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A REVIEW OF ELECTRIC UTILITY UNDERGROUNDING POLICIES AND PRACTICES

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LIPA
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Executive Summary

Throughout the U.S., the majority of electric utility power lines are constructed "overhead" on poles and towers to lower construction costs and facilitate maintenance. Approximately 68% of the distribution lines owned by the Long Island Power Authority ("LIPA") are overhead. Individual customers and communities frequently request that new lines be constructed underground and that existing lines be converted to underground to eliminate the visual impact of overhead lines. It is commonly thought that underground lines will also improve reliability, for example, by reducing damage during storms and eliminating damage from vehicles. In addition, some feel that underground lines are inherently safer because the exposed conductors of overhead lines are eliminated.

In reality, the perceived advantages of underground lines are overstated. For example, the aesthetic improvement of underground lines would come at enormous extra cost compared to overhead construction, possibly triggering large rate increases over time. What's more, the conversion of existing overhead lines to underground construction would require digging trenches in streets, rights of way and customers' premises, and customers would incur costs for converting overhead service lines to underground. Industry experience is that underground lines do not improve overall system reliability – generally substituting longer outages for repairs in exchange for less frequent interruptions compared with overhead lines. Also, workers accidentally digging into underground lines may result in injury and death, while overhead lines can be more easily seen and avoided.

Recognizing the preference of communities for underground lines, LIPA has previously studied the potential for converting existing overhead lines to underground construction (a process called "undergrounding"). In December of 1998, Resource Management International Inc. ("RMI"),[1] presented the results of an investigation on the "Assessment of Transmission and Distribution Construction Practices and their Impact on Public Safety" to LIPA. The report found that the cost of undergrounding the Long Island transmission and distribution ("T&D") system would be $14.7 billion and could potentially raise rates by 100%. Current cost estimates of undergrounding the Long Island T&D system are even higher due in part to increased material costs and changes in design standards. Following review of the 1998 study, the LIPA Board of Trustees initiated a subsequent investigation to provide additional information regarding the costs and benefits associated with underground versus overhead construction of the Long Island T&D system. In June of 1999 RMI released a report entitled "A Review of Electric Utility Undergrounding Policies and Practices" to LIPA concluding that the costs of undergrounding the Long Island system outweighed the benefits. Moreover, undergrounding T&D facilities would not *eliminate* weather related outages.

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[1] At the time RMI was a wholly owned subsidiary of Navigant Consulting, Inc. ("NCI"). In late 1999, RMI was consolidated with NCI.

In light of the continued public interest in placing electric lines underground, LIPA is presently undertaking a fresh look at developing undergrounding policies and practices on Long Island, considering potential reliability and cost impacts. To assist in its evaluation of potential policies and the development of undergrounding practices, LIPA engaged NCI to update the earlier studies and undertake a survey of the current state of the industry on the issue of undergrounding electric distribution systems. This report provides the results of that effort.

Most Outages Occur on LIPA's Distribution Lines

While the reliability of LIPA's distribution system outperforms the statewide average, the majority of LIPA's distribution system, approximately 68%, is overhead. Over 90% of the annual number of customer interruptions on the LIPA distribution system occur on distribution primary and secondary[2] overhead construction. Interruptions on LIPA's transmission system account for less that 2% of the annual number of customer interruptions.

LIPA Transmission and Distribution Line Miles

	Overhead Miles	Underground Miles	Total Miles
Transmission (23 kV and Above)	1019	288	1,307
Distribution System	8,867	4,222	13,089
Estimated Service Drop	11,646	4,333	13,542

Source: LIPA Energy Plan Volume 3, Technical Report, Exhibits 2-7 and 2-14, June 2004.

Undergrounding Existing Lines Would Require Large Cost Increases

The following observations and conclusions can be drawn about policy approaches towards undergrounding electric distributions systems across the nation and on Long Island:

- Almost all jurisdictions investigating undergrounding existing overhead systems have concluded that the cost to underground all existing overhead distribution facilities is prohibitive. Cost estimates for underground construction are estimated at ten times the cost of overhead construction varying from $500,000 to several million dollars a mile.
- A preliminary study performed for LIPA by KeySpan Energy ("KeySpan") estimates the cost to underground the Long Island distribution system, primary main, primary branch and secondary lines, at $24.8 billion. These estimated costs exclude the cost to convert services and third party attachments and are based on an estimated average per mile cost of $5.4 million for a "typical" mile of primary main and $1.7 million per mile for a "typical" primary branch line. This cost per mile is greater than the industry average due to a decision to employ a looped, rather than radial, distribution system design. The looped distribution system design is

[2] "Primary" distribution encompasses the local distribution lines with voltages in the range of 4 kV to 13.2kV. "Secondary" distribution encompasses the lines directly serving most homes and businesses at lower voltages.

standard for the LIPA system and avoids some exceptionally long restoration times for faults occurring on the underground distribution system.

- Another preliminary study performed by KeySpan for LIPA has estimated the cost of undergrounding transmission lines that need to be upgraded or built new during the course of regular business over the next 25 years to be $2.1 billion. When considering the cost of undergrounding the distribution system plus the costs of undergrounding the existing transmission lines and the LIPA portion of customer service drops, the potential impact on rates could be up to a 154% increase. The projected rate impact on LIPA customers for undergrounding various portions of the LIPA transmission and distribution system are shown in the table below.

Estimated Rate Impact on LIPA Customers

Specific LIPA Studies	*Approximate Miles*	*Estimated Cost (Millions $)*	*Example 1st Year Rate Impact (¢/kWh 2005 base)*	*Example 1st Year Rate Increase (13.07¢/kWh base)*	*Example Rate Impact (¢/kWh) (25 year)*	*Example 25 Year Rate Increase (13.07¢/kWh base)*
Underground Existing Overhead Distribution	8,867	$24,800	0.590	4.5%	14.330	109.6%
Underground New/Upgraded Transmission	648	$2,118	0.013	0.1%	1.575	12.1%
Extrapolated from Above Studies						
Underground LIPA Portion of Service Drops	9,208	$3,740	0.089	0.7%	2.161	16.5%
Underground Existing Overhead Transmission	695	$2,721	0.110	0.8%	2.023	15.5%
Total		**$33,379**	**0.802**	**6.1%**	**20.09**	**153.7%**

Source: KeySpan.

Notes:

1. The costs and rate impacts stated in the table above do not include the costs to underground other utility connections, such as telephone and cable, nor does it reflect the costs to individual customer building modifications.
2. An annual variation in costs could occur because of the specific annual project schedule.
3. Estimated costs are in 2005 dollars. The Estimated rate impact calculation includes an assumed 2% annual inflation rate.

- There are also substantial additional costs to convert homes and businesses to underground service. This is estimated at between $500 to $5,000 or more for each customer.
- The primary driver for undergrounding existing overhead power lines continues to be aesthetic considerations, not reliability or economic benefits.
- Like many jurisdictions across the United States, the New York State Public Service Commission ("NY PSC") has detailed undergrounding regulations that mainly apply to new construction in residential subdivisions.

- While underground systems are more reliable than overhead systems under normal weather conditions, suffering only about half the number of outages of an overhead system, they are not impervious to damage. According to the sources reviewed in this investigation, the repair time for underground systems can be from 60% longer to three to four times longer than for overhead systems when damage does occur. LIPA's experience is that underground restoration times can be almost 2.5 times longer than for an overhead system and that the frequency of outages to customers supplied by underground circuits is approximately four to five times better than for overhead systems.
- Underground lines have proven to have a shorter useful life than overhead lines and they are more susceptible to corrosion than overhead lines and can be damaged by flooding, tree roots, rodents, and people digging up the lines.
- Underground lines connecting to overhead lines are still vulnerable to lightning. Also, where only partial circuits are placed underground, the overhead portions are still susceptible to the types of events that affect other overhead lines.
- Burying existing overhead power lines does not completely protect consumers from storm-related power outages. During storms, conditions such as flooding, objects falling on surface-mounted equipment, and over-voltages caused by lightning can cause the loss of power on underground systems. Moreover, long-term system outages such as those associated with major storms may allow moisture to seep in, and this moisture can cause the cable to fail once the system is re-energized.

Utilities Have Adopted a Variety of Programs for Undergrounding Lines

Despite the cost of undergrounding and questionable degree of reliability benefits, dozens of cities and utilities have developed comprehensive plans to bury or relocate utility lines to improve aesthetics. A variety of programs are being used to convert existing overhead lines to underground, for instance, special assessment areas, undergrounding districts, and state and local government initiatives. Some of the approaches taken are:

- The California Rule 20 regulatory framework, which provides a systematic approach towards undergrounding its jurisdictional utility systems. Under California's Rule 20, undergrounding projects are financed by utility rate money, combined rate funds and local tax proceeds through neighborhood special assessment districts, or private funds, depending on whether Rule 20A, Rule 20B or Rule 20C provisions apply. All three of the California publicly owned electric utilities, Southern California Edison, Pacific Gas & Electric Company, and San Diego Gas & Electric Company, have incorporated the Rule 20 structure into their tariffs.
- Florida's recently approved rate mechanism for governmental recovery of undergrounding fees to be included in the tariffs of Florida's two largest electric utilities: Florida Power & Light and Progress Energy. The tariff revisions provide local governments with an optional mechanism for

the recovery of the costs of converting overhead electric service to underground service through a fee on the utility's electric bill. The local government is responsible for establishing an Underground Assessment Area ("UAA") whose customers are responsible for conversion costs.

- Colorado Springs City Council's policy establishing a system improvement fund to provide for burying overhead distribution lines. And the community of Del Mar, California funds undergrounding projects through the creation of assessment districts which finances projects through the issuance of city bonds paid for by the homeowners through their property taxes.
- Dare County, North Carolina's local act (N.C. Session Law 1999-127) authorizing the creation of one or more Utility Districts for the purpose of raising and expending funds to underground electric utility lines in the district. The proceeds of the tax are used for undergrounding electric lines within the district.
- The three funding policy options for undergrounding facilities adopted by the City of Portland, Oregon recommending that the city: 1) Reserve a portion of utility franchise fees for undergrounding; 2) Promote undergrounding options for Urban Renewal Projects and other major infrastructure improvements; and 3) include undergrounding provisions in future franchise agreements.

Targeted Undergrounding May be a Workable Solution

Several utilities have recognized that it may never be cost-beneficial to underground already built communities and have adopted a "targeted" approach to undergrounding projects which focuses on undergrounding portions of the overhead distribution system. For instance:

- Edmond Electric in Oklahoma is taking a one-section-at-a-time approach, concentrating on undergrounding in areas where poles were starting to rot and structural damage from a recent ice storm still needed repair. By doing so, some of the conversion expense was absorbed in previously budgeted annual maintenance and upgrade costs.
- The North Carolina Commission has recommended a selective approach instructing utilities to: 1) identify the overhead facilities in each region it serves that repeatedly experience reliability problems based on measures such as the number of outages or number of customer hours out of service; 2) determine whether conversion to underground is a cost effective option for improving the reliability of those facilities, and, if so, 3) develop a plan for converting those facilities to underground in an orderly and efficient manner, taking into account the outage histories and the impact on service reliability.
- Dominion Virginia Power has also adopted a selective approach of annually identifying the "worst 10 circuits" and "worst 10 devices" in each of its three Virginia regions. Based on the total number of customer-hours out for each circuit and the total number of outages for each device, appropriate steps are taken to improve or replace each of these circuits and devices.

> Among the corrective alternatives of improving a low-ranking circuit or device is the option to convert it to underground. LIPA has also employed a program that identifies worst performing circuits and targets a host programs selectively designed to improve reliability on these circuits. LIPA is currently considering adding a selective undergrounding program as an additional remedial technique within its revised undergrounding policy.

Like these utilities, LIPA is concerned about the adverse rate impact a wholesale undergrounding program on Long Island would present, while at the same time recognizing that there may be the potential to improve system performance and aesthetics through selective undergrounding. To achieve a policy that will improve system performance and aesthetics while mitigating rate impacts, LIPA is investigating alternatives to wholesale undergrounding. One such approach that LIPA is examining is a "targeted" undergrounding program.

