DEE 3143 BASIC ELECTRICAL MACHINE & POWER SYSTEMS

CHAPTER 4
POWER SYSTEM OVERVIEW

by
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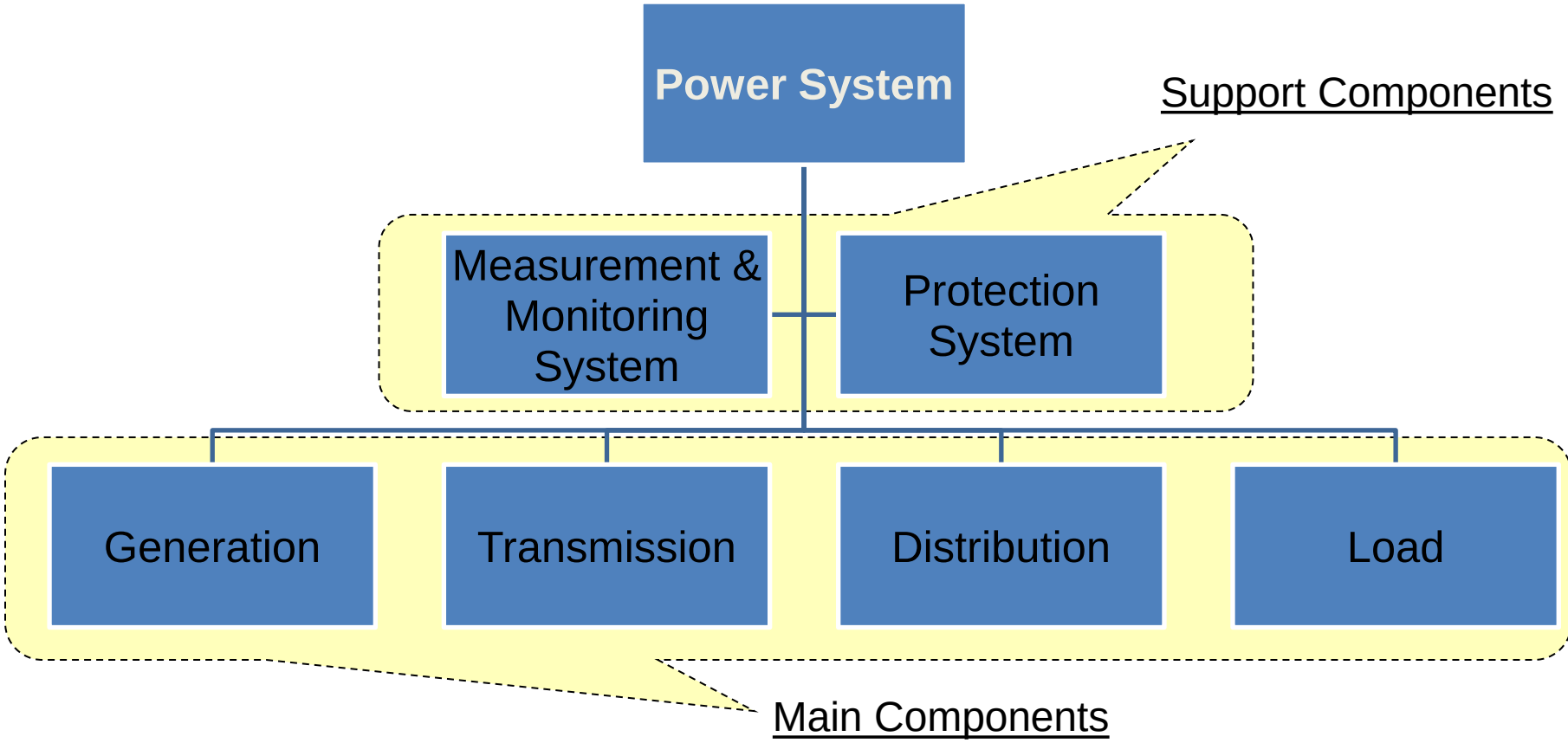
Topic Outcomes

