Electricity generation, transmission and distribution

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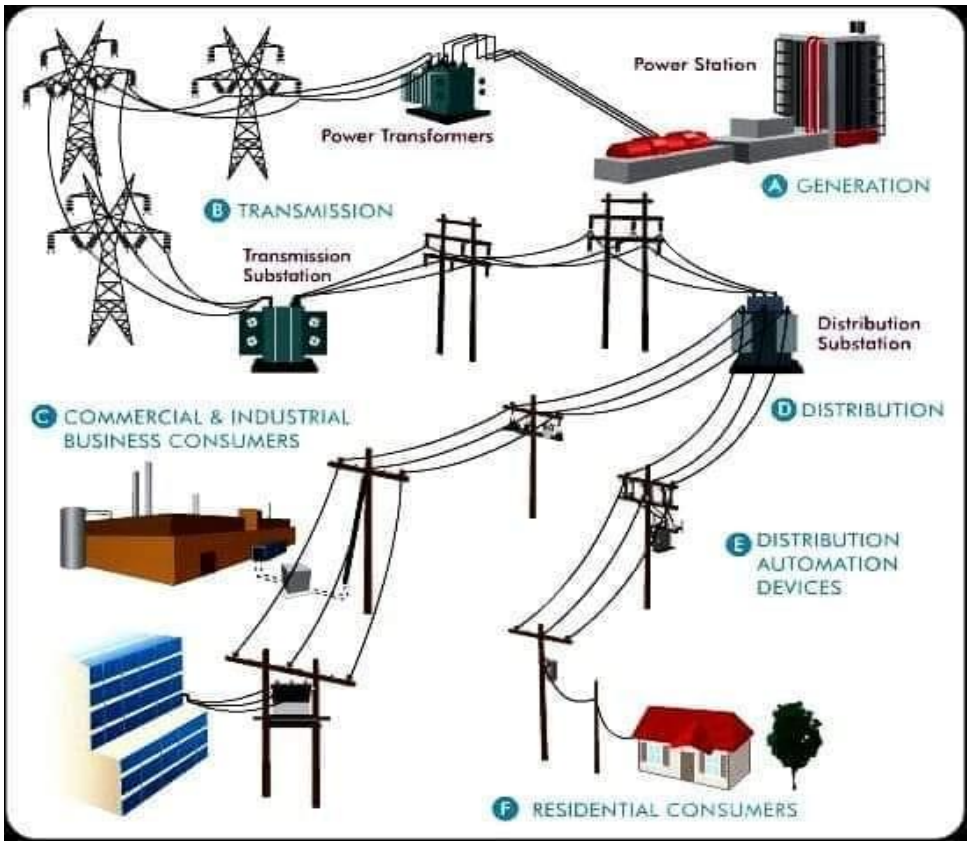


- ## Generation:

The process of generating electric power from sources of primary energy is called Electricity generation. For utilities in the electric power industry, it is the stage prior to its delivery (transmission, distribution, etc.) to end users or its storage (Using, for example, the pumped-storage method).

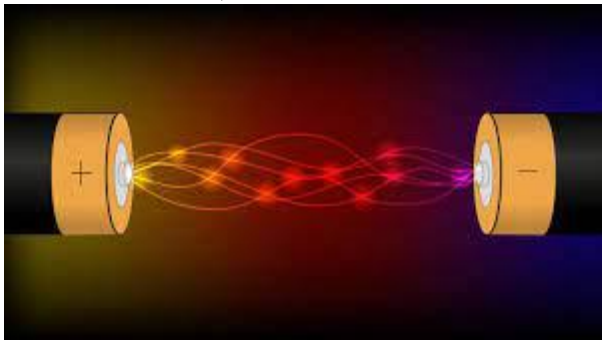
Electricity is not freely available in nature, so it must be "produced" (that is, transforming other forms of energy to electricity). Production is carried out in power stations (Also called "power plants"). Electricity is most often generated at a power plant by electromechanical generators, primarily driven by heat engines fueled by combustion or nuclear fission but also, by other means such as the kinetic energy of flowing water and wind. Other energy sources include solar photovoltaics and geothermal power.

Phasing out coal-fired power stations and eventually gas-fired power stations, or capturing their greenhouse gas emissions, is an important part of the energy transformation required to limit climate change. Vastly more solar power and wind power is forecast to be required, with electricity demand increasing strongly with further electrification of transport, homes and industry.

