WHITE PAPER / **UNDERGROUND AND OVERHEAD TRANSMISSION**

# ARE OVERHEAD WIRES OR UNDERGROUND CABLES THE BEST SOLUTION FOR YOUR TRANSMISSION PROJECT?

**BY Nathan Rochel**, PE

Beginning in the 1880s, the earliest days of the electric power industry, wooden poles were preferred as support structures for power lines. Later, as high-voltage power lines were built over longer distances, metal towers became common. Now, as project priorities shift, underground transmission cables increasingly merit consideration.

Thanks to recent technology advances, plus the shift toward more high-voltage transmission facilities, the need for electric transmission line construction may be at historically high levels. However, this factor is colliding with a desire among many communities for fewer transmission lines visible overhead.

The result has been a transition toward more construction of underground power lines and related facilities.

## COST IS KING

Historically, all-in costs have been the primary consideration for power line construction. If construction costs are the only criterion, overhead transmission generally wins.

These lower costs are attributable mostly to efficiencies gained from long experience among engineer-procure-construct (EPC) contractors in building overhead transmission projects. This has translated into relative comfort with this option among utilities and private developers. Cost is a prime consideration for utilities seeking regulatory approval to place the expenses of these large capital projects into the rate base for recovery.

## LOOK AT THE TOTAL LIFE CYCLE

Determining the correct option — underground or overhead — requires a thorough evaluation during the initial planning process. This step will help utilities and private developers clearly understand project constraints, community requirements and applications of various technologies. Ideally, this evaluation of the advantages and disadvantages will surface clear pros and cons of underground and overhead construction.

While it is important to complete a well-rounded evaluation of the options available for each project, developers and utilities will want to keep cost considerations front and center. But the elements of cost deserve a closer look. Is the evaluation process simply looking at initial capital costs of construction, or are total life cycle costs being considered? Are ongoing operations and maintenance (O&M) costs being factored in?

Installing an overhead line in areas prone to high winds or heavy icing may be less expensive initially, but future costs of repairing or hardening facilities — along with vegetation management, access road maintenance, circuit down time and many other related expenses over a multiyear life cycle — all should be considered.

## THE RELIABILITY FACTOR

Though overhead transmission lines are quite reliable historically, power outages still sometimes result from a variety of external issues including inclement weather, vehicles striking poles, trees falling on conductors, and wildfires. Heavy winds may damage a variety of above-grade structures and overhead transmission poles are no exception. Other causes of damage to an overhead transmission line can include equipment failure or human interaction.

Overhead transmission lines generally sustain extreme weather events moderately well, though some utilities have concluded it is prudent to begin reinforcing or hardening their facilities rather than continue battling these events year after year. Overhead lines can be designed for extreme loadings or storm conditions, though this is an expensive endeavor and still may not fully stormproof the transmission line.

Other hardening strategies may involve relocating certain transmission sections or even entire circuits underground.

Underground transmission systems are generally less susceptible to storm-related outages, though it should be noted they, too, are not completely stormproof. Underground transmission lines still have above-grade termination structures for cables at substations, and these are the most likely source of storm-related outages. Other causes of damage on an underground line can include cable, splice or termination failure, or damage to the cable caused by a third-party excavation.

When an unplanned outage occurs on an underground transmission line, it must be acknowledged that it can be more difficult to locate the source of the problem and thus require more time to complete repairs, compared with events affecting overhead lines. However, these incidents typically occur less frequently and should be a factor when comparing long-term O&M life cycle costs. Fewer unplanned outages mean more uptime on the network, lower repair costs and more revenue. Other factors that should be weighed include reduced economic and social impacts to residential and commercial customers and avoidance of public dissatisfaction over service disruptions.

## OPERATIONS AND MAINTENANCE

Transmission lines are not a build-it-and-forget-it asset for utilities and developers. In general, overhead lines require more maintenance than underground lines, especially if the overhead line is in a vegetation-dense location.

Regular maintenance will be necessary to optimize the life of an overhead transmission asset and to mitigate potential public safety issues. General maintenance for an overhead line includes wire and insulator inspection, inspection and painting of structures, and vegetation management. In addition, periodic clearing and maintenance of access roads will be required in some regions.

General maintenance also is required for modern, solid dielectric underground lines, though this is generally centered around splice, cable and manhole inspections.

## EVALUATING OPTIONS

Not all projects will have the same routing or even interconnection points when evaluating overhead versus underground transmission lines. There may be scenarios in which an alternate substation connection via an underground installation can satisfy the project need. This also may be achieved by building a short section of overhead line in combination with underground sections.

The critical issue during the initial evaluation and planning stage is to explore and evaluate each transmission construction method without preconceptions.

Other evaluation criteria can and often should include the project location and environmental and operational considerations. These environmental considerations can be more significant in one region versus another.
For example, areas prone to extreme weather events such as hurricanes, tornadoes or wildfires may require hardening of facilities, including undergrounding of certain sections. Additionally, different states — and even different cities in the same state — can have varying requirements for transmission lines.