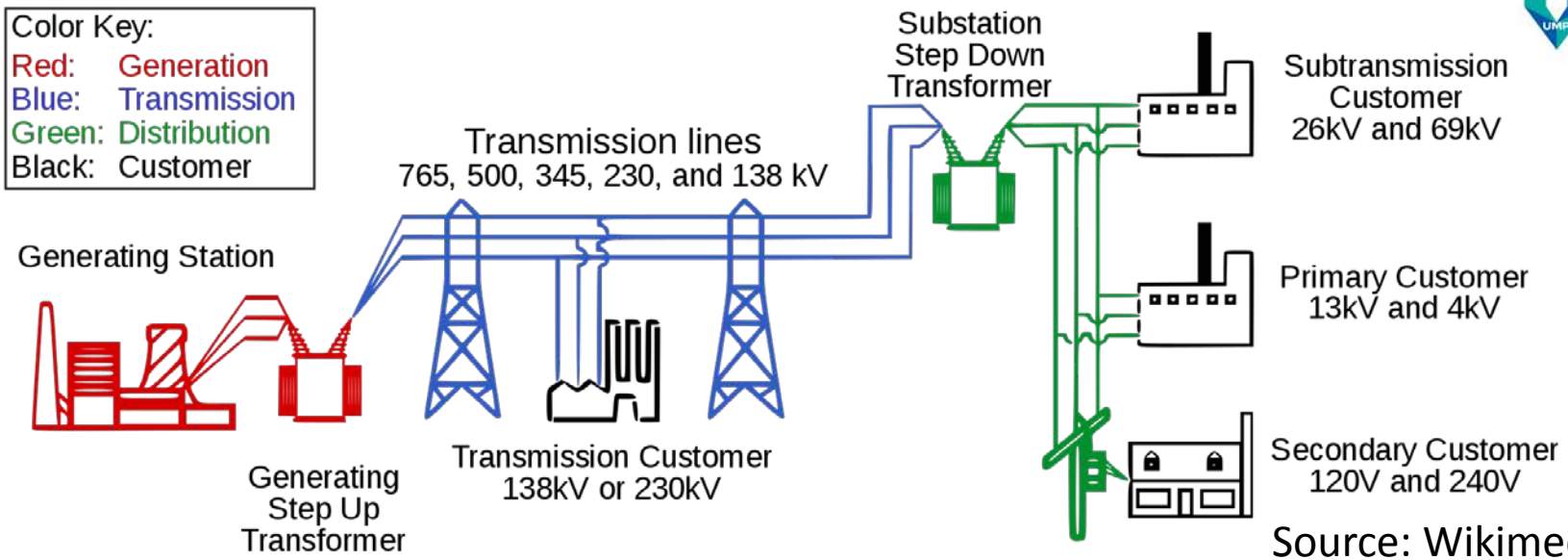
- Identify the role of power system components
- Describe the power system loads
- Calculate the load factor
- Explain power system in Malaysia

Outlines

- Basic components of power systems
- Types and characteristic of power system loads
- Load factor and load demand
- Power system in Malaysia
- National Grid System

