SWITCHGEAR AND PROTECTION

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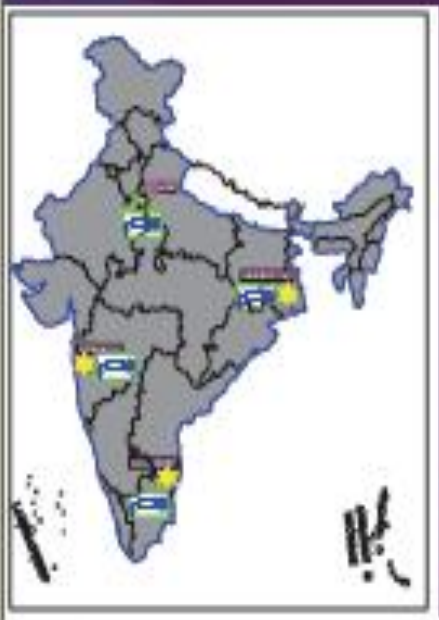
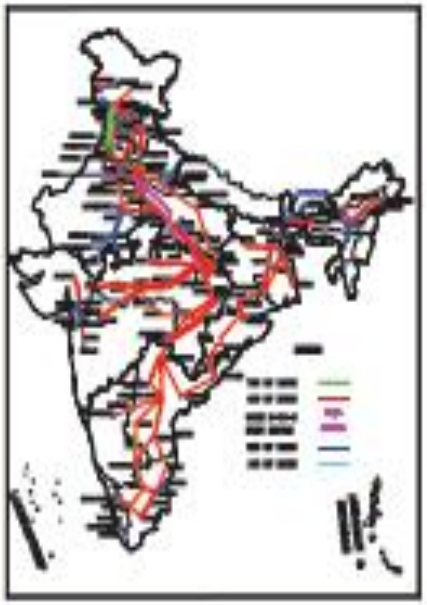
TRANSMISSION GRID : 1947 to 2007

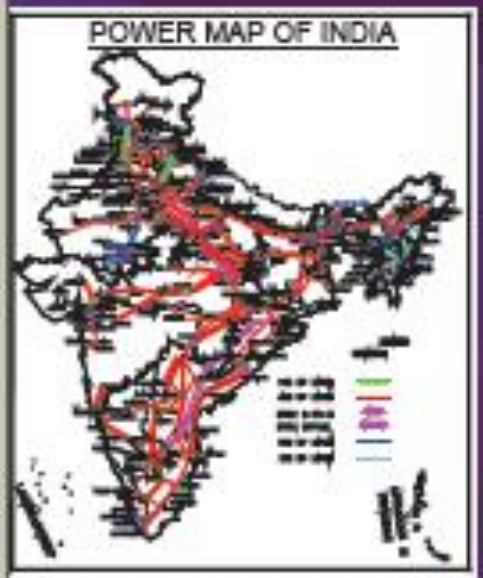




- Installed Capacity : 1349 MW to 1,40,000 MW
- Transmission System : Local Grid to Regional Grid

