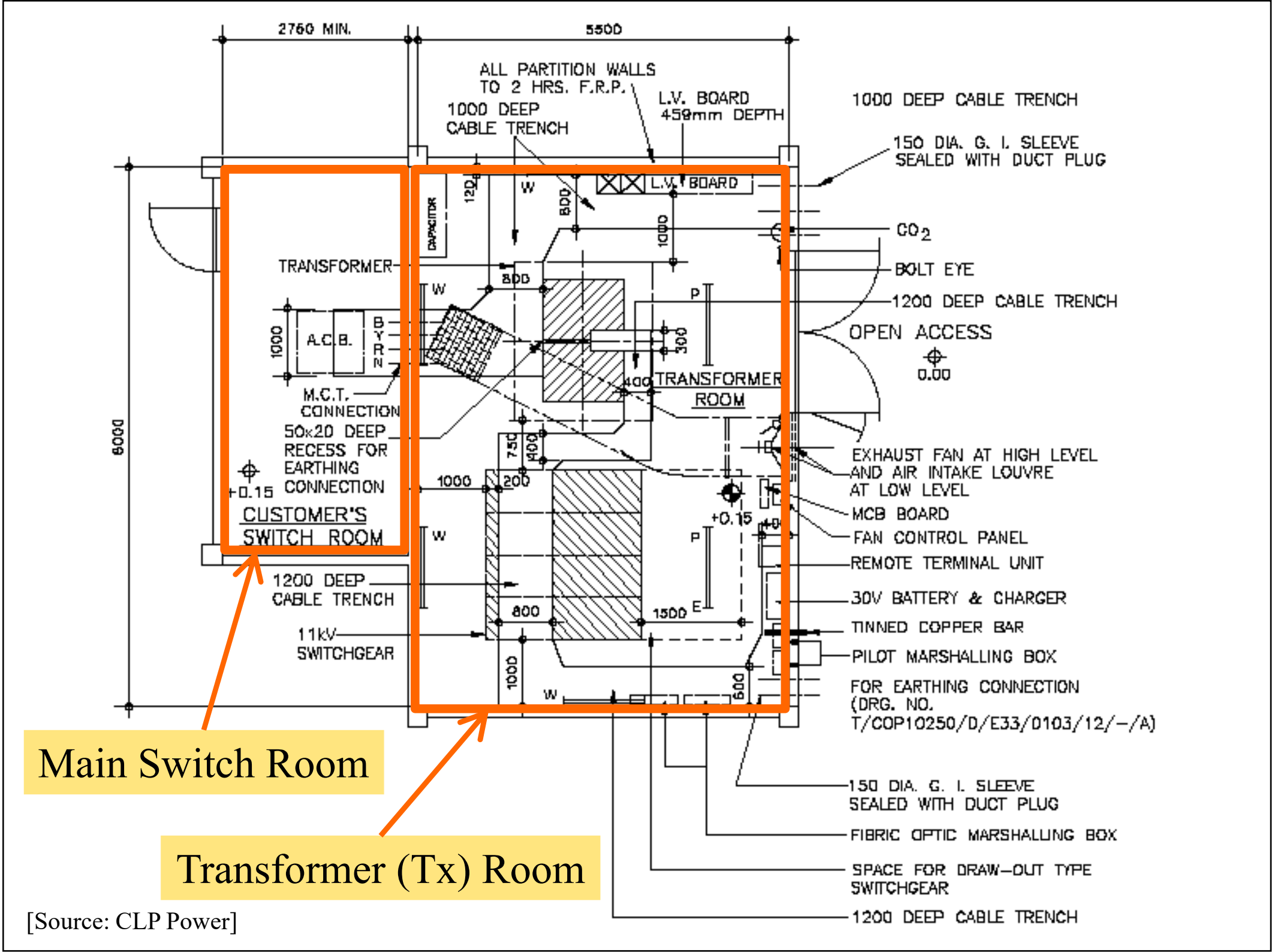
- Three situations for transformer (Tx) location:
  - Ground-floor (G/F) Tx room
  - Basement Tx room
  - Upper floor Tx room
- Must follow the technical requirements of the power company and statutory bodies
  - See HEC's "Guide to Connection of Supply" 接駁電力供應指南, CLP's code of practice, & Supply Rules 供電則例

(See also: CLP, 2020. *Code of Practice 101 for Distribution Substation Design*, Version 15, CLP Power Hong Kong Limited, Hong Kong. https://www.clp.com.hk/en/customer-service/open-and-close-account/cop-101-distribution-substation-design)