In addition to adopting a well-reasoned approach towards identifying areas that would most benefit from undergrounding, many jurisdictions that have found that cooperation with state and local jurisdictions, other utilities, and the community are also essential elements of a comprehensive and effective undergrounding policy. For instance, jurisdictions as opposed to utilities have more options to fund underground lines and may have access to federal funds otherwise closed to utilities. LIPA recognizes that some communities see aesthetic benefits from placing wires underground and is also investigating how to work with communities to place those lines underground if the communities find a way of paying for the work. Additionally, coordination with other utilities can create opportunities for project costs sharing.

I. Introduction

In December of 1998, Resource Management International Inc. ("RMI"),[1] presented the results of an investigation on the "Assessment of Transmission and Distribution Construction Practices and their Impact on Public Safety" to the Long Island Power Authority ("LIPA"). The report found that the cost of undergrounding[2] the Long Island transmission and distribution ("T&D") system would be $14.7 billion and could potentially raise rates by 100%. At the request of the LIPA Board of Trustees, a subsequent investigation was initiated to provide additional information regarding the costs and benefits associated with underground versus overhead construction of the Long Island T&D system. In June of 1999 RMI released a report entitled "A Review of Electric Utility Undergrounding Policies and Practices" to LIPA concluding that the cost of undergrounding the Long Island system outweighed the benefits. Moreover, undergrounding T&D facilities would not *eliminate* weather related outages.

Since the release of the RMI reports, there have been several studies conducted by utilities, state commissions, localities and trade associations across the nation who have taken a close look into the issues, costs and potential benefits of placing electric distribution systems underground.

This report has been prepared at LIPA's request to summarize the findings and conclusions of other jurisdictions and localities and provide an overview on the current state of the industry on undergrounding electric distribution systems.[3] Where appropriate, LIPA's practices are discussed to provide a frame of reference to what other utilities have concluded.

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[1] At the time RMI was a wholly owned subsidiary of Navigant Consulting, Inc. ("NCI"). In late 1999, RMI was consolidated with NCI.

[2] Undergrounding entails putting overhead utility wires underground. Transformers usually remain above ground at street level, and poles are still required for streetlights. Undergrounding also requires affected customers to convert and to reconnect to new underground cables.

[3] During 2004, LIPA instructed KeySpan to perform a quantitative cost/benefit analysis on undergrounding the Long Island distribution system.

II. A Review of Undergrounding Considerations

Present Status

The majority of LIPA's distribution system, approximately 68%, is overhead.[4] While the reliability of LIPA's distribution system outperforms the state average,[5] KeySpan has identified that over 90% of the annual number of customer interruptions on the LIPA distribution system occur on overhead construction.[6]

LIPA has initiated an investigation into developing an undergrounding program in addition to the several reliability improvement programs already maintained. Preliminary results provided by KeySpan indicate that there may an improvement in reducing the number of overhead-related outages, however, this comes at the expense of increased restoration time. KeySpan estimates that at the end of a 40 year program the LIPA system SAIFI (a measure of the number of interruptions) could be improved by almost 70% but at the cost of an almost a 160 % deterioration in system CAIDI (a measure of the duration of interruptions).[7]

LIPA's initial investigation, like many other utilities and state commissions investigating the possibility of undergrounding, concluded that the cost of instituting a wholesale undergrounding program of its distribution system may be prohibitive.[8] KeySpan, in a preliminary undergrounding report, has estimated that the cost of undergrounding all LIPA primary main, primary branch lines and secondary lines is approximately $24.8 billion; based on an estimated average per mile cost of $5.4 million for a "typical" mile of primary main and $1.7 million per mile for a "typical" primary branch line. This cost excludes the cost to convert services and third party attachments. The potential impact on rates could be up to a 154% increase. Customer service conversion costs could run between $500 and $5,000 per customer, depending upon the size/length of the service. LIPA's estimated cost per mile is greater than the reported industry average due to a decision to employ looped, rather than radial, distribution system design. The looped design is standard for the LIPA system and avoids some exceptionally long restoration times for faults occurring on the underground distribution system.

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[4] This figure is an estimate as derived from data in the LIPA Energy Plan, June 23, 2004, available at http://www.lipower.org/projects/energyplan04.html.

[5] New York 2003 Interruption Report, Office of Electricity and Environment, April 2004.

[6] "Economic Reliability Impact of Undergrounding the LIPA Distribution System", KeySpan preliminary report to LIPA, February 9, 2005, at 8 ("KeySpan Preliminary Undergrounding Report").

[7] *Id.* at 10-11.

[8] Resource Management International, "Assessment of Transmission & Distribution Construction Practices and Their Impact on Public Safety", December 1998 ("RMI 1998 Report").

Recognizing potential costs associated with a wholesale undergrounding program, LIPA is considering adopting a "targeted" undergrounding program and has requested that KeySpan investigate the costs and benefits of such a program. A selective approach to undergrounding would be similar to the methods adopted by Dominion Virginia Power and Edmond Electric in Oklahoma.

The New York State Public Service Commission ("NY PSC") has detailed regulations dictating which facilities must be placed underground. Like many jurisdictions across the United States, these regulations mainly apply to new construction in residential subdivisions. In addition to the state regulations governing new construction, LIPA also maintains a list of those areas on Long Island where LIPA mandates that new electric service be installed underground.[9] These areas include small commercial business districts and network areas.

Jurisdictions across the United States have dealt with the issue of undergrounding differently. At one extreme, the California Rule 20 regulatory framework provides a systematic approach towards undergrounding its jurisdictional utility systems. Alternatively, a number of municipalities and local governments have adopted mechanisms to manage undergrounding through special assessment districts, undergrounding districts, and state and local government initiatives. LIPA too is investigating ways to work with communities to place lines underground where those communities are willing to devise a way of paying for the work.

Industry Trends

The primary driver for undergrounding existing overhead power lines continues to be aesthetic considerations, not reliability or economic benefits.[10] To date, almost all jurisdictions investigating undergrounding existing overhead systems have concluded that the cost of undergrounding all existing overhead facilities is prohibitive. Cost estimates for underground construction are approximately ten times the cost of overhead construction. There are also substantial additional costs to connect homes to newly installed underground service estimated at between $500 to $5,000 or more, in the case of large commercial properties.[11]

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[9] LIPA also has four areas listed as Visually Significant Resource areas pursuant to a now sunset NY PSC program requiring underground electric facilities in these areas. *See* Resource Management International, "A Review Of Electric Utility Undergrounding Policies And Practices", June 1999 ("RMI 1999 Report") for more information on this program.

[10] Edison Electric Institute (Brad Johnson), "Out of Sight, Out of Mind? : A study on the costs and benefits of undergrounding overhead power lines", January 2004 ("EEI Report").

[11] Utility Undergrounding Citizens Advisory Committee ("UUCAC"), "A Report to the Portland City Council Compiled by the Utility Undergrounding Citizens Advisory Committee", March 2000, at 4 ("UUCAC Report"). The EEI Report estimates a $2,000 conversion cost if the household electric service must be upgraded to conform to current electric codes.

Utility Underground Costs	
Utility	**Average Cost $ per Mile**
Allegheny Power	764,655
BGE	952,066
PEPCO	1,826,415
Conectiv	728,190
Va Power	950,000
California	500,000
FPL	840,000
Georgia Power	950,400
Puget Sound Energy	1,100,000
Average Overhead Line	***120,000***

Source: Edison Electric Institute (Brad Johnson), "Out of Sight, Out of Mind? : A study on the costs and benefits of undergrounding overhead power lines", January 2004.

Summary of Conversion Costs by Line Type	
Type of Line	**$ Cost per Mile**
Heavy/Commercial Urban	2,053,000
Three-phase Suburban	1,229,000
Three-phase Rural	523,000
Single-phase	284,000

Source: "Report Of The Public Staff To The North Carolina Natural Disaster Preparedness Task Force: The Feasibility Of Placing Electric Distribution Facilities Underground" Before the North Carolina Public Service Commission November 2003.

The actual benefits of placing facilities underground have also been questioned. The Maryland PSC found that "in normal weather and over the long run, there is insufficient evidence to support the proposition that underground lines suffer fewer outages than overhead lines."[12] The North Carolina Commission, while concluding that underground systems are more reliable than overhead systems under normal weather conditions, suffering only about half the number of outages of an overhead system, also observed that "they are not impervious to damage and the repair time for underground systems is almost 60% longer than for overhead systems when damage does occur."[13] A report prepared

[12] "In The Matter Of The Electric Service Interruptions due to Hurricane/Tropical Storm Isabel And The Thunderstorms Of August 26-28, 2003" Before the Public Service Commission of Maryland, Case No. 8977, at 10 ("Maryland PSC").

[13] "Report Of The Public Staff To The North Carolina Natural Disaster Preparedness Task Force: The Feasibility Of Placing Electric Distribution Facilities Underground" Before the North Carolina Utilities Commission, at 2,17 (November 2003) ("North Carolina Report").

by James Lee Witt Associates for Potomac Electric Power Company ("PEPCO") points out that while underground lines have fewer outages than overhead, they are "more susceptible to corrosion, and can be damaged by flooding, tree roots, ants, snakes, rodents, and people digging up the lines."[14] Furthermore, underground lines connecting to aboveground lines are still vulnerable to lightning. And if a problem with the underground lines occurs it can take three to four times longer to fix because the lines are buried and it is harder to identify the exact location of the outage.[15] The Oregon Utility Undergrounding Citizens Advisory Committee ("UUCAC") adds that undergrounded wires offer only "marginal advantages in preventing outages caused by windstorms or vehicular collisions."[16]

Nevertheless, in the case of storm outage prevention, the Maryland PSC concluded that undergrounding is the only option that can fully protect electric facilities that are susceptible to tree damage during a major storm.[17] And that the portions of the overhead electric system that were most appropriate for conversion to underground were overhead sub-transmission and distribution systems, which are vulnerable to storm damage from wind and falling trees.[18] The Edison Electric Institute ("EEI"), however, observed that burying existing overhead power lines does not completely protect consumers from storm-related power outages. The North Carolina Utilities Commission also adds that during storm conditions flooding, objects falling on surface-mounted equipment, and over-voltages caused by lightning can cause the loss of power on underground systems.[19] Moreover, long-term system outages such as those associated with major storms may allow moisture to seep in, which can cause the cable to fail once the system is re-energized.[20]

Despite the cost of undergrounding and questionable degree of benefits, EEI observed that dozens of cities have developed comprehensive plans to bury or relocate utility lines to improve aesthetics. Among these cities a variety of programs are being used to convert existing overhead lines to underground, for instance, special assessment areas, undergrounding districts, and state and local government initiatives.

California has established a framework to allow for the conversion of its existing overhead system to underground. Its Rule 20 is a set of policies and procedures established by the California Public Utilities Commission to regulate the conversion of overhead electric equipment to underground facilities. Rule 20 determines the level of ratepayer funding for different undergrounding arrangements. Under Rule 20, undergrounding projects are financed by utility rate money, combined rate funds and local tax

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[14] James Lee Witt Associates, L.L.C., "Pepco Holdings, Inc., Hurricane Isabel Response Assessment", May 2004, at A-8 ("Witt Report").

[15] *Id.*

[16] UUCAC Report at 4.

[17] Maryland PSC at 10.

[18] *Id.*

[19] North Carolina Report at 17.