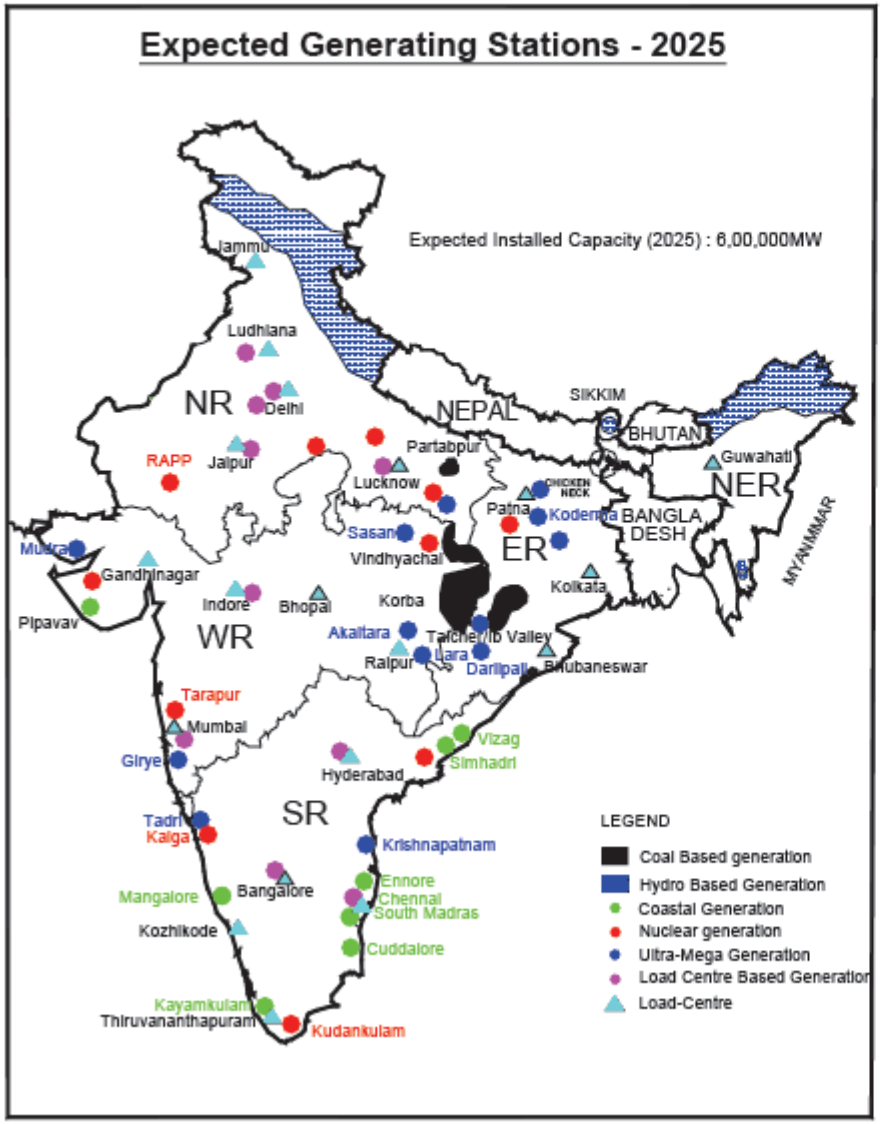
- 1960s - State Grids
- 1970s - Regional Grids
- 1990s - Interconnecting Regional grids asynchronously with Limited Interregional Capacity
- 2000 onwards – towards National Grid

TRANSMISSION GRID : 2007 to 2012



	2007	2012
Installed Capacity	140 GW	210GW
Transmission System	400kV ±500kV HVDC	765kV ±800kV HVDC
Inter-Regional Capacity	18,000MW	37,000MW

Indian Power System – 2022



- **Inst. Capacity : 600GW**
  - Upto 2012 : 210 GW
  - Additional : 390 GW
- **Likely addition :**
  - Hydro : 80 GW
  - Coal Based : 80 GW (Pit head and Load centre based)
  - Coastal (Imported Fuel) : 90 GW
  - Nuclear : 90 GW
  - Distributed Gen : 50 GW

Air Insulated substation

- Statutory clearance to be observed during substation design
  - Safe ground
  - Phase to ground
  - phase to phase
  - Section clearance

- Creep age distance on insulators rising from 25 to 30 to 35 mm/kV
  - Change in ambient or pollution levels
  - Geographical location, altitude

Air Insulated substation

- Size of substation increases with number of feeders /sections
- No utilization of the space above the substation, only guard wires are nested
- Seismic conditions call for specific considerations

- Grounding-mat is essential for containing touch and step potentials

- Corrosion of steel structure is imminent

- Substation is always live

Air Insulated substation

- Hot line washing and regular maintenance of the substation is essential, requires spares inventory and man-power
- Up-grading horizontally (same voltage level) or vertically (higher voltage class) is difficult
- Difficult to plan such substations in high density sub-urban locations

Gas-insulated substations

- Gas-insulated substations (GIS) have been used in power systems over the last three decades because of their high reliability, easy maintenance, small ground space requirement, etc.

Gas Insulated Substation (GIS) also called SF6 Gas Insulated Metal clad Switchgear and are preferred for 12kV, 36kV, 72.5kV, 145 kV, 245 kV, 420 kV, and above voltages.