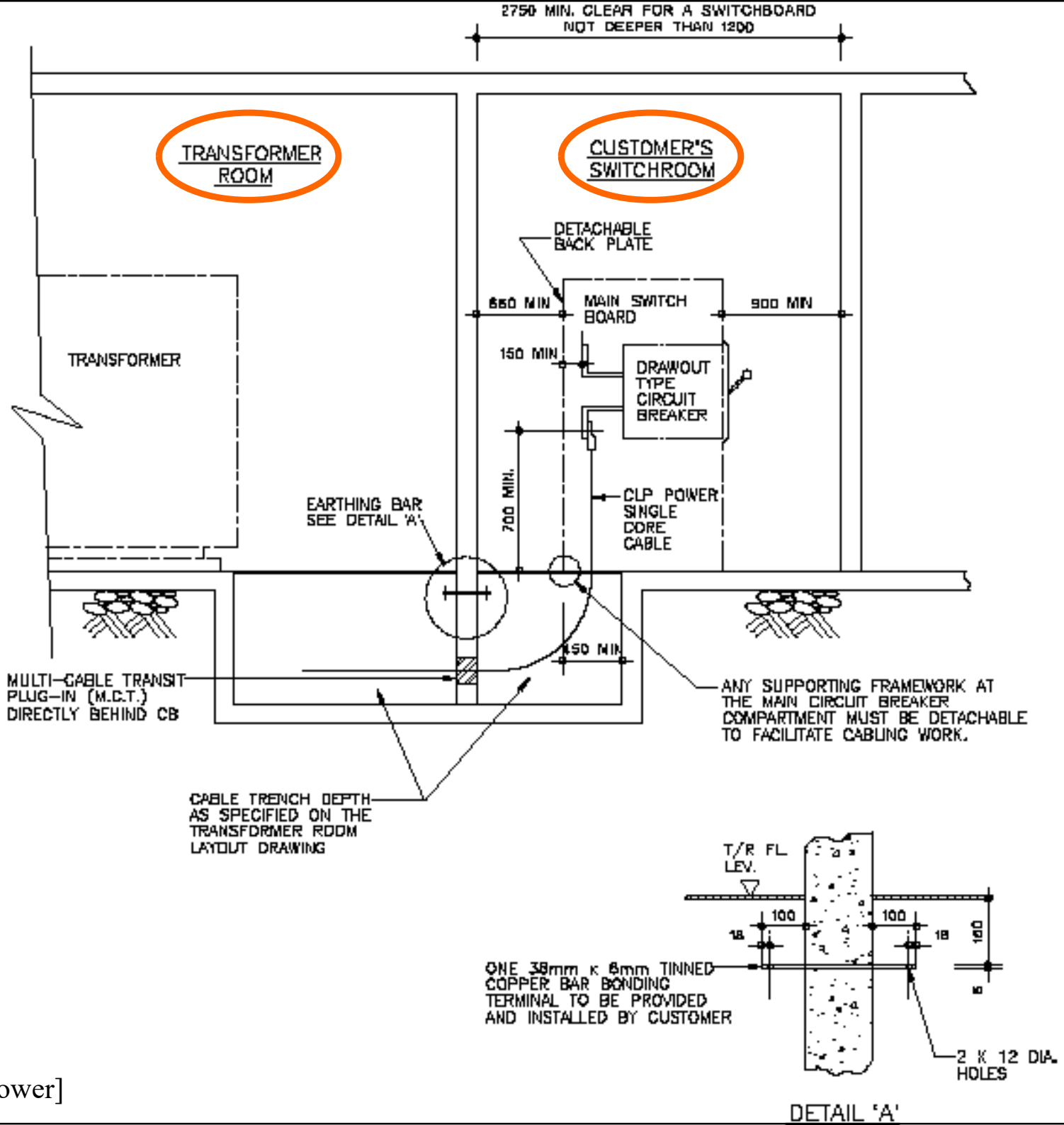
Electrical plantrooms

- Major equipment in Tx rooms
  - Power transformer(s) [@ max. 1500 kVA]
  - 11 kV switchgear (ring main unit, RMU)
- Other equipment *
  - LV switchboard
  - LV capacitor bank
  - Battery & charger
  - Marshalling boxes
  - Meter panel

(*See also: CLP, 2020. *Code of Practice 101 for Distribution Substation Design*, Version 15, CLP Power Hong Kong Limited, Hong Kong. https://www.clp.com.hk/en/customer-service/open-and-close-account/cop-101-distribution-substation-design)



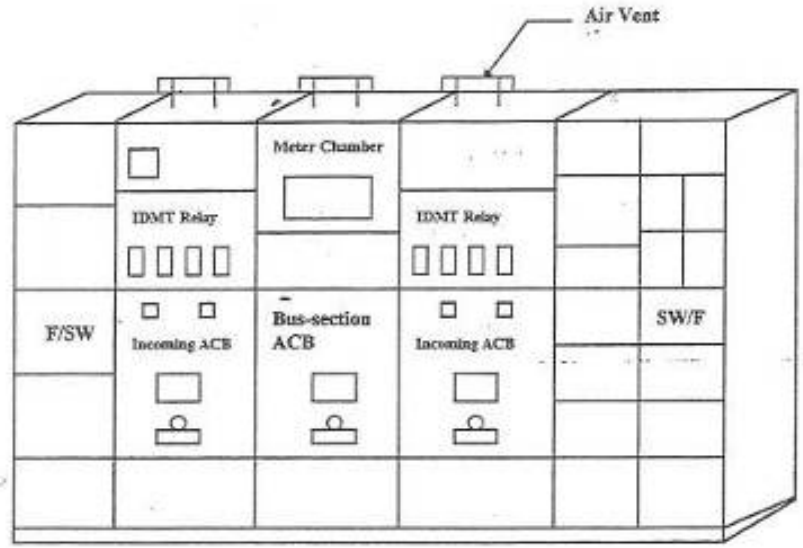
[Source: CLP Power]



[Source: CLP Power]

Electrical plantrooms

- Main Switch Room: major considerations
  - Position
  - Access
  - Dimensions
  - Working space
  - Routing of outgoing circuits
  - No other services
  - Ventilation & illumination