[20] *Id.*

proceeds through neighborhood special assessment districts, or private funds, depending on whether Rule 20A, Rule 20B or Rule 20C provisions apply. All three of the California investor owned electric utilities, Southern California Edison, Pacific Gas &Electric Company ("PG&E"), and San Diego Gas & Electric Company ("SDG&E"), have incorporated the Rule 20 structure into their tariffs. PG&E places underground each year approximately thirty miles of overhead electric facilities, within its service area under the provisions of the company's Rule 20A.[21]

The Florida Public Service Commission has recently approved a mechanism for governmental recovery of undergrounding fees to be included in the tariffs of Florida's two largest electric utilities: Florida Power & Light and Progress Energy.[22] The tariff revisions provide local governments with an optional mechanism for the recovery of the costs of converting overhead electric service to underground service through a fee on the utility's electric bill. To receive service under the proposed underground tariff, the local government must first comply with the tariff's terms and conditions for converting existing electric distribution facilities from overhead to underground service. Then, the local government is responsible for establishing an Underground Assessment Area ("UAA"). The UAA is a geographic area that is used to identify customers who benefit from the underground conversion. Only customers in the UAA are responsible for conversion costs. Following the devastation created by four hurricanes, some authorities speculate that it is likely the Florida State Legislature will re-consider the feasibility of burying lines.[23]

The community of Del Mar in California has also taken the approach of funding undergrounding projects through creating assessment districts.[24] Before undergrounding can proceed, at least two-thirds of the residents on a street must ask the city to create the assessment district. An assessment district is financed through the issuance of city bonds and paid for by the homeowners through their property taxes. Similarly, the Colorado Springs City Council has implemented a policy establishing a system improvement fund to provide for burying overhead distribution lines and a rate increase to create the system improvement fund.[25]

The Witt Report, prepared for PEPCO, identifies another undergrounding approach. Recognizing that it may never be a cost-beneficial solution to consider undergrounding already built communities, the Witt

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[21] Pacific Gas & Electric Company., "Rule 20 Undergrounding Program", available at http://www.pge.com/field_work_projects/street_construction/rule20/.

[22] Order No. PSC-03-1076-CO-EI (September 2003) (approving FP&L tariff change); Order No. PSC-02-1629-TRF-EU (November 2002) (approving Progress Energy Florida tariff change).

[23] Dorschner, John, "After storms, Floridians wonder why above ground power lines still exist", The Miami Herald, September 28, 2004. A four volume report prepared by the Florida PSC in 1992, entitled "Report on Cost-Effectiveness of Underground Electric Distribution Facilities", concluded that putting electric distribution facilities underground wasn't cost-effective.

[24] Steinberg, James, "Del Mar adds 2 areas to underground utility effort", The SanDiego Tribune, October 20, 2004.

[25] Johnson, Stephen G., "Colorado Springs Utilities, Overhead to Underground In Colorado Springs", Transmission & Distribution World. October 1, 1997.

Report states "targeted undergrounding projects in the areas susceptible to frequent outages due to trees or other problems should be given special consideration."[26] Edmond Electric in Oklahoma is taking such a one-section-at-a-time approach, budgeting to convert about 250 homes a year. Edmond Electric observes that by starting with an area that needs attention, "some of the conversion expense could be absorbed in annual maintenance and upgrade costs already budgeted."[27] For instance, undergrounding was begun in an area where poles were starting to rot and structural damages from a recent ice storm still needed repair.

While the North Carolina Utilities Commission rejected a proposal for wholesale conversion of overhead facilities to underground a selective approach was considered. Utilities were recommended to:

1) identify the overhead facilities in each region it serves that repeatedly experience reliability problems based on measures such as the number of outages or number of customer hours out of service,
2) determine whether conversion to underground is a cost effective option for improving the reliability of those facilities, and, if so,
3) develop a plan for converting those facilities to underground in an orderly and efficient manner, taking into account the outage histories and the impact on service reliability.[28]

The North Carolina Utilities Commission identified Dominion Virgina Power's approach to undergrounding as a best practice.[29] Dominion Virginia Power has also adopted a selective approach policy of annually identifying the "worst 10 circuits" and "worst 10 devices" in each of its three Virginia regions. Based on the total number of customer-hours out for each circuit and the total number of outages for each device, appropriate steps are taken to improve or replace each of these circuits and devices. Among the corrective alternatives of improving a low-ranking circuit or device is the option to convert it to underground.

In Oregon, the UUCAC took another approach by adopting three basic funding policy options for undergrounding facilities.

1) Reserve a portion of utility franchise fees for undergrounding.
2) Promote undergrounding options for Urban Renewal Projects and other major infrastructure improvements.
3) Include undergrounding provisions in future franchise agreements.[30]

Dare County, North Carolina took yet another approach. In 1999 the county secured the enactment of a local act (N.C. Session Law 1999-127) authorizing the creation of one or more Utility Districts for the

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[26] Witt Report at A-6.
[27] Sherrick, Dean, "Overhead to Underground Conversion in Oklahoma", Transmission & Distribution World, August 1, 2004.
[28] North Carolina Report at 41.
[29] *Id.*
[30] UUCAC Report at 6-8.

purpose of raising and expending funds to underground electric utility lines in the district.[31] The proceeds of the tax will be used for the purpose of undergrounding electric lines within the district. While the 1999 act applies only to Dare County, other counties or municipalities could seek to have similar statutes enacted.

Undergrounding Considerations

EEI's survey of industry experts revealed the following important considerations pertaining to the reliability of underground facilities:

- Underground lines require specialized equipment and crews to locate a fault;
- In urban areas, underground lines may be more costly to maintain than overhead facilities;
- Underground lines have a higher failure rate initially due to digins and installation problems. After three or four years, however, failures become virtually non-existent;
- As underground cables approach their end of life, failure rates increase significantly and these failures are extremely difficult to locate and repair;
- Water and moisture infiltration can cause significant failures in underground systems when they are flooded, as often happens in hurricanes; and,
- Where only partial circuits are placed underground, the overhead portions are still susceptible to the types of events that affect other overhead lines.[32]

The North Carolina Commission adds the following considerations:

- A well-maintained overhead system has a life expectancy of more than 50 years, primarily because individual components are easy to replace. The life expectancy of underground cable installed today is thought to be greater than 30 years. However, some components of the underground system may have a shorter useful life.
- O&M costs per mile for an overhead system and a direct-buried underground system are comparable. However, the annual average O&M cost per mile of an urban underground system that requires installation in duct bank is more than four times that of an overhead system.[33]

The type of technology available also plays a significant role in controlling costs. As Edmond Electric identified in its case study, installation and restoration costs are the most expensive part of any underground job. They found that the key to success was to take advantage of technological advances, particularly the use of horizontal directional drilling ("HDD") to install conduit.[34] Furthermore, designing for easy access and redundancy helped improve restoration times.

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[31] North Carolina Report at 38.
[32] EEI Report at 10.
[33] North Carolina Report at 10, 23-25.
[34] Sherrick, *supra*.

As the Witt Report notes, jurisdictions as opposed to utilities have more options to fund underground lines.[35] Therefore, any successful undergrounding policy should necessarily include local jurisdictions as part of their overall undergrounding policy. Ocean City, Maryland also found that community input and support is critical to success, as is the cooperation and coordination between the different utilities.[36]

[35] Witt Report at A-7.

[36] *Id.*

III Development of Undergrounding Policies in New York State

New York Regulatory Structure

Title 16 of the New York PSC's Rules and Regulations contains provisions pertaining to undergrounding requirements. Current New York State regulations only require an electric utility to underground electric facilities in new residential subdivisions that meet certain criteria, if required by a governmental authority of competent jurisdiction or at the applicant's request. These undergrounding options require various levels of contributions by the participants.

Part 98 – General Provisions Relating to the Extension of Facilities by Electric Corporation and Municipalities

This rule lists the obligations for both the applicant and utility associated with providing electric service. It defines the guidelines associated with providing either underground or overhead service. Detailed provisions are included in each company's tariff.

The rule provides that where a utility is required, by the Commission or a governmental authority, to provide residential underground service,[37] the cost and expense which a utility must bear includes the material and installation costs for up to a total of 100 feet of underground distribution line and underground service line per dwelling unit served, measured from the utility's existing electric system to each applicant's meter or point of attachment. Where an applicant requests a residential underground service line that is not required to be underground, the cost and expense which a utility must bear shall include the material and installation costs equivalent to those relating to the length of overhead service line which the applicant would otherwise be entitled. For a request for non-residential underground service line by an applicant, or where a governmental authority requires undergrounding, the cost and expense to the utility includes the material and installation costs equivalent to those contained in the utility's tariff in connection with the provision of overhead service.

Part 100 – New construction of distribution lines, service lines and appurtenant facilities in residential subdivisions.

Part 100 requires that all new distribution lines, service lines and appurtenant facilities to be utilized for permanent electric service to one or more multiple occupancy buildings (four or more dwelling units) or residential subdivisions with five or more units be installed underground if the following criteria are met:

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[37] Even if aesthetic advantage of underground as opposed to overhead wiring to houses in new subdivisions was sole basis for challenged determination, commission had authority to order mandatory undergrounding on that basis alone. *Sleepy Hollow Lake, Inc. v. Public Serv. Com.*, 352 N.Y.S.2d 274, (1974, 3d Dept), *appeal denied*, 34 N.Y.S.2d 519 (1974).

1. the residential subdivision will require no more than 200 trench feet of facilities per dwelling unit planned within the residential subdivision; or
2. a utility's tariff provides for such underground service without contribution; or
3. a governmental authority having jurisdiction to do so has required undergrounding; or
4. an applicant requests undergrounding.

A utility does not have to place its facilities underground in a residential subdivision if:

1. the developer of the residential subdivision is not primarily engaged in the construction of dwelling units within the residential subdivision;
2. no governmental authority having jurisdiction to do so has required underground service; and
3. certain criteria involving a time lag in the sales of lots were not met.[38]

In addition to the provisions above, a utility or applicant may apply for a special ruling from the Commission based on environmental and economic factors that support undergrounding within a particular residential subdivision is undesirable.

LIPA Policy and Practices

Leading Causes of Outages

Approximately 78% of LIPA's transmission system is overhead but transmission outages only account for approximately 2% of annual number of customer interruptions.[39] This is not surprising since the LIPA system is designed with at least two transmission circuits supplying each substation and as a result, transmission line outages rarely result in interruption of service to customers. In addition, transmission lines are located along right-of-ways which reduce exposure to outages caused by contacts with trees and vehicular traffic.

LIPA Transmission Line Miles			
	Overhead Miles	**Underground Miles**	**Total Miles**
Transmission (23 kV and Above)	1019	288	1,307

Source: LIPA Energy Plan Volume 3, Technical Report, Exhibits 2-7, June 2004.

Likewise, a majority of the LIPA distribution system in overhead, approximately 68% of all primary mainline and branch miles.

[38] The NY PSC held that where there is no other governmental requirement for undergrounding within a particular subdivision besides the Commission's regulations a utility may install overhead service lines from its existing overhead distribution line to each lot, as each applicant requested service, without requesting a waiver of the regulations. CASE 98-E-0798 (Pine Meadows Subdivision).

[39] "LIPA Transmission System Expansion Overhead vs Underground Analysis", KeySpan preliminary report to LIPA, May 23, 2003, at 7 ("KeySpan preliminary Transmission Report").

Distribution Lines			
	Primary Mainline Miles	**Primary Branch Miles**	**Total Miles**
Overhead	2,621	6,246	8,867
Underground	1,307	2,915	4,222
Total	**3,928**	**9,161**	**13,089**

Source: LIPA Energy Plan Volume 3, Technical Report, Exhibit 2-14, June 2004.

However, KeySpan reports that over 90% of the annual number of customer interruptions on the LIPA distribution system occur on overhead construction.[40] KeySpan also reports tree contact as the leading cause of forced distribution customer interruptions on Long Island. The following table enumerates the outage causes on the LIPA distribution system.

Causes of Forced Distribution Customer Interruptions (2003)	
Trees	24%
Other Equipment (Potheads, Insulators, Cutouts, etc.)	17%
Motor Vehicle Accidents	10%
Lightning	9%
Hotline Clamps/Taps	9%
Cable/Exit Failures	7%
Unknown	7%
Animal Contacts	6%
Substandard Conditions, Customer Equipment, Errors	3%
Overloads	3%
Insulators, Tie Wires	3%
Dig-Ins	1%
Other Accidents	1%

Source: KeySpan Performance Engineering, "LIPA 2003 Electric Transmission and Distribution Reliability Report", April 2004.

Due to the fundamental differences between transmission and distribution, undergrounding transmission circuits will have little impact on service reliability to LIPA customers.

Existing Reliability Programs and System Performance

To ensure optimal performance of the LIPA distribution system and mitigate sustained customer interruptions, several reliability programs have been implemented:

- **Circuit Improvement Program –** Overhead circuits experiencing the lowest reliability levels are identified and field inspected to identify corrective action of all substandard conditions likely o

[40] KeySpan Preliminary Undergrounding Report at 8.

cause interruptions. Field corrections of substandard conditions as well as reliability improvements are then made.

