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Reliable But Costly [1]

Deck:
Recent trends in distribution line undergrounding.

Byline:
William Atkinson

Author Bio:

William Atkinson is a freelancer who writes occasionally for *Public Utilities Fortnightly*. Contact him at w.atkinson@mchsi.com [2].

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Following a large storm causing a lengthy power outage, one can bet that media coverage will turn to at some point to underground lines. Future outages will be averted, presumably, without overhead lines exposed to falling tree limbs. And children will play safer absent the danger of contact with live wires, exposed above ground.

But just as there are pros and cons to overhead distribution lines, the same can be said for undergrounding, starting with cost.

"Building overhead lines is very cost-effective," said Frank Alonso, P.E., manager, transmission line engineering, for Leidos Engineering (Orlando, Fla.), who also has experience with distribution lines.

"The material is less expensive, the insulation requirements are significantly less, and the maintenance is relatively inexpensive compared to underground," he said. Another benefit is that, when an outage occurs, it can almost always be located quickly. "Overhead lines are also very easy to tap into," he said.

Yet overhead lines can prove vulnerable even in good weather.

According to R. John Miner, president of Collaboration Unlimited (Austin, Tex.), a utility consulting firm, overhead lines are subject to intermittent outages that result from shorts, such as those caused by tree branches or squirrels. "In these instances," he notes, "the power may only be off for a few seconds, but it can be a problem for certain commercial and industrial customers with

critical expensive equipment that automatically shuts down even if power is off for only a second or two."

Undergrounding indeed can bring benefits. Three of the most important are reliability, safety and aesthetics.

A five-year study of underground and overhead reliability for North Carolina's IOUs (Duke Energy, Progress Energy and Dominion) found that the frequency of outages on underground systems was 50 percent less than for overhead systems.

Underground lines provide better public safety, since there are no exposed downed lines or poles falling on homes or vehicles or within easy access of children or unsuspecting adults. "Everything that is energized and has a shock hazard is not only underground, but also insulated and enclosed, preventing human touch," said Collaboration Unlimited's Miner.

Also, an underground system is more aesthetically pleasing. One tangible benefit of this is that property values tend to be higher in neighborhoods with underground lines than in comparable (age, location, housing structure, etc.) neighborhoods with overhead lines.

Costs and Benefits

Various studies have found that the cost to build new underground distribution lines is five to ten times more expensive than new overhead construction, depending on where they are built. A 2009 Edison Electric Institute (EEI) study found that the cost of burying existing overhead distribution lines ranged from $80,000 a mile in rural areas to $2.1 million a mile in urban areas.

Are customers willing to fund such costs? The 2013 edition of an annual study published by the EEI, titled "Out of Sight, Out of Mind: An Updated Study on the Undergrounding of Overhead Power Lines," found that 60 percent of customers polled were willing to pay 1 to 10 percent more on their bills for undergrounding, 11 percent were willing to pay up to 20 percent more, and fewer than 10 percent were willing to pay up to 100 percent more.

"Cost is indeed a consideration," said Leidos Engineering's Alonso. "In most states, utilities are not allowed to put any capital improvements into their rate base until those projects are energized and serving the public. As a result, utilities may end up carrying possibly millions of dollars in their capital budgets that cannot be transferred to the rate base calculation until the lines are put into service."

However, while underground is virtually always more expensive than overhead, the differences vary, according to Miner. "Underground may only be two or three times more expensive than overhead in situations [rural areas, for example] that involve burying the cable but having all of the equipment that connects the cable sitting on the ground," he said.

But the price spread grows in urban areas, where that type of construction doesn't work. "Here, things need to be better protected underground, and there is a need to do a lot of excavation, install manholes, and place all of the equipment underground," Miner added.

Underground lines also remain susceptibile to water damage, especially from flooding, as was

made clear in the aftermath of Superstorm Sandy.

"There is an assumption that, if you put everything underground, all of your outage problems will go away, but that's not really true," said Ken Hall, P.E., president of Hall Energy Consulting (Waynesville, N.C.), and author of EEI's "Out of Sight, Out of Mind 2012: An Updated Study on the Undergrounding of Overhead Power Lines." "Underground will improve reliability in general, in that it will mitigate a lot of the problems associated with falling trees and related issues, but underground systems are subject to flooding."

Underground lines also become less reliable with age. One reason is due to insulation deterioration. One study, reported by SCE&G, a South Carolina utility, found that customers served by 40-year-old overhead lines had better reliability than those served by 20-year-old underground lines.

"While underground cable is supposed to last 35 to 40 years, this isn't always the case," said Miner. "Some fail early, which results in huge expenditures for utilities to replace it all earlier than expected."

