NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Understanding the Grid

March 2023

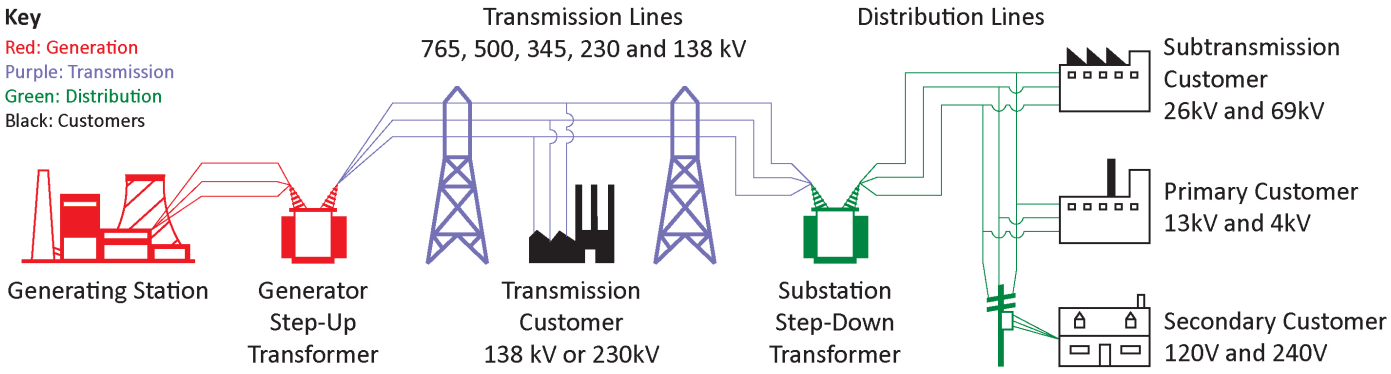
How It Works

Unlike water or gas, electricity cannot be stored in large quantities. It must be generated the instant it is used, which requires supply to be kept in constant balance with demand. Furthermore, electricity flows simultaneously over all transmission lines in the interconnected grid system in inverse proportion to the electrical resistance of the lines, so electricity generally cannot be routed over specific lines. Simply put, electricity, like water, will follow the path of least resistance. This means generation and transmission operations in North America must be monitored and controlled in real time, 24-hours-a-day, to ensure a reliable and continuous supply of electricity to homes and businesses. This requires the cooperation and coordination of hundreds of electricity industry participants.

NERC oversees reliability and security for a bulk power system (BPS) that serves approximately 400 million people and has some 511,099 circuit miles (822,534 circuit kilometers) of transmission greater than 100 kilovolts.

The diagram below depicts the basic elements of the electricity 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 system security as the ability of the BPS to withstand sudden, unexpected disturbances, such as short circuits or unanticipated loss of system elements due to natural causes. In today's world, the security focus of NERC and the industry has expanded to include BPS must be planned, designed, built, and operated in a manner that takes into account these modern threats, as well as more traditional risks to reliability.

Regarding 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
- Interruptible demand: Customer demand that, 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
- Voltage reductions: Referred to as "brownouts" because lights will dim as voltage is lowered
- Rotating blackouts: The term is used because each set of distribution feeders is interrupted for a limited time, typically 20–30 minutes, and then those feeders are put back in service and another set is interrupted, and so on, rotating the outages among individual feeders

All other system disturbances that result in the unplanned or uncontrolled interruption of customer demand, regardless of cause, fall under the heading, "Operating Reliability." 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, again 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 initiated to maintain a balance with available supplies to preserve the overall operating reliability of the interconnected system.