Cubicle-mounted Switchboard

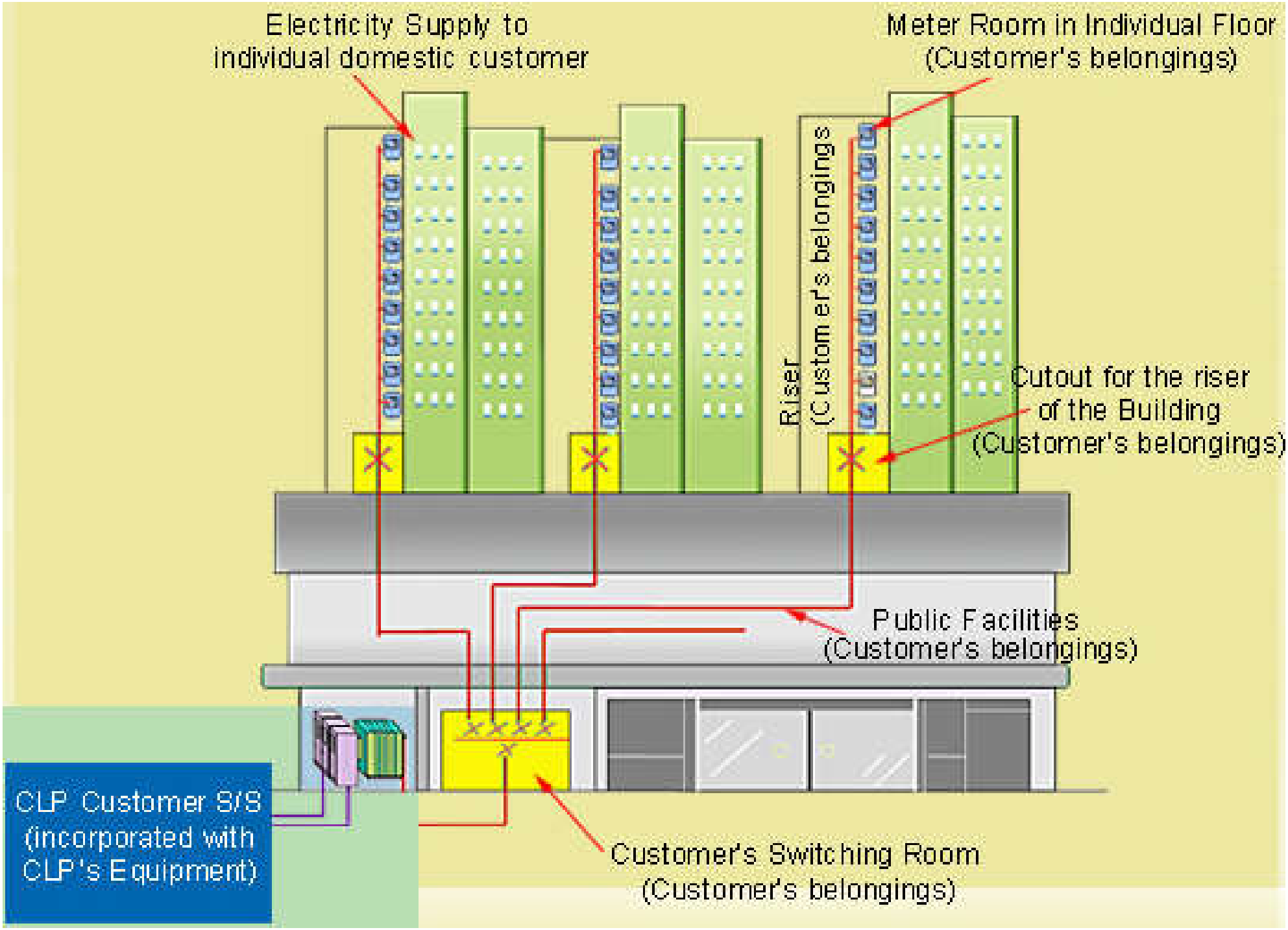
Electrical plantrooms

- Main switchboard 總電掣櫃
  - Receive & distribute the electrical power
  - Fault protection & coordination (circuit breakers)
  - Power factor correction
  - Metering
  - Construction, such as:
    - Assembly method
    - Mechanical protection

Electrical distribution

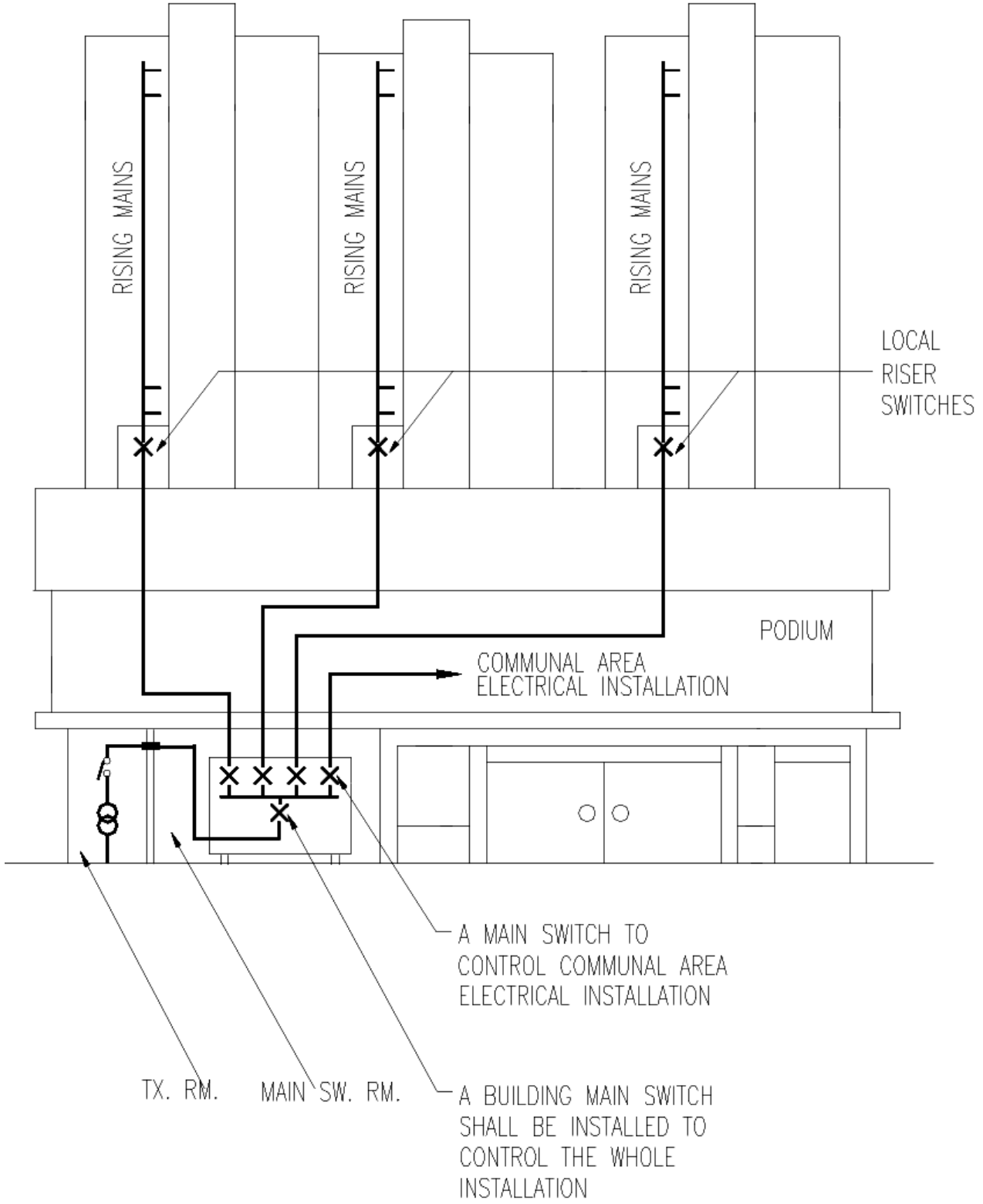
- Distribute electricity throughout the building
  - 3-phase 4-wire tee-off for buildings > 4 floors
  - Separate riser earthing conductor
  - Metering arrangements (e.g. multiple tenants)
    - Switching and isolating
- Types of rising mains 上升總線
  - Cable system (up to 800 A)
  - Busduct or busbar trunking system 匯流排
- Main distribution > Sub-main > Final circuits