Gas insulated substation

VT

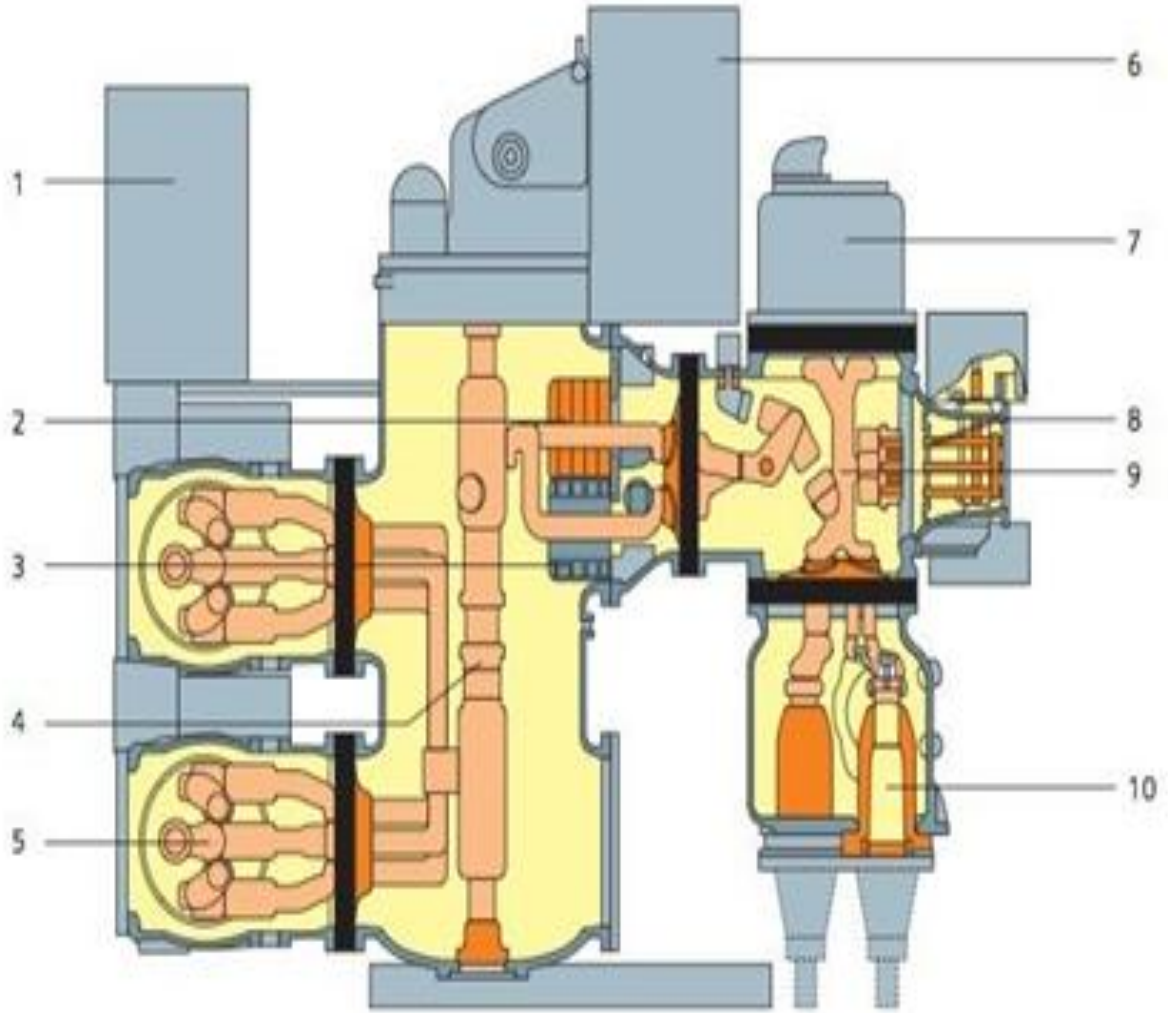
CB

400 kV GIS


ABB

GIS Components

- In a GIS substation, the various equipment like circuit breakers , Bus bars, Isolators, Load break switches, Current transformers, Voltage transformers, Earthing switches, etc.



