# Overhead vs. Underground

## Information about burying high-voltage transmission lines

High-voltage transmission lines transport bulk electricity from generation sources to customers, often over long distances. In 2010, there were approximately 106,000 miles of 345 kilovolt (kV) or greater high-voltage transmission lines in the United States. The percentage of existing underground transmission is estimated at 0.5 percent of this total. There are no underground 345 kV lines on Xcel Energy's system.

Burying high-voltage transmission lines may be appropriate in densely populated urban and suburban settings, near airports, or when sufficient right-of-way is not available for an overhead line. Electric utilities consider the following factors when deciding whether to construct high-voltage transmission facilities (345 kV or higher) above ground or bury them:

### Power restoration

Damage to underground transmission lines is difficult to pinpoint, and repairs may take a few weeks to several months to complete. Damage to overhead lines is easy to locate and typically takes several hours or days to repair.

**Crews work on an underground duct bank extending from a typical 8'x 8'x24' vault**

### Capacity requirements

For underground transmission, a greater number of cables are often required to match the capacity of the overhead circuit. The proposed Pawnee-Daniels Park 345 kV project would require three cables per phase (three phase system, total of nine cables) to match the bundle overhead conductor. The additional components increase the underground cost as an additional duct bank, vaults, splices and terminations are required which can also reduce overall system reliability.

### Line-length challenges

High-voltage underground lines may require additional equipment to ensure proper electrical performance along the distance of the transmission line. The additional equipment translates to a higher overall cost, limits the length of the underground line installation and increases the likelihood of failure because of additional components. A system study would be required to determine if this additional equipment would be required.

### Multiple cables and cooling options

Overhead lines are air cooled and widely spaced for safety. Underground cables are installed in concrete encased PVC duct banks. Heat generated by the cables is dissipated into the earth.

### Construction impacts

Burying transmission lines has more environmental impacts than placing them overhead. A 345 kV overhead line typically requires erecting structures and placing foundations every 800 to 1,000 feet. Typical structures are 150 feet tall, while the diameter of the foundations ranges from 10 to 12 feet.

Burying a 345 kV double circuit transmission line at a minimum would require two continuous trenches or duct banks at least 5 feet wide at the bottom, 7 feet deep, and separated by at

least 20 feet. Considerable clearing and grading would be necessary, and dust and noise from construction would last three to six times longer than it would for overhead construction. Large concrete splice vaults or access structures (see photo) are needed at 1,500- to 2,000-foot intervals. Permanent access to the vaults is required to make repairs when needed.

## Easement and land purchase requirement

An overhead line typically has a wider easement footprint than an underground line. However, undergrounding 345 kV transmission lines requires small substations – called transition substations – wherever the underground cable connects to overhead transmission. Transition substations have a footprint of approximately 250 by 400 feet.

## Life expectancy

Underground high-voltage transmission lines generally need to be replaced after approximately 40+ years, while overhead lines have a life expectancy of more than 80 years.

## Costs

An underground 345 kV line costs 10 to 20 times the cost of an overhead line due to time, materials, process, the need to include transition substations and the use of specialized labor. The proposed Pawnee-Daniels Park project (Including transition substations) would cost an estimated $40 million per mile to bury. The proposed overhead double circuit 345 kV line would cost $1.5 million per mile. Part of the added cost to bury lines may include routing to avoid other underground installations, such as water, natural gas and sewer lines. An overhead line often can be routed around or over these difficult areas.

## Electric and magnetic fields

Electric magnetic fields (EMF) are generally higher directly over an underground installation (the earth does not provide shielding) and directly under an overhead installation. Magnetic fields tend to decrease more rapidly with distance from underground installations compared to overhead lines.

Photo courtesy of Georgia Transmission Corporation

**Underground cable and smaller overhead conductor.**

## Noise and lighting

Overhead high voltage lines can emit hiss or hum noises. Underground lines are silent except in the immediate area near the transition substations, which are lighted throughout the night for security purposes.

## Transition substations

High-voltage underground transmission lines require small substations – called transition substations – wherever the underground cable connects to overhead transmission. Transition substations require grading, access roads, storm water management facilities, fencing and night time lighting.

## Site restoration

Site restoration for underground construction is a much larger endeavor than it is for overhead construction because soil is disturbed along the entire route. Top soils have to be restored and returned to vegetated areas, and all hard surface areas must be reestablished to meet local codes. Vegetated areas may require up to two years to return to preconstruction conditions.

## Underground 345 kV double circuit cable installation