Power System Components

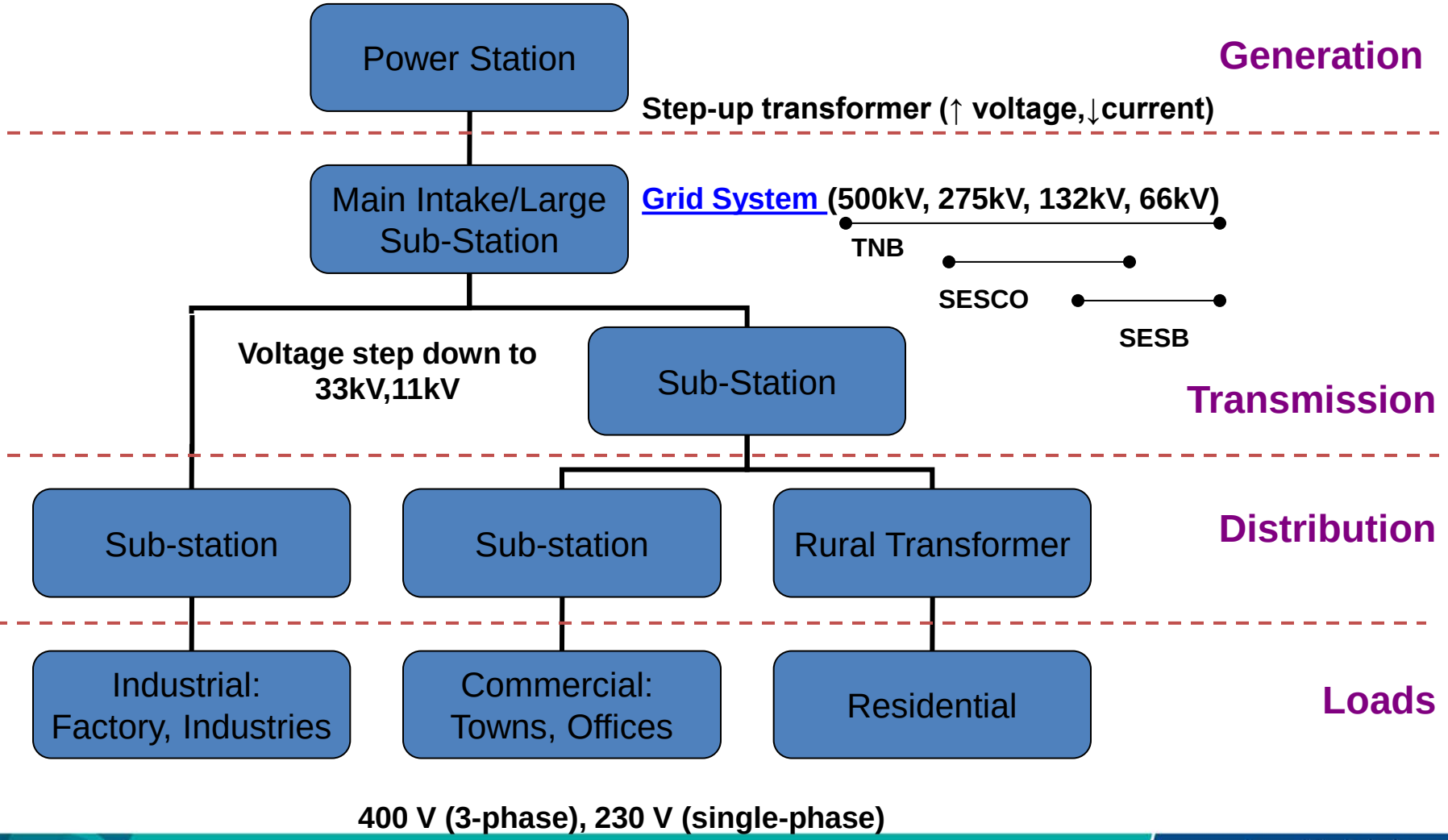




Source: Wikimedia common

- Generation may consists of generation plants and generation substations.
- Transmission may consists of transmission lines, sub transmission lines, transmission switching station and transmission substation.
- Distribution system may consists of distribution substations, primary distribution systems, distribution transformers and secondary distribution systems.

