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STATE HIGHWAY ADMINISTRATION

RESEARCH REPORT

COST BENEFITS FOR OVERHEAD/UNDERGROUND UTILITIES:

EDWARDS AND KELCEY, INC/EXETER ASSOCIATES, INC

SP208B4C
FINAL REPORT

October, 2003

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16. Abstract

Each year the Maryland State Highway Administration (SHA) undertakes a number of projects that require the relocation of utilities either overhead or underground. In order to make cost-effective decisions for future utility relocation projects, SHA has conducted an analysis of the costs of construction, maintenance and emergency repairs of telecommunications including fiber optics and electric distribution facilities associated with overhead versus underground utilities. This report presents specific cost and reliability information for underground and overhead utility installations for four utility companies located throughout Maryland. The report shows that underground installations reduce vehicular crashes with poles and possible fatalities, reduce the exposure to electromagnetism fields reducing health hazards, improve the aesthetics of neighborhoods and may increase the assessment value of the nearby properties. This report also presents some disadvantages of underground installations, including higher installation costs and problems accessing equipment for repairs. Advantages of overhead installations include faster service restoration, streetlights can be easily installed, and they can operate at higher temperatures. However, unlike underground installations, overhead installations can be negatively affected by storms, wildlife and vehicular impacts. The lifecycle cost comparison of overhead and underground utility installations/relocations based on similar service capabilities used several variables to generate a realistic model. . In each scenario analyzed, no result yielded a higher net present value (NPV) of benefits than the NPV of costs.

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Section 1.
EXECUTIVE SUMMARY

1.1 Background

Each year the Maryland State Highway Administration (SHA) undertakes a number of projects that require the relocation of utilities either overhead or underground. In order to make cost-effective decisions for future utility relocation projects, SHA has conducted an analysis of the costs of construction, maintenance and emergency repairs of telecommunications including fiber optics and electric distribution facilities associated with overhead versus underground utilities. Data from numerous local utility, cable, and telephone companies was compiled and analyzed to determine which methods produce the most cost-effective outcome, while maintaining a reliable level of service.

This report presents specific equipment, cost, and reliability information for four utility companies located throughout Maryland. For the purposes of maintaining the confidentiality of the utilities surveyed, the companies will be referred to as Companies A-D throughout this report.

1.2 Methodology

This study was comprised of eight work tasks, including the following:

1. A literature search on the costs and benefits of overhead and underground utilities, including the societal cost as a result of collisions of highway vehicles with above ground utilities.

2. A cost comparison of the initial construction costs of installing utilities overhead and underground. The cost comparisons will include all equipment and labor. Overhead equipment costs will include, but not be limited to poles, crossarms, overhead conductors and wire (telephone and CATV/fiber), insulators, overhead transformers, and switches. Underground equipment costs will include such items as trenching or boring, conduit, manholes, conductors and wire (telephone and CATV/fiber), switches, and pad-mounted transformers.

3. Historical data on routine maintenance costs and repair costs for both overhead and underground facilities under comparable baseline conditions.

4. Obtain historical data on reliability or dependability. Determine the frequency of outages as a result of storms and the associated loss of revenue to the utility companies on an annual basis for both overhead and underground facilities.

5. Develop a lifecycle cost comparison of overhead and underground utility placements/relocations based on similar service capacities.

6. Determine thresholds, e.g. voltage type of service, etc at which the cost benefit of underground utilities is more advantageous compared to installing utilities overhead. Include cost comparisons for pole-mounted transformers vs. pad-mounted transformers.

7. Survey local Maryland jurisdictions that require underground utilities for new installations or for upgrades to existing facilities regarding requirements, practices and how they have addressed cost/benefit issues. Summarize how local jurisdictions are financing underground utilities.

8. Research and provide a summary of how others have reduced the costs associated with underground utilities.

1.3 Summary and Conclusions

Based on the information gathered from each of the eight work tasks, a number of conclusions can be drawn regarding the cost effectiveness of overhead and underground utilities. Data obtained from Maryland utility companies indicate that constructions costs for overhead utilities range from $0.62 million per mile to $1.02 million per mile and underground comparable service ranges from $3.3 million to $8.3 million per mile. The cost of installation varied greatly among the companies studied; future decisions should be analyzed on a case-by-case basis including the benefits that the two installation alternatives offer. Underground installations reduce vehicular crashes with poles and possible fatalities, reduce the exposure to electromagnetism fields reducing health hazards, improve the aesthetics of neighborhoods and may increase the assessment value of the nearby properties. However, disadvantages of underground installations include higher installation costs and problems accessing equipment for repairs. Advantages of overhead installations include faster service restoration, streetlights can be easily installed, and they can operate at higher temperatures. However, unlike underground installations, overhead installations can be negatively affected by storms, wildlife and vehicular impacts.

Data on the reliability of overhead utility installations versus underground utility installations is inconsistent, therefore no conclusion can be drawn from the available information. Data that is necessary to characterize the two types of installations such as length and age of the systems is not available from the utility companies. Based on the available data, only general assumptions can be made. Underground installations will last longer if conduit is used, and the maintenance of underground installations doubles the cost of overhead installations.

Underground installations provide an improvement in aesthetics and may increase the assessment value of adjacent properties. It is estimated that the assessment value will increase by 2.5%. Research indicated that properties in areas where underground utilities are in place are more desirable than properties located in areas with overhead utilities installations.

The lifecycle cost comparison of overhead and underground utility installations/relocations based on similar service capabilities used several variables to generate a realistic model. The model was fed with seven variables: collision frequency reduction, collision severity factor, value of life, incremental utility service interruption, energy usage rate, cost of unserved energy, and property value improvement. In addition to these variables the location of the installation/relocation was taken into account to differentiate rural from urban installation, as well as the company that would be in charge of the specific installation/relocation. In each scenario analyzed, no result yielded a higher net present value (NPV) of benefits than the NPV of costs.

Section 2.
INTRODUCTION

The Maryland State Highway Administration has requested this cost study to assist them in making future decisions in conjunction with highway improvement projects for the relocation of utilities either overhead or underground. This study included the overhead and underground costs to install electric distribution facilities, telephone and CATV/fiber optics.

