ABB Transformation Training : Module - I

Transmission & Distribution Substation

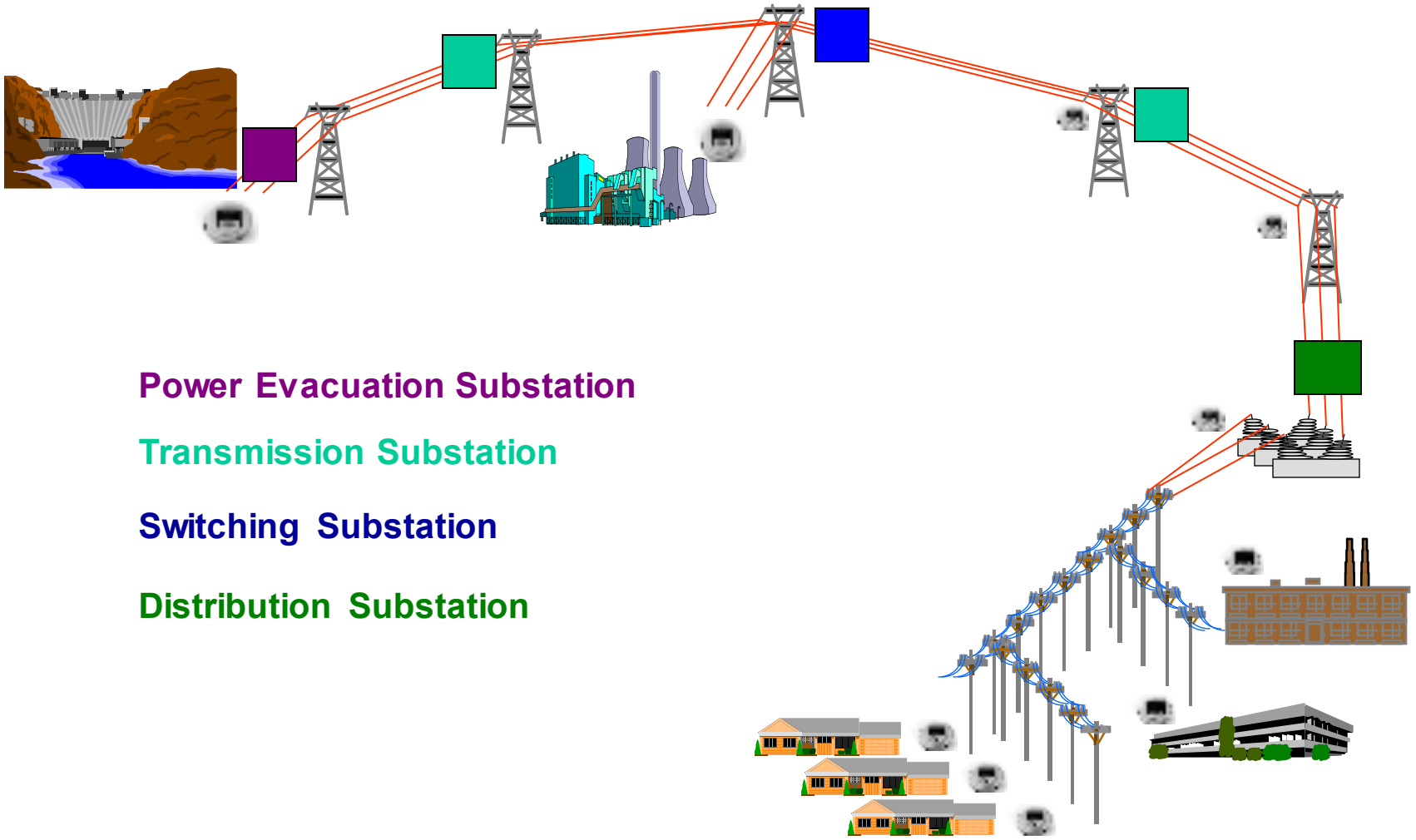
What is Substation ?

Substation is an Electrical installation where power is controlled for transmission & distribution purpose.

Substations can be categorized as:

- Power evacuation substation
- Substation part of Transmission system
- Substation part of Distribution system

The Electric Utility



Power Evacuation Substation

Transmission Substation

Switching Substation

Distribution Substation

Power Evacuation Substation

- Located adjacent to the Power Plant
- Preferred voltage level
  - 420 kV
  - 245 kV
  - 123,145 kV
  - 72.5, 66 kV
- Evacuation voltage level depends on
  - Quantum of power to be evacuated (size of power plant)
  - Distance of Transmission
  - Gird network voltage of surrounding transmission system
- Normally built by
  - Utilities (e.g. NTPC, NHPC, Captive Power Plant by industries)
  - Independent Power Producer (IPP)

Transmission Substation

- Location is decided based on Transmission Grid Network
- Preferred voltage level
  - 420kV
  - 245kV
  - 145kV
- Transmission voltage depends on
  - Quantum of power to be received / transmitted
  - Length of transmission line
- Normally built by
  - Utilities (e.g. Power Grid, State Electricity Boards)

Distribution Substation

- Location is near the load
- Preferred voltage level
  - 245kV
  - 145kV
  - 72.5/36 kV
- Station voltage level depends on
  - Demand of power
  - Utility norms of distribution
- Normally built by
  - Utilities (e.g. State Electricity Broads)
  - Industries

Typical SLD

What is Busbar Configuration ?

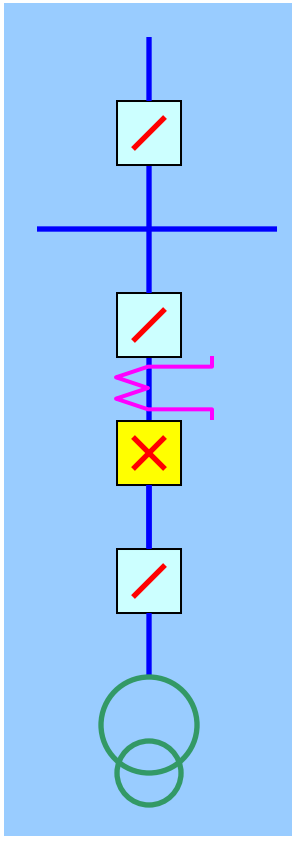
Busbar configuration or Bus switching scheme is the circuit adopted for substation based on following:

- System reliability
- Operational flexibility
- Ease of maintenance
- Limitation of fault level
- Simplicity of Protection system
- Ease of extension
- Availability of Land
- Cost