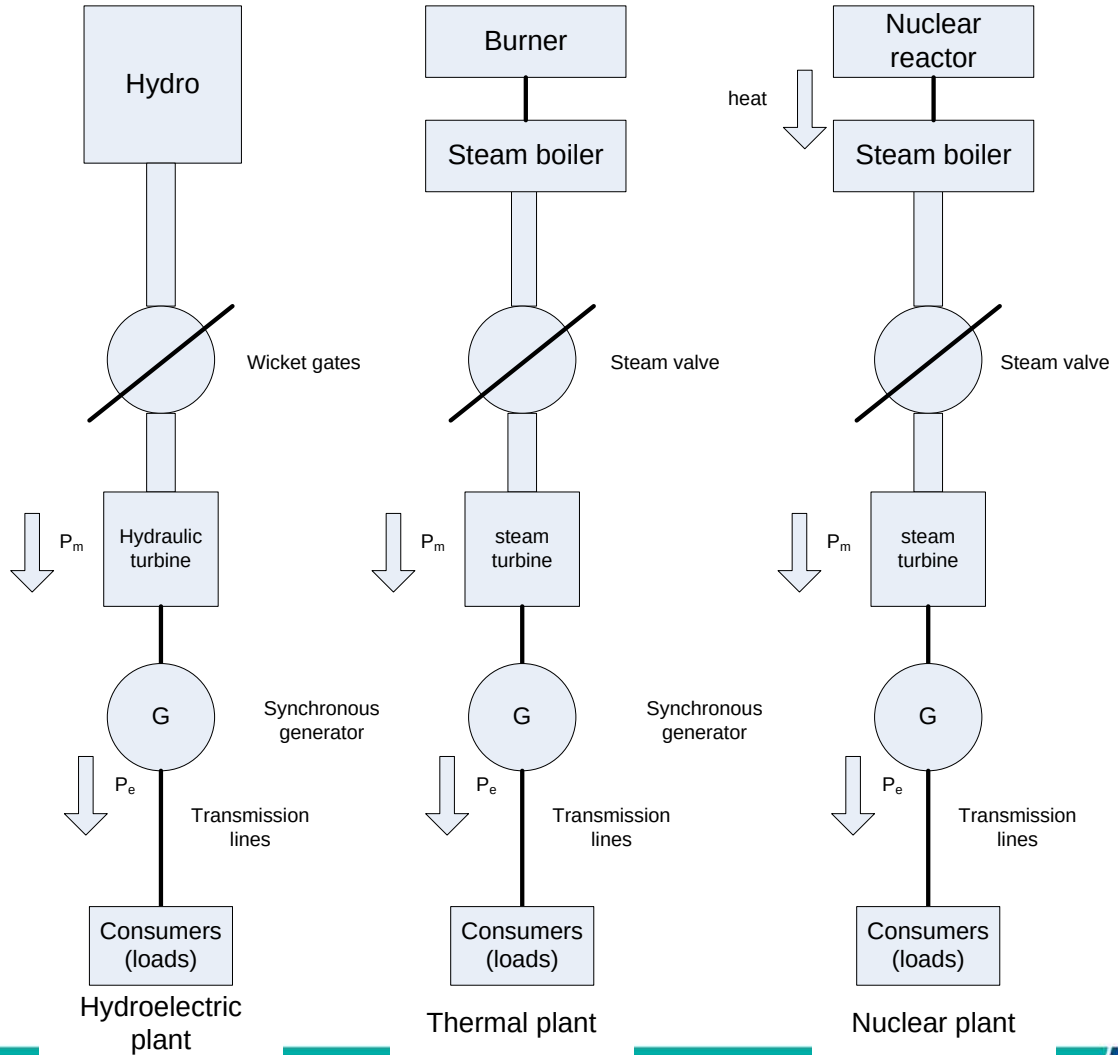
Power System Diagram



Voltage Transformation in Power System

- Power generating station (generating voltage) → 11 – 20kV and frequency of 50 Hz
- Transform to higher voltage (transmission voltage) → 132kV, 275kV and 500kV
- Transform to lower voltage (distribution voltage) → 33kV, 11kV, 400 V and 230 V

Generation


Hydro
Wicket gates
P_m
Hydraulic turbine
G
Synchronous generator
P_e
Transmission lines
Consumers (loads)
Hydroelectric plant
Burner
Steam boiler
Steam valve
P_m
steam turbine
G
Synchronous generator
P_e
Transmission lines
Consumers (loads)
Thermal plant
Nuclear reactor
heat
Steam boiler
Steam valve
P_m
steam turbine
G
P_e
Transmission lines
Consumers (loads)
Nuclear plant

Distributions

- Distribution → Distribute electrical energy to end-user customers and normally operated below 100 kV.
- Components →Sub transmission system, distribution substation, distribution or primary feeders, distribution transformers, secondary circuits, service drops.
- Operating voltages: 33kV, 22kV (rarely), 11kV, 6.6kV (rarely), 415V and 240V

Sub-Transmission

- Deliver energy from bulk power sources to the distribution substations.
- The sub transmission voltage is about between 34.5 and 138 kV
- The distribution substation reduces the sub transmission voltage to a lower primary system voltage for local distribution (using power transformer)
- They may be arranged as radial, loop/ring, or network systems and may be overhead or underground

Function of substation

- To receive energy transmitted at high voltage from the generating stations, reduce the voltage to a value appropriate for local use, and provide facilities for switching.
- To provide points where protection devices may be installed to disconnect circuits or equipment in the event of faults or troubles.
- Some substations are simply switching stations where different connections can be made between various transmission lines.

Source: https://commons.wikimedia.org/wiki/File:Legacy_National_Grid_Substation_-_geograph.org.uk_-_39134.jpg

Substation Equipments

1. The switchboard and switchgear
2. Transformers and regulators
3. Circuit breakers
4. Air break and disconnect switches
5. Grounding switches
6. Surge arresters
7. Current limiting reactors
8. Measuring instruments
9. Relays and protection devices
10. Bus bar
11. Substation layout