2.1 Cost Study Boundaries

2.1.1 Electrical Distribution Systems

The purpose of an electrical distribution network is to transport electricity from bulk power supply point to the consumer. The electric distribution facilities in this study will include 34kv primary and below. This is the primary distribution system between the substation transformers and the transformers providing service to the consumer. The substation transformers determine distribution voltage as they step down the transmission voltages to distribution voltages for delivery to transformers where the voltages are again stepped down for delivery to the customer. An example of this would be a 230kv transmission line entering a substation. The 230kv is then put through a substation transformer where the voltage is reduced from 230kv down to 34kv. The 34kv is the distribution voltage used by the utility for delivery to the transformers, which serve electric utilities customers. The transformers will then step down the 34kv to a secondary voltage of 277/480v 3 phase, 120/208v 3 phase, 120/240v 1 phase, where it then can be utilized by the customers switchgear or electric meter. See Figure 1. It is important to remember that each utility has its own distribution voltage. Company A uses either a 12kv or 34kv distribution system, while Company B uses a 33kv or 33,000-volt distribution system. Company C utilizes a 13kv distribution voltage and Company D has a 12kv distribution system. An illustration of a typical 12kv to 34kv single circuit distribution line and double circuit distribution is illustrated in Figures 2 and 3 below. An example of transmission and distribution sharing a common pole is shown in Figure 4. The poles used for sharing transmission and distribution lines are typically wood or concrete. The different distribution voltages used by various electric utilities will not have an adverse effect on construction costs because the conductor sizes used are the same. The overhead and underground conductors used are similar whether the voltage is 33kv or 13kv.