In terms of moisture, underground cable, equipment, connectors, etc. are designed to be submersible. Yet according to Miner, water vapor can cause a problem.

"If you pour water on a cable with a polyethylene jacket and insulation, the water will shed," he said. "However, water vapor molecules can penetrate this material." As a result, after a few months, there is water vapor throughout the cable insulation. This isn't necessarily a problem, because this is taken into consideration in the design. However, if this is combined certain defects in the cable, some of which may be microscopic, chemical changes can result in the insulation material, which, over time, can lead to cable failure.

Moroever, when underground lines do suffer an outage, the duration can prove problematic. The North Carolina study referenced earlier found that, while the frequency of outages was 50 percent less for underground systems than for overhead systems, the average duration of underground system outages was 58 percent longer than for overhead system outages. One reason that underground outages take longer to repair is that it usually takes longer to locate the actual outage in the first place, whereas above ground outages are usually easy to locate. Then, once the underground outage is located, there is a significant amount of time required for trenching, cable splicing, and re-embedment. In sum, overhead lines can be repaired much faster than underground lines.

Finally, underground lines are not as easy to tap into as overhead lines are. "If you have to add another home or subdivision, you have to tap into an underground cable and put in an underground switch, which is expensive in terms of parts and labor," said Leidos Engineering's Alonso.

New Installations

Certainly, in recent years, a lot of, if not most, new lines are going underground. While it is more expensive to bury the lines than it is to run them overhead, it is less expensive to underground them in new grid extensions than it is to dismantle existing overhead lines and bury them. One

reason relates to the ground itself. In most cases, grid extensions occur in areas that do not yet have a lot of ground and underground infrastructure already in place, such as road and sidewalks, gas and water/sewer lines, and other structures that make trenching time-consuming and expensive. "It is pretty much universally-accepted now that new residential areas in most all parts of the country go underground," said Miner. "One reason this is so common is that utilities don't have to add these costs to their rates. Instead, the homeowners pay the additional cost of underground in the cost of their lots, which ends up being part of their mortgages."

Another reason for the increasing popularity of underground is that costs are decreasing. "While the cost of underground is higher than overhead, a lot of utilities are taking a second look, because some of the pricing on dielectric cable is coming down," said Alonso. "It used to be that the cost ratio of underground to overhead was about six times greater. However, this is starting to be reduced."

At the same time, however, as a result of recent directives from FERC, the U.S. Federal Energy Regulatory Commission, and NERC, the North American Electric Reliability Corp., more utilities are focusing efforts on "hardening" their overhead lines, such as reinforcing poles, becoming more aggressive with vegetation management, and utilizing the "smart grid" to more quickly identify and address overhead outages. Indeed, these initiatives are costly, but not as costly as undergrounding everything that is currently overhead.

Practical Considerations

"First, utilities need to be more aware of public opinion," said Alonso. "This has been increasing a lot because of the recent strong storms. Utilities should not base their decisions on public opinion, but they should at least take it into consideration."

Of course, that requires that utilities first educate the public on the pros and cons of overhead and underground. For example, according to Alonso, while the public may be aware that underground is more expensive than overhead, it can help to explain to them in detail why this is the case. It is also important to explain that, while there are fewer outages with underground, those that do occur tend to last longer, and explain the reasons why.

Regarding cost, there are very few situations where putting lines underground is economically justified, according to Miner, and that suggests a need for initial consensus-building.

"For regulated utilities, regulators need to be prepared to allow greater revenues to pay for that work," Miner suggested. "For non-regulated municipal utilities, the local boards need to be prepared to increase their capital budgets and find various mechanisms to support that additional revenue requirement."

In a similar vein, the North Carolina study suggests that utilities at least take the time to identify their overhead lines that repeatedly or frequently experience reliability problems, and then determine whether it makes sense to move these specific lines underground. That is, rather than underground the whole system, consider undergrounding specific portions that are likely to provide tangible reliability improvements in the future.

The Rural Perspective

One utility that has been studying the pros and cons of overhead and underground distribution lines is South Carolina-based SCE&G. "Currently, about 72 percent of SCE&G's distribution system is overhead," said Eric Boomhower, manager, public affairs, for SCANA Corp. (Cayce, S.C.), SCE&G's holding company. "As with most utilities, overhead lines are considered 'standard service.'" That said, according to Boomhower, most new distribution lines are typically placed underground, and existing policy allows for some of that expense to be covered by the company.

"Developers also contribute toward the cost of the undergrounding, depending on the size of the development and type of facilities that will be installed," he said.