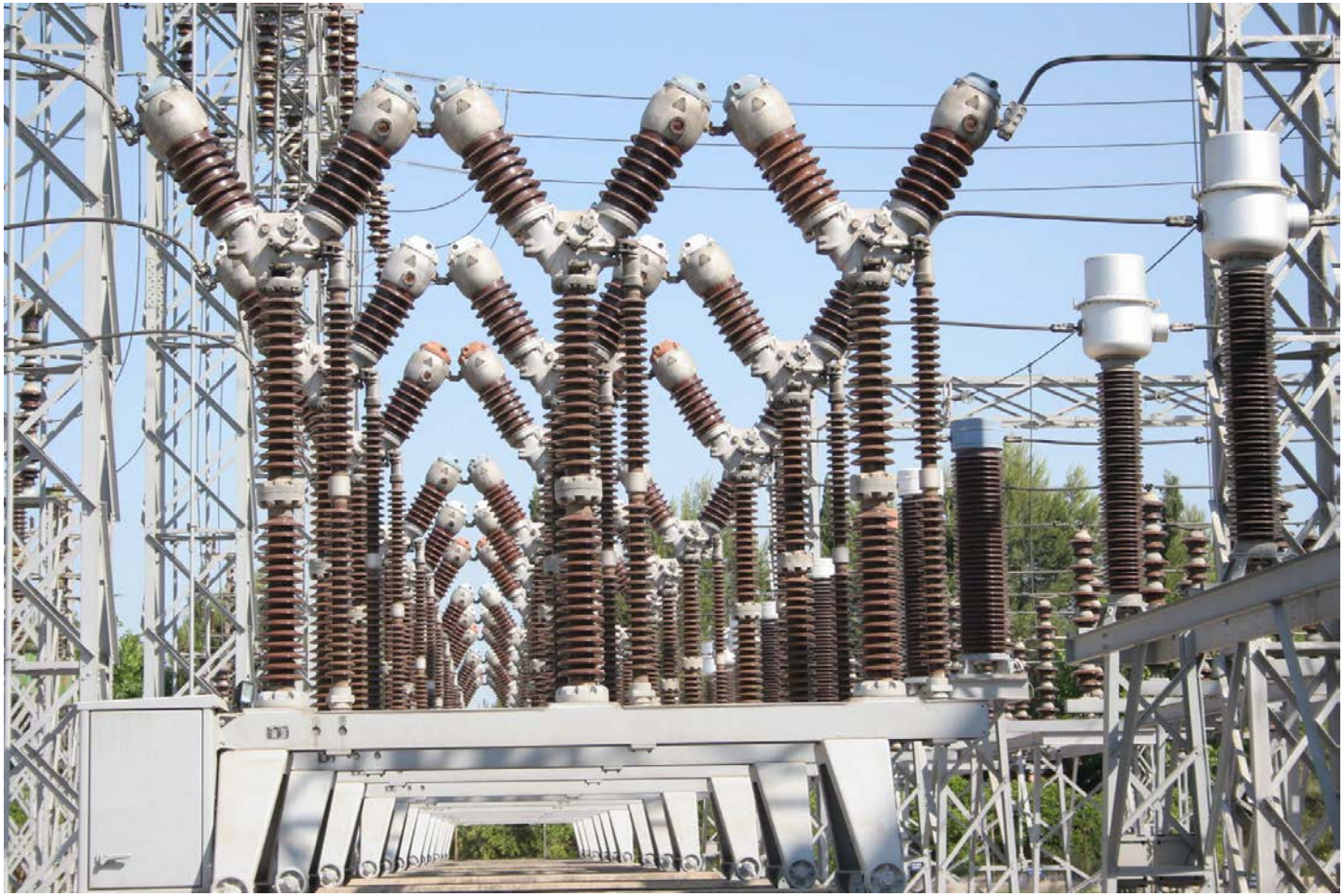
Switchboard and switchgear

- The switchboard is a panel or group of panels made of some insulating material which are mounted the various meters, relays, controls, and indicators for the proper operation of transformer, circuit breakers, and other equipment located in the substation.
- necessary for controlling, protecting, and recording what goes on in a substation.
- Switchgear is an assembly of main and auxiliary switching apparatus for operation, regulation, protection or other control of electrical equipments.

Source: http://bertholdelectric.com/gusberthold/lowmediumvoltageswitchgear.asp

Circuit Breaker (CB)

- For isolate the faulty part from the healthy part of the power system in case of abnormal/fault conditions.
- Protective relay detects abnormal/fault conditions and send signal to CB operate, by ‘breaking’ the circuit.



Source: https://commons.wikimedia.org/wiki/File:Subestaci%C3%B3n_electricidad.jpg

Distribution Substations

- Distribution Intakes (Operating voltages: 33kV, 22kV)
- Distribution Substations (Operating voltages: 22kV, 11kV, 6.6kV)
  - Indoor substation (within the building)
  - Outdoor substation (within the open compound with gates/fences)
  - Pole mounted substation
  - Compact substation (for less space availability)
  - Underground substation (for less space availability)
- Transformer capacity
  - 50kVA (single-phase; rarely),100kVA, 300kVA, 500kVA, 750kVA and 1000kVA

Types of Substations

- Indoor type
  - Entirely closed in a building compartments or as separate buildings.
  - Indoor type – separate building
  - Indoor type - in a compartment
- Outdoor type
  - In fenced enclosures.

Source: http://cnville.en.made-in-china.com/custom-detail/xJxQmEEVynfYQmExEnJrMQln/Transformer-solution-for-220kv-indoor-power-substation.html

Outdoor substation

Source:https://pxhere.com/id/photo/472993

Types of Substations

- Semi-indoor types
  - With transformer mounted outdoor and switchgear indoors.
  - Step-down transformers, high-voltage switches and oil circuit breakers, and lightning arresters located just outside the substation building
- Pole-mounted type
  - With transformer mounted on a pole structures.
  - Satisfactory for rural areas where the load density is low.
  - The maximum capacity of pole mounted substations is 300 kVA.

Pole structure substation

Source: https://commons.wikimedia.org/wiki/File:Pole_mounted_Transformer.jpg

Types of Substations

- Package or compact substation
  - With all components mounted within a restricted enclosure.
  - This type require only small sites.
  - The disadvantage is that they need to be replaced completely, if faults affect any individual components.
  - Available in 500 kVA, 750 kVA, and 1000 kVA capacities.

- In urban areas substations are often equipped with more than 1 transformer due to high load demands.