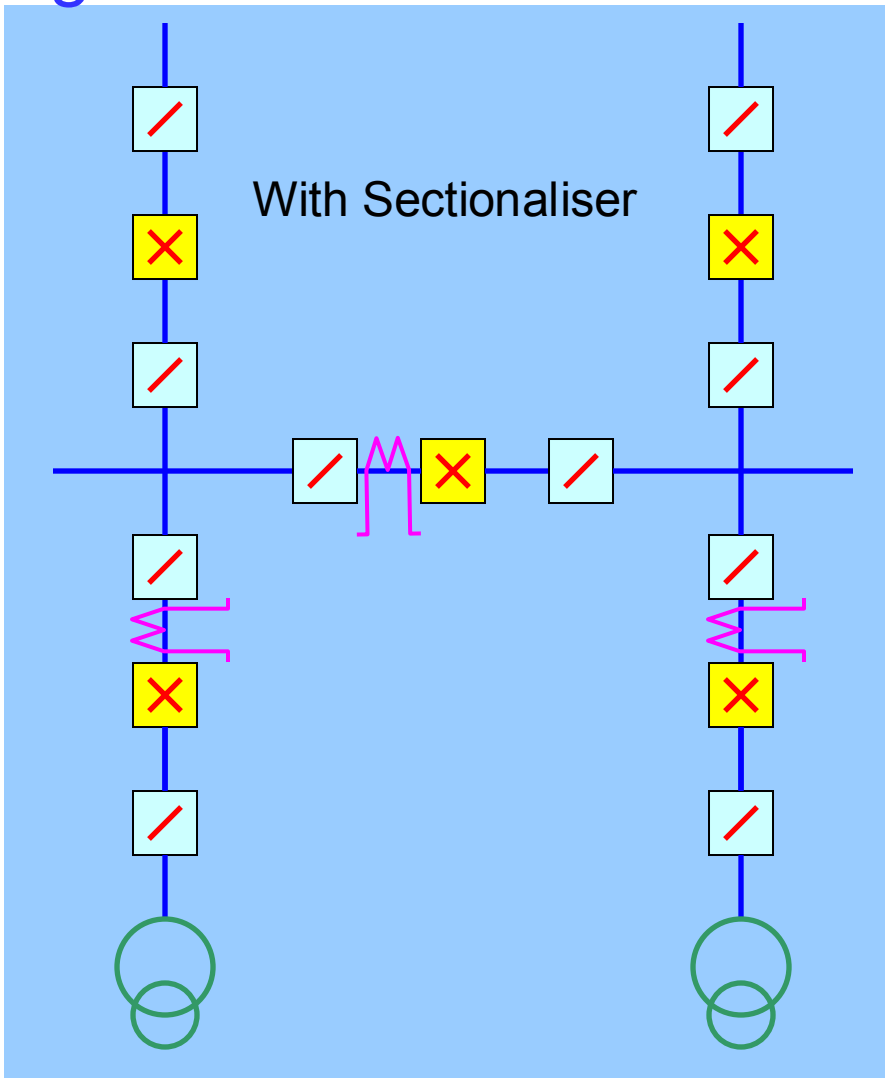
Various Busbar Configuration

- Single Bus Scheme

Without Sectionaliser



With Sectionaliser



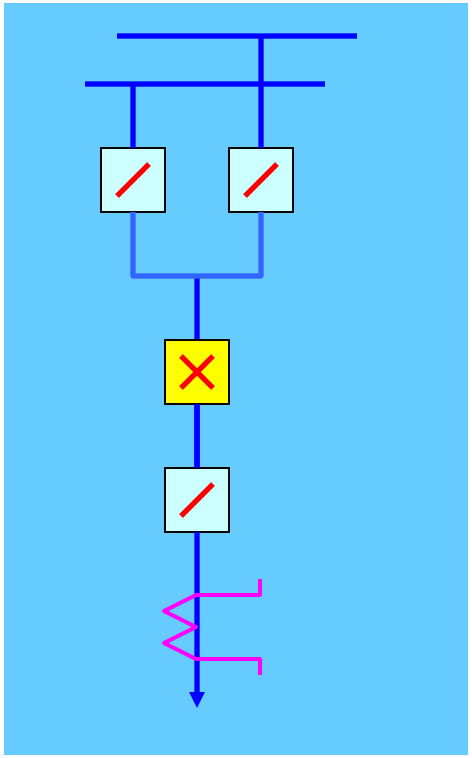
Various Busbar Configuration

Single Bus Scheme

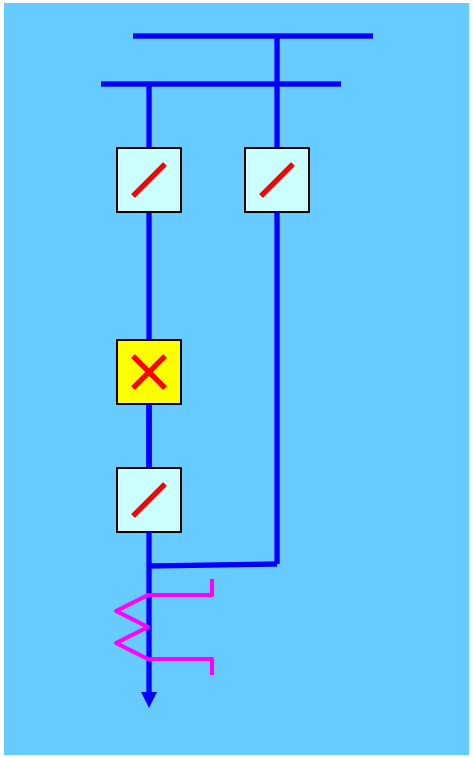
- Application
  - Industrial stations with voltage level generally up to 145kV
  - Also used for 245kV station with 2/3 bays
- Features
  - Simple system
    - Ease of Operation & maintenance
    - Single level bus layout
  - Very simple Control & Protection philosophy
  - Large saving in space
  - No redundancy

Busbar Configuration contd...

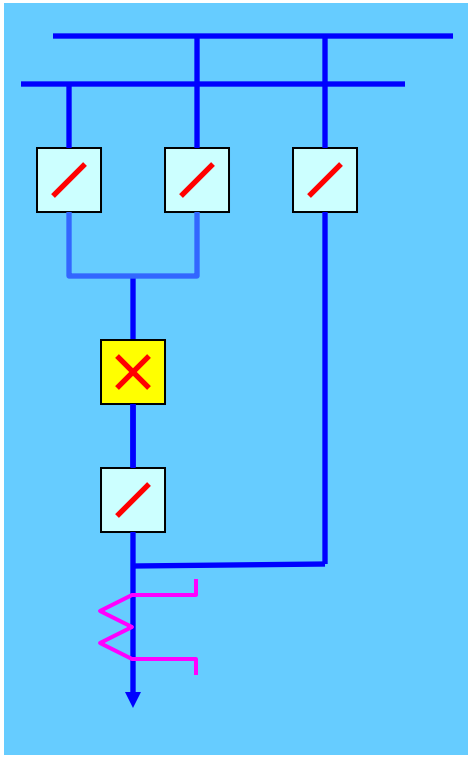
- Double Bus Scheme



Double Bus with two Main & without Transfer



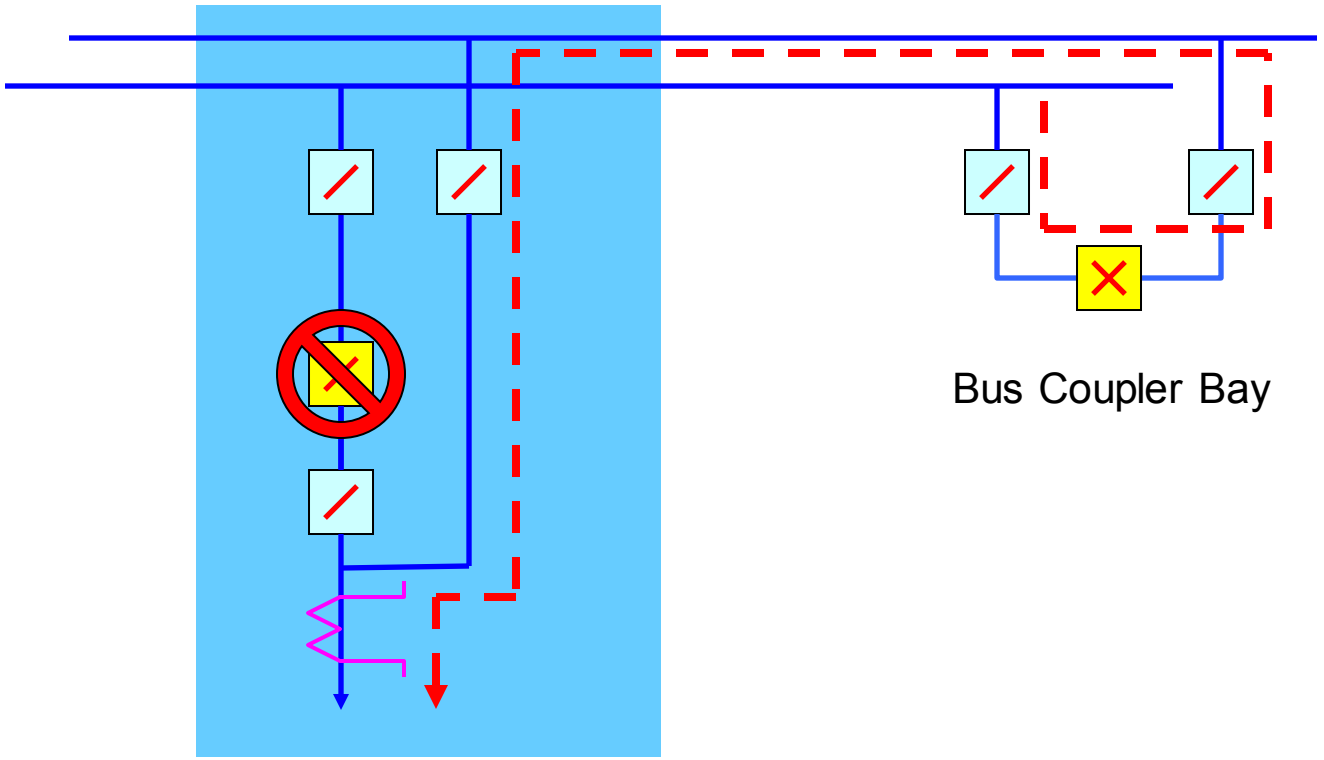
Double Bus with one Main & one Transfer



Double Bus with one Main & one Main cum Transfer

Double Bus Scheme

Double Bus with one Main & one Transfer



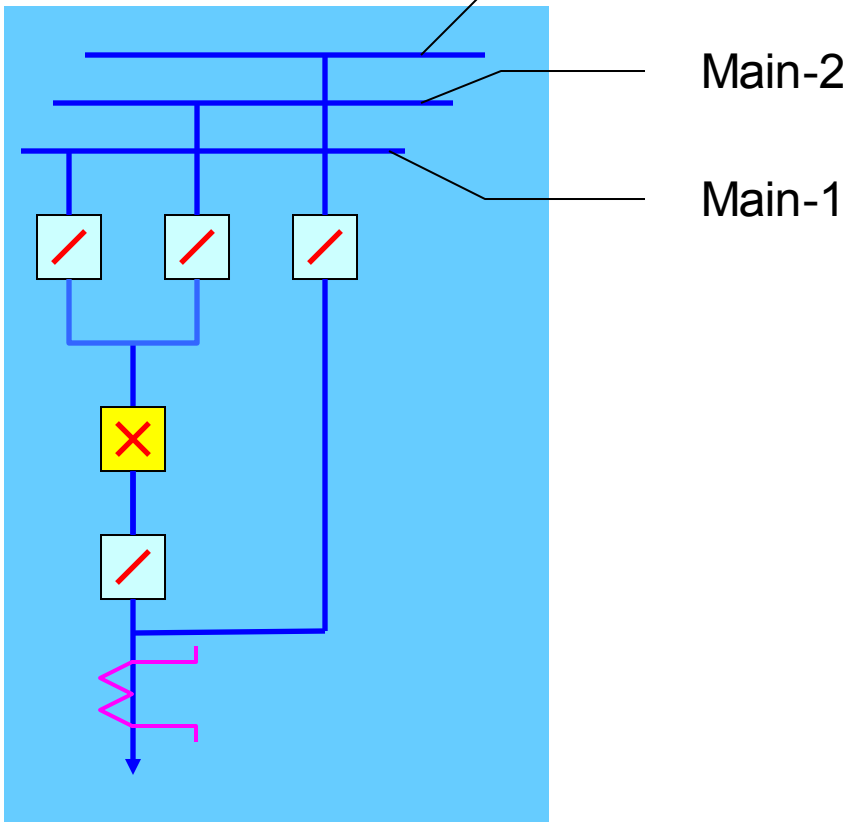
Various Busbar Configuration

Double Bus Scheme

- Application
  - Normally this is used for most industrial stations and some time small power evacuation system
- Features
  - Simpler system
  - Better availability as additional bus is provided
  - Breaker can be taken out for maintenance where transfer bus feature is provided

Busbar Configuration contd...