Figure 1. Electric Utility Distribution System

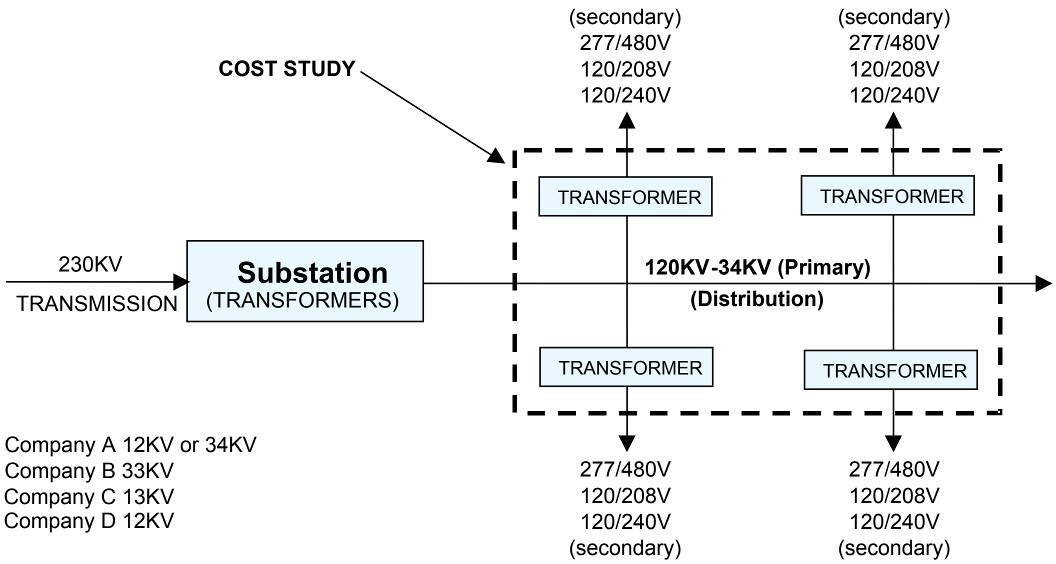


Figure 2. Single Circuit 12KV-34KV Distribution with CATV and Phone

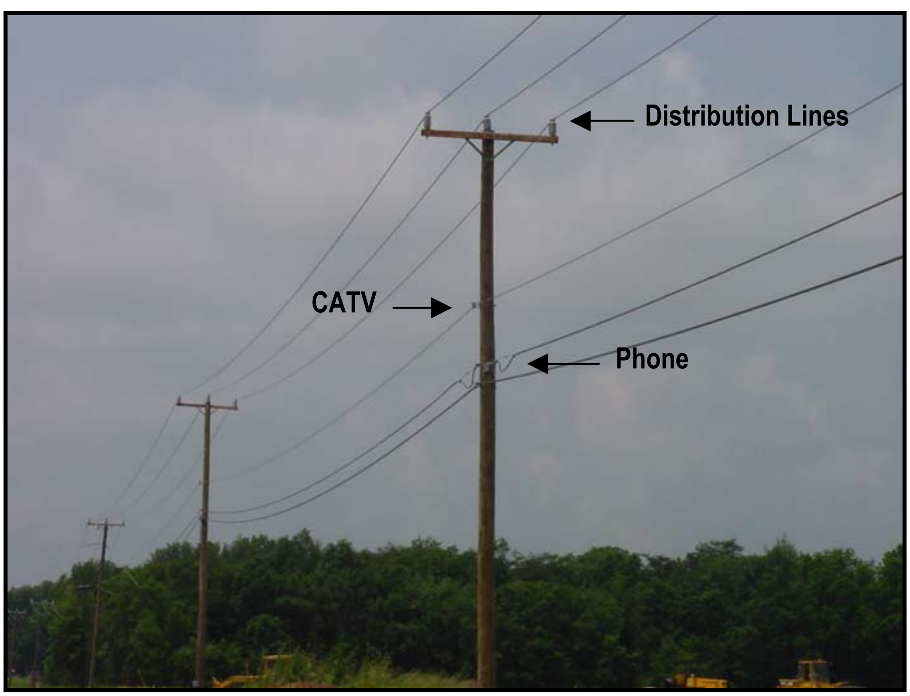


Figure 3. Double Circuit 12KV-34KV Distribution with CATV and Phone

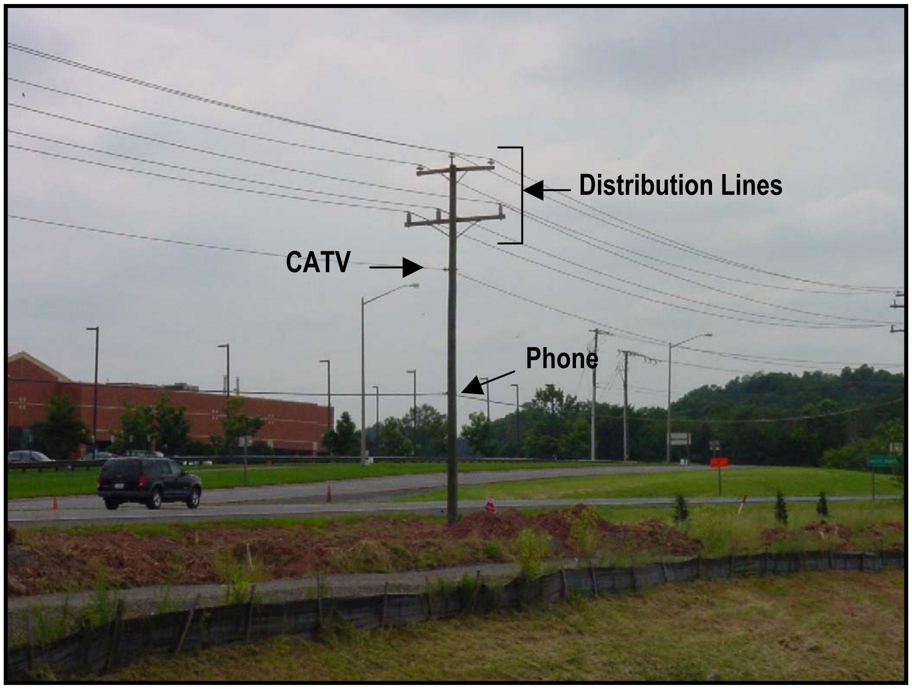
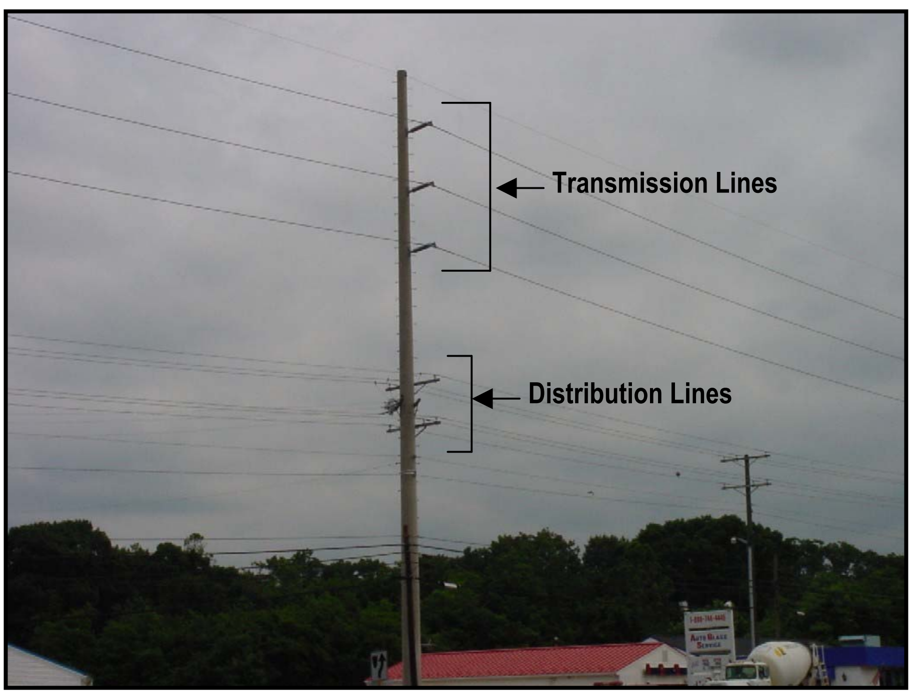


Figure 4. Transmission 69KV-230KV(top) and Double Circuit 12KV-34KV Distribution Sharing the Same Pole



Section 3.
WORK TASKS

3.1 Literature Search of Costs And Benefits of Overhead and Underground Utilities

3.1.1 Underground Utilities

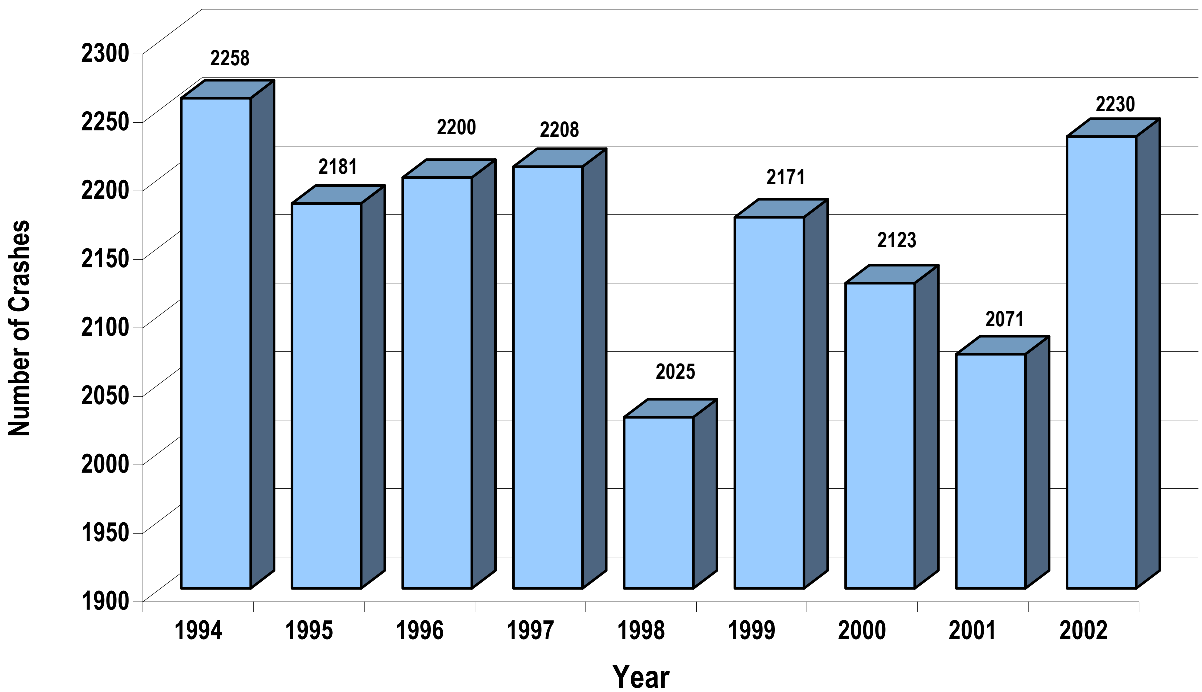
Costs for underground utilities may vary widely from project to project, and are affected by such things as terrain conditions, soil type (e.g. rock), existing subsurface utilities, bridges, roadways and other structures.

Advantages of Underground Utilities

Joint-Use – Underground utilities can utilize a joint-use trench and reduce the overall construction costs of a project. A single trench commonly shared by all utilities will result in lower construction costs. Customer installed conduit, duct bank and manholes can also reduce the cost to install utilities underground.