Compact Sub-station

Source: https://www.flickr.com/photos/sounderbruce/16575240852

Distribution Intake

Source: http://tnbelectricaleng.blogspot.my/2009/12/substation-categories-type-design.html

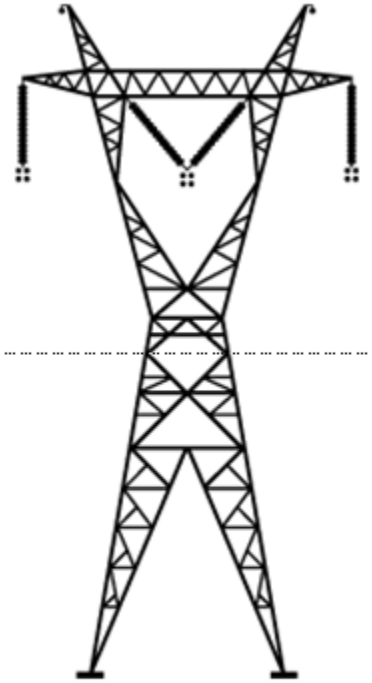
Transmissions

- Transmission conductor/cables/transformers/ switchgear operating at voltages above 100 kV are usually called the transmission system.
- Consists of Transmission conductors/Cables and Sub-stations
- In Malaysia, transmission network operates at 500kV, 275kV and 132kV.

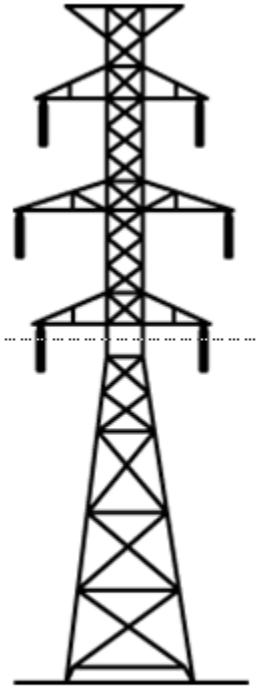
Transmission Components

- Transmission
  - Overhead Lines/conductors
  - Cable
    - Underground Cables
    - Submarine Cables
    - Overhead cables (for Europe countries)
- Sub-stations
- Components
  - Tower support structure
  - Cross-arms
  - Conductors
  - Insulators
  - Earth-wires