Demarcation between power company and users' installations



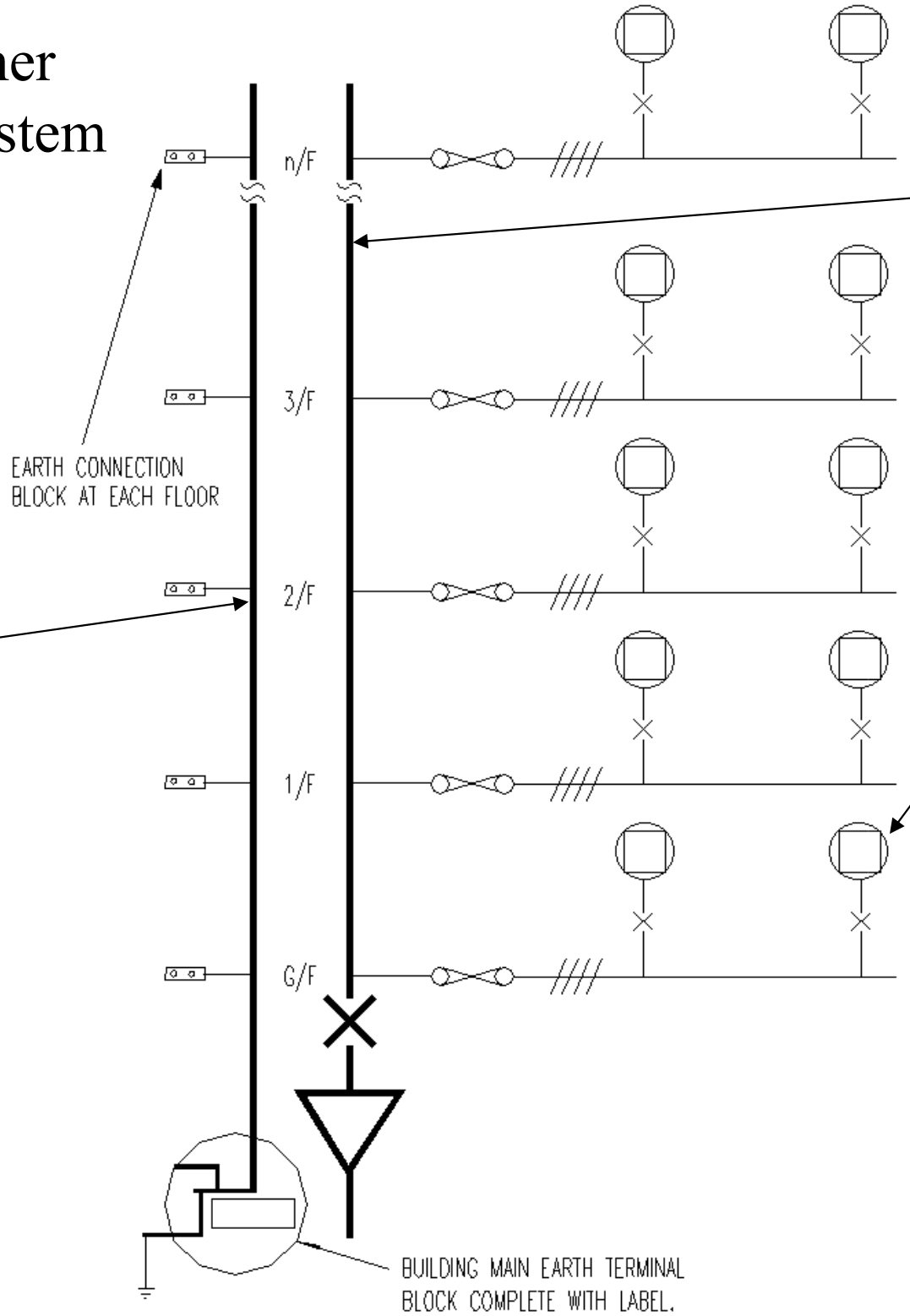
[Source: https://www.clp.com.hk/en/customer-service/electricity-knowledge/demarcation-between-clps-and-users-installations]

Main switch/local riser switch arrangement



Source: HEC's Guide to Connection of Supply

Multi-customer rising mains system

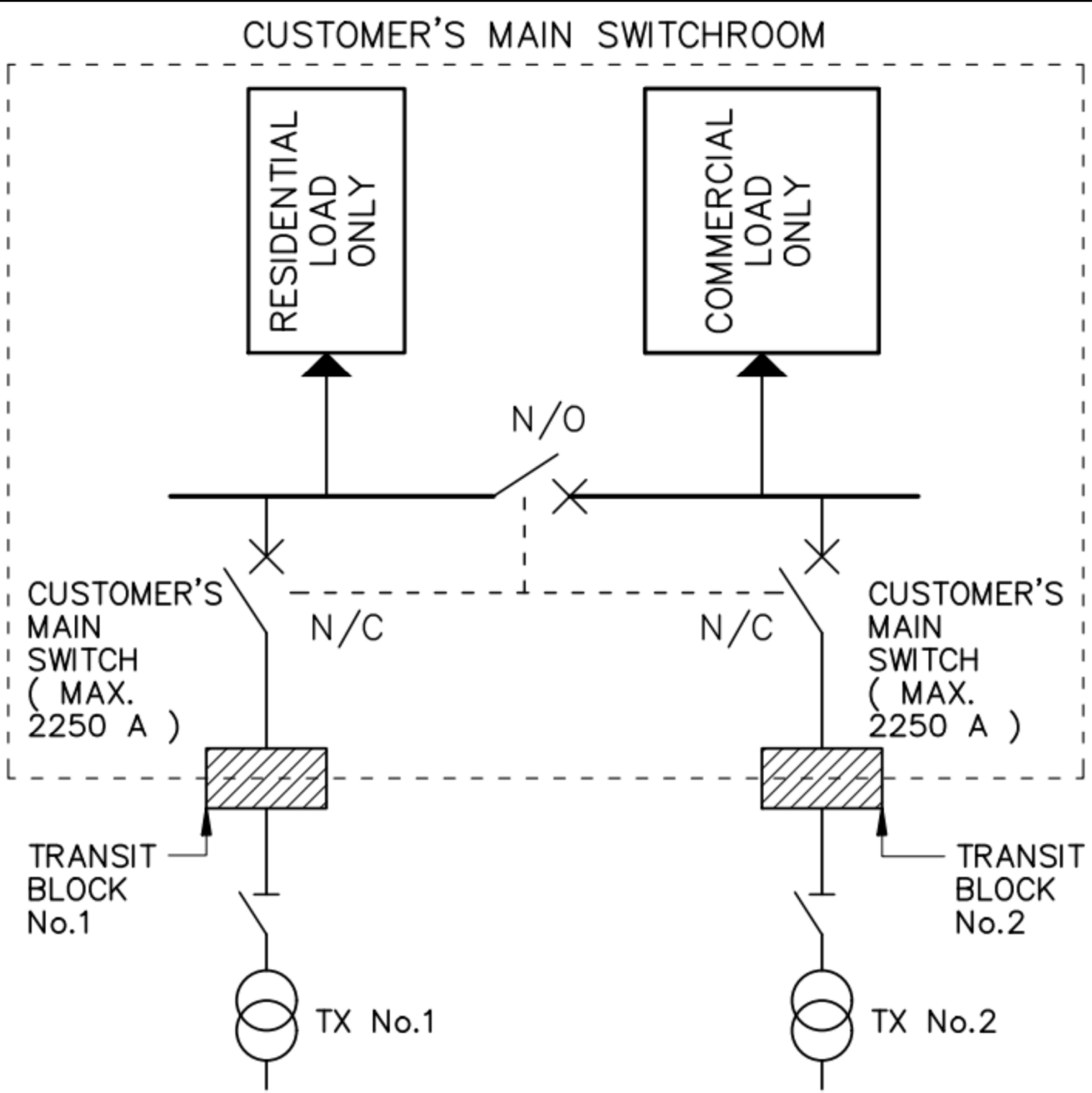


3-phase supply rising mains

Earthing rising mains

Electricity meter

Source: HEC's Guide to Connection of Supply



A design example for connection of residential load & commercial load within the same development

[Source: HEC, 2017. *Guide to Connection of Supply*, 6th Edition, Hongkong Electric Co., Ltd. (HEC), Hong Kong.]

