

Types of Substations (Part 2)

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- Course: Substation Engineering (DI04009011)
- Unit 1: Introduction
- Lecture 4

Classification by Constructional Features

- This classification focuses on how and where the equipment is installed.
- Main types:
 - 1. Indoor Substations
 - 2. Outdoor Substations
 - 3. Underground Substations
 - 4. Pole-Mounted Substations
 - 5. Gas Insulated Substations (GIS)

1. Indoor Substations

- Equipment is installed inside a building.
- Generally restricted to lower voltages (up to 11kV or 33kV) due to clearance requirements.
- Used in heavily populated areas where space is limited.
- Used in industrial plants or areas with extreme weather/pollution.

Advantages and Disadvantages of Indoor Substations

Advantages

- Protected from weather and atmospheric pollution.
- Smaller land footprint.
- Safer for the surrounding public.

Disadvantages

- High civil construction cost.
 - Difficult to expand or upgrade later.
 - Clearance issues limit the maximum voltage.
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2. Outdoor Substations

- Equipment is installed in open air.
- The most common type for voltages above 33kV (up to 765kV).
- Uses air as the primary insulation medium between phases and ground.
- Equipment is designed to withstand rain, wind, snow, and pollution.

Advantages and Disadvantages of Outdoor Substations

Advantages

- Lower civil construction costs (no building needed).
- Easy to expand and add new bays.
- Easy visual inspection of equipment.

Disadvantages

- Requires a massive amount of land.
 - Exposed to lightning, pollution, and severe weather.
 - Higher maintenance required for exposed contacts.
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3. Pole-Mounted Substations

- A specific type of outdoor substation mounted on an H-pole or 4-pole structure.
- Used for distribution (e.g., 11kV to 415V).
- Transformer capacity is usually limited to 250kVA or 500kVA.
- Extremely cost-effective for local neighborhood distribution.

Components of Pole-Mounted Substation

11kV Incoming Line



Lightning Arresters (LA)



Gang Operated Switch (GOS) / Isolator



Drop Out (DO) Fuses



Distribution Transformer



Low Tension (LT) Distribution Box

4. Underground Substations

- Constructed entirely below ground level.
- Used in extremely congested urban areas (mega-cities) where land cost is prohibitive.
- Major challenges include ventilation, cooling, and water ingress.
- Requires highly specialized, fire-resistant equipment.

5. Gas Insulated Substations (GIS)

- The modern revolution in substation design.
- All live components are enclosed in metal housings filled with SF₆ (Sulfur Hexafluoride) gas.
- SF₆ has extraordinary dielectric (insulating) properties compared to air.
- Allows phases to be placed very close together.

Why Choose GIS?

- Requires only 10% to 25% of the space of a conventional outdoor (AIS) substation.
- Highly reliable; components are completely sealed from pollution, dust, and wildlife.
- Minimal maintenance required over a 40-50 year lifespan.
- Significantly higher initial capital cost.

Air Insulated (AIS) vs. Gas Insulated (GIS)

Feature	AIS (Outdoor)	GIS (Indoor/Outdoor)
Insulating Medium	Atmospheric Air	SF6 Gas
Space Required	Very Large	Very Small (1/10th)
Initial Cost	Low	Very High
Maintenance	High (Regular cleaning)	Very Low (Sealed)
Reliability	Moderate (exposed to weather)	Very High

SF6 Gas Environmental Concerns

- SF6 is an extremely potent Greenhouse Gas (GHG).
- Global warming potential is 23,500 times that of CO2.
- Strict regulations govern its handling, leak detection, and disposal.
- Industry is actively researching SF6 alternatives (e.g., dry air, specialized gas mixtures).

Summary of Construction Types

- Outdoor Substations (AIS) remain the standard for high-voltage due to cost.
- Indoor and Underground Substations are utilized when space is restricted.
- Pole-Mounted units provide cheap, local distribution.
- GIS offers massive space savings and reliability through SF6 technology.