Panel discusses pros and cons of undergrounding power lines

Joe Naiman
Village News Correspondent

Thursday, February 19th, 2009.
Issue 08, Volume 13.

Story Last Updated : Sep 10th.

The utility industry's DistribuTech conference February 2-5 at the San Diego Convention Center included a February 4 panel discussion on the advantages and drawbacks of overhead and underground utility lines.

"The Real Cost of Overhead vs. Underground Transmission: It May Not Be What You Think" was moderated by Michael Beehler, the associate vice president of Burns and McDonnell.

The panel was comprised of Pacific Gas & Electric senior consulting engineer Mohan Bhatia, American Electric Power director of transmission line projects engineering Max Chau, and Northeast Utilities System transmission project director Anne Bartosewicz.

The panel noted that neither method was preferred for all cases. "Each project needs to be evaluated on its individual merits," Bhatia said.

Overhead power lines have been the cause of numerous fires in San Diego County in recent years.

In other areas the only homes lost from overhead transmission lines are by the eminent domain process when the line is constructed, but ice storms and hurricanes have led to problems with overhead lines.

"Our industry has seen a lot of outages in years past," Beehler said.

The total restoration costs for Hurricanes Katrina, Rita, Gustav, and Ike totaled approximately $2 billion. Some power lines were downed during both Hurricane Rita in 2005 and Hurricane Ike in 2008.

"We rebuilt the system and then we rebuilt it again," Beehler said.

Heavy winds in Ohio during September 2008 caused an outage which deprived approximately 2.6 million customers of power, and the December 2008 ice storms in the Northeast also cut power to millions of customers.

In addition to the utility's restoration costs, social costs of outages include lost revenue and other business disruptions, public safety and security, and convenience.

The fires and outages have led to calls from government, the media, and the public for the undergrounding of utilities.

"We as an industry need to give them an answer, not just for distribution but for transmission as well," Beehler said.

Advantages of underground lines include aesthetics, higher public acceptance, perceived benefits of protection against electromagnetic field radiation (which is still present in underground lines), fewer interruptions, and lower maintenance costs.

Decreased right-of-way costs, including access roads and vegetation, may also benefit the undergrounding of a distribution line.

The advantages of overhead lines include lower initial costs, faster and less costly restoration, and easier future expansion.

Pacific Gas & Electric has a service territory of approximately 70,000 square miles and has approximately 4.9 million electric accounts and 3.9 million gas accounts.

PG&E serves approximately 14 million customers, or one out of every 22 Americans. The utility currently utilizes approximately 95,500 overhead miles and 23,900 underground miles of electric lines.

Bhatia focused on PG&E's Jefferson-Martin project which serves San Francisco and northern San Mateo County.

The 230 kilovolt (kV) line runs from PG&E's Jefferson substation in Woodside to the Martin substation just south of the San Francisco border.

The California Public Utilities Commission (CPUC) granted a permit on August 19, 2004, nearly two years after PG&E filed its application on September 30, 2002.

Construction began on January 24, 2005, and the line was released to operation on April 29, 2006.

In order to meet the construction schedule, PG&E used four contractors and built the line in five segments.

The final cost for the Jefferson-Martin line was $227.5 million. The 27.5-mile line consists of 3.12 miles of overhead transmission and 24.37 miles of underground wires.

Environmental issues for the Jefferson-Martin line included the San Francisco garter snake, the red-legged frog, and nesting birds in the San Francisco watershed.

PG&E undertook 135 mitigation measures required by the CPUC which included noise, traffic, working hour restrictions, and stormwater constraints.

While undergrounded utilities are normally seven to eight feet below the surface, the electromagnetic frequency concern was mitigated by installing the cable 11 feet deep in residential areas.

Undergrounding was also performed in scenic areas, and barrier fencing was installed to protect endangered species. BART (Bay Area Rapid Transit) right-of-way also contributed to the costs.

The cost for the 3.12 miles of overhead lines averaged $3.8 million per mile, which included replacing a 60 kV tower line. Although that work was within an existing easement, 24 towers were replaced.

The major variables for the overhead work included terrain, access roads, construction hours, removal of the 60 kV lines, and the construction sequence.

The underground costs for the five segments averaged between $5.4 million and $6.8 million per mile. Variables included easement costs, traffic, and environmental and restoration expenses.

In some cases, Bhatia noted, the cost of right-of-way acquisition for overhead lines made underground transmission more attractive.

Another factor is the acceptance of the policy-making boards. "We as a utility can build only projects which are permitted," Bhatia said.

American Electric Power operates in 11 Southwest and Midwest states and currently has approximately 39,000 miles of overhead transmission.

Chau indicated that between 40 and 50 percent of a project's cost is construction labor, between 35 and 40 percent is construction material, between 10 and 12 percent is engineering, between 10 and 20 percent is right-of-way, and between 5 and 10 percent is permitting.

