U.S. Energy Information Administration

Electricity explained
How electricity is delivered to consumers

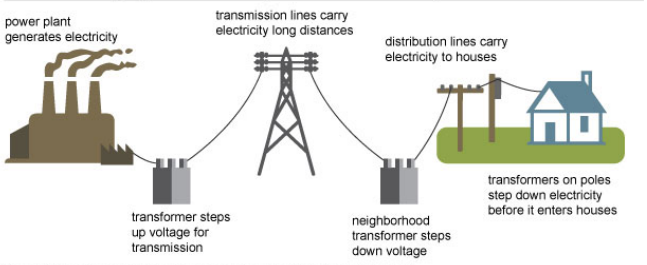
BASICS

The electric power grid

Electricity is generated at power plants and moves through a complex system, sometimes called the *grid*. The grid includes electricity substations, transformers, and power lines that connect electricity producers and consumers. Most local grids are interconnected to maintain reliability and for commercial purposes, forming larger, more dependable networks that helps suppliers consistently produce the right amount of electricity to meet demand.

In the United States, the entire electricity grid consists thousands of miles of high-voltage power lines and millions of miles of low-voltage power lines. This network of power lines connects thousands of power plants to hundreds of millions of electricity customers across the country.

Electricity generation, transmission, and distribution



Source: Adapted from National Energy Education Development Project (public domain)

Electricity sources and types of providers

The origin of the electricity that consumers purchase varies. Some electric utilities generate all the electricity they sell using just the power plants they own. Other utilities purchase electricity from other utilities, power marketers, and independent power producers or from a wholesale market organized by a regional transmission reliability organization.

The retail structure of the electricity industry varies from region to region. The company selling you power may be:

- A not-for-profit municipal electric utility
- An electric cooperative owned by its members
- A private, for-profit electric utility owned by stockholders (often called an investor-owned utility)

In some states, electric utility customers can purchase electricity through a power marketer, and the electricity is delivered by a local distribution utility. A few federally owned power authorities—including the Bonneville Power Administration and the Tennessee Valley Authority, among others—also generate, buy, sell, and distribute power. Local electric utilities operate the distribution system that connects consumers with the grid regardless of the source of the electricity.

The process of delivering electricity

Power plants generate the electricity that is delivered to customers through transmission and distribution power lines. High-voltage transmission lines, such as those that hang between tall metal towers, carry electricity over long distances. Higher voltage electricity is more efficient and less expensive for long-distance electricity transmission. Lower voltage electricity is safer for use in homes and businesses. Transformers at substations increase (step up) or reduce (step down) voltages to adjust to the different stages of the journey from the power plant on long-distance transmission lines to distribution lines that carry electricity to homes and businesses.

Evolution of the electric power grid

At the beginning of the 20th century, more than 4,000 electric utilities operated in isolation from each other. As the demand for electricity grew, especially after World War II, utilities began to connect their transmission systems. These connections allowed utilities to share the economic benefits of building large and often jointly owned power plants to serve their combined electricity demand at the lowest possible cost. Interconnection also reduced the amount of extra generating capacity that each utility had to hold to ensure reliable service during times of high and peak demand. Over time, three large, interconnected systems evolved in the United States.

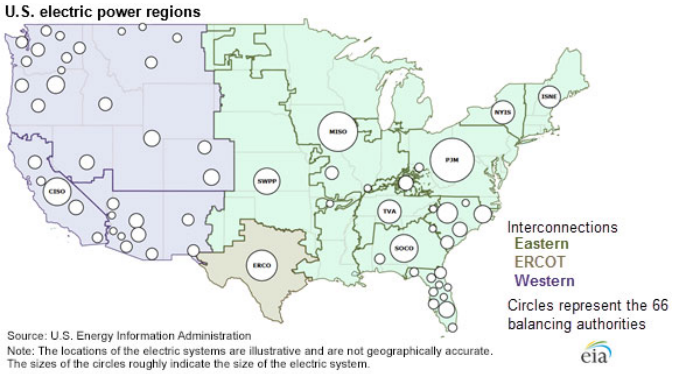
U.S. electrical system interconnections

The stability of the electricity grid requires electricity supply to constantly meet electricity demand, which in turn, requires numerous entities that operate different components of the grid to coordinate with each other. Local electricity grids are interconnected to form larger networks to maintain reliability and for commercial purposes. At the highest level, the U.S. power system in the Lower 48 states is made up of

three main interconnections, which operate largely independently from each other with limited transfers of electricity between them:

- The Eastern Interconnection covers the area east of the Rocky Mountains and a portion of the Texas panhandle.
- The Western Interconnection covers the area from the Rocky Mountains to the west.
- The Electric Reliability Council of Texas (ERCOT) covers most of Texas.