## PERMITTING COMPLEXITY

Though transmission lines are critical to maintaining reliable power, the permitting approval process for new lines can be lengthy and complex and often involve significant public opposition. This factor should be carefully weighed in evaluating overhead versus underground options.

Environmental assessments are often required by state and federal regulators, along with many other approvals that may depend on region. No two permitting processes for transmission projects are exactly alike.

A preliminary look at data from an identified study area can help determine the complexity associated with a project before significant money is invested. These desktop assessments are a good first step to gather pertinent public data on land parcels, public and private ownership of those parcels, and an inventory of existing infrastructure within the study area, including substations and other transmission assets along with roads and rail lines.

This survey can reveal potential environmental obstacles, such as the presence of wetlands or documented cultural sites. This preliminary evaluation can help the utility or developer forecast costs and length of time it might take to gain approvals, based on the complexity of environmental issues that are identified. This step is an important precursor to a more detailed route analysis.

## LAND USAGE

Transmission line routes can range from city streets to agricultural land and everything in between. While the current use of the land is known during the routing and conceptual phases of the project, it is important to consider both current and future land use.

Are there known plans for the proposed right-of-way to be developed in the future? Though an overhead line may go through relatively undeveloped areas at the time it is built, future economic development may be possible. Will the overhead transmission line deter future economic development in the area?

## FATAL FLAW ANALYSIS

Constructing new transmission lines is becoming more difficult, particularly as more land areas are developed. A fatal flaw analysis designed to evaluate potential future events is an important part of the planning process. It will look at past patterns of development in given areas and assign metrics to determine the likelihood of those patterns continuing, based on a number of economic and population growth factors. This can be particularly tricky because transmission projects are typically routed and planned years in advance of construction. Land uses along a proposed route may have shifted in the interim between the initial planning process and notice to proceed with construction.

Overhead transmission lines have typically faced intense scrutiny when proposed for residential areas. Homeowners and surrounding businesses often claim that the projects will cause aesthetic harm to their neighborhoods, potentially lowering real estate values.

Input from stakeholders will almost certainly be a factor in the siting and permitting process. These stakeholders can have significant potential impact, and it is important to maintain a proactive stance toward understanding those potential concerns during initial project evaluation. For this reason, it may be prudent to evaluate both underground and overhead transmission facilities as a step to avoid project delays, increased costs or outright cancellation.

Undergrounding sections of the transmission installation can mitigate potential public concerns, particularly if the project proposes to incorporate public benefits such as bike and hiking trails and related green spaces.

## ENVIRONMENTAL CONSIDERATIONS

Each project will have unique constraints and considerations, particularly related to environmental limitations or restrictions. Such limitations could include items such as wetlands and water bodies, tree and vegetation clearing, or steps needed to accommodate migratory or threatened and endangered species. The environmental assessment should consider whether environmental protections are likely to continue or even become more stringent.

Environmental impacts are not limited just to the initial construction of the project. They also extend to the O&M period for the transmission asset. One potentially large issue is the environmental impact and operational expense of vegetation management post-construction. Again, it is important to understand the project location. Arid regions or other areas where trees are sparse will experience fewer of these post-construction issues.

When faced with an environmentally sensitive constraint, a cost and environmental impact analysis should be considered. This could lead to alternative solutions or routing where one transmission method may be able to avoid these constraints while still considering overall project life cycle cost.

## CONCLUSION

There are many factors that should be evaluated in deciding between an overhead or underground project. Both methods have distinct advantages and disadvantages, and both must be evaluated in a balanced and fair manner during the project planning process. The key question to ask is: Which method, or combination of methods, will accomplish long-term project objectives and be the right solution for the owner and interested stakeholders?

Capital costs are an important factor, but overall life cycle costs and other constraints must be considered as well. Installing an overhead line may potentially limit the additional infrastructure that can be built along that same corridor, while an underground installation may provide flexibility to avoid those issues. It's true that underground transmission lines may not offer unlimited future development options, but with narrower right-of-way requirements and fewer above-grade constraints, those possibilities are greater.

The right option will ultimately be the solution that meets the most project criteria. Arriving at this decision requires a balanced and fair evaluation of all current and future factors.

## BIOGRAPHY

**NATHAN ROCHEL, PE,** is an electrical engineer in the Transmission & Distribution Group at Burns & McDonnell. He specializes in the design of underground transmission lines and manages the underground transmission department. He has been involved in the design of underground transmission projects ranging from 5-kV through 500-kV. His experience includes all aspects of underground transmission design, including project development, routing and feasibility through detailed design, construction support, commissioning and testing. He has experience on a range of transmission installations for investor-owned utilities and developers including interconnects, renewable installations (solar, wind, offshore wind), inside station connections, industrial installations, trenchless installations and generation facility tie-ins.

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