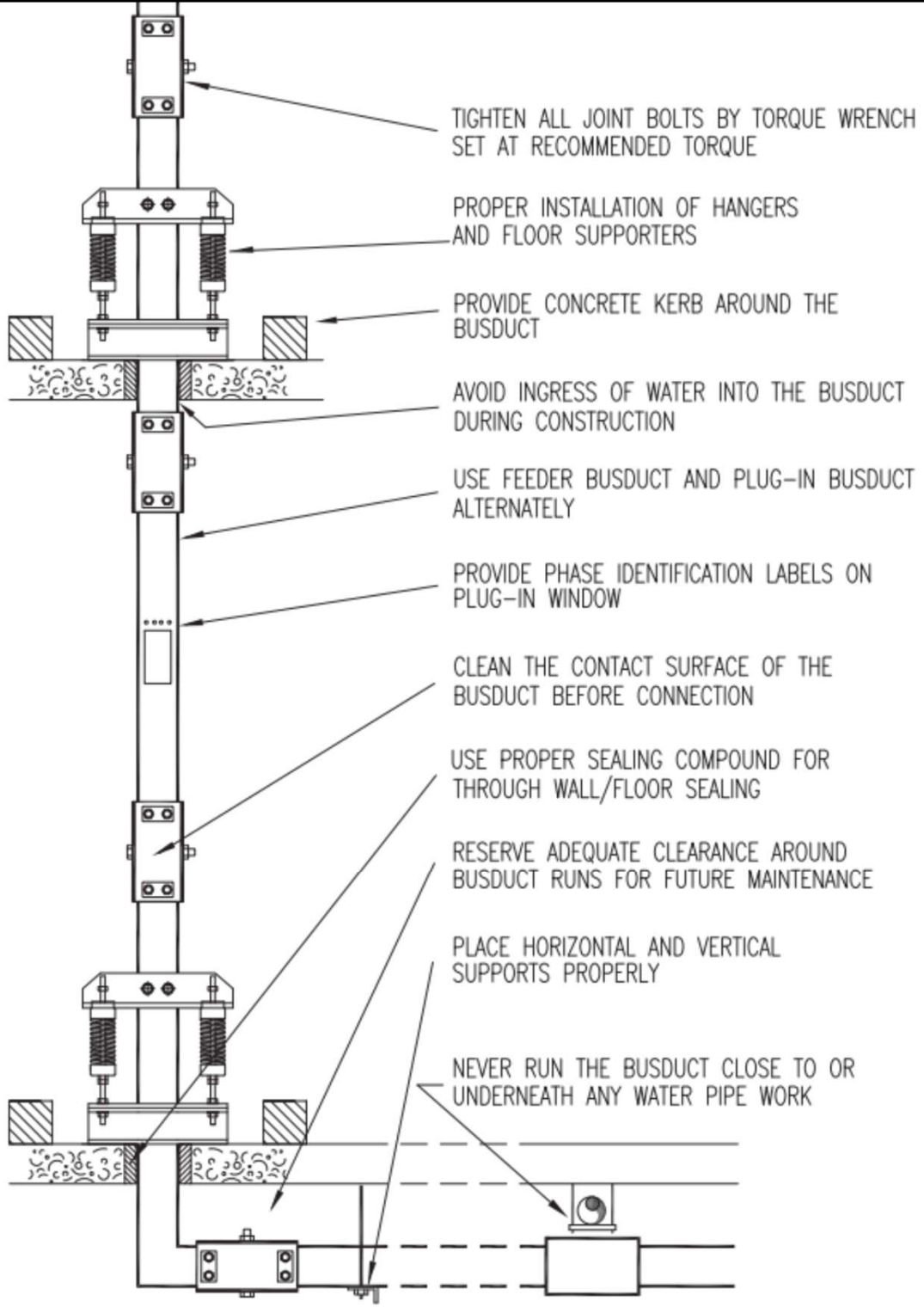
Electrical distribution

- Busduct installation
  - Hoisting & handling
  - Busduct support
  - Joint assembly
  - Plug-in devices
  - Protection against ingress of liquid
- Busduct maintenance
  - Inspect periodically & after major electrical fault
  - Check for moisture condensation, dust, corrosion

Common problems with busduct risers

1. Rusty casing
2. Busduct joint bolt not tightened to manufacturer's recommended torque
3. Peeled-off conductor coating
4. Damaged/tucked insulation sheath for conductor
5. Insulation resistance of riser exceeds recommended value
6. Busduct flange end & power cable are not jointed properly
7. Powdery particles/oxidation at busduct conductor surface
8. Spring hanger unit not installed well
9. Stain of cement water/cement at busduct joint position
10. Fire barrier not provided between floors
11. Alignment of busduct spring hanger is not up to standard
12. Alignment of busduct section is poor
13. Spring hanger nuts are not fully tightened
14. Conditions of duct room is not good

