NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Understanding the Grid

September 2025

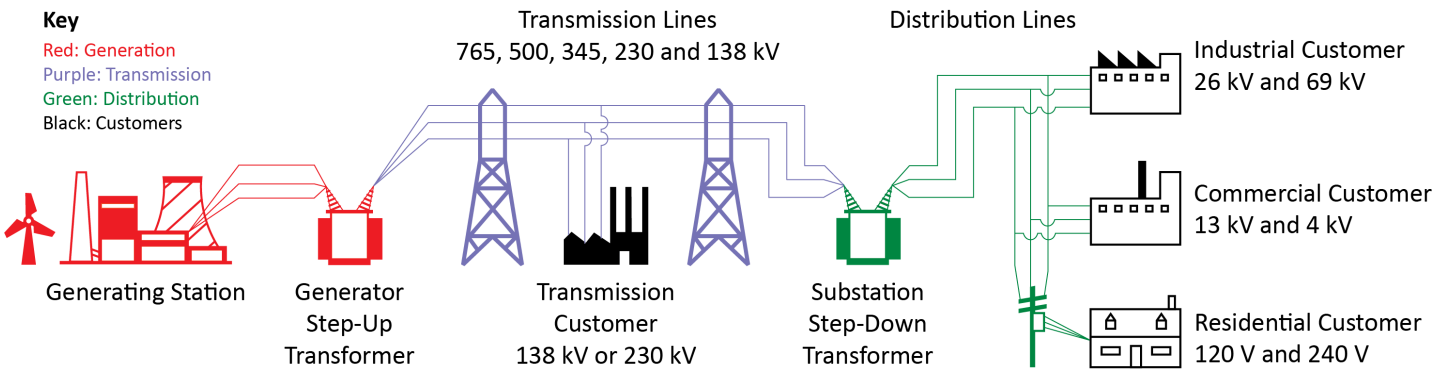
How It Works

Unlike water or gas, electricity cannot be stored in large quantities. Because it must be generated the instant it is used, supply must be kept in constant balance with demand. Electricity flows simultaneously over all transmission lines in the interconnected grid system directly proportional to voltage and inversely proportional to the electrical resistance of the lines. Unless power flow controllers are deployed on the alternating current lines or high-voltage direct current is used, electricity generally cannot be routed over specific lines. Simply put, electricity, like water, will follow the path of least resistance. The reliable and continuous supply of electricity to homes and businesses depends on the cooperation and coordination of hundreds of electric industry participants operating generation and transmission in North America and monitoring and controlling the system in real time 24 hours a day.

NERC oversees reliability and security for a bulk power system (BPS) that serves approximately 400 million people and has some 526,833 circuit miles (847,856 circuit kilometers) of transmission greater than 100 kilovolts.

The diagram below depicts the basic elements of the electric system: how electricity is created at power generating stations and transported across high-voltage transmission and lower-voltage distribution lines to reach homes and businesses. Transformers at generating stations step up the electric voltage for efficient transport and then step down the voltage at substations to efficiently deliver power to customers.

The generation and transmission components and their associated control systems comprise the BPS.



Reliability Concepts

NERC defines the reliability of the interconnected BPS in terms of two basic and functional aspects:

- **Adequacy:** Adequacy means having sufficient resources to provide customers with a continuous supply of electricity at the proper voltage and frequency, virtually all of the time. Resources refer to a combination of electricity generating and transmission facilities that produce and deliver electricity and demand-response programs that reduce customer demand for electricity. Maintaining adequacy requires system operators and planners to take into account scheduled and reasonably expected unscheduled outages of equipment while maintaining a constant balance between supply and demand.
- **Operating Reliability:** For decades, NERC and the electric industry defined powering reliability (formerly "security") as the ability of the BPS to withstand sudden, unexpected disturbances, such as short circuits or unanticipated losses of system elements due to natural causes. Today, NERC and industry's reliability focus has expanded to include how the BPS is planned, designed, built, and operated and considers modern as well as more traditional risks to reliability.

To maintain resource adequacy, system operators may be required take "controlled" actions or procedures to maintain a continual balance between supply and demand within a balancing area (formerly called a control area). These actions include public appeals and increased transfers from neighboring systems if energy is available. Some customers, in accordance with contractual arrangements, can be interrupted by direct control of the system operator or by action of the customer at the direct request of the system operator. Brownouts caused by voltage reductions will cause lights to dim, whereas rotating blackouts occur when each set of distribution feeders is interrupted for a limited time, typically 20–30 minutes. Those feeders are then put back in service and another set is interrupted, thereby rotating the outages among individual feeders. More recently, system operators have been able to take advantage of Bulk Electric System storage facilities such as batteries.

All other system disturbances that result in the unplanned or uncontrolled interruption of customer demand, regardless of cause, fall under the "Operating Reliability" heading. When these interruptions are contained within a localized area, they are considered unplanned interruptions or disturbances. When they spread over a wide area of the grid, they are referred to as "cascading blackouts"—the uncontrolled successive loss of system elements triggered by an incident at any location. Cascading results in widespread electric service interruption that cannot be restrained from sequentially spreading beyond an area predetermined by studies.

Uncontrolled cascading blackouts occurred in 1965, in 2003 in the Northeast, and in 2011 in the Southwest. The cold weather event in February 2021 that affected Texas and the South-Central United States was the result of supply not being able to meet all the demand, referred to as controlled load shed of 23,418 MW (the largest controlled firm load shed in U.S. history). This controlled interruption of customer demand was part of the operating procedures initiated to maintain a balance with available supplies to preserve the overall operating reliability of the interconnected system.