The Eastern and Western Interconnections in the United States are also linked with Canada's power grid. The network structure of the interconnections helps maintain the reliability of the grid by providing multiple routes for power to flow and allowing generators to supply electricity to many load centers. This redundancy helps prevent transmission line or power plant failures from causing interruptions in service to retail customers.



Balancing authorities

The three major grid interconnections describe the large-scale physical structure of the grid. The regional operation of the electric system is managed by entities called *balancing authorities*. They ensure that electricity supply constantly matches power demand. Most of the balancing authorities are electric utilities that have taken on the balancing responsibilities for a specific part of the power system. All of the regional transmission organizations in the United States also function as balancing authorities. ERCOT is unique because the balancing authority, interconnection, and regional transmission organization are all the same entity and physical system.

A balancing authority ensures that electricity demand and supply are finely balanced to ensure the grid is safe and reliable. If electricity demand and supply fall out of balance, local or even widespread blackouts can result. Balancing authorities maintain appropriate operating conditions for the electric system by ensuring that enough electricity is available to serve expected demand, which includes managing electricity transfers with other balancing authorities.

Electric reliability organizations

Electric utilities are responsible for maintaining the safety of their systems and planning for the future power needs of their customers. Initially, the electric power industry developed voluntary standards to ensure they coordinated with linked interconnections. Today, mandatory reliability standards for planning and operating power systems and for addressing security concerns at critical electrical infrastructure are in place. The North American Electric Reliability Corporation developed and enforces mandatory grid reliability standards approved by the Federal Energy Regulatory Commission (FERC). In Canada, Canadian regulators fill this role.

A smart electricity meter

Source: Stock photography (copyrighted)

did you know?

The *smart grid* incorporates digital technology and advanced instrumentation into the traditional electrical system, which allows utilities and customers to receive information from and communicate with the grid. A smarter grid makes the electrical system more reliable and efficient by helping utilities reduce electricity losses and to detect and fix problems more quickly. The smart grid can help consumers manage energy use, especially at times when demand is significantly high or when low electricity demand is needed to support system reliability.

Smart devices in homes, offices, and factories can inform consumers and their energy management systems of times when an appliance is using relatively higher-priced electricity. These alerts help consumers, or their intelligent systems, to optimally adjust settings that can lower electricity bills when supported by demand reduction incentives or time-of use electricity rates. Smart devices on transmission and distribution lines and at substations allow a utility to more efficiently manage voltage levels and more easily find out where an outage or other problem is on the system. Smart grids can sometimes remotely correct problems in the electrical distribution system by digitally sending instructions to equipment that can adjust the conditions of the system.

Challenges facing the power grid

Construction of electricity infrastructure in the United States began in the early 1900s and investment was driven by new transmission technologies, central-station generating plants, and growing electricity demand, especially after World War II. Now, some of the older, existing transmission and distribution lines have reached the end of their useful lives and must be replaced or upgraded. New power lines are also needed to maintain the electrical system's overall reliability and to provide links to new renewable

energy generation resources, such as wind and solar power, which are often located far from where electricity demand is concentrated.

Several challenges exist for improving the infrastructure of the grid:

- Siting new transmission lines (getting approval of new routes and obtaining rights to the necessary land)
- Determining an equitable approach for recovering the construction costs of a new transmission line built in one state when the line provides benefits to consumers in other states
- Addressing the uncertainty in federal regulations regarding who is responsible for paying for new transmission lines, which affects the private sector's ability to raise money to build transmission lines
- Expanding the network of long-distance transmission lines to renewable energy generation sites where high-quality wind and solar resources are located, which are often far from where electricity demand is concentrated
- Protecting the grid from physical and cyber attacks

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