Increased Public Safety – Burying utilities can reduce the potential for fatalities and injuries as well as outages as a result of contact with overhead conductors. In addition, burying utilities can eliminate the potential for fatalities and injuries as a result of collisions of vehicles with utility poles. Data for the State of Maryland from 1994-2002 shows that in an average year there will be in average about 2,150 vehicular impacts with utility poles. See Figure 5. Downed overhead conductors and poles can slow emergency personnel and be deadly to the public. Often times these downed lines are still energized with very high voltages up 34kv for distribution. Underground utilities reduce the risk of accidents caused by lines, which are down by storms or by vehicle accidents caused by collision with poles. Undergrounding will also reduce the danger of fire. Contact between overhead conductors and trees or limbs can cause fires. Fires endanger both human life and personal property. Burying utilities can also reduce the public's exposure to electromagnetic fields (EMFs). Electric overhead conductors produce an Electric Magnetic Field (EMF) where electric and magnetic fields are interrelated. Exposure to EMF reduces as the distance increases from overhead conductors. The scientific evidence of the dangers of EMF has been inconclusive relating to exposure and any possible health hazards it may cause.

Figure 5. Number of Vehicular Crashes with Utility Poles



Source: Robert Cunningham, Maryland State Highway Administration - Traffic Safety Analysis Division

Aesthetics – A primary reason to bury overhead utilities is aesthetic. Aesthetic benefits include increased property values by preserving the natural beauty of the land, more attractive streetscapes with greater pedestrian activity, and a better quality of life. The one time investment of undergrounding produces aesthetic rewards for generations. Undergrounding results in fewer poles and improved pedestrian access.

Upgrade Existing Utilities – Overhead communications lines are often copper lines. The conversion of these lines underground will allow for high-capacity fiber-optic lines to be installed.

Tree Trimming – Underground utilities do not require regular tree trimming/bush clearing.

UV Exposure – Underground utilities are not exposed to the elements of animals or UV degradation.

Vandalism – Burying utilities reduces vulnerability to vandalism.

Interference – Burying utilities will reduce interference with both radio and television reception.

Maintenance Costs – Maintenance costs for the replacement of old or damaged poles does not exist.

Disadvantages of Underground Utilities

Costs – Underground utilities have higher installation costs.

Reliability – Older cable deteriorates over time resulting in poor reliability as compared to overhead cable.

Excavation – Disruption in service can occur as private property or lawns are excavated.

Cable Failures/Repair Costs – It is more difficult and time consuming to repair subsurface utilities.

Equipment Access – Property owners provide unauthorized screening of pad-mounted equipment and underground cables.

3.1.2 Overhead Utilities

Overhead utilities require less materials and labor to install resulting in lower construction costs as compared to underground utilities.

Advantages of Overhead Utilities

Joint Use – With overhead utilities there can be one pole owner with an attachment fee charged by the pole owner to the other utilities who may want to attach to the owners pole.

Service Restoration – Overhead cable faults can be located easier and more quickly resulting reduced outage times. Repairing overhead utilities is made easier because broken or faulty equipment can be located quickly. Underground utilities require special equipment such as fault indicators and cable thumpers to locate and isolate cable cuts and cable faults. Once located, a splice pit must be opened to expose the damaged cable before repairs can be made. Underground utilities are more difficult to inspect, diagnose and repair increasing outage times.

Excavation – There is no threat of damage to overhead utilities from excavators except at poles and guy wires.

Streetlights – Streetlights can be easily installed on poles and maintained at a lower cost.

Power Supplies – CATV power supplies to boost signals can be pole mounted resulting in lower installation and maintenance costs.

Operating Temperatures – Overhead conductors can operate at a much higher temperature than underground conductors. Excessive heat in underground conductors may result in more cable failures. Placement of cable in conduit must allow for heat to be dissipated. The larger the conduit the more easily heat can be dissipated resulting in a longer cable life.

Obstructions – Overhead utilities are not as adversely affected by terrain, rocks, water and existing sub-surface utilities.

Disadvantages of Overhead Utilities

Storms – Overhead utilities are more susceptible to outages associated with storms, wind and ice.

Wildlife – Overhead lines are exposed to wildlife

Vehicular Contact – The risk of motor vehicle contact with poles and guy wires is greater.

Protection – More lightning protection is required with overhead lines.

Hazards – Contact with overhead lines is more likely by persons and equipment such as cranes.

Guy Wires – Guy wires can be a danger to the public especially if no guy guards.

3.2 Cost Comparison for Initial Overhead and Underground Construction Costs

The electric utility companies operating in the state of Maryland are comprised of Investor Owned Systems such as Baltimore Gas and Electric Company (BG&E), Allegheny Power and Potomac Electric Power Company (PEPCO). It is important to note that Delmarva Power and Light Company as depicted in Figure 6 is now Connectiv Power, a subsidiary of PEPCO. The investor owned systems are the largest in terms of geographic territory covered in the state of Maryland. For the purposes of this study on initial construction costs for installing utilities overhead and underground, data has been collected from four Maryland-based utility companies. As equipment and installation costs are considered proprietary by the electric utilities, the companies surveyed are represented as Companies A-D. This study assumes that the electric utility will be the pole owner with both Verizon and CATV/Fiber attachments sharing the same poles. Typical pole span widths were assumed to be between 175 feet and 200 feet in rural areas and approximately 125 feet in urban areas.

Other electric utility companies operating in the state of Maryland are Municipal Systems and Rural Electric Cooperative Systems. Municipal Systems include Berlin Municipal Electric Company, The Easton Utilities Commission, Hagerstown Municipal Electric Light plant, Thurmont Municipal Light Company and Williamsport Municipal Electric Light System. The Rural Electric Cooperative Systems are A&N Electric Cooperative, Choptank Electric Cooperative, Inc., Somerset Rural Electric Cooperative and Southern Maryland Electric Cooperative. See Figure 6.

Verizon Communications provides service throughout the state of Maryland and provided both the telephone costs and fiber costs for this study. The fiber costs provided by Verizon were compared to studies already done to determine the installation of Fiber Optics/CATV in the right-of-way. Using both the Verizon cost and the studies performed, an average per foot price was determined.

3.2.1 Overhead Attachments

Typical attachment heights using a 40-foot pole are as follows: Electric primary 34', neutral 29'4", CATV 26' and Verizon 23' 6". Multiple attachments by Verizon or CATV require 12 inches of additional horizontal separation per attachment on the pole. In no case should the lowest attachment on the pole be less than 21 feet. If calculations determine that the lowest attachment on the pole will be less than 21 feet, then a taller pole would be installed. There is currently no underground joint-use agreement between the electric utilities and Verizon in areas other than residential. This means that trenching will not be shared and will have to be performed by each utility. In some well-planned and coordinated projects, utility companies may permit the placement of their facilities in a common trench with other utilities.

3.2.2 Underground Separation of Utilities

Horizontal and vertical separation must be maintained from other underground structures as required by the National Electric Safety Code and the individual utilities. Section 32 Rule 320B and Section 35 Rule 353 of the National Electric Safety Code 2002 pertain to the required separation for both underground conduit systems and direct buried cable. An explanation of each rule is listed below.