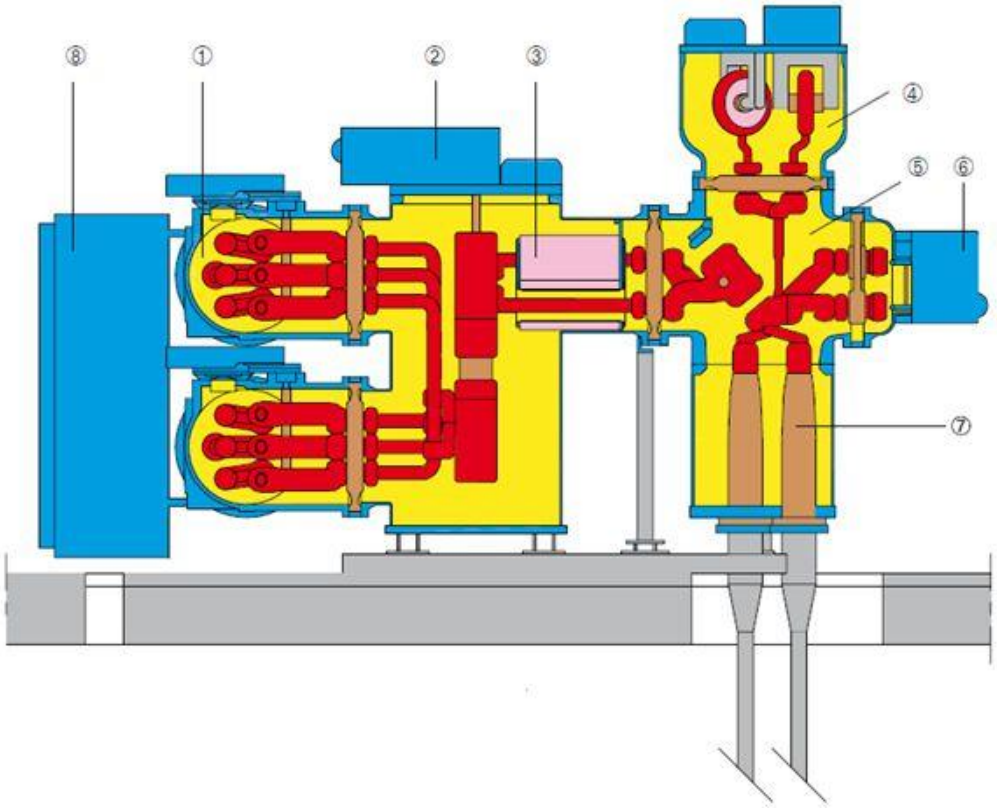
1. Integrated local control cubicle
2. Current transformer
3. Busbar II with disconnector and earthing switch
4. Interrupter unit of the circuit-breaker
5. Busbar I with disconnector and earthing switch
6. Spring-stored energy mechanism with circuit-breaker control unit
7. Voltage transformer
8. High-speed earthing switch
9. Outgoing feeder module with disconnector and earthing switch
10. Cable sealing end

Gas-tight bushing
Gas-permeable bushing

145kV GIS

(ABB ELK04)

① Busbar with disconnector and earthing switch
② Circuit breaker
③ Current transformer
④ Voltage transformer
⑤ Feeder disconnector and earthing switch
⑥ Make-proof earthing switch
⑦ Cable end unit
⑧ Local control cabinet



Active parts under high voltage
Enclosure
SF_6-Gas
Insulation material
Mechanical parts, structures
Low voltage parts

- They are housed in separate metal-enclosed modules filled with SF6 gas.
- The SF6 gas provides the phase to ground insulation.
  - As the dielectric strength of SF6 gas is higher than air, the clearances required are smaller.
  - Hence the overall size of each equipment and the complete sub-station is reduced.

- The various modules are factory assembled and are filled with SF6 gas. Thereafter, they are taken to site for final assembly.

- SF6 Gas Insulated Substations are compact and can be installed conveniently on any floor of a multi-storeyed building or in an underground substation.