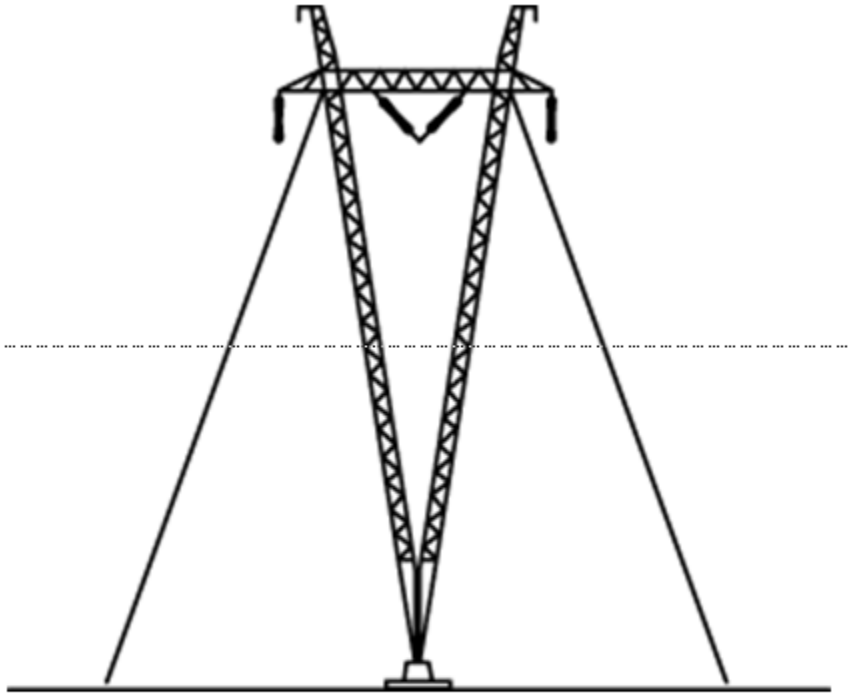
Transmission tower



Waist-Type Tower



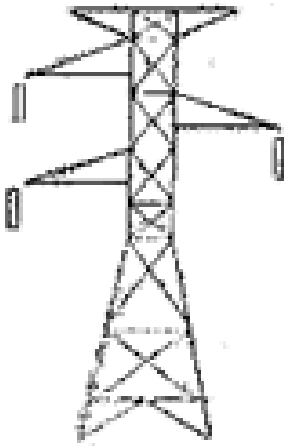
Double Circuit Tower



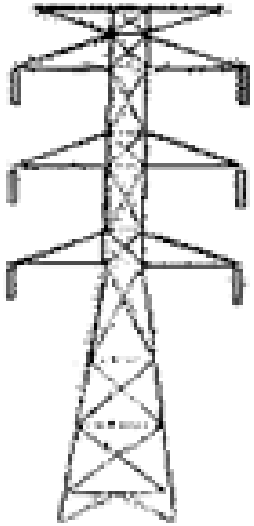
Guyed-V-Tower

Source: TNB

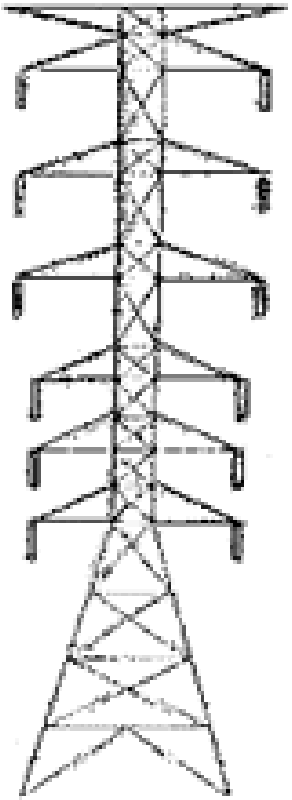
Transmission tower



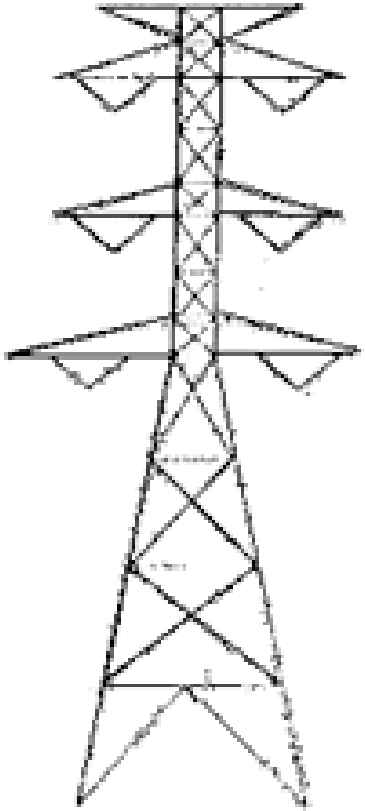
Single Circuit



Double Circuit



Quadraple Circuit



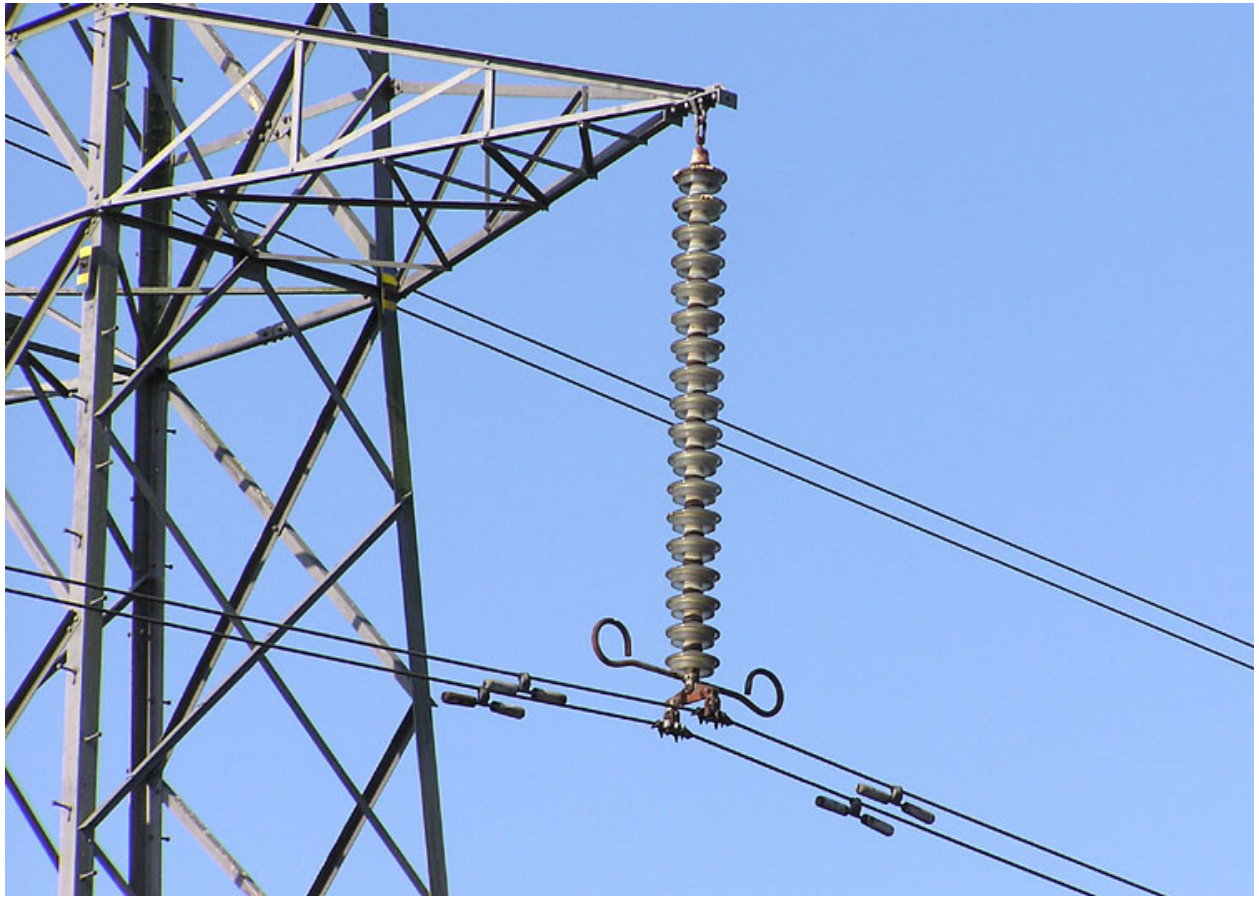
Double Circuit
500 kV

Source: TNB

Overhead Line

Source: Pixabay

Insulators



Source: https://commons.wikimedia.org/wiki/File:Pylon.detail.arp.750pix.jpg

Overhead lines

- Capital cost of overhead conductor is cheaper than cable
- Aluminum conductor material often used where it weight and less expensive than copper
- Copper conductor is used due to its high current conducting capacity (the weightage of power transfer is more than cost)
- Overhead conductor is vulnerable to lightning strike, which may cause temporary surge/fault on the line.
- Auto-reclosers of circuit breaker are employed on transmission lines in order to cater with temporary surge/fault.

Overhead lines

- Advantages:
  - Less expensive
  - Easy to locate fault
- Disadvantages:
  - Vulnerable to lightning, trees, animals, humans, construction machines (excavator)