Section 32. Underground Conduit Systems

Rule 320 B. Separation From Other Underground Structures

1. **General**

   The separation between a conduit system and other underground structures paralleling it should be as large as necessary to permit maintenance of the system without damage to the paralleling structures. A conduit that crosses over another subsurface structure shall have a separation sufficient to limit the likelihood of damage to either structure. These separations should be determined by the parties involved.

2. **Separations Between Electric and Communication Conduit Systems**

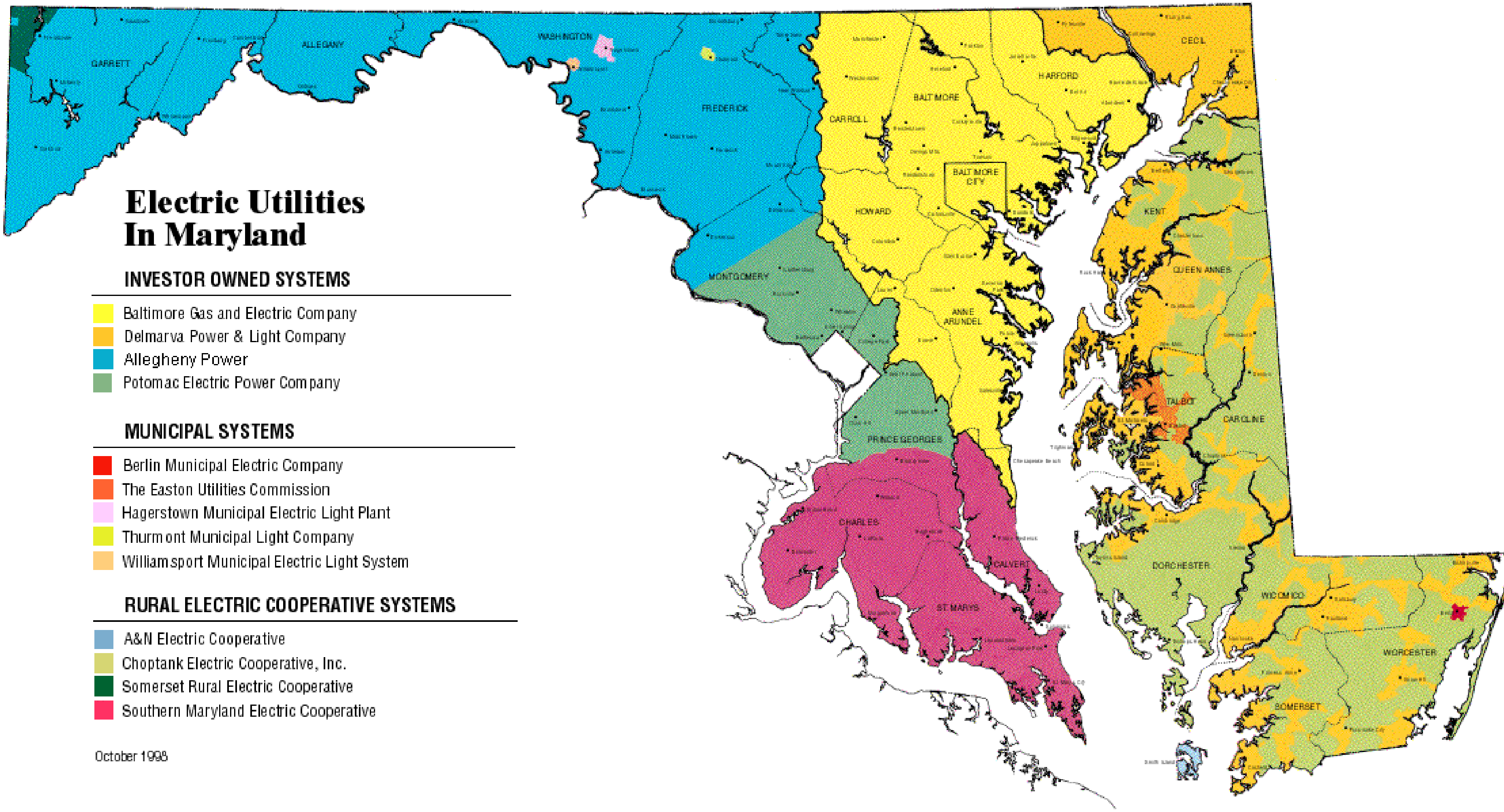
   Conduit systems to be occupied by communication conductors shall be separated from conduit systems to be used for electric systems by 3 inches of concrete or 4 inches of masonry or 12 inches of well-tamped earth.

3. **Sewers, Sanitary and Storm**

   If conditions require a conduit to be installed parallel to and directly over a storm sewer, it may be done provided both parties are in agreement as to the method.

Figure 6. Electric Utilities in Maryland

Source: http://www.psc.state.md.us/psc/images/new_elec_map.gif



Where a conduit run crosses a sewer, it shall be designed to have suitable support on each side of the sewer to limit the likelihood of transferring any direct load onto the sewer.

4. Water Lines

Conduit should be installed as far as practical from a water main in order to protect it from being undermined if the main breaks. Conduit that crosses over a water main shall be designed to have suitable support on each side as required to limit the likelihood of transferring any direct loads onto the main.

5. Gas and Other Fuel Lines

Conduit should have sufficient separation from gas and other fuel lines to permit the ue of pipe maintenance equipment. Conduit shall not enter the same manhole, handhole, or vault with gas or other fuel lines.

6. Steam Lines

Conduit should be installed as to limit the likelihood of detrimental heat transfer between the steam and conduit systems.

Section 35. Direct-Buried Cable

Rule 353 Deliberate Separations-Equal to or Greater than 12 Inches From Underground Structures or Other

1. General

These rules apply to a radial separation of electric and communications cables or conductors from each other and from other underground structures such as sewers, water lines, gas and other fuel lines, building foundations, steam lines, etc., when separation is equal to or greater than 12 inches.

The radial separation should be adequate to permit access to and maintenance of either facility to limit the damage to the other.

2. Crossings

Where a cable crosses under another underground structure, the structure shall be suitably supported to limit the likelihood of transferring of a detrimental load onto the cable system.

Where a cable crosses over another underground structure, the cable shall be suitably supported to limit the likelihood of transferring a detrimental load onto the structure.

Adequate support may be provided by installing the facilities with sufficient vertical separation.

3. Parallel Facilities

Where a cable system is to be installed directly over and parallel to another underground structure (or another underground structure installed directly over and parallel to a cable), it may be done providing all parties are in agreement as to the method. Adequate vertical separation shall be maintained to permit access to and maintenance of either facility without damage to the other.