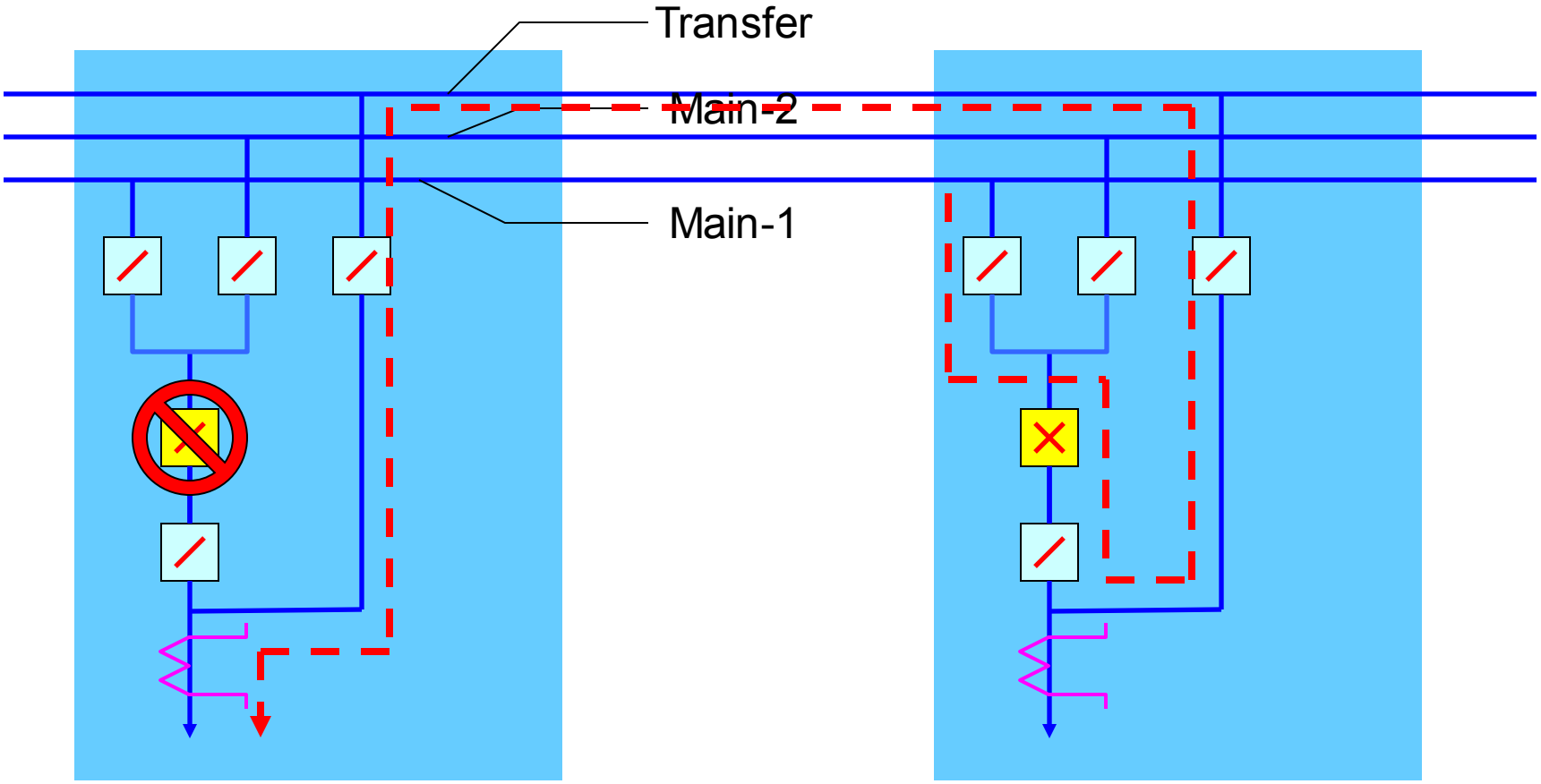
- Three Bus Scheme



Three Bus with Main I & II
and separate Transfer Bus

Three Bus Scheme

Three Bus with Main I & II and separate Transfer Bus



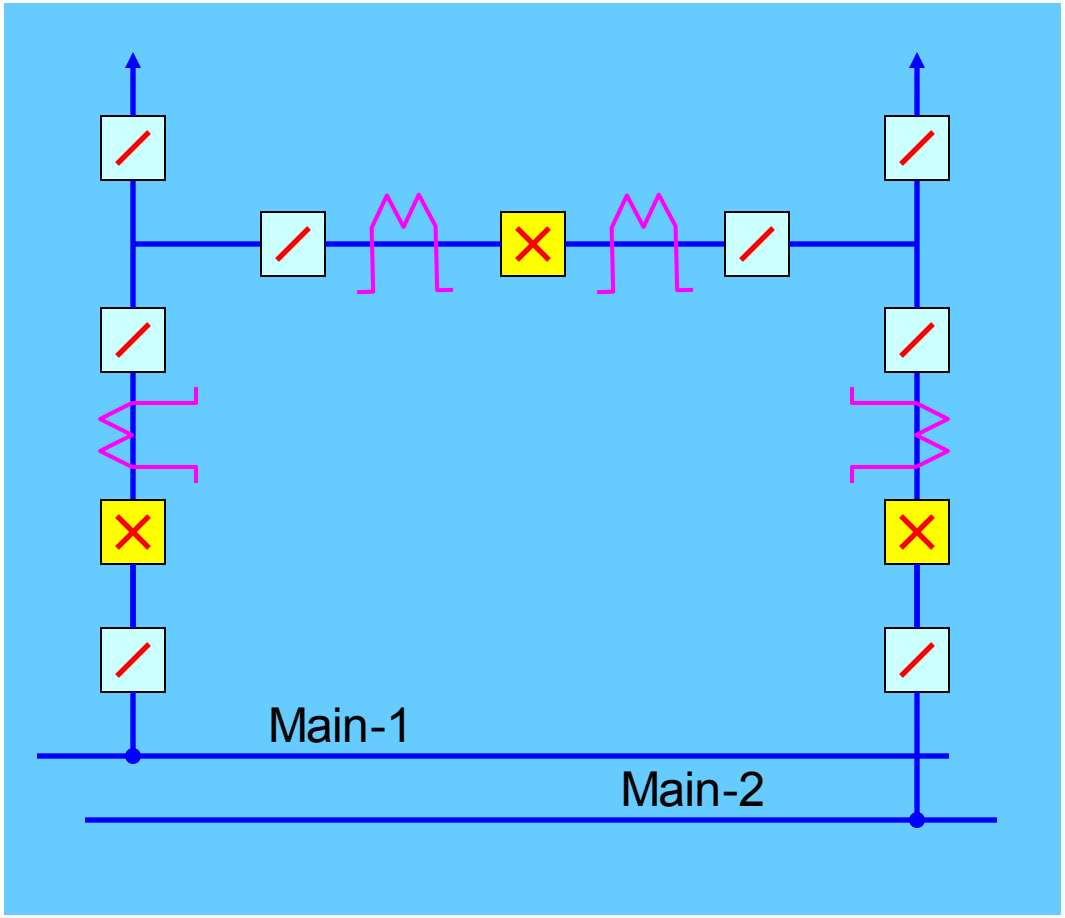
Various Busbar Configuration

Three Bus Scheme

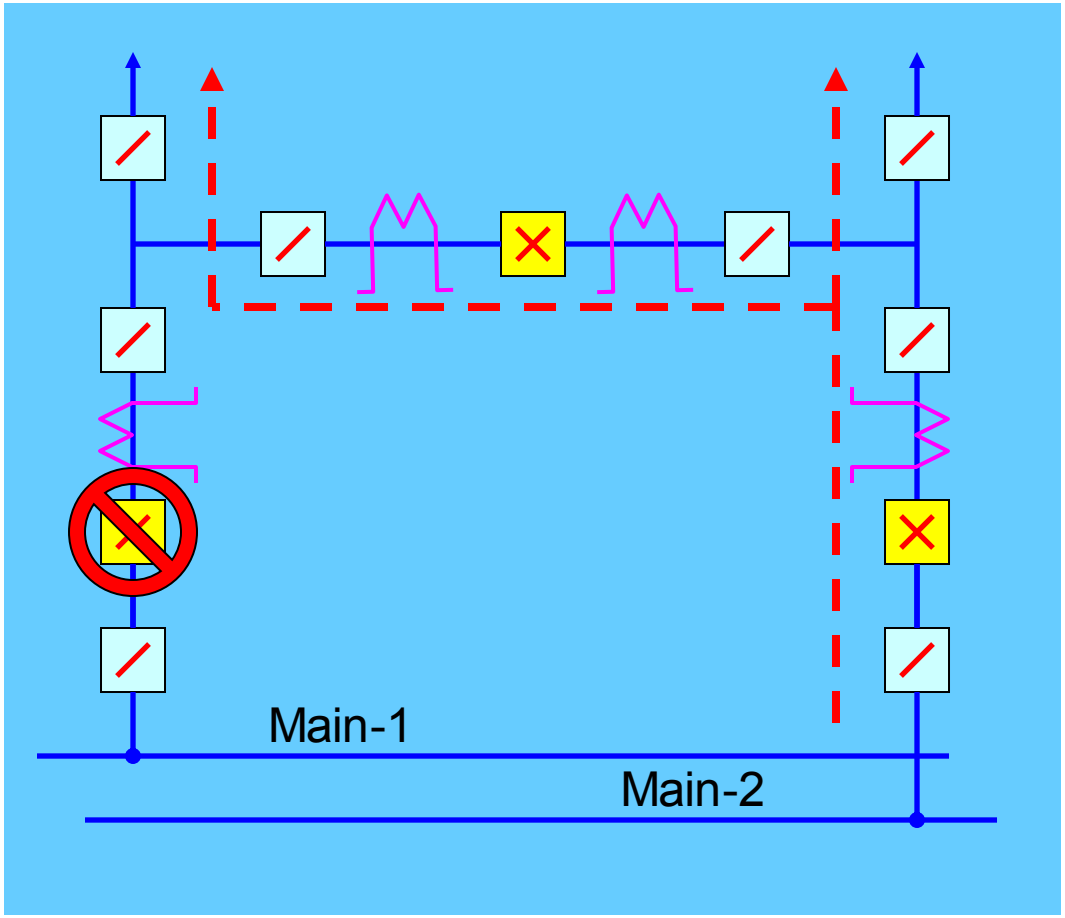
- Application
  - Power evacuation station
  - Interconnecting substation for transmission lines
  - Heavy Industrial stations viz. Steel, Aluminium, Petro-chemicals
- Features
  - Independent two buses sharing the feeder
  - Better load management
  - Better reliability
  - One transfer bay is in-built for redundancy of one bay
  - Complex Control & Protection system

Busbar Configuration contd...

- One & half breaker scheme



- One & half breaker scheme



Various Busbar Configuration

One & half breaker scheme

- Application
  - Mostly this configuration is adopted where high reliability is required
