

DRAFT



**GUIDELINES FOR
USAGE OF
AIR INSULATED SUBSTATION (AIS)
OR
GAS INSULATED SUBSTATION (GIS)**



CENTRAL ELECTRICITY AUTHORITY

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1. Introduction

Substations are an important part of the electrical distributions. They transform the voltage from high to low level, and provide the ties, transformation, switching and protection of the distribution systems. A typical distribution substation houses transformer, bus-bar, conductor, breaker, isolator, protection devices etc. Type of insulation medium used in sub-station is a major factor in determining the size of a sub-stations. The following sections will deliberate on various types of distributions sub-stations used in the country and their advantages and disadvantages and factors to be considered before going for a typical type of sub-stations.

1.1 Air Insulated Substations (AIS)

The conventional Substations use air for insulation between various live parts and ground in the substations and mostly are being used in power sector. These substations require more space than Gas insulated Substations.



1.2 Gas Insulated Substations (GIS)

Gas Insulated Substations (GIS) are different from Air Insulated Substations as all the substation equipment such as bus bars, circuit breakers, current transformer, potential transformers and other substation equipment are placed inside the modules filled with SF₆ gas. SF₆ gas having high dielectric property acts as insulating medium between the live parts and ground. Generally, Gas Insulated Substations (GIS) are indoor type and it requires substantially less space compared to the conventional air-insulated substations.



1.3 Hybrid Switchgear

The Hybrid switchgear is a mix of AIS and GIS technology and can be installed indoor as well as outdoor. Outdoor installation is preferred because of the saving in civil works of building. Following are the features of Hybrid Switchgear:

- Represents a complete bay
- Approx. 30% Less Switch Yard Area
- Approx. 9 No. Lesser Foundations per bay
- Quick installation
- Plug and Play Unit
- Dry Type Ring CTs. Less damage in case of CT burst event.



2. AIS Vs GIS Vs Hybrid Technology

The following table shows the comparative analysis between AIS, GIS and Hybrid based on various parameters:

Sl. No	Parameters	AIS	GIS	Hybrid
a	Land /Space Required	Min. 6800 Sq. M. (80x85 sq. M.)	Min. 2400 sq. M. (60x40 sq. M.) (appx 1/3 rd area)	Min. 4200 sq. M. (60x70 sq. M.)
b	Features	<ul style="list-style-type: none"> All Bay Equipment installed in Outdoor Area Individual Equipment are connected with Jumpers having minimum clearances and offering higher contact Resistance 	<ul style="list-style-type: none"> Indoor Type Panels Unitise system with all equipment housed in single unit 	<ul style="list-style-type: none"> Outdoor Type Equipment Unitised system with all bay equipment housed in single unit
c	Strength / Weakness	<ul style="list-style-type: none"> Outdoor Yard involved Larger Space required Less Cost Regular Maintenance Higher losses Higher Maintenance Cost Personnel Safety is less Low Reliability (prone to breakdowns) 	<ul style="list-style-type: none"> GIS Building to be constructed Smaller Space for substation High Cost Low Maintenance Required Low losses High Reliability More Safety for Personnel 	<ul style="list-style-type: none"> GIS Building need not to be constructed lesser Space for substation compared to AIS, but 50% more than that in GIS Moderate Cost Easy addition of bays (Flexibility) Low Maintenance Low losses Moderate reliability Safety of operating personnel
d	Cost Comparison (In case land is taken on lease) for a	Rs. 22.90 Cr. (Rs. 17 Cr. for Grid + Rs. 0.34 Cr. per year Land Premium (Annuity basis) +	Rs. 27.70 Cr. (Rs. 26 Cr. for Grid + Rs. 0.12 Cr. Land Premium (Annuity basis)+	Rs. 23.80 Cr. (Rs. 21 Cr. for Grid + Rs. 0.18 Cr. . Land Premium (Annuity

typical 33/11 kv S/s (Price Level 2017)	Rs, 0.25 Cr. Per Year Maintenance Cost (Annuity basis))	Rs, 0.05 Cr. Per Year Maintenance Cost(Annuity basis))	basis) + Rs, 0.10 Cr. Per Year Maintenance Cost (Annuity basis))
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Note: Cost may vary depending upon substation installed capacity, bus bar configuration (Single bus, Double bus, One-an-half breaker etc.) , current rating and land cost in a particular city/ town.