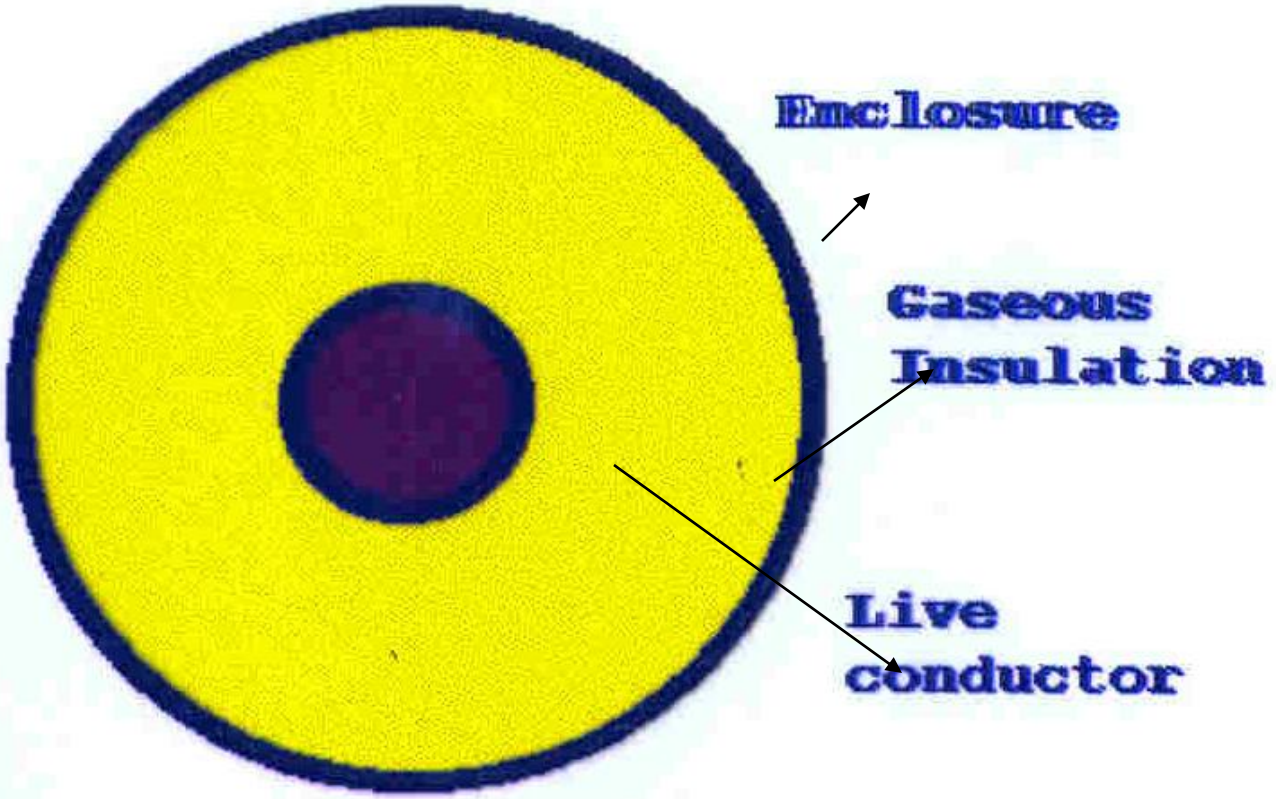
- As the units are factory assembled, the installation time is substantially reduced.

- Such installations are preferred in composition cities, industrial townships, hydro stations where land is very costly.

- The higher cost of SF6 insulated switchgear is justified by saving to the reduction in floor-area requirement.

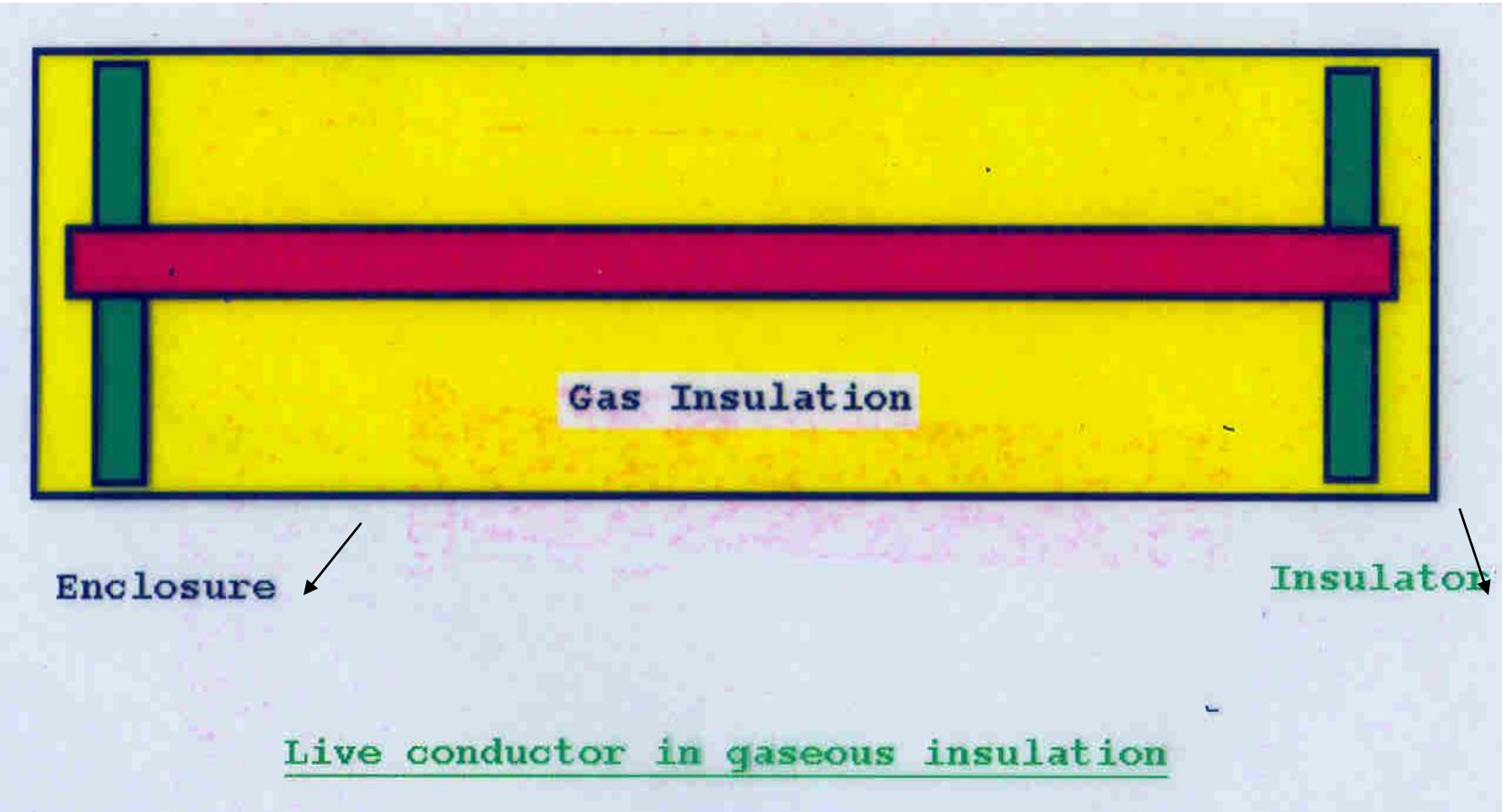
- SF6 insulated switchgear is also preferred in heavily polluted areas where dust, chemical fumes and salt layers can cause frequent flashovers in conventional outdoor substations.