  - Power evacuation station for big power plant
  - Interconnecting transmission substations with 420/245kV level
- Features
  - Very high reliability
  - Costly because of increase no. of Circuit Breaker
  - Complex Control & Protection philosophy

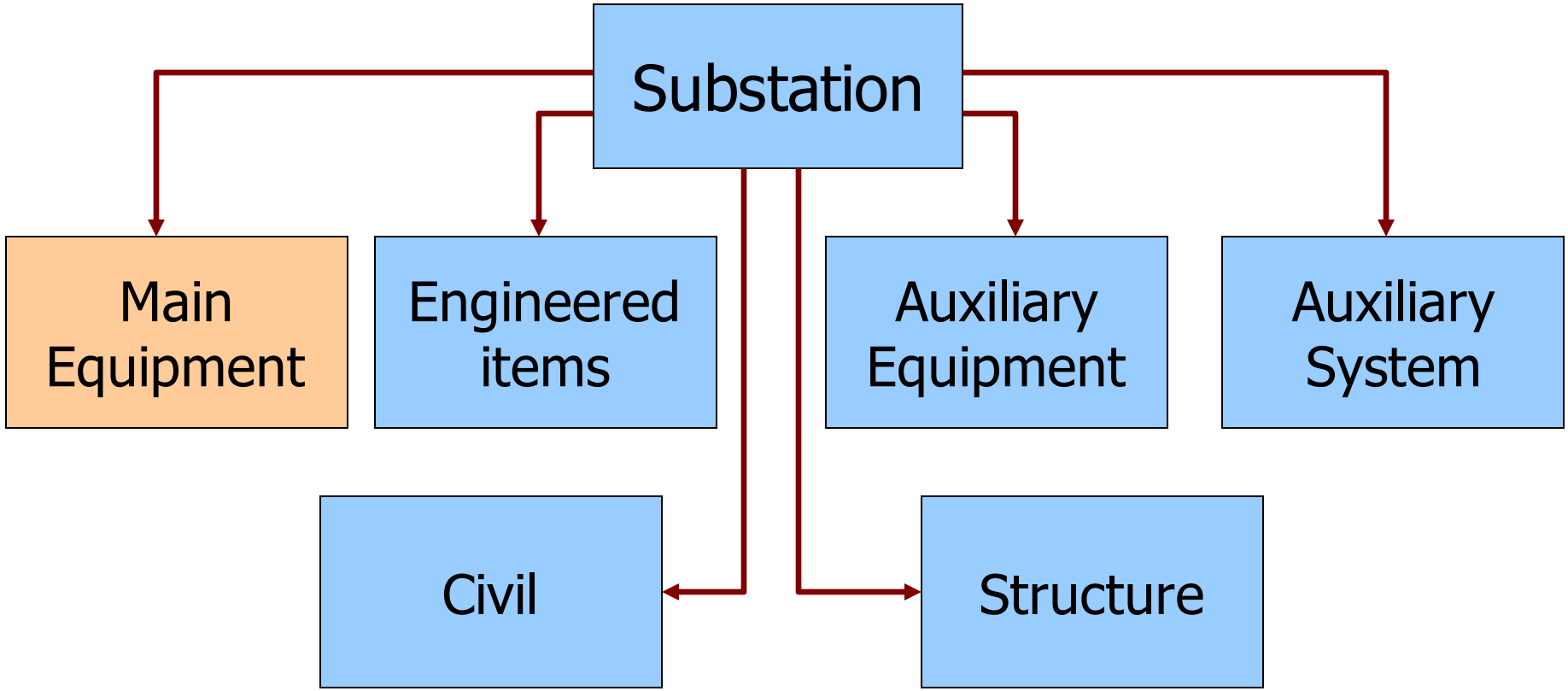
Busbar configuration adopted by..

- Power evacuation Substations
  - Double bus scheme
  - Three bus scheme
    - Two Main & one Transfer
  - One & half breaker scheme
- Transmission Substations
  - Double bus scheme
  - Three bus scheme
    - Two Main & one Transfer
    - One Main & Main cum Transfer
  - One & half breaker scheme

Busbar configuration adopted by..

- Distribution Substations
  - Single Bus with / without sectionaliser
  - Double bus scheme
  - Three bus scheme
    - Two Main & one Transfer
    - One Main & Main cum Transfer

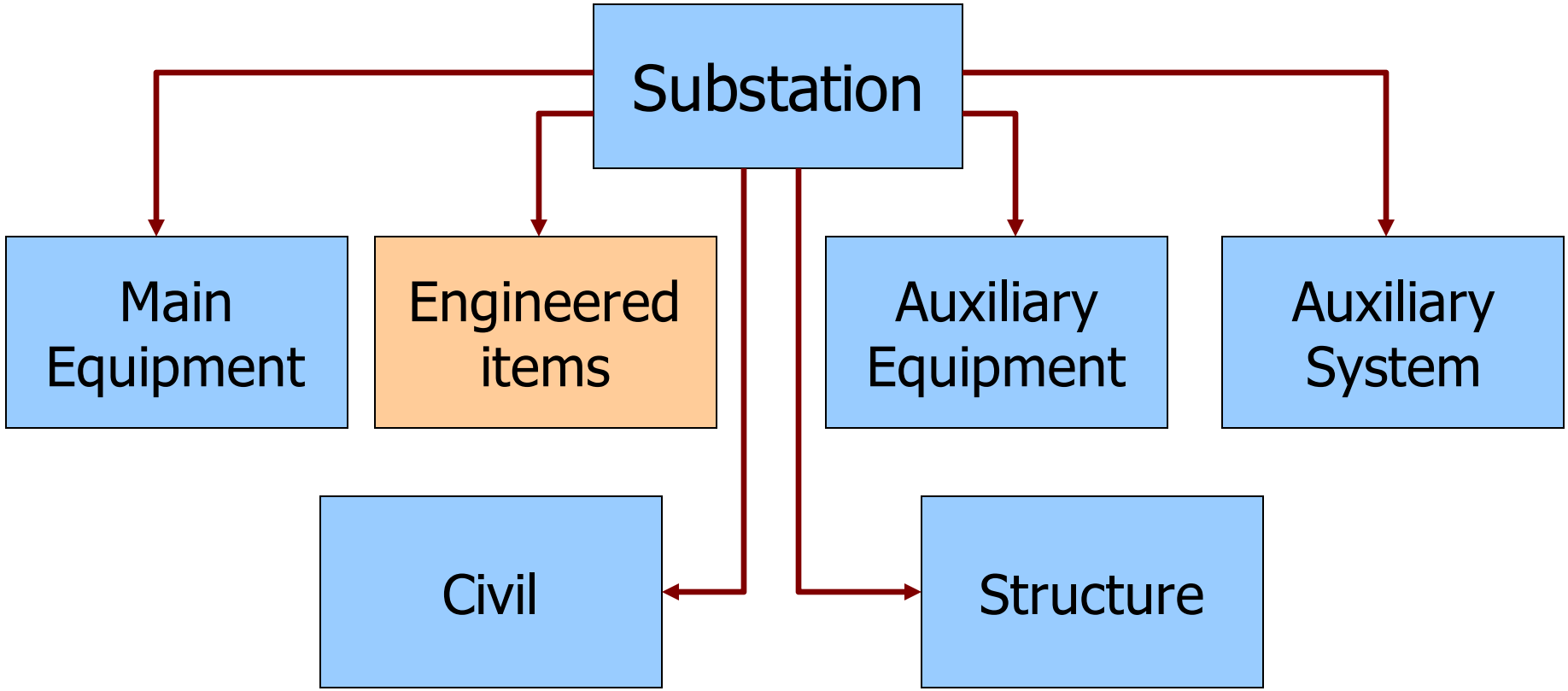
What does a substation contains..