Chau also noted challenges of construction. Construction labor is becoming scarce, engineering and other expertise is retiring, and major material items require time to obtain.

Although the Advertisement
Youngren Construction Inc.
Youngren Construction Inc. recession has dropped copper and aluminum prices since mid-2008, those commodities increased considerably in previous years. "This is extremely susceptible to the market," Chau said.

Chau noted that variables include permitting costs, right-of-way cost and width, terrain and the type of equipment used, accessibility, soil type, traffic control, and the presence of other utilities.

American Electric Power includes Ohio. "Underground's less subject to the elements," Chau said.

On the other hand, when the 138 kV underground Dublin-Davidson line in the Columbus area was energized and "soaked" in February 2005, the line took 18 days to be placed back in service.

"To locate a failure of the underground cable is a lot more challenging," Chau said.

The outage rate per mile per year is 0.005 for overhead and 0.001 for underground and the mean delay time between failures is 200 days for overhead and 606 days for underground.

The mean repair time, however, is nine hours for overhead and 21 days for underground.

Maintenance is a cost for both. Tree trimming can be costly for overhead utilities while easements for underground lines must be cleared for access and visibility.

"Somebody's going to pay for the difference," Chau said. "The issue has to do with who is going to pay."

The most powerful known underground line is a 500 kV line in China which covers about 1,500 feet inside a hydroelectric substation. The highest-power underground lines in the United States are 345 kV.

Northeast Utilities includes Connecticut Light and Power, and approximately 50 percent of Connecticut's population lives in the southwestern portion.

The infrastructure there did not meet reliability criteria, so Northeast Utilities replaced existing lines with 345 kV and 115 kV transmission.

Bartosewicz focused on the Middletown-Norwalk line. The right-of-way for that line dates back to the 1920s, and only one additional mile was needed for the overhead portion of that project.

Because the line runs along Connecticut Route 1 (the alternative to Interstate 95), detours were needed and night work was required.

Three alternatives were presented. The actual project carried a $1.4 billion cost for 115 overhead and 35 underground miles.

Alternative A had a $1.35 billion cost for 140 overhead and 31 underground miles. Alternative B, which called for 164 overhead and 9 underground miles, was the least expensive at $1.272 billion.

A public utility has the power of eminent domain in Connecticut, which has been a sensitive issue there as the rest of the nation would find out after the 2005 Supreme Court decision Kelo v. City of New London.

Alternative B would have required the acquisition of 31 homes while Alternative A would have required two homes to be taken.

The most expensive version required no houses and only 28.6 acres of right-of-way acquisition, and 13 eminent domain cases were needed. "For us the decision was fairly easy," Bartosewicz said.

The incremental overhead lines had become cost-prohibitive. The 52 miles of overhead 345 kV lines had an average cost of $3.4 million per mile with a range of $2.3 to $3.8 million.

The 63 miles of 115 kV overhead transmission averaged $2.1 million per mile with a range of $1.0 to $3.8 million.

Railroad crossing issues led to an average cost of $12.5 million per mile and a range of $12.4 to $12.6 million for the 34 miles of 345 kV underground lines, and the one underground mile of the 115 kV line which ran through a residential neighborhood cost $6.5 million.

Underground costs included railroad and bridge crossing issues, utility conflicts, soil and water handling, business disruption, and the night work limitations.

Approximately 2,000 gas, water, electric, and other utility conflicts complicated the construction.

Some agreements with businesses compensated the business for lost revenue if it was fully blocked during construction.

In addition to the Department of Transportation hours limitation for the work along Connecticut Route 1, the shoreline location of that road created issues for the undergrounding.

"We were constantly de-watering," Bartosewicz said.

Since Northeast Utilities was not allowed to dump water into the sewers, that water had to be carted away. Army Corps of Engineers permits were also required for the project.

"Cost per mile comparisons are very deceiving," Bartosewicz said.

The entire Middletown-Norwalk project took seven years to complete.

One of Northeast Utilities' other projects in Connecticut, the Glenbrook Gables project, involved tunneling in Darien.

That tunnel has a considerable amount of open space, since the only tunneling machine available produced a tunnel 60 feet wide and the excess space was less costly than building a machine with a smaller bore.

"It's best to be done in solid rock," Bartosewicz said of tunneling. "Otherwise you'll get fractured rock."

Underground lines also have less transfer ability than overhead transmissions. "The deeper the cable was, the less transfer capability I was going to have," Bartosewicz said.

Beehler believes that the time to locate and repair underground failures will eventually decrease, noting that the overhead repair process benefits from decades of experience.

"We've had limited experience with underground. That might come down," he said.

Some solar or other renewable energy customers put electricity back into the grid; the panel found no advantages of either underground or overhead for that process.

"Either would work just as well," Beehler said.