- **Distribution Circuit Tree Trim Program** – Trees on the distribution system are trimmed on a cyclic basis to mitigate tree caused interruptions. The program prunes trees and branches near overhead electric lines to meet at least the six foot clearance standard. Distribution circuit trim is performed on a three, five, or seven year cycle depending on the location and historic performance of the circuit.
- **Automatic Sectionalizing Unit Installation program** – Supervisory controlled and auto-sectionalizing switches are installed on 13 kV distribution circuits at the mid tie point in a circuit. Circuits are selected based on the risk for future customer interruptions.
- **Infrared Scans of Transmission and Distribution Lines** – Infrared scans of overhead distribution lines examine line clamps, taps, splices, and equipment for possible overheating in order to replace a component or splice before failure causes an outage. Repairs are prioritized based on the severity of overheating.
- **Microprocessor-Controlled Relay Installation Program** – Replaces obsolete and aging electromechanical relays on distribution circuits, along with all associated ammeters, switches, transducers, lights and auxiliary relays with new microprocessor-controlled relays.
- **Exit Cable Replacement Program** – Replaces distribution circuit exit cables based on failure history and age.
- **Distribution Transformer Load Management Program** – Replaces distribution transformers that have been identified as having high loads for upgrade before the summer period.
- **Wood Pole Inspection, Replacement, and Reinforcement Programs** – Identifies distribution poles evidencing decay, shell rot, insect infestation or other damage. Poles are categorized for immediate replacement, future replacement or reinforcement.
- **Secondary Network Refurbishment Program** – Replaces primary cable and installs additional padmount switchgear and network protectors to underground secondary distribution networks that serve major load centers. Refurbishment facilitates rapid switching and restoration and load relief during summer months.

Distribution system performance can be measured through several reliability indices. Two leading indices used to measure distribution system performance are outage frequency and duration.

- **Frequency (SAIFI)** measures the average number of interruptions experienced by customers served by the utility. It is the customers affected divided by the customers served.
- **Duration (CAIDI)** measures the average time that an affected customer is out of electric service. It is the customer hours divided by the customers affected.

LIPA's distribution system performance as to outage frequency and duration is better than the statewide average.[41]

Comparison Of Service Reliability Indices (Excluding Major Storms)						
	1999*	**2000**	**2001**	**2002**	**2003**	**5 YR AVG**
LIPA						
Frequency	0.79	0.76	0.78	0.99	0.89	**0.84**
Duration	1.14	1.06	1.06	1.15	1.08	**1.10**
Statewide (without Con Edison)**						
Frequency	0.90	0.91	0.92	0.99	0.92	**0.93**
Duration	1.68	1.72	1.64	1.70	1.67	**1.68**

Notes:

* All New York utilities included the heat-related outages in 1999, except for LIPA.

**Con Edison has by far the lowest frequency numbers and tends to distort the statewide data because much of Con Edison's distribution system consists of a secondary network. In a secondary network, a customer is fed from multiple supplies, making the probability of an interruption relatively rare.

Comparison of Service Reliability Indices (Including Major Storms)						
	1999*	**2000**	**2001**	**2002**	**2003**	**5 YR AVG**
LIPA						
Frequency	1.31	0.80	0.94	1.23	1.09	**1.07**
Duration	2.35	1.14	1.33	1.51	1.44	**1.55**
Statewide (without Con Edison)						
Frequency	1.28	1.16	1.05	1.41	1.54	**1.29**
Duration	3.60	2.25	1.82	3.00	5.93	**3.32**

Notes:

* All New York utilities included the heat-related outages in 1999, except for LIPA.

**Con Edison has by far the lowest frequency numbers and tends to distort the statewide data because much of Con Edison's distribution system consists of a secondary network. In a secondary network, a customer is fed from multiple supplies, making the probability of an interruption relatively rare.

[41] New York PSC, Office of Electricity and Environment, "The 2003 Interruption Report", April 2004.

Current LIPA Undergrounding Practices

The policies and procedures followed by LIPA today are contained in its currently approved tariff. The LIPA electric service tariff provides guidelines that applicants for electric service may use to determine whether they prefer overhead or underground service for new construction. Factors such as governmental jurisdiction, current regulations, type of existing electric distribution system, environmental impacts, engineering designs and costs will determine the extent to which LIPA will contribute to the costs associated with the service type preferred by the applicant. Where a new residential underground service is requested off an existing overhead system, the customer is given an allowance equal to the cost of the overhead service, within particular footage constraints. The customer would be responsible for any additional incremental costs. For a new residential underground service off an existing underground system, LIPA would pay the full cost of providing underground service, within particular footage constraints. All costs above the particular footage are the responsibility of the customer.

There are areas on Long Island where LIPA mandates that new electric service be installed underground. These areas include small commercial business districts and network areas that are demarcated by Town in the LIPA Rules and Regulations for Electric installations.

KeySpan Undergrounding Analysis of the LIPA Distribution System

The preliminary findings of a study on undergrounding the LIPA distribution system being performed by KeySpan concludes that underground construction is more reliable compared to overhead construction. KeySpan notes that "Although the fault rates for overhead primary distribution equipment including failures for transformers, taps, clamps, insulator problems, etc. and for primary underground equipment including underground cables, cable terminations, splices, transformers, etc. are similar (approximately 11 faults per 100 miles), *the real advantage of underground construction is less exposure to outages related to external factors* such as inclement weather, trees, animals and motor vehicle accidents which has the potential to significantly reduce customer interruptions.[42] Keyspan notes that the risk of these types of outages would be avoided if the overhead system were to be placed underground and that "*historical electric interruption data indicates that the frequency of outages to customers supplied by underground circuits is approximately four to five times better than for overhead systems.*"[43]

KeySpan estimates that undergrounding the LIPA distribution system will result in a SAIFI improvement rate of approximately 4% to 5% per year in the early years of the program.[44] The annual rate of SAIFI improvement is anticipated to decrease somewhat with each successive year since the worst performing circuits will be addressed first. At the end of a 40 year program KeySpan estimated the LIPA system SAIFI would be approximately 0.24 interruptions per year, almost a 70% improvement.

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[42] KeySpan Preliminary Undergrounding Report at 8-9.
[43] *Id.* at 9.
[44] *Id.* at 10.

Conversely, KeySpan reports that the transition from overhead to underground circuits results in an approximate 2% annual worsening in CAIDI.[45] At the end of the 40 year program, the LIPA system CAIDI would be approximately 170 minutes, almost a 160 % deterioration.

The estimated average cost of undergrounding all primary main and primary branch lines of an overhead circuit has been approximated by KeySpan to be $5.4 million for a "typical" mile of primary main and $1.7 million per mile for a "typical" primary branch line.[46] These costs assume LIPA's standard looped underground system design which avoids some exceptionally long restoration times for faults occurring on the underground distribution system. The estimated cost to underground the entire LIPA distribution system is in excess of $24.8 billion (2005 current dollars); exclusive of the cost to convert services and third party attachments.[47] This cost does, however, include the work needed to install all wires in conduit and all equipment in public right of way. The cost of converting customer services and extending them to the public right of way are not included in the estimate and could be in the magnitude of $500 to $1,000 per residential customer and as much as $5,000 per large commercial customer, depending upon the size/length of the service.

When considering the costs to underground the existing distribution system plus the costs of undergrounding the existing transmission lines[48] and the LIPA portion of customer service drops, undergrounding could potentially increase rates up to 154%. The projected rate impact on LIPA customers for undergrounding various portions of the LIPA transmission and distribution system are shown in the table below.

[45] *Id.* at 11.
[46] *Id.* at 4.
[47] *Id.* at 4.
[48] Another preliminary study performed by Keyspan for LIPA has estimated the cost of undergrounding transmission lines that need to be upgraded or built new during the course of regular business over the next 25 years to be $564 million for the years 2003 through 2009. KeySpan preliminary Transmission Report at 4. Extrapolating this figure out over the 25 year period, assuming 25 miles per year after 2009, yields an estimated cost of approximately $2.1 billion.

Estimated Rate Impact on LIPA Customers							
Specific LIPA Studies	*Approximate Miles*	*Estimated Cost (Millions $)*	*Example 1st Year Rate Impact (¢/kWh 2005 base)*	*Example 1st Year Rate Increase (13.07¢/kWh base)*	*Example Rate Impact (¢/kWh) (25 year)*	*Example 25 Year Rate Increase (13.07¢/kWh base)*
Underground Existing Overhead Distribution	8,867	$24,800	0.590	4.5%	14.330	109.6%
Underground New/Upgraded Transmission	648	$2,118	0.013	0.1%	1.575	12.1%
Extrapolated from Above Studies						
Underground LIPA Portion of Service Drops	9,208	$3,740	0.089	0.7%	2.161	16.5%
Underground Existing Overhead Transmission	695	$2,721	0.110	0.8%	2.023	15.5%
Total		**$33,379**	**0.802**	**6.1%**	**20.09**	**153.7%**

Source: KeySpan Electric Service, LLC.

Notes:

1. The costs and rate impacts stated in the table above do not include the costs to underground other utility connections, such as telephone and cable, nor does it reflect the costs to individual customer building modifications.
2. An annual variation in costs could occur because of the specific annual project schedule.
3. Estimated costs are in 2005 dollars. The Estimated rate impact calculation includes an assumed 2% annual inflation rate.

Due to the relatively high cost, an overhead circuit undergrounding program is difficult to justify on averted customer outages alone. Often, the issue of improving overall aesthetics (and possible increases in property value) becomes the driving factor but these "aesthetic" benefits are difficult to quantify.

As an alternative to a comprehensive undergrounding program of all primary and secondary, LIPA has instructed KeySpan to investigate a phased approach to undergrounding selected portions of circuits experiencing the poorest performance. The worst circuits would be identified and evaluated as to whether performance could be improved by placing portions underground. There are likely to be very few primary distribution circuits for which undergrounding is cost effective and will significantly improve reliability. Under this approach about 10 miles of primary and 25 miles of secondary would be replaced per year at an estimated total program cost of $2.4 billion (2005 current dollars) over the 25-year program period.[49]

[49] *Id.* at 7.

IV. Industry Undergrounding Practices and Experiences

Edison Electric Institute Report on Undergrounding

In January of 2004, EEI performed a study, entitled "Out of Sight, Out of Mind? : A study on the costs and benefits of undergrounding overhead power lines", examining the major issues associated with undergrounding existing overhead power lines. The report concludes that undergrounding existing overhead power lines will continue to be justified primarily by aesthetic considerations, not reliability or economic benefits. The report estimates that, on the average, undergrounding can cost up to $1 million/mile, almost 10 times the cost of a new overhead power line. [50] EEI concluded this expense cannot be justified solely on unquantifiable benefits such as improved community or neighborhood aesthetics. Moreover, EEI notes that burying existing overhead power lines does not completely protect consumers from storm-related power outages. However, underground power lines do result in fewer overall power outages, but the duration of power outages on underground systems tends to be longer than for overhead lines.

Improvements in Reliability

There are two primary metrics for measuring electric reliability: outage frequency and outage duration. While it is EEI's opinion that accurately measuring electric reliability is difficult since most utility outage-reporting systems cannot differentiate between overhead and underground faults that has not been the experience of NCI and KeySpan. For example, KeySpan in their outage tracking system has the capability to differentiate between underground and overhead type failures. They further have the ability, similar to other utilities in our experience, to determine if it was transmission or distribution related, located on a mainline, branch or service and by type of cable or splice that failed. Nevertheless, EEI concludes that while the frequency of outages on underground systems can be substantially less than for overhead systems, when the duration of outages is compared, underground systems lose much of their advantage. EEI's survey of industry experts revealed the following important considerations pertaining to the reliability of underground facilities:

- Underground lines require specialized equipment and crews to locate a fault;
- In urban areas, underground lines may be more costly to maintain than overhead facilities;
- Underground lines have a higher failure rate initially due to digins and installation problems. After three or four years, however, failures become virtually non-existent;

[50] The EEI estimate reflects an average cost based on typical underground designs. Additional costs may be associated with undergrounding in a densely populated area with significant existing infrastructure or difficult ground conditions.