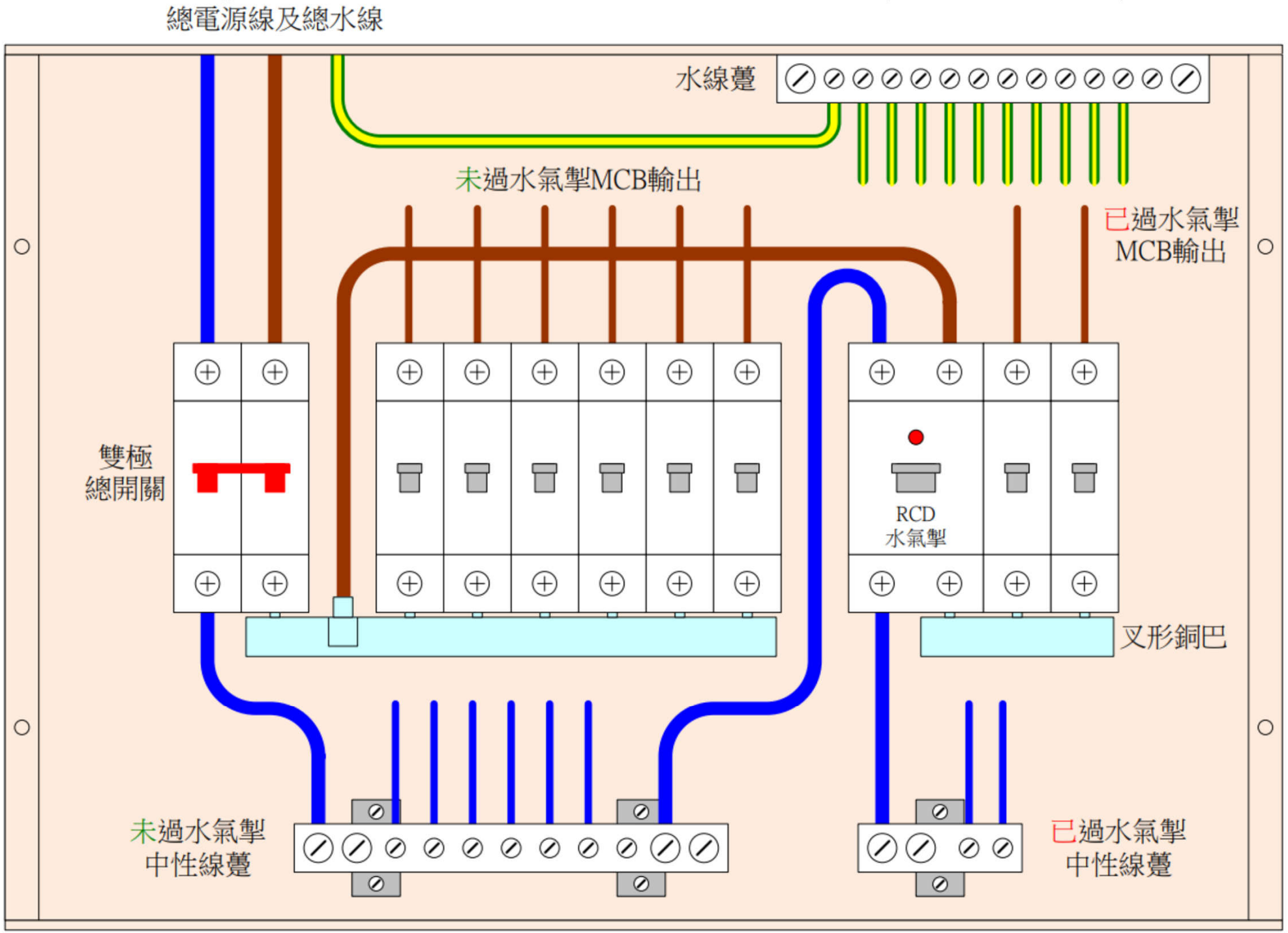
[Source: HEC, 2017. *Guide to Connection of Supply*, 6th Edition, Hongkong Electric Co., Ltd. (HEC), Hong Kong.]



Important points on busduct work

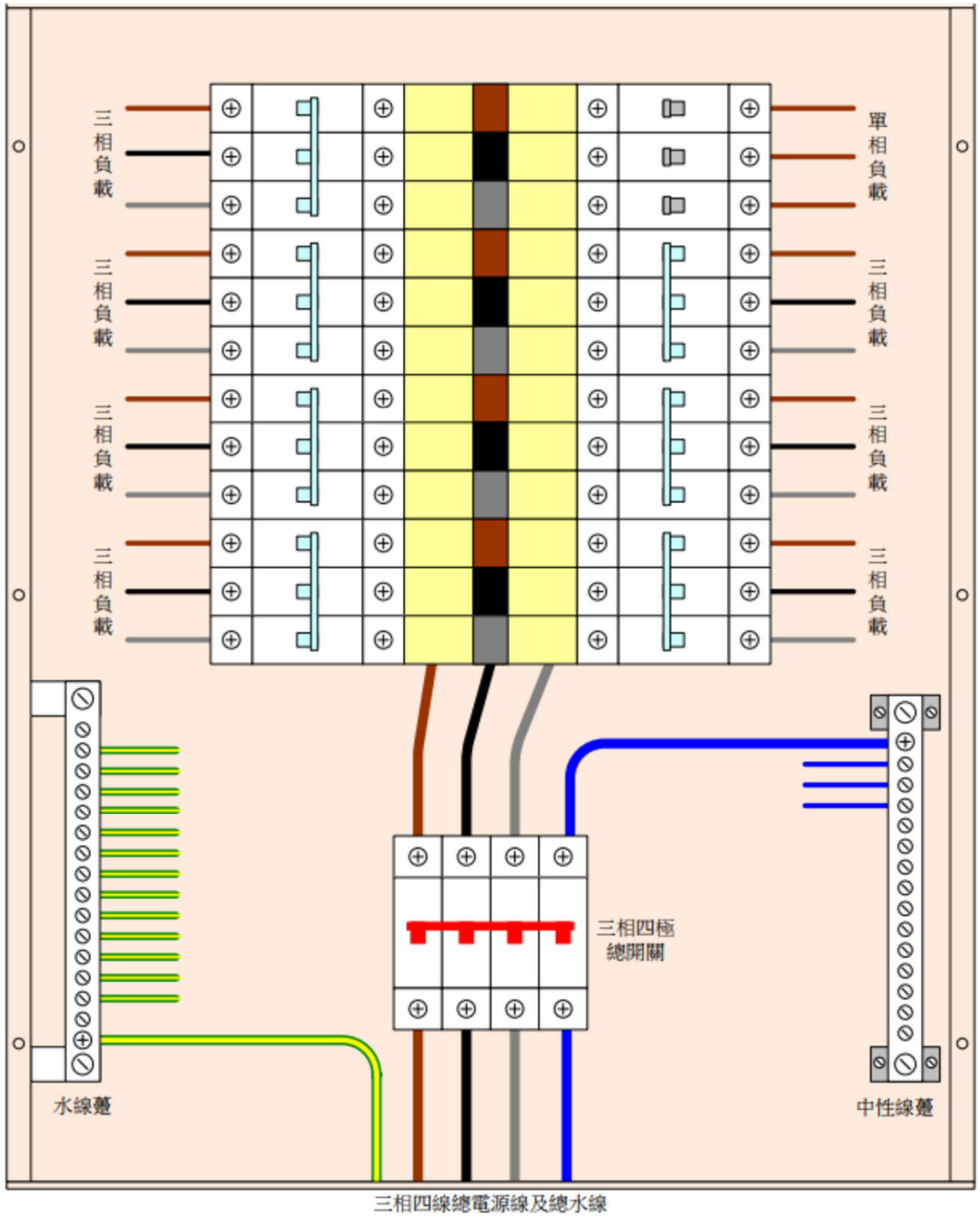
[Source: HEC, 2017. *Guide to Connection of Supply*, 6th Edition, Hongkong Electric Co., Ltd. (HEC), Hong Kong.]