4. Thermal Protection

Cable should be installed with sufficient separation from other underground structures, such as steam or cryogenic lines, to avoid thermal damage to the cable. Where it is not practical to provide adequate clearance, a suitable thermal barrier shall be placed between the two facilities.

3.2.3 Utility Company Cost Comparisons

The costs for overhead and underground installations for four Investor Owned Systems (Companies A, B, C, and D) were collected and are presented in Figures 7, 8, 9 and 10. Fiber and CATV costs were provided by Verizon Communications for each cost analysis. The cost of one mile of overhead three-phase installation cost varies between $620,000 and $1,020,000. Company C has the highest overhead cost of installation while Company D has the lowest. One mile of underground three-phase installations range between $3,295,000 (Company D) and $8,314,000 (Company C). Companies A and B have similar costs for both overhead and underground installations.

Figure 7. Cost Comparison for Company A

COST/FOOT FOR INSTALLATION OF OVERHEAD VS COST/FOOT OF INSTALLATION OF UNDERGROUND UTILITIES

Title of this Project	**Cost Considerations/Benefits OH vs UG**	Date	**7/9/2003**	Client	**Maryland SHA Contract No. SP208B4C Task 7**
Prepared By:	**W H Albeck**				
Description of the Build Area	Maryland Highway Right-Of-Way			Difficutly factor for this Build Area	1.00

COMPANY A-RURAL OVERHEAD THREE PHASE INSTALLATION COSTS INCLUDING VERIZON AND CATV

Company A-This price includes all labor and material to install 27 poles (200' spans), all crossarms, insulators, down guys, 3-795 AL. primary with 556 neutral.
Verizon-This price includes all labor and material to install 1-1800, 1-1500 & 1-1200 pair copper wire to exisiting poles.
Telecommunications (fiber)-This price includes al labor and material to install 1-216 fiber to existing poles.

	Construction or Service	# of Units per Mile	Estimated Cost per unit/foot	Factored Cost per Unit	Description of the Work or Service; Include assumptions.	Cost per Mile
1	Company A-3-Phase 34.5kv or 12kv 795AL. Pri. W/556AL. Neu	5280.00	$57.00	$57.00	Labor & Material (poles, wire, crossarms, guys, insulators)	$300,960
2	Company A-69kv Transmission on ex. Poles	5280.00	N/A	N/A		N/A
3	Company A-3-phase Urban Additive w/43 poles	5280.00	$33.80	$33.80	Labor & Material. Additive to item #1 (125' spans, 43 poles @ $11,150.00 ea.	$178,464
4	Verizon 1800 Pair Copper	5280.00	$25.00	$25.00	Labor and Material. Includes guys, anchors, and splicing. Attach to ex. Poles.	$132,000
5	Verizon 1500 Pair Copper	5280.00	$18.00	$18.00	Labor & Material. Includes guys, anchors and splicing. Attach to ex. Poles.	$95,040
6	Verizon 1200 Pair Copper	5280.00	$16.00	$16.00	Labor & Material. Includes guys, anchors and splicing. Attach to ex. Poles.	$84,480
7	Verizon Urban Additive 20% of items 4-6	5280.00	$12.00	$12.00	Labor and Materials with 3 additional attachments per pole.	$63,360
8	Telecommunications 1-216 fiber	5280.00	$15.00	$15.00	Labor and Material. Includes guys, anchors, and splicing. Attach to ex. Poles.	$79,200
9	Telecommunications Urban Additive 20% of item 8.	5280.00	$3.00	$3.00	Labor & Material For Additional Attachments	$15,840
			$179.80	$179.80	Per Mile SubTotal:	$949,344

COMPANY A RURAL UNDERGROUND THREE PHASE INSTALLATION COSTS INCLUDING VERIZON AND CATV

Company A-This price includes a 6" x4 way customer installed concrete encased duct bank including trenching and conduit, 750 MCM Al. underground three phase conductor, splicing, labor to install the conductor in conduit, 1 customer installed and Company A provided manhole every 1300' (4 manholes), assumes 4 padmounted switches/mile.
Verizon-This price includes a 4" X 9 way concrete encased duct bank including trenching, with ten (10) 12'W x 6'L x 7' H manholes, 1800 pair copper wire, splices labor to install wire in conduit.
Telecommunications-This price includes 2 handholes/mile, 1-216 fiber cable, 3-1 1/2"concrete encased conduit, labot to install conduit in open trench, labor to pull fiber in conduit.

	Construction or Service	# of Units per Mile	Estimated Cost per unit/foot	Factored Cost per Unit	Description of the Work or Service; Include assumptions.	Cost per mile
1	Company A-customer Installed 6" x 4 way duct bank	5280.00	$40.00	$40.00	Conduit material cost	$211,200
2	Company A-manholes customer installed 4/mile	5280.00	$6.07	$6.07	Labor to install Allegheny supplied MH's 4 @ $8,000.00 ea.	$32,050
3	Customer trench, inst. conduit in trench, conc. Enc., backfill	5280.00	$94.69	$94.69	Labor and Materials	$499,963
4	Company A-750 MCM AL.(34.5kv or 12kv) w/ manholes	5280.00	$94.70	$94.70	Cable, labor to install cable in ex. Conduit. 8'x8'x8' MH every 1300'	$500,016
5	Company A-Switches 4/mile @ $50,000.00 ea.	5280.00	$37.88	$37.88	Labor and Material	$200,006
6	Customer Directional Bore Additive	5280.00	$142.04	$142.04	Add to item 3 for directional bore ($500,000 (Trench) x 2.5 (bore)=$1,250,000-$500,000=$750,000	$749,971
7	Company A-Urban Duct Bank Additive 30% of item #1-3	5280.00	$42.22	$42.22	Add to items 1-3 for urban areas for additional Labor, manholes & conduit	$222,922
8	Verizon 1800 Pair Copper	5280.00	$25.00	$25.00	Labor and Materials	$132,000
9	Verizon 4" x 9 way duct bank w/12Wx6Lx7H MH's	5280.00	$230.00	$230.00	Conduit, concrete, 10 MH's @ $15k ea. w/10 splices, labor, material	$1,214,400
10	Verizon Directional Bore Additive 40% of item #9	5280.00	$138.00	$138.00	Add to item 9 for directional bore ($485,760 (Trench) x 2.5 (bore)=$1,214,000-$485,760.00=$728,640	$728,640
11	Verizon Urban Duct Bank Additive 30% of item #9	5280.00	$69.00	$69.00	Add to item 9 for urban areas for additional Labor, manholes & conduit	$364,320
12	Telecommunications Handholes	5280.00	$1.51	$1.51	2 per mile @ $4,000.00 ea., labor, materials	$7,973
13	Telecommunications 1-216 Fiber	5280.00	$5.00	$5.00	Materials, splices	$26,400
14	Telecommunications Conduit 3-1 1/2"	5280.00	$8.00	$8.00	Materials, including concrete encasement., Labor to install conduit in open trench	$42,240
15	Telecommunications Pull Fiber	5280.00	$1.00	$1.00	Labor to pull fiber in conduit	$5,280
16	Telecommunications Urban Additive 30% of items 12-15.	5280.00	$4.65	$4.65	Additional labor and material.	$24,552
17						
18						
19						
			$939.76	$939.76	Per Mile SubTotal:	$4,961,933

