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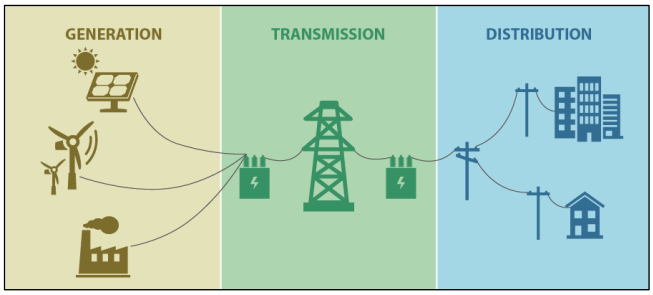
Introduction to Electricity Transmission

The U.S. electricity transmission system connects the electricity generation system—where electricity is made—and the electricity distribution system—where electricity is used.

Figure 1. Electric Power Sector System Schematic



Source: CRS, adapted from U.S.-Canada Power System Outage Task Force, *Final Report on the August 14, 2003, Blackout in the United States and Canada: Causes and Recommendations*, April 2004, p. 5.

Notes: Not all types of components in each system are shown.

The transmission system includes hundreds of thousands of miles of power lines that carry electricity at relatively high voltages. Transmission line voltages range from 230 thousand volts (kV) to 765 kV, though lower voltages can be used as well. The higher the voltage, the more power can move through the line. Approximately 98% of the U.S. transmission system uses alternating current (AC) power, in which the direction of electrical charge changes 60 times per second. The remainder uses direct current (DC), in which the direction of charge does not change. AC power can be converted relatively easily and cheaply between high and low voltages, making it more suitable for delivering it to customers that use low voltage AC (e.g., 120 V for most household uses). DC lines require expensive conversion stations, but can be more efficient over very long distances and better suited for specialized applications, such as undersea cables.

The transmission system also includes thousands of transformers that change voltage levels, "stepping up" or "stepping down" voltages to higher or lower levels, respectively. Transformers also provide electric stability to the grid. High-voltage transformers vary in size (measured in input/output voltage or power levels), and typically are custom-built for specific locations in the transmission system.

Ownership and Regulation

Most transmission lines are owned by private, for-profit companies, though some are owned by public entities: the federal government, publicly-owned utilities (e.g., divisions of a municipal government), or member-owned electric cooperatives.

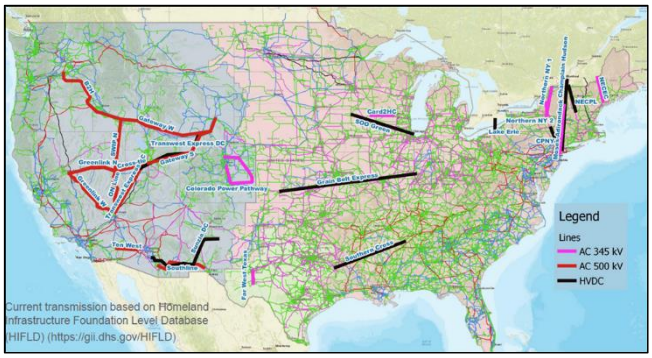
The Federal Energy Regulatory Commission (FERC) regulates the rates these transmission owners charge for delivering electricity across state lines. FERC also can approve financial incentives for certain construction and operational activities. For example, FERC can incentivize the use of new technologies and participation in regional transmission organizations in which power resources are shared in a region. Power sharing is believed to increase reliability and lower overall costs for consumers.

The federal government does not have general siting authority for transmission lines—in most cases, state and local governments have authority for siting. Federal permits may be necessary for portions of some transmission lines, such as those that cross federal lands (e.g., National Forests) or waters under jurisdiction of the U.S. Army Corps of Engineers. Congress gave FERC backstop authority for siting transmission lines in areas designated by the U.S. Department of Energy (DOE) to be in the national interest. In these cases, FERC can site transmission lines when state or local governments fail to take action or deny an application. To date, no transmission lines have been approved under this authority.

Perceived Transmission Needs

Some advocates have expressed interest in expanding and enhancing the U.S. transmission system. Part of this interest relates to a desire to use more renewable energy for electricity generation. Many of the country's best renewable energy resources are concentrated in a few areas: onshore wind in the central United States, solar in the Southwest, and offshore wind in the Northeast. New transmission lines are likely needed to cost-effectively develop these resources and deliver the electricity to consumers. Some of the advocates propose a greater use of DC transmission to move electricity from these areas across the country. A number of transmission projects have been proposed associated with these areas of strong renewable energy resources, as shown in **Figure 2**. (The figure also shows proposed lines that would allow greater import of hydropower from the Canadian province of Quebec.) These proposed projects are unique from other transmission projects in that they cross multiple states and connect different regions of the electricity grid with each other.