Single Phase MCB Distribution Board (單相配電箱)



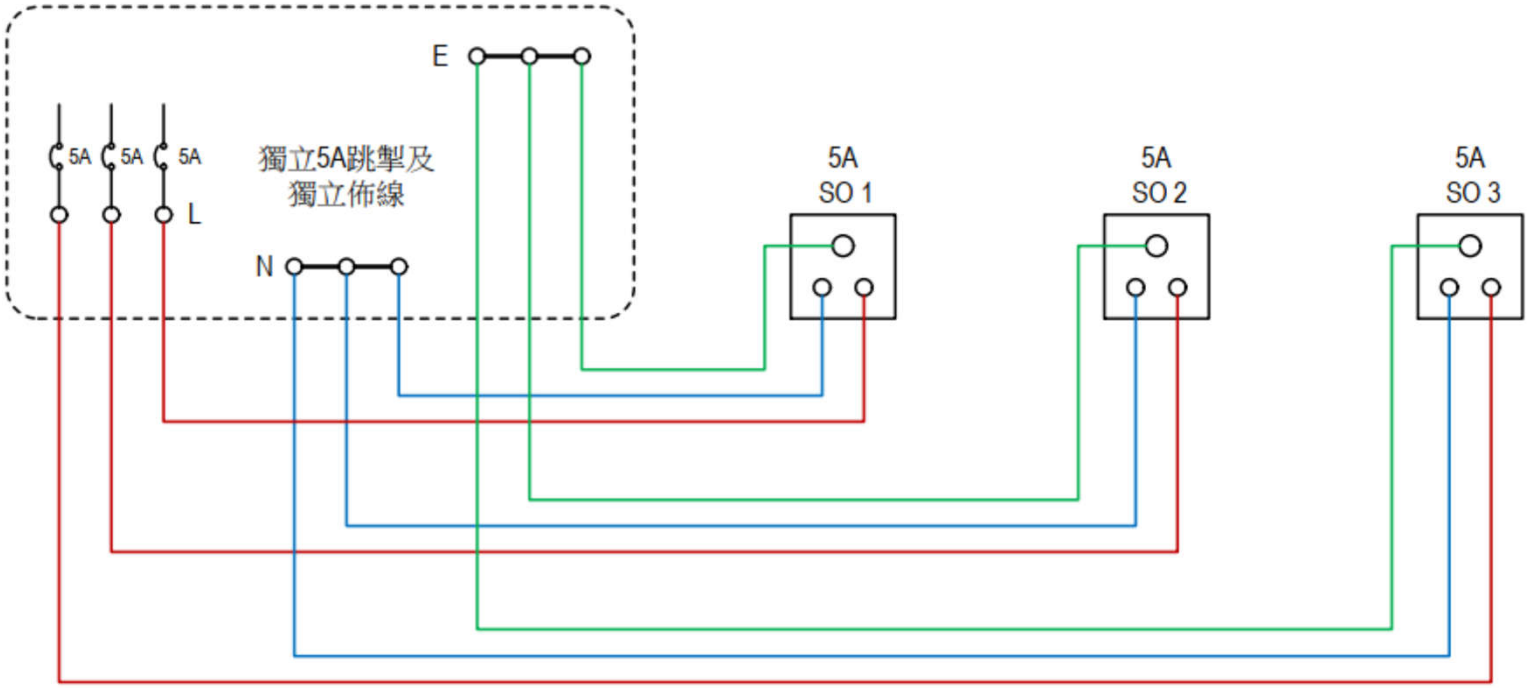
[Source: http://www.ksmak-sir.com/pdf/EIT.zip]

3 Phase MCB Distribution Board (三相配電箱)

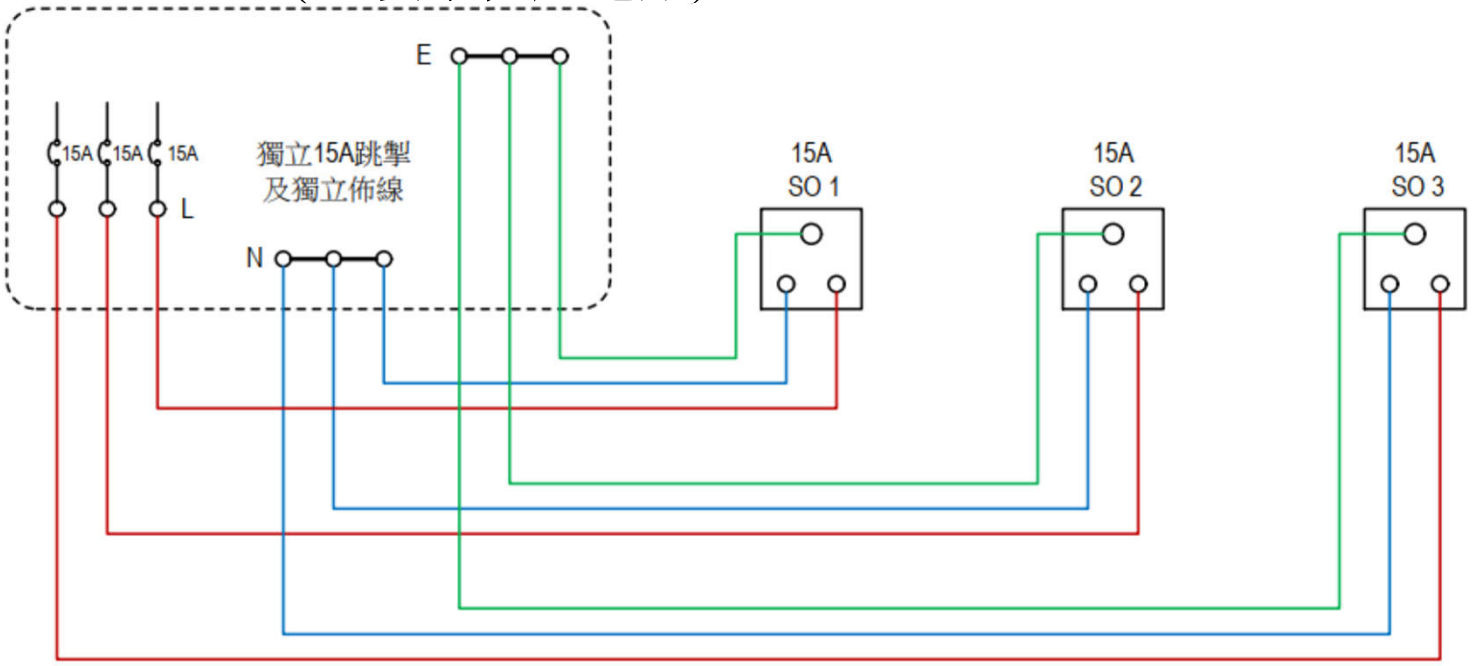


[Source: http://www.ksmak-sir.com/pdf/EIT.zip]

