High Voltage Direct Current

High-voltage direct current is an electric transmission technology that employs direct current instead of more widely-used alternating current on the grid. HVDC technology can move large amounts of power over very long distances. HVDC technology can also be used to interconnect two AC systems or electric grids that operate at different frequencies.

AC vs. DC

Transmission lines deliver electricity largely as alternating current (AC), and increasingly, as direct current (DC). Alternating current changes direction 60 times per second. Direct current flows constantly in one direction.

In the early days of the power industry, direct current transmission pioneered by Thomas Edison proved inefficient to carry power much farther than a mile from a generator to customers. At the time, more cost-effective AC current systems developed by Nikola Tesla were widely adopted, using transformers to step voltage up for transmission and down to serve load. With this capacity to effectively transport electricity within cities and between states, AC was embraced as industry standard transmission technology. As a result, high voltage lines on most bulk electric systems feature AC technology, on lines ranging from 68 kV to as high as 500 kV.

High Voltage Direct Current

- HVDC transmission uses direct current to transport electricity on the grid.
- In the early days of the electricity industry, direct current (DC) technology was inefficient for grid transport. Instead, alternating current (AC) became the industry standard of the bulk electric systems
- In recent decades, HVDC has evolved as a more efficient transmission technology in some scenarios, particularly for transport of electricity over long distances. These attributes are sought after to connect regional grid systems or carry electricity from renewable resources in faraway

Power Superhighways

Transporting electricity via AC over very long distances, however, comes with costly power losses on the highest-voltage lines. Engineers in the 1950s pioneered HVDC systems capable of converting AC current to DC for more efficient long range transmission and then back to AC at the destination to serve demand. The need for converter stations at each end of a line to transform power from AC to DC (rectification) and DC to AC (inversion) can add significant costs. HVDC converter stations also contribute to the overall losses on the transmission system. Still, as a solution for interregional, long range transmission, HVDC systems have evolved to deliver cost and design advantages over AC high voltage transmission. Uses range from undersea cables to deliver bulk electricity from offshore wind to the coast, or overland HVDC systems to transport renewable solar and wind power located in unpopulated areas to urban areas. HVDC technology can also connect regional grids which operate at different frequencies.

There are more than 100 HVDC transmission projects around the world, including lines stretching more than 6,000 miles from northwest China to the coast. In North America, there are several thousand miles of HVDC in operation, according to the U.S. Dept. of Energy. Between PJM and the New York ISO, several HVDC projects provide service. More HVDC projects are pending active in PJM's interconnection queue.

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(866) 400-8980 | (610) 666-8980