  - Require large space/land

Distribution - Wood Poles

- Types of wood:
  - Cengal, balau (hard wood)
  - Keruing, simpuh, merpauh, kulim, mertas (treated)
- Used mainly in rural areas and rarely in urban areas.
- Weight of wood poles range from 180 kg to 210 kg depending on type of wood and dryness of the pole.

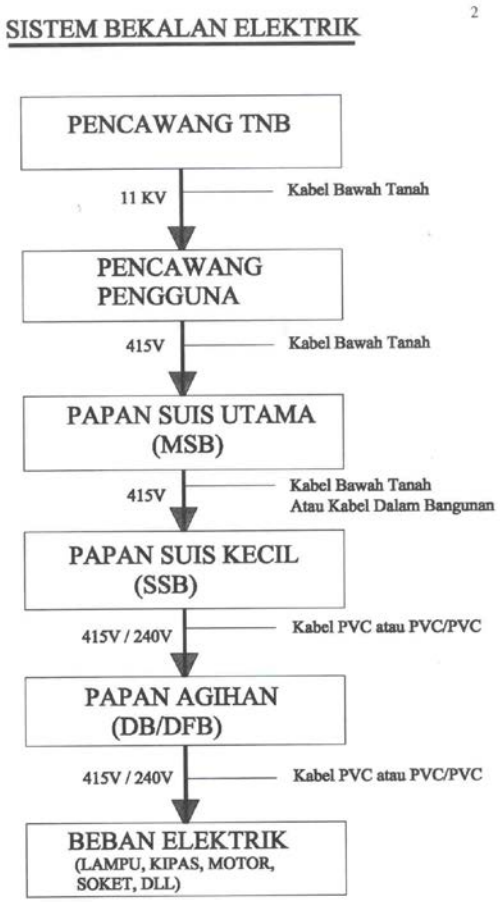
Distribution - Wood Poles

- Advantages:
  - Cheaper than concrete or steel
  - Lighter in weight, easier to handle and transport.
  - Natural insulation between energize conductors and ground.
  - Easy to climb and attach line equipments
- Disadvantages:
  - Shorter life span
  - Susceptible to rat and attack by insects, birds' nest.
  - Regular check on poles are required.

Distribution - concrete poles

- Weight of poles are 300 kg to 400 kg.
- In general, they are used in LV overhead lines and service in any area.
- Advantages:
  - No maintenance required and the span is very long unless damaged by vehicles
- Disadvantages:
  - Heavy and difficult to transport
  - More expensive compared to wood poles.

Malaysian Distribution System



Source: TNB

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Research interest: Reliability, Distribution network, smart grid, risk asessment