Generators:

Electric generators transform kinetic energy into electricity. This is the most used form for generating electricity and is based on Faraday's law. It can be seen experimentally by rotating a magnet within closed loops of conducting material (e.g., copper wire). Almost all commercial electrical generation is done using electromagnetic induction, in which mechanical energy forces a generator to rotate.

Electrochemistry:



Electrochemistry is the direct transformation of chemical energy into electricity, as in a battery. Electrochemical electricity generation is important in portable and mobile applications. Currently, most electrochemical power comes from batteries. Primary cells, such as the common zinc–carbon batteries, act as power sources directly, but secondary cells (i.e., rechargeable batteries) are used for storage systems rather than primary generation systems. Open electrochemical systems, known as fuel cells, can be used to extract power either from natural fuels or from synthesized fuels. Osmotic power is a possibility at places where salt and fresh water merge.

Photovoltaic effect:

The photovoltaic effect is the transformation of light into electrical energy, as in solar cells. Photovoltaic panels convert sunlight directly to DC electricity. Power inverters can then convert that to AC electricity if needed. Although sunlight is free and abundant, solar power electricity is still usually more expensive to produce than large-scale mechanically generated power due to the cost of the panels. Low-efficiency silicon solar cells have been decreasing in cost and multijunction cells with close to 30%

conversion efficiency are now commercially available. Over 40% efficiency has been demonstrated in experimental systems. Until recently, photovoltaics was most commonly used in remote sites where there is no access to a commercial power grid, or as a supplemental electricity source for individual homes and businesses. Recent advances in manufacturing efficiency and photovoltaic technology, combined with subsidies driven by environmental concerns, have dramatically accelerated the deployment of solar panels. Installed capacity is growing by 40% per year led by increases in Germany, Japan, United States, China, and India.

- ## Transmission:

Electric transmission is the process by which large amounts of electricity produced at power plants (such as hydro, thermal and wind), is transported over long distances for eventual use by consumers. Due to the large amount of power involved, and the properties of electricity, transmission normally takes place at high voltage (69-kilovolt or above) to reduce losses that occur over long distances. Electricity is usually transmitted to a substation near a populated area. At the substation, the high voltage electricity is converted to lower voltages suitable for consumer use, and then transmitted to end users through relatively low-voltage electric distribution lines that are owned and operated by local electric utilities.

The construction, operation, and maintenance of new high-voltage transmission lines and associated facilities create a range of environmental impacts. The type and magnitude of the impacts associated with transmission line construction, operation and maintenance varies depending on line type and size, as well as the length of the transmission line, and a variety of other site-specific factors. The main components of high-voltage electric transmission lines and associated facilities include the following:

Transmission Towers

Transmission towers are the most visible component of the electric transmission system. Towers support high-voltage conductors (cables that transmit the electricity, otherwise known as lines) above the ground and separate them from other lines, buildings, and people. Towers vary in design and dimensions. The transmission towers proposed for the I-5 Corridor Reinforcement Project would be lattice steel between 110 and 150 feet tall. A 150-foot right-of-way would be needed for the area around the towers and the spans between the towers.

Conductors (Transmission lines)

Conductors are the cables on the transmission towers that carry the electricity to substations. On the I-5 project, there would be three conductors on each tower. Conductors are constructed primarily of twisted metal strands, but newer conductors may incorporate ceramic fibers in a matrix of aluminum for added strength with lighter weight.

Fiber Optic Cable

A fiber optic cable is sometimes strung on the transmission towers below the conductor. Fiber optic cables could have up to 72 fibers. The fiber is used for communications as part of the power system. Fiber optics technology uses light pulses instead of radio or electrical signals to transmit messages. This communication system can gather information about the system, such as which transmission lines are in service and the amount of power being carried, meter reading at interchange points, and status of equipment and alarms. The fiber optic cable allows voice communications between power dispatchers and line maintenance crews and provides instantaneous commands that control the power system operations.

Right-of-Way

The right-of-way for a transmission corridor includes the land set aside for the transmission line and associated facilities, and land set aside for a safety margin between the line and nearby structures and vegetation. Having the safety margin helps avoid the risk of fire and other accidents. The right-of-way width needed for the proposed I-5 Corridor Reinforcement transmission line is 150 feet. The right-of-way is also used for access roads.

BPA follows new regulations to prevent outages, protect public safety. Vegetation that could pose a danger to a transmission line or tower is removed inside the right-of-way, and outside the right-of-way if it could come too close to lines and towers. On the right-of-way, low-growing vegetation is allowed to grow after construction and disturbed areas are reseeded with native vegetation to prevent the spread of noxious weeds.