Main Equipment

- Circuit Breaker
- Instrument Transformer (CT/CVT)
- Surge Arrester
- Isolator
- Transformer & Reactor
- Bus Support Insulator
- Line Traps
- Control & Protection system
- Power Line Carrier Communication system

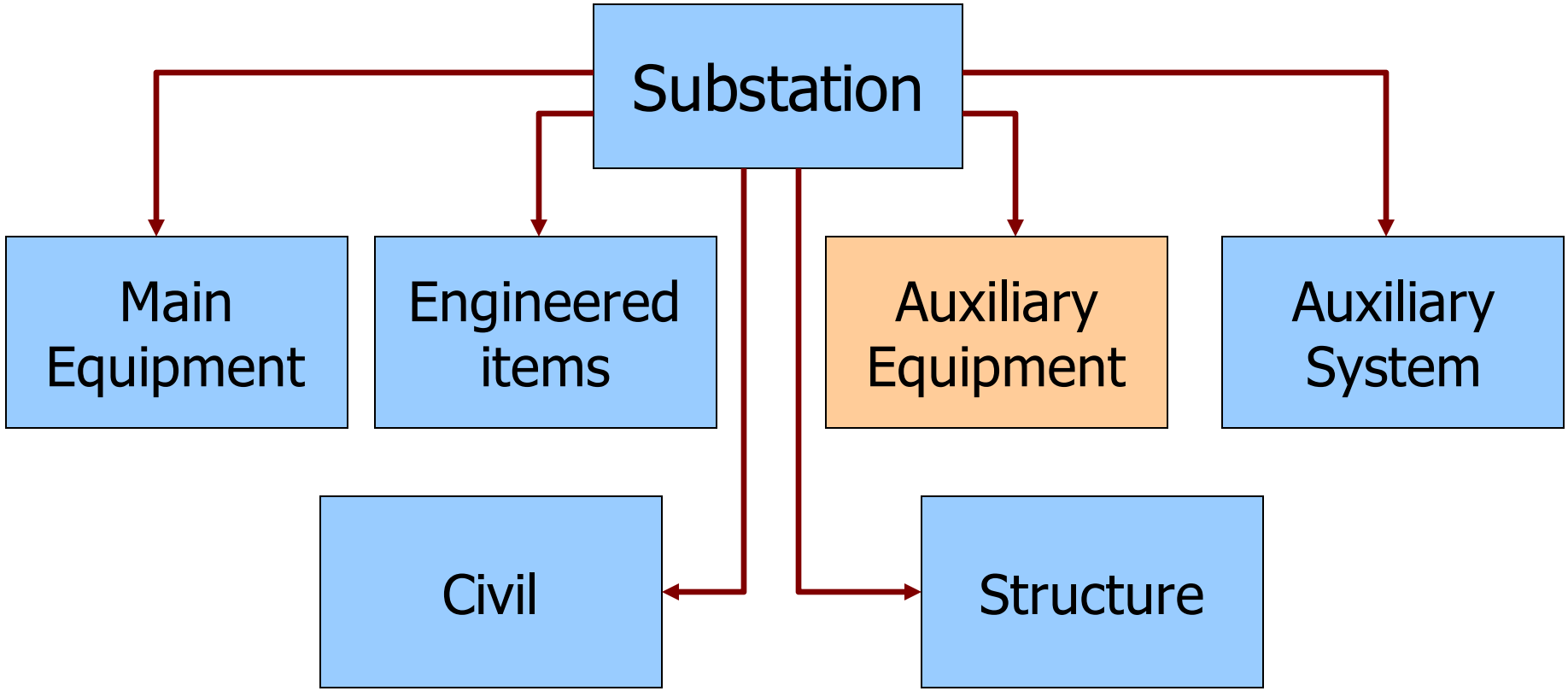
What does a substation contains..



Engineered items

- Busbar Materials
  - Strung bus conductor (ACSR)
  - Rigid bus conductor (AL Tube)
  - Clamps & Connectors
  - String Insulator & Hardware
- Earthing Materials
  - Main earthing materials (Rod or Flat)
  - Earth Pits
- Cables & accessories
  - LT Power & Control cable
  - HT Power Cable
  - Cable terminations, gland, lugs, ties, marker etc.
  - Cable supporting materials

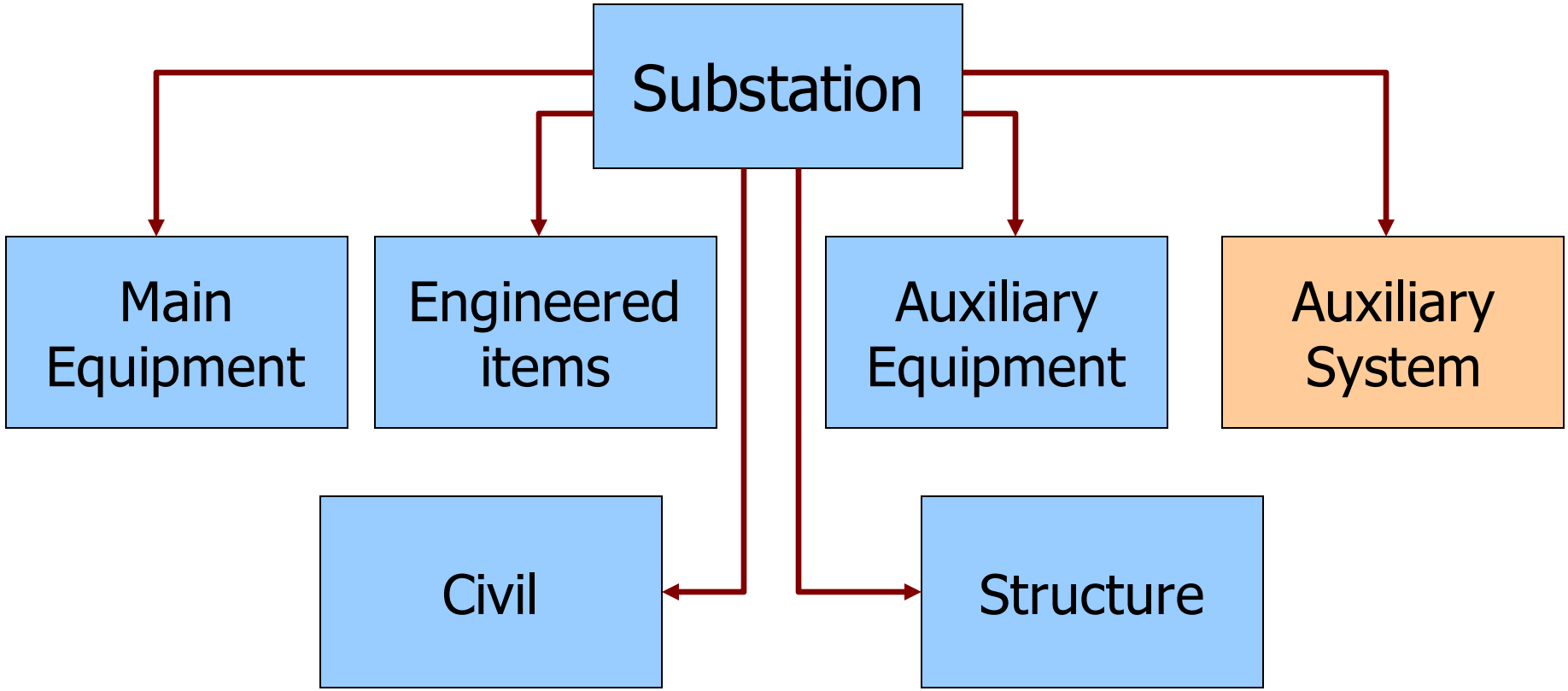
What does a substation contains..