For many municipalities wanting to place existing power lines underground, there is a mechanism called a "non-standard service fund." "This fund is included in most franchise agreements with the municipalities that we serve," Boomhower said. The fund takes a portion of the franchise fees that SCE&G collects on behalf of the city/town and establishes a maximum annual amount that the municipality may contribute toward non-standard service projects. SCE&G agrees to match that amount, and then the municipality decides which projects to undertake. "Moving or placing distribution facilities underground would be an example of a project that could be paid for through the 'non-standard service fund,'" he said.

"Of course, in all cases, we must consider the feasibility of placing lines underground purely from an engineering perspective," Boomhower added. "In some instances, it is simply not practical or possible to put lines underground."

A little over a decade ago, following a major ice storm in North Carolina, utility regulators in that state formally studied the idea of placing the overhead power lines of the state's three investor-owned utilities underground. "They determined that replacing the existing overhead distribution lines with underground lines would be prohibitively expensive, costing about $41 billion and requiring about 25 years to complete," said Boomhower. "They also estimated that such an undertaking would result in an increase of more than 125 percent to the average residential customer's monthly electric bill." (A copy of that report can be found at: www.ncuc.commerce.state.nc.us/reports/undergroundreport.pdf [4])

"Bottom line, we generally try to work with communities and municipalities in our state to accommodate requests for lines to be placed underground, as long as it is feasible from an engineering standpoint, and there is a way to cover the additional cost," said Boomhower.

The Urban Perspective

Another utility that has actively been addressing the overhead-underground issue is Potomac Electric Power Co. (Pepco), an electric distribution utility headquartered in Washington, D.C., and a subsidiary of Pepco Holdings.

"Overhead systems are not very reliable in heavily-treed areas, and the Washington D.C. area has a lot of very tall and mature trees that are well above overhead lines, which pose a risk to our overhead network," said Bill Gausman, senior vice president, strategic initiatives, at Pepco

Holdings. "Furthermore, there is a desire within the District [the term that locals use for the city of Washington] to increase the number of trees and tree density, and there are a number of initiatives in place to increase the planting. As a result, we are working with the city to make sure this is done in a way that doesn't add additional impact to the overhead system."

While Pepco does have a lot of overhead lines, it also has a long history of undergrounding. "A large portion of our system has always been underground, since Congressional regulations prohibited overhead lines being built in certain portions of the downtown area from the beginning of electric service," he said.

One reason Pepco's underground system is so reliable is that it has a tremendous amount of redundancy built into it that doesn't exist on the overhead system. "This is especially important for the critical loads that we serve," he said.

While flooding can pose a reliability problem for some underground distribution systems, it has not been a problem for Pepco, according to Gausman. One reason is that traditional urban underground distribution systems are often referred to as "subway systems," in that they are designed to be able to operate while under water, given that all of the equipment is sealed. "In addition, we don't have a lot of flooding in our areas," he said. "We will occasionally have manholes that fill up with water, but it is not a widespread problem."

Still, despite the benefits of underground for Pepco, there are some challenges. "Construction is more expensive, especially since we are in an urban environment, which requires building concrete-encased manhole conduit systems," said Gausman. It is also more time-consuming to make repairs when an outage does occur. However, with the underground designs that are being used today, according to Gausman, service can still be restored relatively quickly, because of the redundancy and transfer capabilities in the system.

As a result of the increasing number of strong storms that hit the Washington, D.C. area in recent years and caused power outages, the mayor began to look for ways to make the electric system more resilient. "This was especially important in light of the fact that there are indications that the number and severity of the storms is likely to increase," said Gausman. The mayor created a committee jointly chaired by the city administrator and the chairman of Pepco Holdings. The committee represented a wide range of interested parties, including a number of different government agencies and peoples' councils.

"We started out by looking at the costs and benefits of undergrounding the entire overhead system and quickly realized that wasn't realistic, given the cost," he said. "In addition, in terms of benefits, the group quickly acknowledged that this was not an aesthetics program, but rather a reliability program." At that point, the focus became on identifying where the real benefits were to be gained. This came down to the idea of undergrounding the high-voltage lines and transformers on the circuits that had the most impact on storm events. "The secondaries would stay on the pole, because we determined that the benefits were small relative to the cost," he said.

All of the parties came up with a plan that allowed for the approval of legislation that authorized spending to underground selective lines over the next seven or eight years. That legislation has been passed. In June, Pepco filed a plan with the Public Service Commission of the District of

Columbia on how it will move forward with this plan. "If we receive approval, we should be starting construction right after the first of the year," he said.

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Lines Up, Inc. (703) 842-3762

3033 Wilson Blvd., Suite 700, Arlington, VA 22201

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