Access Roads

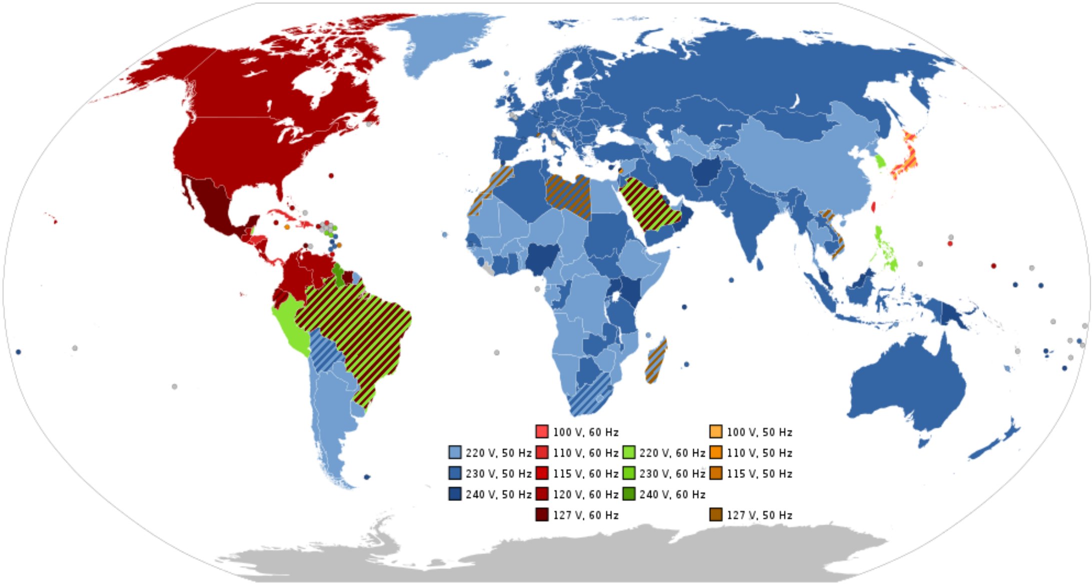
Access is needed to the transmission tower sites for both line construction and maintenance. Grading and clearing vegetation may be required for access road construction. Roads are usually graveled. Access roads can be permanent or temporary depending on the need during construction and land use. On most rights-of-way, permanent access roads provide a way to repair and maintain the towers and line and are available for emergencies.

In cropland and other areas where the existing land use is not compatible with a permanent access road, BPA uses temporary access roads during construction, then removes the roads and replants or otherwise restores the original land use.

Substations

The high voltages used for electric transmission (e.g., 500 kV) are converted for consumer use to lower voltages (e.g., 13.8 kV) at substations. Substations vary in size and configuration but may cover several acres, and are cleared of vegetation and surfaced with gravel. Access is limited to authorized personnel and the substation is fenced and gated for safety and security. In general, substations include a variety of structures, conductors, fencing, lighting, and other features that result in an "industrial" appearance.

- **Electric power distribution:**



The final stage in the delivery of electric power; it carries electricity from the transmission system to individual consumers. Distribution substations connect to the transmission system and lower the transmission voltage to medium voltage ranging between 2 kV and 35 kV with the use of transformers. Primary distribution lines carry this medium voltage power to distribution transformers located near the customer's premises. Distribution transformers again lower the voltage to the utilization voltage used by lighting, industrial equipment and household appliances. Often several customers are supplied from one transformer through *secondary* distribution lines. Commercial and residential customers are connected to the secondary distribution lines through service drops. Customers demanding a much larger amount of power may be connected directly to the primary distribution level or the subtransmission level.

The transition from transmission to distribution happens in a power substation, which has the following functions:

- Circuit breakers and switches enable the substation to be disconnected from the transmission grid or for distribution lines to be disconnected.
- Transformers step down transmission voltages, 35 kV or more, down to primary distribution voltages. These are medium voltage circuits, usually 600–35000 V.

- From the transformer, power goes to the busbar that can split the distribution power off in multiple directions. The bus distributes power to distribution lines, which fan out to customers.

Urban distribution is mainly underground, sometimes in common utility ducts. Rural distribution is mostly above ground with utility poles, and suburban distribution is a mix. Closer to the customer, a distribution transformer steps the primary distribution power down to a low-voltage secondary circuit, usually 120/240 V in the US for residential customers. The power comes to the customer via a service drop and an electricity meter. The final circuit in an urban system may be less than 15 metres (50 ft), but may be over 91 metres (300 ft) for a rural customer.