- As underground cables approach their end of life, failure rates increase significantly and these failures are extremely difficult to locate and repair;
- Water and moisture infiltration can cause significant failures in underground systems when they are flooded, as often happens in hurricanes; and,
- Where only partial circuits are placed underground, the overhead portions are still susceptible to the types of events that affect other overhead lines.

EEI's report also dispels the popular misconception that burying electric power lines will protect customers from power outages caused by storms. Though significantly less susceptible than the overhead system, underground power systems are not completely immune from storm related outages. For example, EEI reports that Baltimore Gas & Electric experienced over two hundred underground equipment failures during Hurricane Isabel.

Aesthetic and Safety Considerations

One of the most commonly cited benefits of undergrounding is the removal of unsightly poles and wires. Aesthetic benefits are difficult to quantify but are often the primary justification for undergrounding projects. EEI notes that while the U.S. has never conducted a national undergrounding study, an Australian undergrounding study identified four items as significant in the benefit/cost calculus: Motor-vehicle accidents, Maintenance costs, Tree-trimming costs, and Line Losses.

Construction Costs

The cost of placing overhead power lines underground is five to ten times the cost of new overhead power lines. According to EEI's data, the cost of new overhead construction is approximately $120,000 per mile while underground construction costs range from $500,000 per mile in California to $1,826,415 for PEPCO. While EEI does not explain the cost difference, understanding that PEPCO operates in the metro Washington D.C. area, any undergrounding program would most likely require a manhole and duct system, verses the lower cost alternative of direct buried. EEI also identifies other factors that can result in substantial additional customer costs for undergrounding projects. These include:

- Costs of other utilities, such as cable and telephone, whose costs will likely be passed on to cable and telephone consumers.
- Substantial additional costs to connect homes to newly installed underground service.

Despite the cost of undergrounding and questionable degree of benefits, EEI observes that dozens of cities have developed comprehensive plans to bury or relocate utility lines to improve aesthetics. A variety of programs are being used to convert existing overhead lines to underground. They include special assessment areas, undergrounding districts, and state and local government initiatives.

California's Rule 20 Program

Rule 20 is a set of policies and procedures established by the California Public Utilities Commission to regulate the conversion of overhead electric equipment to underground facilities (undergrounding). Rule 20 determines the level of ratepayer funding for different undergrounding arrangements. Under Rule 20, undergrounding projects are financed by utility rate money, combined rate funds and local tax proceeds, or private funds, depending on whether Rule 20A, Rule 20B or Rule 20C provisions apply. All three of the California publicly owned electric utilities (Southern California Edison, PG&E, and SDG&E) have incorporated the Rule 20 structure into their tariffs.

A second phase of Rule 20 changes is currently under study. Topics include competitive bidding, incentive mechanisms, establishing a point after which no more overhead facilities will be constructed, and cost recovery for telecommunications undergrounding projects.

Rule 20A – Public Interest Projects

Rule 20A projects are typically in areas of a community that are used most by the general public and are paid for by customers through future electric rates.

To qualify, the governing body of a city or county must, among other things, determine, after consultation with the electric company, and after holding public hearings on the subject, that undergrounding is in the general public interest for one or more of the following reasons:

- Undergrounding will avoid or eliminate an unusually heavy concentration of overhead electric facilities.
- The street or road or right-of-way is extensively used by the general public and carries a heavy volume of pedestrian or vehicular traffic.
- The street or road or right-of-way adjoins or passes through a civic area or public recreation area or an area of unusual scenic interest to the general public.

Recent changes by the California Public Utilities Commission have expanded Rule 20A to cover arterial and collector streets and allows local governments to borrow, or "save up", allocations forward to five years provided adequate utility capital and personnel are available.

PG&E places underground each year approximately 30 miles of overhead electric facilities, within its service area under the provisions of the company's Rule 20A.

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Rule 20B – Large Projects

Rule 20B projects are usually done with larger developments. The developer or applicant pays for the majority of the costs. Undergrounding under Rule 20B is available for circumstances where the area to be undergrounded does not fit the Rule 20A criteria. Rule 20B projects must be sited along public streets, for at least 600 feet, or roads or other locations mutually agreed to by the applicant organization and the utility. Under Rule 20B, the applicant is responsible for the installation of the conduit, substructures and boxes. The cost of removing overhead facilities will be paid by the utility. The applicant then pays for the cost to complete installation of the underground electric system, less a credit for an equivalent overhead system,[51] plus the ITCC (tax), if applicable. The remaining cost is funded by local governments or through neighborhood special assessment districts.

Recent revisions to Rule 20B by the California Public Utility Commission allow a local government to use allocation levels as "seed money," a value that the local government can borrow against to perform initial engineering and design studies for Rule 20B projects. If the project is not approved within two an one half years after planning stages are complete, the city or county has 90 days to reimburse the seed money.

Rule 20C – Small Projects

Rule 20C projects are usually smaller projects involving a few property owners and the costs are almost entirely borne by the applicants. Undergrounding under the provisions of Rule 20C is available where Rule 20A or Rule 20B does not apply. Under Rule 20C, the applicant pays for the entire cost of the electric undergrounding, less salvage credit.

City of Del Mar Assessment Districts

Another approach to funding undergrounding projects is through creating assessment districts. The City of Del Mar, California has taken major strides to eventually eliminate all overhead utility lines and improve some views and property values. Recently, two new underground utility districts were created. At least two-thirds of the residents on a street must ask the city to create an assessment district before undergrounding can proceed. An assessment district is financed through the issuance of city bonds and paid for by the homeowners through their property taxes. Residents who finance undergrounding themselves do so on a "proportional basis" relating to lot size and the number of lines serving each property and the degree to which their property benefits through an improved ocean view.

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[51] The overhead credit is usually about 20% of the total undergrounding project cost, plus the cost of removing the existing overhead system, which can be 5- 20% of the total cost.

The actual cost of removing utility poles and overhead wiring and burying the new wiring was estimated at $20,000 to $50,000 per residence. However, SDG&E will cover the cost of two new undergrounding projects approved by the council because both projects are along major roadways and considered public projects falling under Rule 20A. The only cost to residents in the two new districts created by the council will be for the electric, telephone and cable TV service connections between the new underground wires and their homes. The cost will vary but are not anticipated to exceed $5,000 per residence.

Colorado System Improvement Fund

The Colorado Springs City Council has established a 15-member Underground Policy Advisory Committee to develop recommendations for a policy on the burial of power lines. Representation on the committee reflects: neighborhoods with underground lines; neighborhoods with overhead lines; neighborhoods scheduled for a change in service; high technology manufacturers; the Council of Neighborhoods Organizations; the Housing and Building Association; the Colorado Springs Senior Center; the Department of Defense; school districts; high energy users; small businesses; non-profit organizations, the City of Manitou Springs; the City of Fountain; and El Paso County. Committee meetings are open to all citizens.

The committee developed a guideline for Colorado Springs Utilities ("CSU") to follow when determining the underground or overhead placement of lines. The guideline follows policy recommendations to establish a system improvement fund; provide recommendations for CSU's 115- and 230- kV lines; and provide an appeal process for the policy.

System Improvement Funding

A rate increase was recommended by the committee to create a system improvement fund for burying overhead distribution lines. The fund was sized to initially generate $500,000 annually and is kept in a separate account specifically earmarked to bury power lines.

Use priorities have been established for customers submitting proposals to match funds on a 50/50 basis to bury a power line. The priority ranking is: top priority – homeowners; second priority - any non-residential private interest; and, third priority - any public or governmental agency. If the available money is not used through one of these options, it is made available for one year on a first-come, first served matching funds basis. If the funds are still not used the following year, CSU would call on the committee for guidance. The projects that bring about the greatest aesthetic improvement for CSU customers will be given the highest priority. The fund money is not used to bury service lines serving individual customers since existing policy already provides for a shared-cost approach with customers for the service wire.

CSU coordinates its efforts with second and third party attachments on poles such as cable TV or telephone, in a joint trench during the conversion.

Appeal and Review

The undergrounding policy is subject to review if conditions change. In addition, the policy will not endure longer than ten years following its implementation without a significant review of the process.

Florida Underground Assessment Areas

In wake of four hurricanes Florida legislators and neighborhoods may rethink policy on undergrounding electric distribution lines. While some feel it is likely that the state Legislature will consider the feasibility of burying lines at its next session,[52] Florida utilities and power industry experts remain skeptical of the benefits of moving overhead lines underground pointing out that underground systems offer no guarantees against outages. In addition, Florida Power & Light estimates that buried lines cost three to ten times as much as overhead lines. The subject of undergrounding was last addressed in 1992 when the Public Service Commission produced a four-volume report that concluded putting electric distribution facilities underground was not cost-effective.

The Florida PSC has recently approved a mechanism for governmental recovery of undergrounding fees to be included in the tariffs of Florida's two largest electric utilities: Florida Power & Light and Progress Energy.[53] The tariff revisions provide local governments with an optional mechanism for the recovery of the costs of converting overhead electric service to underground service through a fee on the utility's electric bill.

In order to receive service under the proposed underground tariff, the local government must first comply with the tariff's terms and conditions for converting existing electric distribution facilities from overhead to underground service. In addition, the local government is responsible for establishing an Underground Assessment Area ("UAA"); a geographic area that is used to identify customers who benefit from the underground conversion. Only customers in the UAA will be responsible for the

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[52] Dorschner, John, "After storms, Floridians wonder why above ground power lines still exist", The Miami Herald, September 28, 2004.

[53] Order No. PSC-03-1076-CO-EI, September 2003 (approving FP&L tariff change); Order No. PSC-02-1629-TRF-EU, November 25, 2002 (approving Progress Energy Florida tariff change).

conversion costs. The local government is responsible for securing financing to pay the contracted conversion and the programming costs.

The local government also has the option of adding additional costs related to the conversion project for recovery through the proposed tariff. These additional costs can include right-of-way acquisition and charges paid to an electrical contractor hired by the local government to convert customer-owned meters to receive underground service. After the conversion project is complete, the amount the local government is eligible to recover annually is determined, subject to limitations on the maximum fee customers can be assessed (*e.g.*, for FP&L residential customers 15% of the customers bill to a maximum of $30).

The city of Winter Park, Florida, is moving ahead with its plan to take over the electric system within its boundaries from Progress Energy in June 2005. The impetus behind Winter Park's decision is its frustration over Progress Energy's poor service record. Establishing the municipality is expected to provide $26 million in net present value over a 20-year period that the city plans to reinvest in the municipality, mostly by improving reliability through undergrounding distribution lines and other means.[54]

Maryland Undergrounding Studies

Maryland Public Service Commission Undergrounding Cases

Following Hurricane Isabel the Maryland Public Service Commission initiated a proceeding, CN 8977, which among other issues investigated whether placing electric distribution underground would prevent storm interruptions. As a result of Isabel, the four investor-owned electric utilities operating in Maryland dealt with a total of almost 1.7 million electric service interruptions, 52% of the Isabel outages were tree-related.

Electric Outages and Tree-Related Outages

Utility	MD Customer Outages	% Tree Related	Tree Related Outage
BGE	790,450	58%	459,176
PEPCO	545,000	53%	286,338
Conectiv	231,625	32%	74,980
AP	113,518	44%	50,397
TOTALS	1,680,593	52%	870,891

[54] Electric Utility Week, "Florida community to review proposals to operate, maintain muni; to begin next year", The McGraw-Hill Companies, Inc., July 19, 2004.

Source: "In The Matter Of The Electric Service Interruptions due to Hurricane/Tropical Storm Isabel And The Thunderstorms Of August 26-28, 2003" Before the Public Service Commission of Maryland, Case No. 8977.

BGE noted that "[t]he BGE overhead distribution system was significantly impacted by whole trees and portions of trees, which caused distribution wires and poles to come down."[55] Another utility, PEPCO, added in their storm report for Isabel that, "entire trees had fallen into the lines where in previous storms, broken branches have been more prevalent."[56] The Maryland PSC noted that "for the most part, electric utility tree trimming programs are designed to enhance the reliability of electric lines when they coexist peacefully with trees, not when whole trees fall down on them."[57] ANSI tree trimming standards only call for the removal of nearby trees with structural defects that place them at risk for damaging overhead facilities. It is interesting to note that KeySpan tree trimming procedures on Long Island also allow "healthy" trees (as deemed by a KeySpan arborist) to remain within close proximately of the primary (*e.g.*, in some cases within one foot). Also, many of the fallen trees causing damage during Isabel were from whole tree failures on private property, not growing on the utilities' rights-of-way. Given the nature of the tree related outages, the Maryland PSC Engineering Division did not recommend any changes to utility tree trimming practices.