3. Economics - Life cycle cost (LCC) comparison

The initial capital investment is more in GIS as compare to AIS / Hybrid but due to less maintenance cost over the years, the overall higher initial cost can be recovered in subsequent years through savings in maintenance cost of GIS S/S. However, after considering the less requirement of land cost, the difference in initial capital cost of GIS and AIS is very less now a days. Also, for evaluation of overall substation project cost, the **Life Cycle Cost (LCC)** should be considered, including primary hardware cost, maintenance cost, operation cost, outage cost and disposal costs etc.

The LCC comparison of AIS and GIS is as follows:

3.1 Primary hardware

Primary hardware for primary equipment, **GIS is more expensive than AIS**. However, the price of land and auxiliary equipment such as support, conductors, land, installation, control, protection and monitoring can lead to small cost difference between the two systems.



3.2 Maintenance

The failure rate of circuit breaker and disconnecting switch in GIS is **one-fourth of that of AIS and one tenth in case of busbar**, thus the maintenance cost of GIS is less than that of AIS over the lifetime.

3.3 Operation cost

The operational cost of GIS and AIS is same. The cost for training personnel engaged in GIS Operation is higher than in AIS.

3.4 Outage cost

The failure rate of GIS is lower, **resulting in less outage cost compared to AIS.**

3.5 Disposal cost

The cost of decommissioning and disposal after use should be capitalized. The value of future expenses must be taken into account.

3.6 Typical LCC evaluation of AIS and GI

Life Cycle Cost	Air insulated substation (AIS)	Hybrid substation	Gas insulated substation (GIS)
Planning and Engineering	100%	90%	80%
Real estate	100%	60%	40%
Primary equipment	100%	110%	120%
Secondary equipment	100%	100%	100%
Earthwork, civil work, structures	100%	90%	60%
Electrical assembly and erection	100%	80%	70%
Maintenance	100%	70%	50%
Outage	100%	70%	50%
LCC after 10 years	100%	Max 80%	Max 70%

3.7 Safety

As the enclosures of GIS are at earth potential there is no possibility of accidental contact by service personnel to live parts. In conventional open terminal AIS, personnel have to be doubly sure before taking maintenance tools, ladders, vehicles etc.

3.8 Environmental impact

The latest GIS technology has less environmental impact than previous technology. **The SF6 leakage rate is less than 1% (in experiment <0.5%)**. Due the design characteristics, GIS has a better impact on environment than AIS. All current breaking parts of switchgear of GIS are contained in the metal enclosure, resulting in an extreme reduction in corona noise level.

4. Decision Matrix

The following matrix has been prepared based on the above discussion on various parameters of analysis:

S. No.	Parameters	AIS	GIS	Hybrid
1	Land Requirement	High	Low	Moderate
2	Initial Cost	Low	High	Moderate
3	Civil Cost	Low	High	Low
4	Flexibility	High	Low	High
5	Safety	Low	High	Moderate
6	Reliability	Low	High	Moderate
7	Maintenance Cost	High	Low	Moderate
8	Maintenance Periodicity	High	Low	Moderate
9	Maintenance Hours/year	High	Low	Moderate
10	Breakdown Restoration Time	Low	High	Low
11	Losses	High	Low	Moderate

5. Analysis /Observations

➤ GIS is an advanced technology, needs lesser space (35%), lower maintenance costs and outages compared to AIS.

- Initial cost of GIS is higher by about 50% than AIS but when the cost of land is considered in capital cost, the overall capital cost is comparable.
- Wherever land is a constraint, GIS is the only option.
- Hybrid Technology that is a mix of AIS & GIS combines the benefits of both AIS and GIS (Initial capital cost -20% higher than AIS)
- Hybrid technology requires moderate land size (50% of AIS and 50% higher than GIS).
- Flexibility in term of future expansion in Hybrid technology is high (similar to AIS).

6. Recommendation:

- Wherever land is a constraint, GIS technology should be adopted. It would also provide more safety and reliability . Keeping in view the space constraint and higher cost of land in big cities/ towns , GIS should be preferred.
- The future expansion of existing AIS substations may be done with hybrid technology keeping in view the less space requirement.
- Wherever sufficient land is available, AIS substations may still be preferred due to low upfront cost. Hybrid Technology may also be used, wherever we want to optimize in terms of space & cost and may be most useful in extension of existing substations.