Auxiliary Equipment

- LTAC Switchgear panel
- AC Distribution board
- Battery & Battery Charger
- DC Distribution board
- Auxiliary LT transformer
- Lighting Transformer
- Main Lighting Distribution board
- Emergency Lighting Distribution board
- Diesel Generator
- UPS

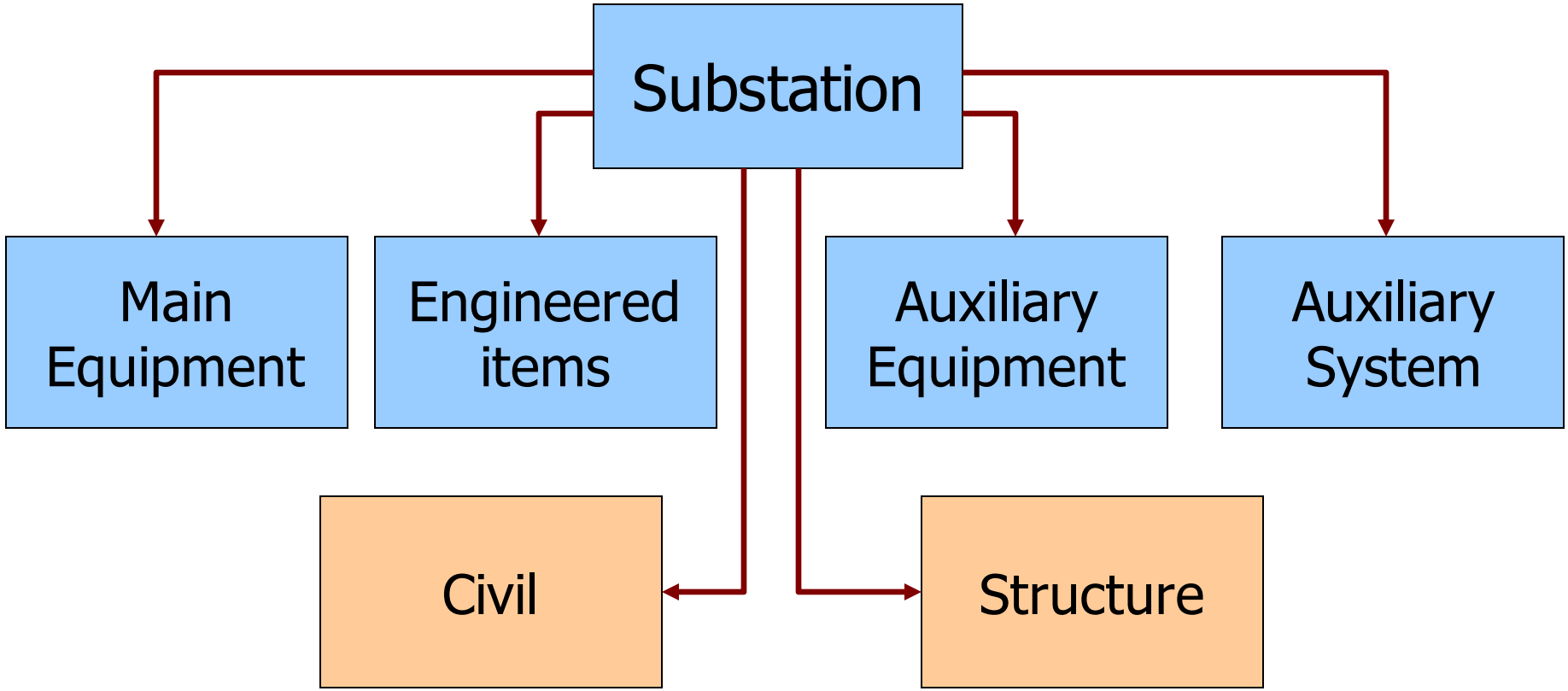
What does a substation contains..



Auxiliary System

- Illumination system
  - Indoor (Control Room Building, DG, FFPH Building.)
  - Outdoor switchyard
- Fire fighting and fire detection system
- Air conditioning and ventilation system

What does a substation contains..



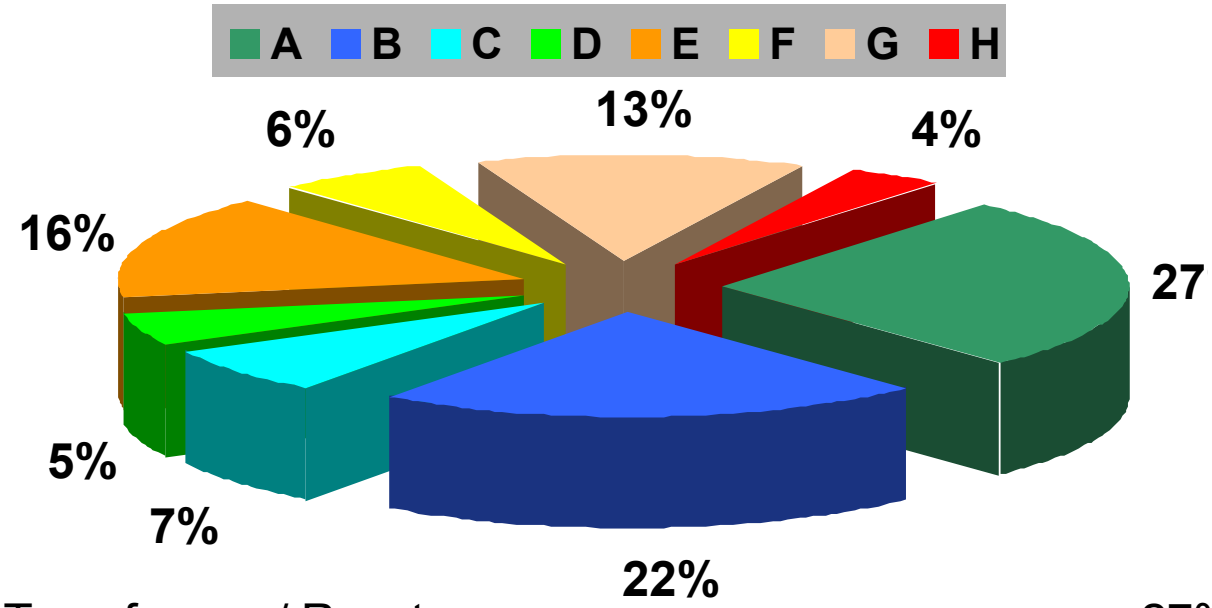
Substation Structures

- Main Column and Beam structures
- Equipment supporting structures

Substation Civil

- Foundation for gantry column & equipment
- Foundation for Transformer / Reactor
- Control room building / DG, FFPH building
- Outdoor switchyard cable trench
- Surface drainage
- Roads
- Fencing and gate

A typical substation content wise cost structure.



A > Transformer / Reactor---------- 27%
B > EHV Circuit Breaker, CT, CVT, LA, Isolator, BPI------- 22%
C > Control, Protection & PLCC---------- 7%
D > Medium Voltage Switchgear---------- 5%
E > Cables, AC/DC Aux., Lighting, Busbar etc.---------- 16%
F > Structures---------- 6%
G > Civil---------- 13%
H > Erection---------- 4%

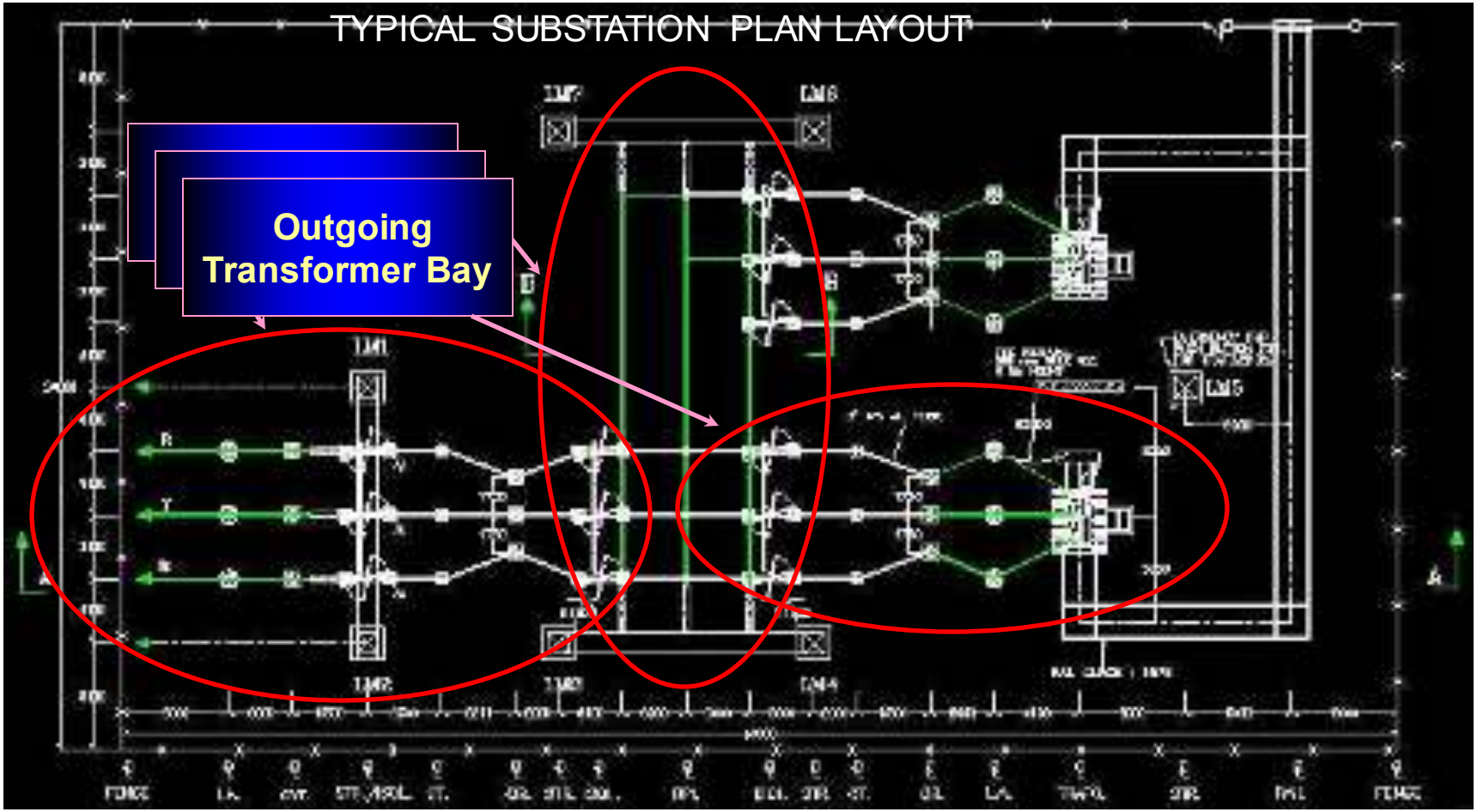
What is Substation Layout ?

