SITE SELECTION OF SUB-STSTION.

The site should be near the load center keeping in view the future load growth.

Some general factors to be considered are listed. It should be remembered that some of the factors are actually interdependent.

- Access road to the site for smooth movement of construction machines, equipments and transformers. Good Roadways to construction site and shorter distance to rail head are desired.
- The site should be chosen to avoid soil filling, earth removal etc. The requirement of soil filling and earth removal takes time and increases total cost of substation
- Historical data of worst flood is taken into account to avoid water logging of the substation in case of possibility of flood. Flood plains and wetlands are avoided.
- Atmospheric conditions like salt and suspended chemical contaminants influence selection of equipments and maintenance requirements.
- Interference with communication signals. The construction company have to take permission from the appropriate authority.
- Electric and magnetic field strength are of particular concern especially for Ultra High Voltage (UHV) systems at 765 kV,1200 kV or above. Research organisations has shown the impact of strong Electric/magnetic fields due to UHV substations and lines on human health. Such new concerns are also required to be addressed properly
- Forest land, sanctuaries and national parks are avoided. Almost all governments has laid stringent rules to comply for approval of forest land and wild life sanctuary. The usual process takes time to get approval from the concerned authorities. This process delays the construction activities.
- Approval is also required from aviation authority. Substation should be away from airport and defence establishments.
- Water supply and sewage system are the two most important facilities to be given due consideration.

Some other factors related to the general public:

- The substation should be located far from the crowded places. Efforts are always made to locate transmission substations outside the city areas.
- The locals should be made aware of the upcoming substation. To avoid public resentment it is better to involve the local people in the process. If required they should be educated and trained. Many times the local people also plays an important role to check vandalism and theft.
- Heritage sites and tourist spots are avoided.
- Electric substation is a source of noise. While charged transformers, reactors and EHV lines are sources of continuous hissing noise, operation of different equipment also emit sudden noise. The design should be adopted to tackle the issues by complying to the standards set by the appropriate authority for reduction of noise pollution and avoid public resentments.

- Landscaping should be done to keep the substation out of direct view of common people.

Classification of Sub-Stations

There are several ways of classifying sub-stations. However, the two most important ways of classifying them are according to

1. Service requirement and
2. Constructional features.

1. According to service requirement. A sub-station may be called upon to change voltage level or improve power factor or convert a.c. power into d.c. power etc. According to the service requirement, sub-stations may be classified into :

1. **Transformer sub-stations.** Those sub-stations which change the voltage level of electric supply are called transformer sub-stations. These sub-stations receive power at some voltage and deliver it at some other voltage. Obviously, transformer will be the main component in such substations. Most of the sub-stations in the power system are of this type.
2. **Switching sub-stations.** These sub-stations do not change the voltage level i.e. incoming and outgoing lines have the same voltage. However, they simply perform the switching operations of power lines.
3. **Power factor correction sub-stations.** Those sub-stations which improve the power factor of the system are called power factor correction sub-stations. Such sub-stations are generally located at the receiving end of transmission lines. These sub-stations generally use synchronous condensers as the power factor improvement equipment.
4. **Frequency changer sub-stations.** Those sub-stations which change the supply frequency are known as frequency changer sub-stations. Such a frequency change may be required for industrial utilisation.
5. **Converting sub-stations.** Those sub-stations which change a.c. power into d.c. power are called converting sub-stations. These sub-stations receive a.c. power and convert it into d.c. power with suitable apparatus (*e.g.* ignitron) to supply for such purposes as traction, electroplating, electric welding etc.
6. **Industrial sub-stations.** Those sub-stations which supply power to individual industrial concerns are known as industrial sub-stations.

2. According to constructional features. A sub-station has many components (*e.g.* circuit breakers, switches, fuses, instruments etc.) which must be housed properly to ensure continuous and reliable service. According to constructional features, the sub-stations are classified as :

- Indoor sub-station
- Outdoor sub-station
- Underground sub-station
- Pole-mounted sub-station

1. **Indoor sub-stations.** For voltages upto 11 kV, the equipment of the sub-station is installed indoor because of economic considerations. However, when the atmosphere is contaminated with impurities, these sub-stations can be erected for voltages upto 66 kV.
2. **Outdoor sub-stations.** For voltages beyond 66 kV, equipment is invariably installed outdoor. It is because for such voltages, the clearances between conductors and the space required for switches, circuit breakers and other equipment becomes so great that it is not economical to install the equipment indoor.
3. **Underground sub-stations.** In thickly populated areas, the space available for equipment and building is limited and the cost of land is high. Under such situations, the sub-station is created underground. The reader may find further discussion on underground sub-stations in Art. 25.6.
4. **Pole-mounted sub-stations.** This is an outdoor sub-station with equipment installed overhead on *H*-pole or 4-pole structure. It is the cheapest form of sub-station for voltages not exceeding 11kV (or 33 kV in some cases). Electric power is almost distributed in localities through such substations.