Design of GIS



Live conductor in gaseous insulation

Design of GIS



Why SF6 is Used?

- SF6 is used in GIS at pressures from 400 to 600 kPa (100kPa = 1bar) absolute.

- The pressure is chosen so that the SF6 will not condense into a liquid at the lowest temperatures the equipment experiences.

- SF6 has two to three times the insulating ability of air at the same pressure.

- SF6 is about 100 times better than air for interrupting arcs.

- SF6 insulated switchgear is also preferred in heavily polluted areas where dust, chemical fumes and salt layers can cause frequent flashovers in conventional outdoor sub-stations.

- The GIS require less number of lightning arresters than a conventional one.

- This is mainly because of its compactness.

Advantages of GIS

The following are the main advantages of Gas Insulated Substations over Air Insulated Substations and Hybrid Substations.

Compactness of GIS

- The space occupied by SF6 installation is only about 10% of that of a conventional outdoor substation.
- High cost is partly compensated by saving in cost of space.

Protection from pollution

- The moisture, pollution, dust etc., have little influence on SF6 insulated sub- stations.
- However, to facilitate installation and maintenance, such substations are generally housed inside a small building.
- The construction of the building need not be very strong like conventional power houses.

Reduced Switching over voltages

- The over voltages while closing and opening line, cables motors capacitors etc. are low.

Reduced Installation Time

- The principle of building-block construction (modular construction) reduces the installation time to a few weeks.
- Conventional sub-stations require a few months for installation.

Superior Arc Interruption

- SF6 gas is used in the circuit-breaker unit for arc quenching. This type of breaker can interrupt current without over voltages and with minimum arcing time. Contacts have long life and the breaker is maintenance free.

Gas Pressure

- The gas pressure (4 kPa /cm2) is relatively low and does not pose serious leakage problems.

Increased safety

- As the enclosures are at earth potential, there is no possibility of accidental contact by service personnel to the live parts

Disadvantages of GIS

The following are the main disadvantages of Gas Insulated Substations over Air Insulated Substations and Hybrid Substations.

1. High cost compared to conventional outdoor sub-station.
2. Excessive damage in case of internal fault. Long outage periods as repair of damaged part at site may be difficult.

- Requirements of cleanliness are very stringent. Dust or moisture can cause internal flashovers.

- Such sub-stations generally indoor. They need a separate building.

- This is generally not required for conventional outdoor sub-stations.

- Procurement of gas and supply of gas to site is problematic. Adequate stock of gas must be maintained.

THANK YOU