Substation Layout is the conception which transforms to reality through engineering, execution & commissioning.

Layout Engineering . . . .

- is the basic document to be sent to Customer / Consultants for approval
- forms the basis of entire project scope
- forms basis for engineering estimates
- form input for civil & structure design
- basic document for statutory approval

What is Substation Layout ?



Layout Engineering

Following details form the input for layout engineering:

- Bay & Busbar configuration
- Bay width & depth, Height of busbar, Distance to fence, Building and total dimensions.
- Statutory clearances (Phase to Phase, Phase to Earth, Sectional clearance)
- Lightning Mast, Gantries (Column & Beam), String Insulators, Busbar, Equipment etc.
- Position of various drive box, junction box, Marshalling box.

Layout Engineering

Bay Width it depends on…

- Phase to Phase & Phase to Earth clearances
- Sectional Clearances
- Tower width
- Swing of conductor
- Bird clearances
- Cable trench routing
- Maintainability of equipment
- Tandem Isolator arrangement

Equipment Distances it depends on…

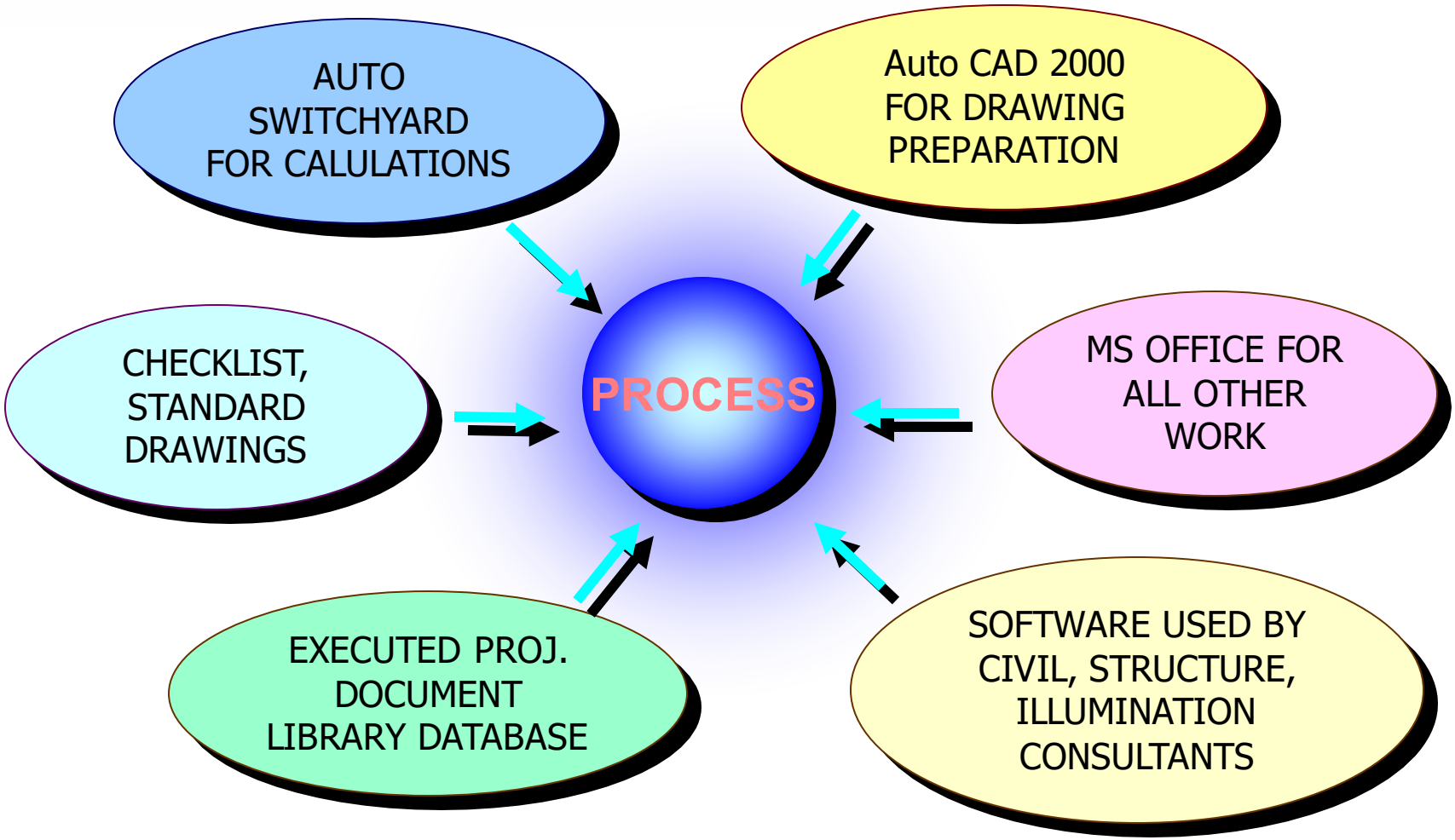
- Phase to Phase & Phase to Earth clearances
- Sectional Clearances
- Position of switch cubicle, junction box, drive box etc.
- Maintainability of equipment

Layout Engineering

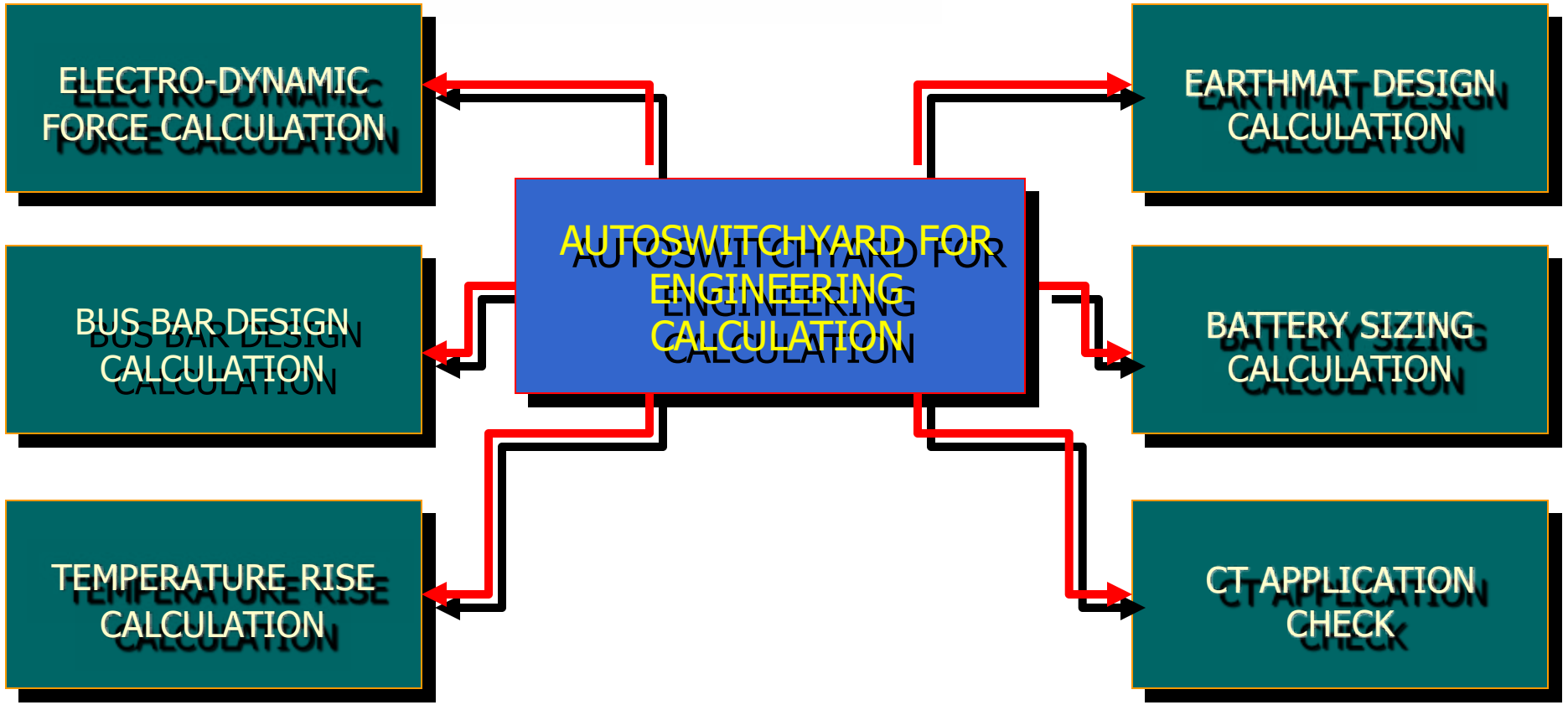
Standard bay width & clearances

System Voltage	Phase to Phase Distance	Phase to Earth Distance	Bay width
kV	mm	mm	mm
66	2000	2000	8000
132	2700	2500	9400
132 (Standard)	3000	3000	12000
220 (standard)	4500	4000	17000
220 (Industry)	4500	4500	18000
220 (IPP)	5000	4000	18000
400	7000	6500	27000