As part of the Maryland PSC's evaluation of undergrounding as a storm outage prevention measure, they reviewed the recommendations of the Selective Undergrounding of Electric Transmission and Distribution Plant Working Group (CN 8826). The recommendations were:

- Utilities should continue to underground electrical and other facilities under the same circumstances as presently occurs: to furnish service to new customers, at the customer's request, or as appropriate for reliability reasons.
- When other reliability initiatives fail and undergrounding is necessary to improve service, utilities should keep detailed cost and operation information concerning the subject line section over the service life of the underground project.

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[55] Maryland PSC at 4.
[56] *Id.*
[57] *Id.*

The final report of this working group found that "in normal weather and over the long run, there is insufficient evidence to support the proposition that underground lines suffer fewer outages than overhead lines."[58] The final report did note that undergrounding facilities reduces their exposure to outages caused by storms, except when there is widespread flooding on underground conduits. The report listed the following remedial actions that could be taken to improve reliability before resorting to the most expensive option of undergrounding:

- Enhanced tree trimming.
- Tree wire, aerial cable and spacer cable.
- Overhead infrared inspection.
- Enhanced wildlife protection.
- Better sectionalizing through additional fusing.
- Changing overhead construction from crossarm to armless design.
- Relocating an overhead line to a less tree covered, or otherwise compromised, route.

The Maryland PSC accepted the recommendations of the working group in Order No. 77132, July 30, 2001, and decided not to mandate an increased use of undergrounding as a solution to service reliability and restoration issues.

In the case of storm outage prevention, the Maryland PSC noted that remedial actions #1 through #6, listed above, were not likely to have lessened the affect of tree damage during Isabel. Action #7 may be beneficial for some facilities, depending on the availability of a less tree-covered route. However, the Maryland PSC did conclude that undergrounding is the only option that can fully protect electric facilities that are susceptible to tree damage during a major storm. The PSC went on to identify which portion of the overhead electric system were most appropriate for conversion to underground concluding that Overhead sub-transmission and distribution systems are vulnerable to storm damage from wind and falling trees and are therefore good candidates for undergrounding. The following points repeat their analysis and conclusions.

1. *Transmission lines operate above 69 kV and are used to move large amounts of power long distances.* These lines are typically located on rights-of-way that are cleared of all trees. Also, transmission systems have built in redundancy. Based on these factors, Staff did not recommend transmission lines as suitable candidates for undergrounding to improve storm resistance.
2. *Sub-transmission lines are operated at voltages ranging from 69 kV to 34.5 kV.* These lines are typically used to move power from the transmission system to distribution substations. These lines may be on cleared rights-of-way, but are often located next to roads. Sub-transmission systems have less redundancy than transmission, with the degree of redundancy varying among the utilities. During Isabel, sub-transmission outages were more frequent than transmission outages and usually resulted in service interruptions for customers. Staff

[58] *Id.* at 10.

considered sub-transmission as a good candidate for undergrounding when the system does not have redundancy and the lines are not on cleared rights-of-way.

3. *Distribution lines are operated at voltages ranging from 13 kV to 4 kV and are commonly referred to as distribution feeders.* These lines move power from distribution substations to customer transformers. Just after the substation, all three phases of these feeders typically travel along the same path and are referred to as mainline feeders. Single and double phase laterals branch out to provide service to customers remote from the mainline feeder. Distribution lines experienced significant damage during Isabel. Staff considered distribution lines as a prime candidate for undergrounding to improve storm resistance, especially the mainline feeders since three phases would be protected from tree damage.
4. *Secondary lines are typically operated at less than 600 volts and move power from the customer transformer to the customer.* A single customer transformer generally serves between one and ten customers. Secondary lines also experienced significant damage during Isabel. However, Staff did not consider secondary lines to be appropriate candidates for undergrounding. The expense associated with undergrounding secondary lines provides storm resistance to only a few customers. Also, the customer owns a portion of the overhead secondary line and would be responsible for converting that portion to underground.

The Maryland PSC created a working group to develop a methodology for prioritizing portions of the electric system that could be undergrounded to increase storm resistance and propose a funding mechanism. Several guidelines were given: prioritizing should be based upon an analysis of storm outages to determine the facilities most frequently damaged by storms and undergrounding projects should be dispersed throughout the service area of an electric utility to ensure incremental increases in storm resistance are equitable among local jurisdictions. Funding for undergrounding should take into consideration contributions from various customer classes.

Potomac Electric Power Company Undergrounding Study

Following hurricane Isabel, PEPCO retained James Lee Witt Associates, L.L.C. to conduct an investigation into whether placing its distribution system underground would avoid system outages resulting from future storms ("Witt Report"). The study identified several key undergrounding program elements:

- **Timing** – Community redevelopment projects provide a good opportunity to retrofit the infrastructure underground;
- **Cost-sharing** – The overall financial burden to bury power lines can be significantly reduced when the community, electric, telecom, and cable companies all work together and share the costs. Whether it is cost-beneficial or not, utilities should also consider undergrounding projects within localities where the community or other utilities are willing to share a portion of the costs;

- **Community-driven decision-making** – Communities that are invested in the process will usually establish some sort of cost-share program with the utilities, oversee the project, work with the residents and businesses to obtain easements, and bring all of the stakeholders to the table to discuss the best solutions for the community; and
- **Location** – It may never be a cost-beneficial solution to consider undergrounding already built communities. However, targeted undergrounding projects in the areas susceptible to frequent outages due to trees or other problems should be given special consideration.

Engineering Considerations

The Witt Report found that there is insufficient evidence to show that underground lines were more reliable overall than overhead lines.

It was observed that while underground lines could provide greater reliability during storm events, underground lines are more susceptible to corrosion, and can be damaged by flooding, tree roots, ants, snakes, rodents, and people digging up the lines. Underground lines connecting to aboveground lines are also still vulnerable to lightning. If a problem with the underground lines occurs it can take three to four times longer to fix because it is harder to identify the exact location of the outage. Also, the average life span of underground lines is estimated to be 30 years, while overhead lines have an average life span of 50 years.

Subterranean obstacles such as tree roots, rocks, gas, and water and sewer lines also present challenges in the burial of lines. The Witt Report also relates that according to a presentation held by the Maryland Invasive Species Council on June 2, 2003, underground lines need to be surrounded in oil in order to remain cool, which can be harmful to the environment. The presentation also noted that it is impractical to try and install this kind of infrastructure through hills, mountain and wetland regions, and through rocky areas. Also indicated in the Witt Report is that the destruction of vegetation during installation of the lines could cause erosion due to lost vegetation.

Economic Considerations

PEPCO estimated that it would cost more than $10.5 billion to bury the remaining lines in Montgomery and Prince George's Counties. The Maryland PSC estimated that the cost of digging up streets and building an underground system could run as high as $3 million a mile, which is approximately ten times more than the cost of installing overhead lines. PEPCO and Conectiv estimated the cost to underground 13 kV lines is between $3 and 5 million per mile, while the costs to underground 69 kV lines is $5 million per mile.

The Witt Report observed that few alternatives exist for utilities themselves when it comes to financing the undergrounding of power lines; primarily through either rate increases or special charges to monthly utility bills. Conversely, jurisdictions have much greater flexibility and alternatives to consider in paying for undergrounding, for example:

- Charging a flat fee to all property owners within the jurisdiction;
- Create special districts within communities which could be added to monthly utility bills or tax bills;
- Community-financing through their operating budgets and General Obligation Bonds;
- Pooling monies from residents to pay for their own lines, or at least the portion that runs from the pole to their home meters;
- Implementing a small local tax on rooms, meals, liquor, and/ or retail sales;
- Using economic development, housing and community development, and other creative grant funding from resources such as the State Highway Administration, FEMA, and the State General Assemblies; and
- Coordinate the timing and location with State and local infrastructure projects such as road, water, or gas line replacement to save on overall costs.

Best Practices

The Witt Report also identified several best practices, which could serve as a model for all communities located within the PEPCO and Conectiv service areas.

In the community of Ocean City, Maryland a cooperative and cost-effective approach is taken towards undergrounding. Under an ongoing initiative, the town manages all of the conversion activities, obtaining easements and coordinating with all of the utilities, property owners, and regulatory agencies. Conectiv and the other utilities submit their electric designs to the town for review and approval. The town installs the conduits, manholes, concrete pads, and customer equipment, and Conectiv installs the cables and removes the de-energized overhead lines. Once the utility's work is complete, the town restores the roadways, sidewalks, and private property. The town finances the projects through General Obligation Bonds. Ocean City found that community input and support is critical to the success of this undertaking, as is the cooperation and coordination between the different utilities.

Town of Summerset Request for Legislative Action

The Town of Summerset has repeatedly petitioned the Maryland Assembly to take legislative action calling upon the Maryland PSC to establish comprehensive set of strategies and recommendations to encourage and facilitate the undergrounding of utilities in residential neighborhoods and convert existing overhead utility services to underground.[59] Elements of their proposed comprehensive strategy include:

- Streamlining of administrative and technical procedures;
- Reducing construction costs (such as through reform of applicable standards, competitive contracting for conversion services, creative use of new construction systems, and application of new distribution technologies);
- Broadening the funding base (such as through rate-basing of a portion of the costs; cost-sharing with local communities; and developing additional sources of funding, including a range of possible federal and state sources);
- Cutting financing costs (such as through standardized, lower-cost financing);
- Eliminating possible add-on taxes (such as the federal/state gross-up taxes);
- Investigating opportunities to work with existing provider(s) of local distribution facilities to integrate undergrounding into the life-cycle management of their distribution infrastructure;
- Exploring possibilities for competitive or alternate procurement of replacement underground delivery facilities (including, for example, possible community purchase and conversion of facilities if existing providers are unwilling to perform this on a cost-effective basis); and
- Initiating pilot projects to demonstrate proofs of concept, identifying and overcoming specific obstacles and refining supporting processes.

The Town cites the success of the state law requiring underground distribution facilities in new residential developments and argues that "with the assistance of 'smart government' through planning, creativity, support and cooperation with private sector partners the benefits of undergrounding can be shared with residents of neighborhoods in the state that were developed before enactment of the state's mandatory undergrounding provisions."[60]

Maine Inquiry Into Undergrounding Facilities

Following a severe ice storm that occurred in Maine during January 1998, leaving most homes and businesses in Maine without utility services, the Maine Public Service Commission initiated an inquiry into the response by Maine public utilities to the storm. The report, among other issues, addressed the placement of facilities underground.[61]

The inquiry concluded that while the placement of electric infrastructure underground might have benefits in lower outage frequency, less susceptibility to weather events, and aesthetics, it was also likely

[59] Town of Somerset, Maryland, "Undergrounding Initiative - Letter to MML Legislative Committee", June 29, 2001.
[60] *Id.*
[61] "Inquiry into the Response by Public Utilities in Maine to the January 1998 Ice Storm" Before the State Of Maine Public Utilities Commission, December 1998, Docket No. 98-026.

to give rise to higher outage durations, higher susceptibility to flooding and excavation events, winter access and repair times.

Based on a 1988 study, Central Maine Power Company ("CMP") estimated that placing facilities underground would cost about ten times the cost of the overhead system in use. CMP estimated that changing to an underground distribution system would cost at least $8.5 billion in 1988, plus costs of removal, regulators and transformers, and labor, resulting in a monthly increase of $95 to each CMP customer bill. Bangor Hydro-Electric Company ("BHE") estimated that underground facilities cost between 50% and 100% more for new home construction due to both higher costs for underground cable and its installation as compared to overhead lines.

While continued placement of underground facilities in urban areas or new developments may be desirable under some circumstances, the Maine Commission did not believe that the advantages that could be achieved from relocating overhead facilities underground would offset likely disadvantages and costs. The Commission recommended that utilities owning poles, lines, and transformers in Maine should monitor undergrounding projects in other areas to determine whether new technologies or materials may affect the economics of undergrounding new or existing facilities in Maine in the future.