5A Socket Outlet Circuit (5 安培插座電路):



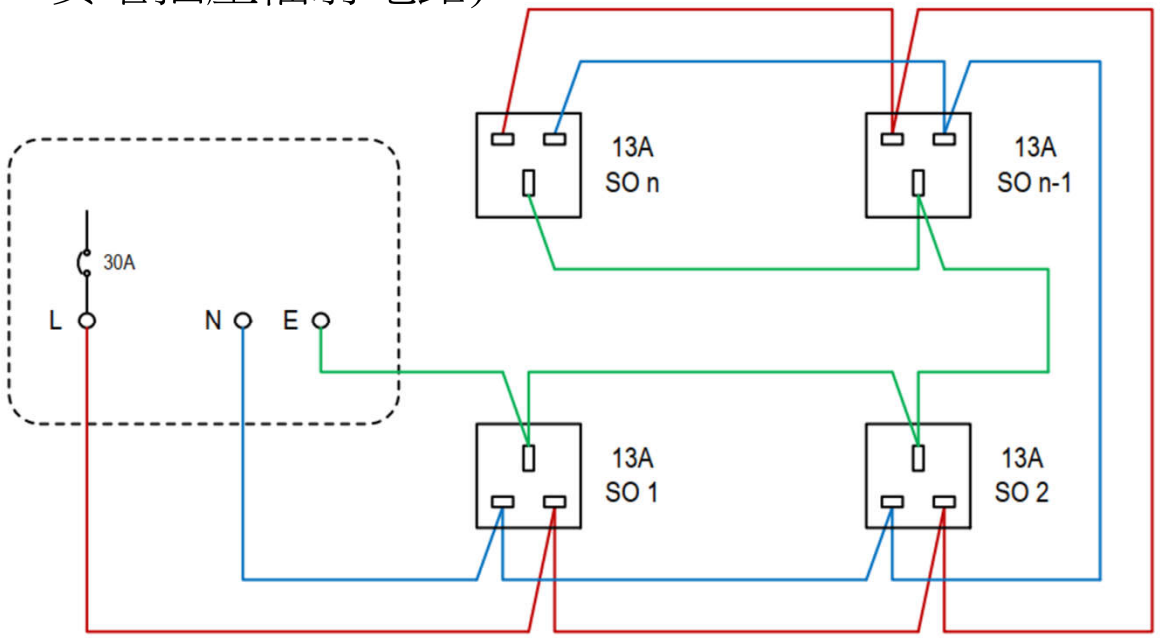
15A Socket Outlet Circuit (15 安培插座電路):



[Source: http://www.ksmak-sir.com/pdf/EIT.zip]

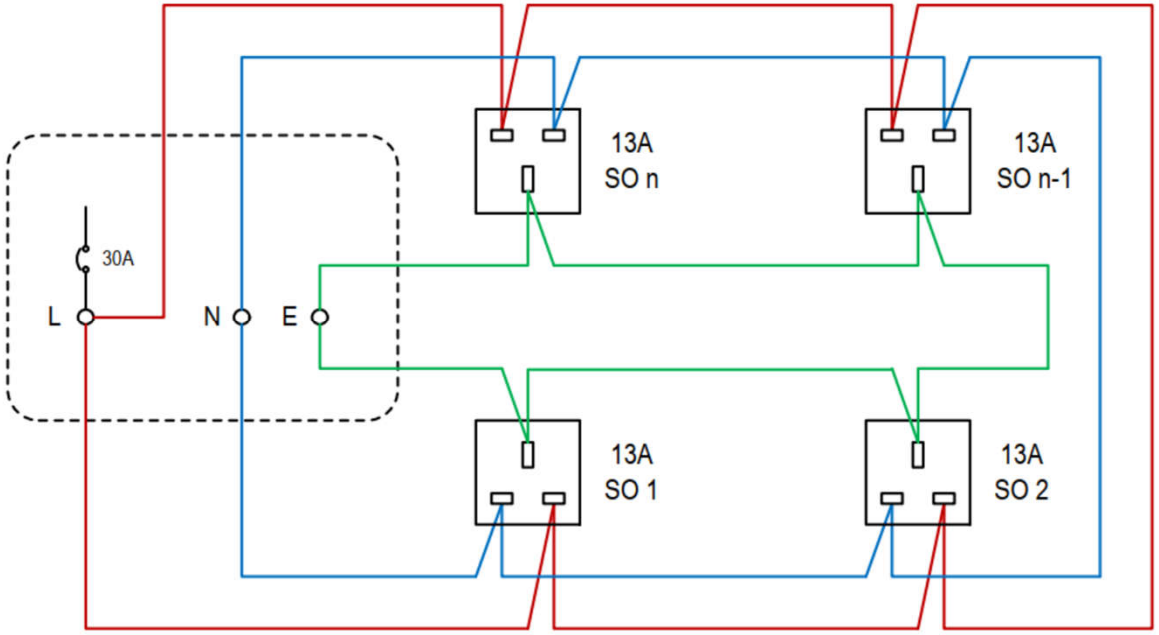
13A Socket Outlet Radial Circuit (13 安培插座幅射電路):

規格 / 接法	Cable 導線 (mm^2)	MCB 斷路器 (A)	Area 面積 (m^2)
Radial 幅射	***2.5***	***20***	***20***
	4.0	***30***	***50***
Ring 環形	2.5	30	100



13A Socket Outlet Ring Circuit (13 安培插座環形電路):

規格 / 接法	Cable 導線 (mm^2)	MCB 斷路器 (A)	Area 面積 (m^2)
Radial 幅射	2.5	20	20
	4.0	30	50
Ring 環形	***2.5***	***30***	***100***



[Source: http://www.ksmak-sir.com/pdf/Basic_Circuit.pdf]