Figure 2. Existing and Proposed Transmission Lines



Source: DOE, National Transmission Planning Study, "Technical Review Committee Meeting #1," May 20, 2022, p. 45.

Notes: AC = alternating current; HVDC = high voltage direct current; kV = kilovolts. Narrow lines of various colors show existing transmission lines. Thick lines show proposed transmission lines, with colors indicating different voltage levels.

Additional interest relates to the reliability, resilience, and security of the transmission system. Some areas of the country (e.g., Texas, California, New England) have elevated risks of electricity supply shortages during certain times of the year. Additional transmission lines could help deliver electricity from neighboring regions during times of electricity shortages, alleviating reliability risks. Resilience is not formally defined, but typically refers to the ability of the transmission system to withstand and recover from disruptions such as wildfires, hurricanes, or attacks. Transmission lines can be strengthened in various ways to better withstand some events. Measures include using stronger materials for supporting structures and burying lines underground. Components of the transmission system are vulnerable to physical and cyberattacks. FERC's statutory authority over transmission reliability includes security. FERC administers both mandatory standards and financial incentives aimed at improving security.

Perceived Transmission Challenges

Two main issues have been raised as challenges to addressing perceived transmission needs—costs and permitting.

Ultimately, electricity consumers bear the cost of building, operating, and maintaining the transmission system. The construction of new transmission lines or upgrades to existing lines raise costs for consumers. FERC and state regulators seek to balance these costs with any benefits, such as increased use of renewable energy or improved reliability, resilience, or security. In many cases, these benefits are difficult to monetize, complicating a benefit-cost comparison. Additionally, benefits may be distributed among many consumers, even those far away from a new or upgraded transmission line. Historically, transmission costs have been allocated mostly to nearby consumers. Critics say this approach makes it more challenging for transmission projects to demonstrate positive benefit-to-cost ratios when benefits are distributed broadly. Proponents say this approach protects consumers from higher electricity prices by having them pay only for transmission projects with direct and clear benefits to them. In April 2022, FERC began a rulemaking process to examine potential changes in its cost allocation methodology.

Some proponents of new transmission lines criticize the time required to permit, finance, and construct projects—reportedly 10 years or so on average. They say a main reason for this timeline is the current regulatory framework, under which local approval is required along the length of a transmission line. Multiple proposed transmission lines in recent years have been delayed or cancelled over landowner opposition. Opposition to new transmission lines varies by project, though typical concerns are the environmental impacts (e.g., tree clearing) of new transmission lines, visual impacts, and loss of property values. Despite high profile examples of cancelled projects, overall investment in the U.S. transmission system has been increasing since the mid-2000s.

Additional challenges relate to planning and supply chains. The current planning process is not optimized for transmission lines that connect different regions of the grid. Such transmission lines are believed to be helpful in promoting use of renewable energy and improving reliability and resilience. FERC also is evaluating transmission planning as part of its transmission rulemaking process. For a discussion of supply chain issues for transformers, see CRS Insight IN12048, *Electric Power Transformers: Supply Issues*.

117th Congress Action and Options

The 117th Congress enacted legislation aimed at accelerating transmission development. For example, the Infrastructure Investment and Jobs Act (IIJA; P.L. 117-58) amended FERC's backstop siting authority and appropriated $11 billion in grant programs for grid reliability and resilience (some of which may be used for the distribution system). IIJA also appropriated $2.5 billion for a new Transmission Facilitation Program through which DOE can provide financial and technical assistance for transmission line construction. Other pre-existing programs administered by DOE and the U.S. Department of Agriculture provide financial assistance for certain types of transmission projects. These received supplemental appropriations from IIJA and P.L. 117-169, commonly known as the Inflation Reduction Act. Congress could consider oversight activities for these programs.

Congress could consider reforms to the transmission permitting process. For instance, a proposal to give FERC authority for permitting a broader number of transmission lines was included as part of an infrastructure permitting reform package released by Senator Manchin, Chairman of the Senate Committee on Energy and Natural Resources, in September 2022.

Other options for Congress could include conducting oversight on transmission issues or providing statutory guidance for FERC's transmission policies. Congress also might consider additional legislation to address any of the perceived needs or challenges related to transmission.

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