North Carolina Undergrounding Study

Following the Ice Storm related outages of the Winter of 2002 that resulted in service interruption to approximately two million electric customers, the North Carolina Public Staff Utilities Commission initiated an investigation into the feasibility of undergrounding electric distribution facilities. A report entitled "Report Of The Public Staff To The North Carolina Natural Disaster Preparedness Task Force: The Feasibility Of Placing Electric Distribution Facilities Underground" was completed in November 2003 and covered the following items:

- A comparison of operational advantages and disadvantages of overhead and underground power distribution systems.
- Estimates and comparisons of capital costs of converting overhead lines to underground, including analysis of the difference in operation and maintenance costs for the two types of systems.
- Estimates of time and human resources required to bury underground lines.
- Identification of potential additional costs to customers, municipalities, and other utilities that may result from conversion.
- Exploration of options for financing conversion projects.

Upon reviewing the report's findings, the PSC determined that replacing existing overhead distribution lines with underground lines would be prohibitively expensive; the cost was estimated to be $41 billion.

Additionally, it was estimated that the undertaking would require approximately 25 years to complete. Therefore, the Commission did not recommend the wholesale conversion of overhead facilities to underground.

It was, however, recommended that each of the Utilities:

- identify the overhead facilities in each region it serves that repeatedly experience reliability problems based on measures such as the number of outages or number of customer hours out of service,
- determine whether conversion to underground is a cost effective option for improving the reliability of those facilities, and, if so,
- develop a plan for converting those facilities to underground in an orderly and efficient manner, taking into account the outage histories and the impact on service reliability.

Additionally, the Commission recommended that utilities continue their current practices of:

- placing new facilities underground when the additional revenues cover the costs or the cost differential is recovered through a contribution in aid of construction,
- replacing existing overhead facilities with underground facilities when the requesting party pays the conversion costs, and
- replacing overhead facilities with underground facilities in urban areas where factors such as load density and physical congestion make service impractical from overhead feeders.

Comparison of Overhead to Underground

The primary reason raised against burying power lines is the high cost. Underground lines cost more to install than overhead lines. The North Carolina Commission estimates that current costs for such projects range from $500,000 to $3,000,000 per mile compared to $120,000 per mile for installing overhead lines. The table below contains a summary of conversion costs by type of line for the North Carolina Utilities.

Conversion Costs by Line Type

Type of Line	Miles of Line	Cost per Mile	Total Cost (Billions)
Heavy/Commercial Urban	3,004	$2,053,000	$6.2
Three-phase Suburban	13,129	$1,229,000	$16.1
Three-phase Rural	15,296	$523,000	$8.0
Single-phase	36,846	$284,000	10.5
Total	68,275	Not Applicable	$40.8

Source: "Report Of The Public Staff To The North Carolina Natural Disaster Preparedness Task Force: The Feasibility Of Placing Electric Distribution Facilities Underground" Before the North Carolina PSC November 2003.

The North Carolina Utilities Commission found that while underground systems are more reliable than overhead systems under normal weather conditions, suffering only about half the number of outages of an overhead system, they are not immune to damage. Moreover, the repair time for underground systems is almost 60% longer than for overhead systems when damage does occur. LIPA's experience, however, is that this number is extremely conservative and that underground restoration times can be up to 240% longer than for an overhead system.

In order to compare the reliability of an underground system to an overhead system, the Commission Staff obtained average reliability data from the Utilities for the last five years for normal conditions, excluding outages due to major storms. It was found that an overhead system experienced almost twice the number of interruptions as an underground system during this period. Based on five years of reliability data, the utilities experienced an average annual system rate of 0.57 interruptions per mile of overhead line compared to 0.30 interruptions per mile of underground line. Tap lines had an average annual interruption rate of 0.35 and 0.17 per mile for overhead and underground systems, respectively. However, the data also demonstrated that the typical underground outage takes 145 minutes to repair compared to 92 minutes for an overhead outage.

The North Carolina Commission found that while underground distribution lines will reduce the number of outages experienced during normal weather and limit the damage to the electrical distribution system from severe weather-related events, they are not invulnerable. During storm conditions flooding, objects falling on surface-mounted equipment, and over-voltages caused by lightning can cause the loss of power on underground systems. Long-term system outages such as those associated with major storms may allow moisture to seep in, and this moisture can cause the cable to fail once the system is re-energized.

The report also notes that a well-maintained overhead system has a life expectancy of more than 50 years, primarily because individual components are easy to replace. Comparatively, the life expectancy of underground cable installed today is approximately 30 years. However, other components of the system, such as surface-mounted equipment, may have less than 30 years of useful life. O&M costs per mile for an overhead system and a direct-buried underground system were found to be comparable. However, the annual average O&M cost per mile of an urban underground system that requires installation in duct bank is more than four times that of an overhead system.

Financing Underground Facilities

All of the North Carolina Utilities have plans on file with the Commission detailing the terms, conditions, and charges under which they agree to extend distribution service to customer locations.

Although distribution facilities are usually installed overhead, each utility will install underground facilities upon request in accordance with its line extension plan.

New Lines

- **Residential Customer –** An economic feasibility test is applied. This test involves a comparison of the extension cost to expected revenue over a period of time, such as five or seven years. Construction costs that exceed the revenue projection are charged to the customer. If an underground primary extension is requested, the costs may be included in the revenue comparison calculation, or additional charges may apply based on the higher costs of installing underground facilities.
- **Developers** - Developers are also subject to the economic feasibility test in which the construction costs to extend facilities are compared to some assumed level of revenue over a shorter period of time (often two or three years). The developer is required to pay for any excess of cost over revenues. To recognize the higher cost of providing underground facilities, some utilities use a "cost difference" approach rather than the revenue comparison for the additional cost of underground. Under this approach, the developer pays some or the entire differential in the cost of installing underground versus overhead facilities.

Converting Overhead Facilities to Underground

The charges established for a line extension plans for conversions of existing service from overhead to underground vary from one company to another.

- **Progress Energy** - Requires that the customer pay the cost of the underground facilities, plus the depreciated cost of the existing overhead facilities reduced by their salvage value, plus the cost of removing and rearranging the overhead facilities, minus the cost of new overhead facilities. Progress Energy has included a provision in its line extension plans where, upon request, it will convert overhead facilities to underground without charge in a downtown commercial area, provided the area has sufficient load density. The municipality must agree to receive underground street lighting service and satisfy certain other requirements.
- **Duke** - Provides that when the existing overhead distribution system is adequate to serve the customer's load, the customer payment will be equal to the cost of comparable underground facilities, less any salvage value of the overhead system. In some cases Duke has converted overhead facilities in downtown areas to underground at its expense.
- **Dominion Virginia Power** - When the existing facilities provide adequate capacity, the customer requesting conversion to underground must pay the cost of performing the requested work. Dominion has adopted a provision authorizing it to designate a major metropolitan, high-load density center as an "Underground Distribution Area," but its tariff does not indicate whether it will bury existing overhead lines at its own expense in such an area, nor does it

specify numerical load density criteria for designating underground distribution areas. Also, as a result of the Roanoke Voyages Corridor Commission ("RVCC") litigation in the early 1980s, Dominion has an added provision in its tariff that "when any governmental authority requires that electric lines and related facilities be located or relocated underground the cost incurred by the Company will be charged, in a manner approved by the Commission, to the Customers receiving electric service within the jurisdiction imposing the requirement." Dominion has never had occasion to apply this provision. Dominion Virginia Power has also adopted a policy of annually identifying the "worst 10 circuits" and "worst 10 devices" in each of its three Virginia regions, based on the total number of customer-hours out for each circuit and the total number of outages for each device. Among the options to improve circuit performance of a low-ranking circuit or device may be to convert it to underground.

Roanoke Voyages Corridor Commission

Although the Roanoke Voyages Corridor Commission ("RVCC") was unsuccessful in its efforts in the 1980s to require the construction of underground facilities at Virginia Electric Power Company's (now Dominion) expense, Dare County has continued to take an interest in burying electric lines. In 1999 the county secured the enactment of a local act (N.C. Session Law 1999-127) authorizing the creation of "one or more Utility Districts for the purpose of raising and expending funds to underground electric utility lines in the district." The county commissioners may define the boundaries of a utility district to include any area outside a municipality, and any municipality may join the district. The county commissioners may levy a tax of up to $1 per month on each bill for residential electric service within the utility district, and up to $5 per month on each bill for commercial service. The tax is collected by the electric suppliers, which will retain a percentage as compensation for their collection services. The proceeds of the tax are used for the purpose of undergrounding electric lines within the district. The 1999 act applies only to Dare County, but other counties or municipalities could seek to have similar statutes enacted in the future. The North Carolina Commission observes that the main difficulty with the act is that even if the $1 and $5 per month taxes are collected for a number of years, they may not prove sufficient to place underground more than a small portion of the electric lines in the district.

Oklahoma Underground Conversion

Edmond Electric, a municipally owned electric utility just north of Oklahoma City, has recently decided that the benefits of long-term improvements in system reliability, positively affecting customer loyalty, outweighed the costliness of an overhead to underground conversion program.[62]

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[62] Sherrick, Dean, "Overhead to Underground Conversion in Oklahoma", Transmission & Distribution World, August 1, 2004.

Edmond is taking a one-section-at-a-time approach, converting about 250 homes a year. The city council has approved budget line item for overhead to underground conversion of $750,000 a year for the next five years.

The utility first identified areas already in need of repair and upgrade. By starting with an area that needed attention, some of the conversion expense could be absorbed in annual maintenance and upgrade costs already budgeted.

The Henderson Hills project was completed in July 2004, converting nearly 500 residents to buried electric cable in conduit. The next project, which begins in September 2004, will target a similarly sized neighborhood, Clegern Park Edition, where outages have been high and older equipment needs replacement and repairs.

Edmond Electric identifies that installation and restoration costs are the most expensive part of any underground job. They state that the key to the success is the use of horizontal directional drilling ("HDD") to install the conduit and the many technological advancements of method. Edmond Electric points out that the most significant advancement of HDD is the compactness of self-contained units. The smaller footprint makes them easy to get into tight places, and the newer models are built with higher thrust and pullback capacities. Edmond Electric had installed a total of more than 18,300 feet of conduit using HDD; very little was open-cut. When rocky conditions were encountered, Edmond Electric states their contractor used new "bear claw" type bits with carbide-plated teeth, which negated the need for bringing in larger, more expensive, HDD drill units. Another advancement in HDD that contributed to the success of the project was the growing knowledge of drilling fluids and selection of tooling.

The Edmond Electric underground system was also designed for easy access. The underground cable was encased in highdensity polyethylene ("HDPE") schedule-40 conduit for ready access. Their design also included redundancy and loop-fed capabilities to all equipment. In the case of a cut line or cable failure, power can be rerouted to restore service quickly.

The accessibility strategy has already been tested and confirmed. Edmond Electric reports that last spring, a fault in one of the new secondary lines, possibly caused by a manufacturer defect in the new cable, was isolated, the wire was pulled and replaced in less than 30 minutes, mainly due to the new all-conduit encasement design.

Communication with the target communities is also essential. Edmond Electric discovered the importance of quickly responding to questions and problems before they became serious concerns. They appointed a public education specialist who worked throughout the project hanging door hangers, answering phone calls and educating the neighborhood on the advantage of having underground lines and what to do when directional drilling rigs began showing up on their street.

Community meetings helped keep people informed about the Henderson Hills project. More than 100 citizens attended the first meeting, where the project was explained and the benefits to the community were presented.

One valuable lesson that was learned was the need for better coordination with other utilities. Edmond Electric stated that other utilities affected by the conversion program were not prepared for the relocation of their facilities. With sufficient notice, cable and phone companies may take advantage of the opportunity for common burial in some areas and sharing the cost.

Oregon - City of Portland Undergrounding Policy

In August 1998, the Portland City Council established a committee to study the viability of undergrounding utilities in Portland communities. The Utility Undergrounding Citizens Advisory Committee ("UUCAC") was made up of thirteen people with different backgrounds and varied interests and included representatives from PGE, Pacific Power, US West, Tri Met, Metro and various neighborhoods and affiliated organizations.