Source:Verizon-Candy Pickett (301) 595-6848
Danella Construction-Tim Rioux (703) 481-8766 (Customer trench & duct bank)

Figure 8. Cost Comparison for Company B

COST/FOOT FOR INSTALLATION OF OVERHEAD VS COST/FOOT OF INSTALLATION OF UNDERGROUND UTILITIES

Title of this Project	Cost Considerations/Benefits OH vs UG	Date	7/9/2003	Client	Maryland SHA Contract No. SP208B4C Task 7
Prepared By:	W H Albeck				
Description of the Build Area	Maryland Highway Right-Of-Way			Difficutly factor for this Build Area	1.00

COMPANY B-RURAL OVERHEAD THREE PHASE INSTALLATION COSTS INCLUDING VERIZON AND CATV

Company B-This price includes all labor and material to install 27 poles (200' spans), all crossarms, insulators, down guys, 3-500 AL. primary with 4/0 neutral.
Verizon-This price includes all labor and material to install 1-1800, 1-1500 & 1-1200 pair copper wire to exisiting poles.
Telecommunications (fiber)-This price includes al labor and material to install 1-216 fiber to existing poles.

	Construction or Service	# of Units per Mile	Estimated Cost per unit/foot	Factored Cost per Unit	Description of the Work or Service; Include assumptions.	Cost per Mile
1	Company B-3-Phase 33kv 500AL. Pri. & 4/0 Neu.	5280.00	$56.82	$56.82	Labor & Material (poles, wire, crossarms, guys, insulators)	$300,010
2	Company B-69kv Transmission on ex. Poles	5280.00	N/A	N/A		N/A
3	Company B-3-phase Urban Additive w/43 poles	5280.00	$33.67	$33.67	Labor & Material. Additive to item #1 (125' spans, 43 poles @ $11,111.00 ea.	$177,778
4	Verizon 1800 Pair Copper	5280.00	$25.00	$25.00	Labor and Material. Includes guys, anchors, and splicing. Attach to ex. Poles.	$132,000
5	Verizon 1500 Pair Copper	5280.00	$18.00	$18.00	Labor & Material. Includes guys, anchors and splicing. Attach to ex. Poles.	$95,040
6	Verizon 1200 Pair Copper	5280.00	$16.00	$16.00	Labor & Material. Includes guys, anchors and splicing. Attach to ex. Poles.	$84,480
7	Verizon Urban Additive 20% of items 4-6	5280.00	$12.00	$12.00	Labor and Materials with 3 additional attachments per pole.	$63,360
8	Telecommunications 1-216 fiber	5280.00	$15.00	$15.00	Labor and Material. Includes guys, anchors, and splicing. Attach to ex. Poles.	$79,200
9	Telecommunications Urban Additive 20% of item 8.	5280.00	$3.00	$3.00	Labor & Material For Additional Attachments	$15,840
			$179.49	$179.49	Per Mile SubTotal:	$947,707

COMPANY B-RURAL UNDERGROUND THREE PHASE INSTALLATION COSTS INCLUDING VERIZON AND CATV

Company B-This price includes a 5" x 8 way concrete encased duct bank including trenching and conduit, 500 MCM Al. underground three phase conductor, splicing, labor to install the conductor in conduit, assumes 1 elec. manhole every 600' (9 manholes), assumes 4 padmounted switches/mile.
Verizon-This price includes a 4" X 9 way concrete encased duct bank including trenching, with ten (10) 12'W x 6'L x 7' H manholes, 1800 pair copper wire, splices labor to install wire in conduit.
Telecommunications-This price includes 2 handholes/mile, 1-216 fiber cable, 3-1 1/2"concrete encased conduit, labot to install conduit in open trench, labor to pull fiber in conduit.

	Construction or Service	# of Units per Mile	Estimated Cost per unit/foot	Factored Cost per Unit	Description of the Work or Service; Include assumptions.	Cost per mile
1	Company B-5" x 8 way ductbank, cable and 9 manholes	5280.00	$200.00	$200.00	Conduit, trench, MH's every 600' ,concrete, labor, materials, 500 MCM ug conductor	$1,056,000
2	Company B-Padmounted Switchs	5280.00	$30.30	$30.30	4/mile @$40,000 ea.Includes, labor, material, terminations	$159,984
3	Company B-Directional bore Additive 40% of item #1	5280.00	$120.00	$120.00	Add to item 1 for directional bore ($422,400 (Trench) x 2.5 (bore)=$1,056,000-$422,400=$633,600	$633,600
4	Company B-Urban Duct Bank Additive 30% of item #1	5280.00	$60.00	$60.00	Add to item 1 for urban areas for additional Labor, manholes & conduit	$316,800
5	Verizon 1800 Pair Copper	5280.00	$25.00	$25.00	Labor and Materials	$132,000
6	Verizon 4" x 9 way duct bank w/12Wx6Lx7H MH's	5280.00	$230.00	$230.00	Conduit, concrete, 10 MH's @ $15k ea. w/10 splices, labor, material	$1,214,400
7	Verizon Directional Bore Additive 40% of item #6	5280.00	$138.00	$138.00	Add to item 7 for directional bore ($485,760 (Trench) x 2.5 (bore)=$1,214,000-$485,760.00=$728,640	$728,640
8	Verizon Urban Duct Bank Additive 30% of item #6	5280.00	$69.00	$69.00	Add to item 7 for urban areas for additional Labor, manholes & conduit	$364,320
9	Telecommunications Handholes	5280.00	$1.51	$1.51	2 per mile @ $4,000.00 ea., labor, materials	$7,973
10	Telecommunications 1-216 Fiber	5280.00	$5.00	$5.00	Materials, splices	$26,400
11	Telecommunications Conduit 3-1 1/2"	5280.00	$8.00	$8.00	Materials, including concrete encasement., Labor to install conduit in open trench	$42,240
12	Telecommunications Pull Fiber	5280.00	$1.00	$1.00	Labor to pull fiber in conduit	$5,280
13	Telecommunications Urban Additive 30% of items 9-12.	5280.00	$4.65	$4.65	Additional labor and material.	$24,552
14						
15						
16						
17						
18						
19						
			$892.46	$892.46	Per Mile SubTotal:	$4,712,189