Synchronous phase modifier

Application

• Constant voltage transmission

For constant voltage transmission , especially designed synchronous motor , called the synchronous phase modifiers, are installed at receiving end , which maintain the voltage drop across the line constant with the change in load,power factor of the system is changed by the synchronous motors and thus voltage drop along the line remains constant. The advantage and disadvantage is given below .

Merits of constant voltage transmission

1. Possibility of carrying increased power for a given conductor size in case of long distance heavy power transmission

2. Improvement of power factor at times of moderate and heavy loads.

3. Possibility of better protection for the line due to possible use of higher terminal reactances.

4. Availability of steady voltage at all loads at the line terminals.

5. Improvement in system stability due to inertia effect of synchronous phase modifier and reduction in effect of sudden changes in load.

Demerits of constant voltage transmission

1. Increase of short –circuit current of the system and, therefore, increase in the circuit breaker ratings.

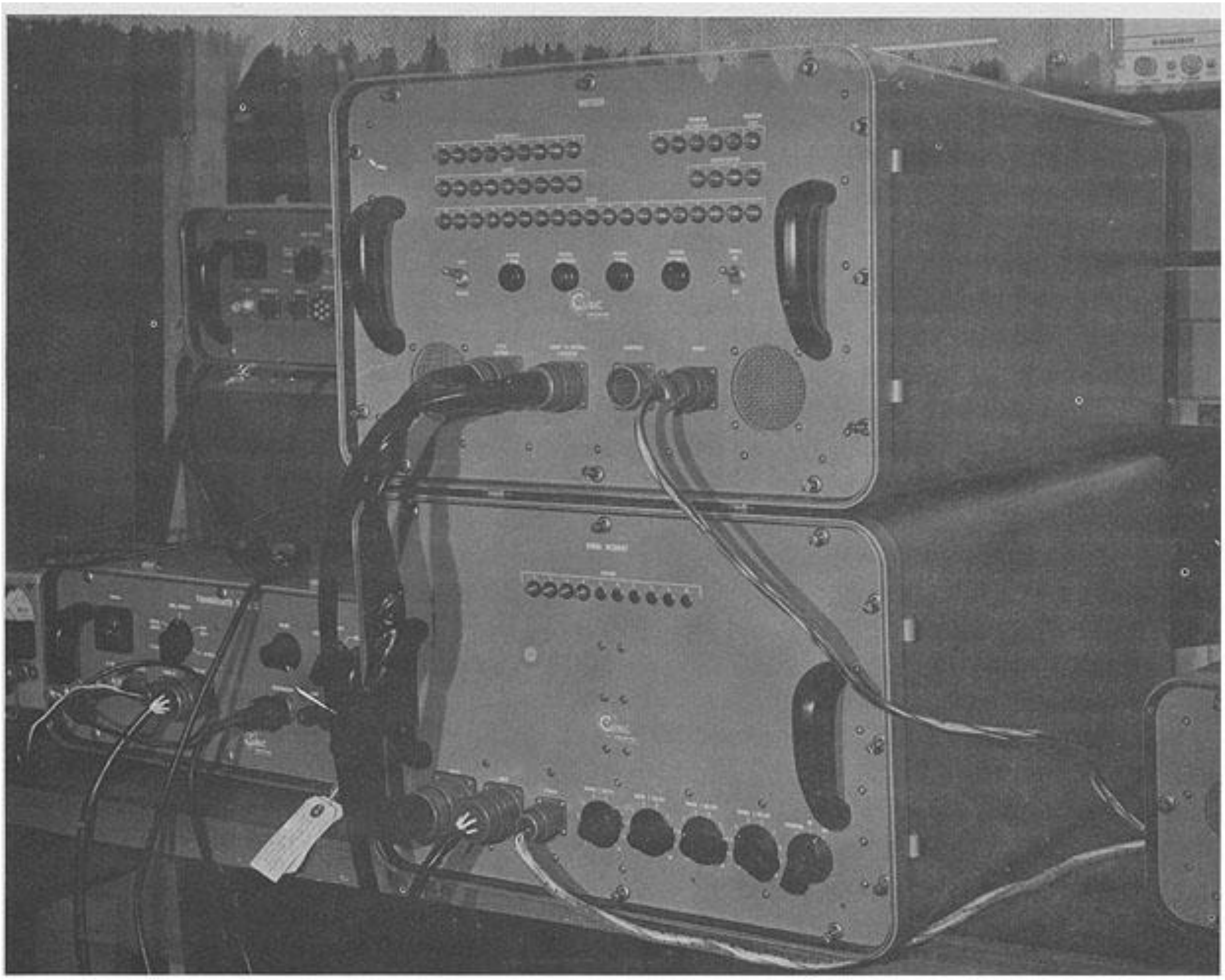
2. Increase risk of interruption of supply due to falling of synchronous motors, called the synchronous phase

modifiers, out of synchronicity.