The UUCAC considered the following issues:

- Benefits and liabilities of undergrounding;
- Affordability;
- Cost determinants;
- Budget constraints;
- Cost to individual property owners and to the City;
- Fairness and equity of funding mechanisms;
- Criteria for prioritizing project selection; and,
- On-going operations and maintenance.

Undergrounding Advantages

The UUCAC study found the primary reason to bury overhead wires is aesthetics and that underground wires offer only marginal advantages in preventing outages caused by windstorms or vehicular collisions. It was further noted that distribution problems in an underground system, while far less frequent, can be more difficult to locate and may cause longer interruptions of service.

While the committee majority desired to see the entire city utility system undergrounded, the estimated cost of $1.6 billion was prohibitive. Beyond the aesthetic improvements several additional benefits were identified:

- A one-time investment, undergrounding produces aesthetic returns for generations.
- Undergrounding creates equity between parts of the central city that have been undergrounded for years, and other areas of the city.
- Undergrounding facilitates construction of buildings to maximum heights by avoiding building-to-wire clearances.
- Undergrounding results in fewer poles, less clutter and better pedestrian access.
- Undergrounding allows a greater variety of approved street trees to be planted and to grow to their natural canopy.
- Maintenance costs, now attributed to expenses such as pole replacement and tree trimming, are less.
- More attractive streetscapes may encourage greater transit use and pedestrian activity.
- Undergrounding may encourage improved urban design.
- Undergrounding may promote pride in and patronage of neighborhood commercial areas as attractive places to frequent and shop.
- Undergrounding may contribute to increased property values in affected areas.

Undergrounding Costs

The UUCAC found the costs of undergrounding in communities vary widely, between $100/foot and $1,000/foot. Among the conditions accounting for the variance are differences in terrain, existing right of ways, number of service providers, population density, type of utility service, conflicting underground uses, excavation costs, engineering costs and conflicts with other existing infrastructure.

In addition to the cost of undergrounding the distribution system, UUCAC noted that there was the cost to property owners for conversion and reconnection to the underground system. This cost also varied widely from $500 to $5,000 or more, in the case of large commercial properties (roughly 5 percent to 33 percent of total undergrounding costs to customers).

As an example of the different costs the UUCAC cites the Lents Town Center undergrounding project, which encompassed 4,100 lineal feet or six blocks long. The estimate was $410,000 for the distribution undergrounding cost of trenching, vaults and conduit and $125,000 for property conversion/reconnects for a total of $535,000. An additional associated cost was the optional replacement of utility poles with standing street lamps with unit costs ranging from $2,500, for basic cobra-head fixtures and poles, to $15,000, for high-end twin ornamental street lights.

Undergrounding costs can be reduced if work is done in conjunction with other street improvements such as the replacement of pavement or sidewalk. Complementary work could be one of several criteria used in prioritizing projects.

Undergrounding Policy Development

Three basic funding policy options were adopted by the UUCAC:

(1) Reserve a portion of utility franchise fees for undergrounding. Part of any increase in franchise fees would be set aside to help finance utility undergrounding projects. It was estimated that between one third and one half of inflation adjusted revenue increases in franchise fees would be needed to pay for a long-term undergrounding effort. This funding source was found appealing for two reasons:

- Undergrounding wires would be paid for by the funds generated by a system overwhelmingly reliant on overhead wires. In other words, the problem itself would be the source of funds paying for the solution.
- Because the funds for undergrounding are based on revenue increases over a budget baseline, new allocations would not cut into existing spending levels.

The UUCAC report noted that if one half of this franchise increase had been available for undergrounding for fiscal year 97-98, nearly $1 million would have been available for undergrounding in the FY 99-00 budget.

(2) Promote undergrounding options for Urban Renewal Projects and other major infrastructure improvements. Urban Renewal projects and other major infrastructure improvement projects often have access to state, federal or private monies. As a result, non-City funds could be made available to do some undergrounding, such as federal CMAQ and Transportation Enhancement ("TE") funds. For funds that require some kind of match, area utilities investments may be used to leverage more outside money.

(3) Include undergrounding provisions in future franchise agreements. Undergrounding provisions could be levied on new phone, cable, and internet service providers asking for franchises to serve the city residents. Franchise agreements with these firms could be structured to include a provision requiring them to set aside 1% for undergrounding on construction costs. Among the funding options considered and rejected are:

- **Voluntary "check-off" contributions from utility bills.** Voluntary approach commendable, but questionable whether a check-off would raise amounts needed.
- **Local Improvement Districts and Underground Utility Districts.** Potential divisiveness (as in Hillsdale), fairness and equity questions and narrow funding base.
- **City mandate requiring that costs be paid either by ratepayers** in the whole city or by those in the affected area. Problem same as with establishing underground utility districts. Concerns about fairness, equity and cost/benefits would likely prompt ratepayer resistance. The City has not used this PUC-granted authority.

- **State rate adjustments approved by the State Public Utility Commission.** The PUC, set on keeping rates low and concerned about equity in fund distribution, would likely disapprove.
- **Statewide, legislature-approved surcharge.** Although used in California, the Oregon Legislature is likely to resist such a tax increase.
- **"Second Line" fee on internet connections.** Concern that a tax on new technology might discourage its spread. Moreover, services are expected to be combined onto a single "first" line, making a "second line" moot. There may also be a federal prohibition on such a tax.
- "**Blight Tax" on billboards**, animated signs, advertising sold by Tri Met, and other off-premises signs deriving benefit from proximity to the public right of way. City may lack authority and capacity to impose such a tax.
- **Federal funding for transportation** and/or transit through Metropolitan Transportation Improvement Program ("MTIP"). Under current MTIP criteria, utility undergrounding along city streets could be funded in conjunction with "boulevard-like" streetscape improvements, which are focused primarily in key 2040 Growth Concept areas. MTIP funds are limited and undergrounding would have to compete with numerous other regional priorities. It is unclear whether federal highway funds can be used for utility relocation or undergrounding.
- **Voter approved bonds**. This source of funds would have to compete with other bond measures for voter approval.
- **Self-imposed tariff** approved by city voters, subject to City Council and PUC approval. Likely voter resistance due to perceived lack of benefit.

V. Findings and Conclusions

Many jurisdictions have studied the feasibility of implementing a comprehensive undergrounding initiative. Time and again discussion centers on cost, aesthetics and reliability.

The greatest detractor to undergrounding remains the cost, while the predominant driver behind undergrounding existing overhead lines is aesthetics. Almost all jurisdictions investigating undergrounding existing overhead systems have concluded that the cost of wholesale undergrounding of existing overhead facilities is prohibitive. Cost estimates for underground construction are estimated at ten times the cost of overhead construction varying from $500,000 to several million dollars a mile. The December 1998 RMI investigation for LIPA concurs, concluding that the cost of "undergrounding" the Long Island T&D system would be $14.7 billion and could potentially raise rates by 100%. These system costs may be even higher today; undergrounding estimates on the Long Island system run about $24.8 billion. This translates into a potential rate increase of 154% for the implementation of a wholesale undergrounding program. There are also substantial additional costs to connect homes to newly installed underground service estimated at between $500 to $5,000 or more, in the case of large commercial properties.

While underground systems are more reliable than overhead systems under normal weather conditions and may offer some reliability advantaged during adverse weather conditions, they are not impervious to damage and the repair time for underground systems is longer than for overhead systems when damage does occur. Underground lines are more susceptible to corrosion than overhead lines and can be damaged by flooding, tree roots, ants, snakes, rodents, and people digging up the lines. Underground lines connecting to aboveground lines are still vulnerable to lightning and where only partial circuits are placed underground, the overhead portions are still susceptible to the types of events that affect other overhead lines. Also, burying existing overhead power lines will not completely protect consumers from storm-related power outages. During storm conditions flooding, objects falling on surface-mounted equipment, and over-voltages caused by lightning can cause the loss of power on underground systems. Long-term system outages such as those associated with major storms may also allow moisture to seep in, and this moisture can cause the cable to fail once the system is re-energized.

Where jurisdictions have rejected wholesale undergrounding programs, they have as an alternative considered selective undergrounding programs that could be implemented in conjunction with existing reliability programs. In many instances undergrounding is considered on the worst performing circuits or circuits where substandard conditions exist. Such selective programs can realize the advantage of undergrounding while at the same time controlling costs.

Furthermore, it has been recognized that undergrounding programs can realize the greatest potential when coordinated with governmental programs. Jurisdictions as opposed to utilities have more funding options to undergrounding lines. Among these funding options are the creation of special assessment districts, undergrounding districts, and state and local government initiatives. Furthermore, as with any large-scale program, community input and support is critical as is the cooperation and coordination between the different utilities.

There are also several technical considerations to be evaluated. These include the location and terrain in which overhead to underground conversion is to be effected and the undergrounding technology available.

References

1. Dorschner, John. The Miami Herald. September 28, 2004. "After storms, Floridians wonder why above ground power lines still exist".
2. Edison Electric Institute (Brad Johnson). January 2004. "Out of Sight, Out of Mind? : A study on the costs and benefits of undergrounding overhead power lines".
3. Electric Utility Week. July 19, 2004. The McGraw-Hill Companies, Inc. "Florida community to review proposals to operate, maintain muni; to begin next year".
4. Florida Public Service Commission. September 2003. Order No. PSC-03-1076-CO-EI, (approving FP&L tariff change). November 25, 2002. Order No. PSC-02-1629-TRF-EU, (approving Progress Energy Florida tariff change).
5. James Lee Witt Associates, L.L.C. May 2004. "Pepco Holdings, Inc., Hurricane Isabel Response Assessment".
6. Johnson, Stephen G. Transmission & Distribution World. October 1, 1997. "Colorado Springs Utilities, Overhead to Underground In Colorado Springs".
7. KeySpan Electric Service, LLC. February 9, 2005. Preliminary report to LIPA on the "Economic Reliability Impact of Undergrounding the LIPA Distribution System".
8. KeySpan Electric Service, LLC. May 23, 2003. Preliminary report to LIPA on the "LIPA Transmission System Expansion Overhead vs Underground Analysis".
9. KeySpan Performance Engineering. April 2004. "LIPA 2003 Electric Transmission and Distribution Reliability Report".
10. New York PSC, Office of Electricity and Environment. April 2004. "The 2003 Interruption Report".
11. North Carolina Public Service Commission. November 2003. "Report Of The Public Staff To The North Carolina Natural Disaster Preparedness Task Force: The Feasibility Of Placing Electric Distribution Facilities Underground".
12. Pacific Gas & Electric Company. "Rule 20 Undergrounding Program." http://www.pge.com/field_work_projects/street_construction/rule20/
13. Public Service Commission of Maryland. "In The Matter Of The Electric Service Interruptions due to Hurricane/Tropical Storm Isabel And The Thunderstorms Of August 26-28, 2003" Comments of the Public Service Commission Case No. 8977.
14. Resource Management International. December 1998. "Assessment of Transmission & Distribution Construction Practices and Their Impact on Public Safety".

15. Resource Management International. June 1999. “A Review Of Electric Utility Undergrounding Policies And Practices”.

16. Sherrick, Dean. Transmission & Distribution World. August 1, 2004. “Overhead to Underground Conversion in Oklahoma”.

17. Southern California Edison. “Undergrounding Electric Lines and Equipment.” http://www.sce.com/sc3/001_cust_care/001m_Undergrounding.htm

18. State Of Maine Public Utilities Commission. December 1998. “Inquiry into the Response by Public Utilities in Maine to the January 1998 Ice Storm”. Docket No. 98-026.

19. State of New York Official Compilation of Codes Rules and Regulations. 2004. Title 16.

20. Steinberg, James. The SanDiego Tribune. October 20, 2004. “Del Mar adds 2 areas to underground utility effort”.

21. Town of Somerset, Maryland. June 29, 2001. “Undergrounding Initiative - Letter to MML Legislative Committee”.

22. Utility Undergrounding Citizens Advisory Committee (“UUCAC”). March 2000. “A Report to the Portland City Council Compiled by the Utility Undergrounding Citizens Advisory Committee”.