DESIGN & ENGINEERING TOOLS

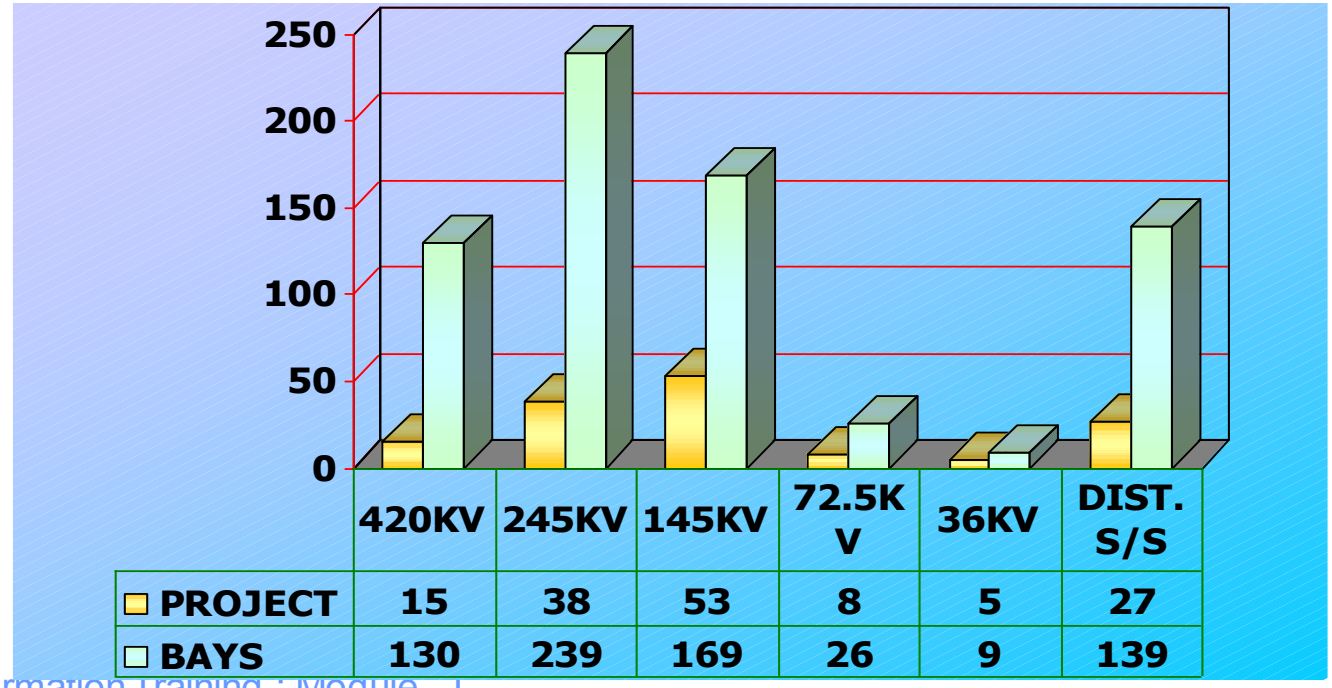


DESIGN ENGINEERING TOOLS



COMPETENCE - Our People

- 180 man-years of experience with average of 12 years experience
- Number of job engineered with different
  - Voltage level
  - Bus configuration
  - Protection requirement
  - Customer specific requirement



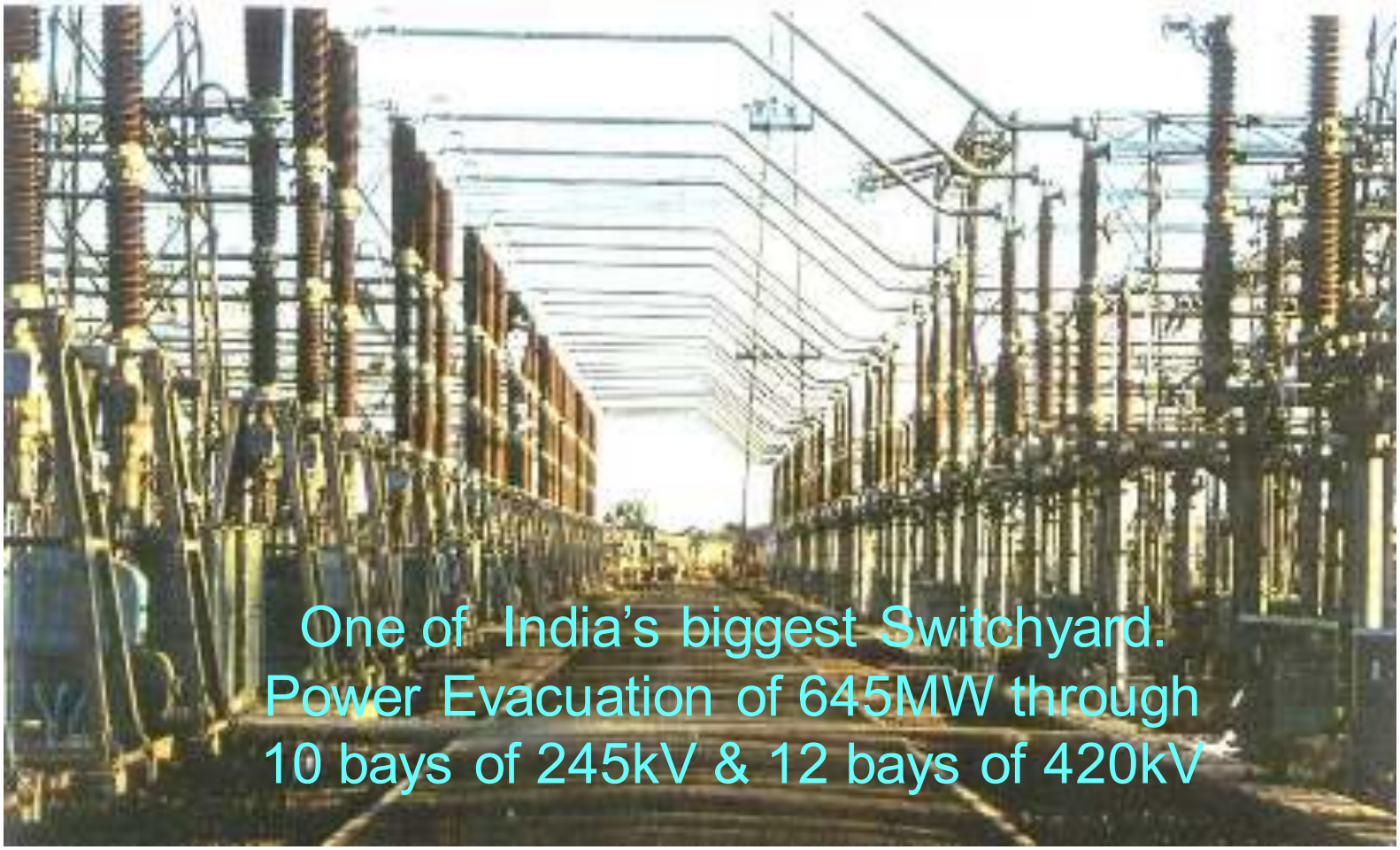
	420KV	245KV	145KV	72.5KV	36KV	DIST. S/S
PROJECT	15	38	53	8	5	27
BAYS	130	239	169	26	9	139

Our Business ...

Our Business ...

Our Business ...

NTPC GANDHAR



NTPC GANDHAR

IPCL Dahej Project

Dabhol (Enron) Project

One of our valued IPP customer ….

Dabhol (Enron) Project

400kV Equipment Erection..

Switchyard for Reliance Petroleum at Jamnagar

POWERGRID, Jallandhar

POWERGRID, Jallandhar

Transmission & Distribution Substation

The many FIRSTS ……..

- FIRST 400kv Switchyard in India - UPSEB
- 220KV Switchyard for India's FIRST IPP - GVK Rajamundary
- India's biggest ever Power Distribution project for Durgapur Integrated Steel Plant
- 400kV Switchyard for ENRON'S FIRST power plant in India.
- APSEB and MSEB'S FIRST 220KV Substation turnkey order
- placed on us.
- Turnkey substation for India's FIRST Barge mounted Power Plant
- IPP - Tanir bavi

Voltage wise summary

- **Air Insulated Sub-Stations (AIS)**

Voltage	No. of Projects	No. of Bays
420 kV	15	130
245 kV	37	280
145 kV	65	324
72.5 kV	10	36
36 kV	11	183
Plant Distribution	21	262 [Load Center]

Market segmentwise summary

Air insulated Sub-Stations (AIS)	No. of Projects
Power Transmission	43
Industry	
# Steel	23
# Cement	10
# Oil & Gas, Petrochemical	7
# Chemical & Fertilizers	10
# Minerals	5
# Others	22
Research & Development	5
Exports	6

Total:	131
	===