3. Lower reserve of lines in case of line trouble.

Synchronous phase modifier

It is well known that a synchronous motor can be made to take either a lagging or leading current from the line by alternating its excitation. Idle-running synchronous motor were first employed in connecting in connection with power plants to correct for low power factor of the load, and thus reduced the current and power losses in the feeders and generators. The synchronous machines used for power factor improvement are usually referred to as synchronous condensers as they are always required to take a leading current. However and idle-running synchronous motor can be used for voltage regulating purposes by connecting it in parallel with the load at the receiving end of a line , as shown in diagram since the machines used for voltage regulation as a synchronous modifiers . They are usually of salient pole design with 6 or 8 poles with rating up to 60MVA, 11KV and connected to high voltage system through transformers.



Synchronous phase modifier differ from the ordinary synchronous motor is as much as they are built for the highest economical speeds, and provided with smaller shafts and bearings and special attention is paid for securing a high overall efficiency . Standard machines for this purpose are designed to give their full-load output at leading power factor, and can carry about 50% of their rated capacity at lagging power factor. machines can , however, be designed to operate at full rating on both leading and lagging power factor s but they are larger in size , have poor efficiency and are more expensive than standard machines .

Synchronous Phase Modifiers

It is well known that **asynchronous motor** can be made to take either a lagging or leading current form the line by altering its excitation. Idle-running synchronous motors were first employed in connection with power plants to correct for low power factor of the load, and thus reduce the current and power losses in the feeders and generators.

The synchronous machines used for power factor improvement are usually referred to as ‘synchronous condensers’ as they are always required to take a leading current.

However, an idle running **synchronous motor** can be used for voltage regulating purposes by connecting it in parallel with the load at the receiving end of a line. Since the machines used for voltage regulation are required to run part of the time with leading current and part of the time with lagging current depending upon the load conditions, therefore, it is more appropriate to refer to these machines as ‘ synchronous phase modifiers.’

Synchronous phase modifiers differ from the **ordinary synchronous motors** in as much as they are built for the highest economical speeds and provided with smaller shafts and bearings and special attention is paid for securing a high overall efficiency. Standard machines for this purpose are designed to give their full-load output at leading power factor, and can carry about 50% of their rated capacity at lagging power factor. Machines can, however, be designed to operate at full rating on both leading and lagging power factors but they are larger in size, have poor efficiency and are more expensive than standard machines.

Synchonous condenser

An over-excited synchronous motor has a leading power factor. This makes it useful for power factor correction of industrial loads. Both transformers and induction motors draw lagging (magnetising) currents from the line. On light loads, the power drawn by induction motors has a large reactive component and the power factor has a low value. The added current flowing to supply reactive power creates additional losses in the power system. In an industrial plant, synchronous motors can be used to supply some of the reactive power required by induction motors. This improves the plant power factor and reduces the reactive current required from the grid.

A synchronous condenser provides step-less automatic power factor correction with the ability to produce up to 150% additional vars. The system produces no switching transients and is not affected by system electrical harmonics (some harmonics can even be absorbed by synchronous condensers). They will not produce excessive voltage levels and are not susceptible to electrical resonances. Because of the rotating inertia of the synchronous condenser, it can provide limited voltage support during very short power drops .

The use of rotating synchronous condensers was common through the 1950s. They remain an alternative (or a supplement) to capacitors for power factor correction because of problems that have been experienced with harmonics causing capacitor overheating and catastrophic failures. Synchronous condensers are also useful for supporting voltage levels. The reactive power produced by a capacitor bank is in direct proportion to the square of its terminal voltage, and if the system voltage decreases, the capacitors produce less reactive power, when it is most needed, while if the system voltage increases the capacitors produce more reactive power, which exacerbates the problem. In contrast, with a constant field, a synchronous condenser naturally supplies more reactive power to a low voltage and absorbs more reactive power from a high voltage, plus the field can be controlled. This reactive power improves voltage regulation in situations such as when starting large motors, or where power must travel long distances from where it is generated to where it is used, as is the case with *power wheeling*, the transmission of electric power from one geographic region to another within a set of interconnected electric power systems.

Synchronous condensers may also be referred to as *Dynamic Power Factor Correction* systems. These machines can prove very effective when advanced controls are utilized. A PLC based controller with PF controller and regulator will allow the system to be set to meet a given power factor or can be set to produce a specified amount of reactive power.

On electric power systems, synchronous condensers can be used to control the voltage on long transmission lines, especially for lines with a relatively high ratio of inductive reactance to resistance.[4]

Gallery[edit]

Synchronous Condenser unit at Templestowe substation, Victoria Australia.

Side view of the condenser unit

Front end of condenser unit

Blueprint diagram showing interior construction of condenser

Synchronous Condensers
A synchronous condenser is a synchronous machine running without mechanical load and supplying or absorbing reactive power to or from a power system. Also called a synchronous capacitor, synchronous compensator or rotating machinery. In November 1995, the first static synchronous compensator began operating at a TVA substation in Knoxville,

Tennessee. This compensator can regulate voltage without expensive external capacitors or reactors.