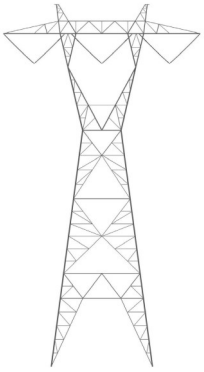
Transmission System Components

A variety of components are required to successfully deliver electricity from generating stations to local residential and commercial areas. The primary components include the transmission structures, conductors, insulators, and ground wires.

Transmission structures are the most visible component of transmission lines. Transmission structures come in many different designs, but two common types are:

- ***Lattice Steel Towers (LST)*** consist of a steel framework of individual structural components that are bolted or welded together.
- ***Tubular Steel Poles (TSP)*** are hollow steel poles fabricated either as one piece or as several pieces fitted together.

Conductors ("wires") are comprised of materials that readily conduct electric current. Conductors used in transmission lines are usually aluminum placed over a steel core for reinforcement. Transmission line conductors are not insulated; insulation is provided by the air.



500-kV single-circuit LST

500-kV single-circuit TSP

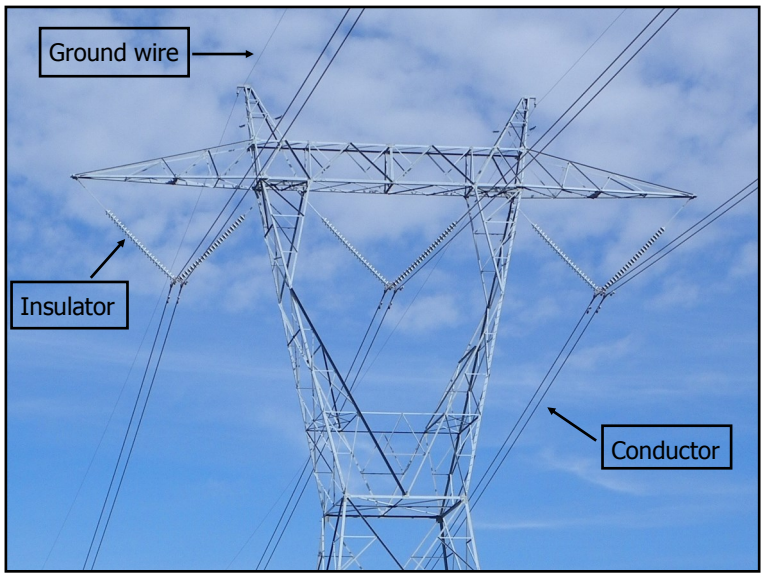
Conductors are connected to towers via **insulators** that support the conductors on the tower. They must withstand normal operating voltage and surges due to switching and lightning. Insulators have commonly been comprised of porcelain or toughened glass, which need routine cleaning to eliminate dust build-up that can lead to insulator flashover and noise. Newer insulators are composed of polymer or silicon, which are lightweight and shatter-resistant. There are two common types of insulators:

- ***Horizontal post-type***, which supports the conductor to the side of the structure.
- ***Suspension-type***, which suspends the conductor below the structure (see photo below).

A **circuit** is made up of three phases (for alternating current). Towers can carry one or more circuits, depending on the design (e.g., single-circuit vs. double-circuit towers). For voltages up to 200 kV, a phase is typically a ***single conductor*** (3 wires total per circuit). For voltages over 200 kV, ***bundled conductors*** are often used to increase the current-carrying capability of the line and reduce power loss. Bundled conductors consist of two or more conductor cables connected by non-conducting spacers. 220-kV and 500-kV lines often have two conductors per phase (6 wires total per circuit).

Voltage in a phase conductor is not constant; surges can happen, and fluctuations occur due to demand at any given time. A 500-kV line can accommodate up to and slightly above 500 kV, but usually carries lower voltages.

Ground wires (also called shield or earth wires) are strung along the tops of the towers to protect the system from lightning strikes. High-voltage systems usually have two ground wires. Transmission systems must have reliable communications for control of the lines and substations. For example, substations have built-in mechanisms to detect problems and shut down line sections. Telecommunication lines can be attached to the transmission towers or installed in separate locations, such as nearby streets. The ground wire sometimes incorporates a fiber optic communications line.



Single-circuit LST illustrating three phases supported by insulators. Note the three sets of bundled conductors which combine to make one circuit. Two ground wires are located at the top of the structure on raised peaks.

Note: This information is applicable to electric transmission systems in general and not specific to any project.

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Substations and Switchyards

- ***Substation.*** The function of a substation is to transform voltage to a lower or higher level of voltage, and to provide the ties, transformation, switching, and protection for the transmission and distribution systems. Substations contain transformers in order to convert voltage levels, as well as circuit breakers, and a large amount of protection and control equipment. Substations can vary in size, depending on the amount of voltage being transferred and the number of lines terminating at or originating from the substation. There are various types and classifications assigned to different substations, based on the amount of voltage, transformation desired, and equipment on site. Substations can be manned or unmanned.

Electric substation, with transformers and associated equipment shown in the foreground, and transmission towers and lines present in the background. (photo credit: www.ethospower.in)

- ***Switchyard.*** A switchyard is a substation without transformers which operates only at a single voltage level. These systems can be associated with a transformer substation, or can be a separate, stand-alone facility. Switchyards can be manned or unmanned. Switchyards are mainly used for connections and interconnections. The switchyard delivers generated power from the power source to the nearest grid or transmission line.

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