Source: Verizon-Candy Pickett (301) 595-6848

Figure 9. Cost Comparison for Company C

COST/FOOT FOR INSTALLATION OF OVERHEAD VS COST/FOOT OF INSTALLATION OF UNDERGROUND UTILITIES

Title of this Project	**Cost Considerations/Benefits OH vs UG**	Date	**7/9/2003**
Client	**Maryland SHA Contract No. SP208B4C Task 7**		
Prepared By:	**W H Albeck**		
Description of the Build Area	Maryland Highway Right-Of-Way	Difficutly factor for this Build Area	1.00

COMPANY C-RURAL OVERHEAD THREE PHASE INSTALLATION COSTS INCLUDING VERIZON AND CATV

Company C-This price includes all labor and material to install 30 poles (175' spans), all crossarms, insulators, down guys, 3-477AL. primary with 4/0 neutral.
Verizon-This price includes all labor and material to install 1-1800, 1-1500 & 1-1200 pair copper wire to exisiting poles.
Telecommunications (fiber)-This price includes al labor and material to install 1-216 fiber to existing poles.

	Construction or Service	# of Units per Mile	Estimated Cost per unit/foot	Factored Cost per Unit	Description of the Work or Service; Include assumptions.	Cost per Mile
1	Company C-3-Phase 13kv 477AL. Pri. & 4/0 Neu.	5280.00	$43.00	$43.00	Labor & Material (poles, wire, crossarms, guys, insulators)	$227,040
2	Company C-69kv Transmission on ex. Poles	5280.00	$41.28	$41.28	Labor & Material. Additive to item #1 w/69kv $445,000/mile-$227,040=$217,960	$217,958
3	Company C-3-phase Urban Additive w/43 poles	5280.00	$19.00	$19.00	Labor & Material. Additive to item #1 (125' spans, 43 poles @ $7,500.00 ea.	$100,320
4	Verizon 1800 Pair Copper	5280.00	$25.00	$25.00	Labor & Material. Includes guys, anchors and splicing. Attach to ex. Poles.	$132,000
5	Verizon 1500 Pair Copper	5280.00	$18.00	$18.00	Labor & Material. Includes guys, anchors and splicing. Attach to ex. Poles.	$95,040
6	Verizon 1200 Pair Copper	5280.00	$16.00	$16.00	Labor & Material. Includes guys, anchors and splicing. Attach to ex. Poles.	$84,480
7	Verizon Urban Additive 20% of items 4-6	5280.00	$12.00	$12.00	Labor and Materials with 3 additional attachments per pole.	$63,360
8	Telecommunications 1-216 fiber	5280.00	$15.00	$15.00	Labor & Material. Includes guys, anchors and splicing. Attach to ex. Poles.	$79,200
9	Telecommunications Urban Additive 20% of item 8.	5280.00	$3.00	$3.00	Labor & Material For Additional Attachments	$15,840
			$192.28	$192.28	Per Mile SubTotal:	$1,015,238

COMPANY C-RURAL UNDERGROUND THREE PHASE INSTALLATION COSTS INCLUDING VERIZON AND CATV

Company C-This price includes a 5" x 8 way duct bank including trenching and conduit with concrete encasement, 600 MCM Al. underground three phase conductor, splicing, labor to install the conductor in conduit, assumes 1 elec. manhole every 600' (9 manholes), assumes 4 padmounted switches/mile.
Verizon-This price includes a 4" X 9 way concrete encased duct bank including trenching, with ten (10) 12'W x 6'L x 7' H manholes, 1800 pair copper wire, splices labor to install wire in conduit.
Telecommunications-This price includes 2 handholes/mile, 1-216 fiber cable, 3-1 1/2"concrete encased conduit, labot to install conduit in open trench, labor to pull fiber in conduit.

	Construction or Service	# of Units per Mile	Estimated Cost per unit/foot	Factored Cost per Unit	Description of the Work or Service; Include assumptions.	Cost per mile
1	Company C-5" x 8 way duct bank w/ 9 MH's	5280.00	$520.83	$520.83	Conduit, trench, concrete, mahnoles, labor, materials, restoration	$2,749,982
2	Company C-3-Phase 13kv 600 MCM Al. conductor	5280.00	$54.00	$54.00	Material & Labor including splices	$285,120
3	Company C-Padmounted Switchs	5280.00	$49.25	$49.25	4/mile @$65,000 ea.Includes, labor, material, terminations	$260,040
4	Company C-Directional bore Additive 40% of item #1	5280.00	$312.50	$312.50	Add to item 1 for directional bore ($1,100,000 (Trench) x 2.5 (bore)=$2,750,000-$1,100,000=$1,650,000	$1,650,000
5	Company C-Urban Duct Bank Additive 30% of item #1	5280.00	$156.00	$156.00	Add to item 1 for urban areas for additional Labor, manholes & conduit	$823,680
6	Verizon 1800 Pair Copper	5280.00	$25.00	$25.00	Labor and Materials. Includes 10 Splices.	$132,000
7	Verizon 4" x 9 way duct bank w/12Wx6Lx7H MH's	5280.00	$230.00	$230.00	Trenching, conduit, concrete, 10 MH's @ $15k ea. , labor, material	$1,214,400
8	Verizon Directional Bore Additive 40% of item #7	5280.00	$138.00	$138.00	Add to item 7 for directional bore ($485,760 (Trench) x 2.5 (bore)=$1,214,000-$485,760.00=$728,640	$728,640
9	Verizon Urban Duct Bank Additive 30% of item #7	5280.00	$69.00	$69.00	Add to item 7 for urban areas for additional Labor, manholes & conduit	$364,320
10	Telecommunications Handholes	5280.00	$1.51	$1.51	2 per mile @ $4,000.00 ea., labor, materials	$7,973
11	Telecommunications 1-216 Fiber	5280.00	$5.00	$5.00	Materials, splices	$26,400
12	Telecommunications Conduit 3-1 1/2"	5280.00	$8.00	$8.00	Materials, including concrete encasement., Labor to install conduit in open trench	$42,240
13	Telecommunications Pull Fiber	5280.00	$1.00	$1.00	Labor to pull fiber in conduit	$5,280
14	Telecommunications Urban Additive 30% of items 10-13.	5280.00	$4.65	$4.65	Additional labor and material.	$24,552
15						
16						
17						
18						
19						
			$1,574.74	$1,574.74	Per Mile SubTotal:	$8,314,627

Source: Verizon-Candy Pickett (301) 595-6848

Figure 10. Cost Comparison for Company D

COST/FOOT FOR INSTALLATION OF OVERHEAD VS COST/FOOT OF INSTALLATION OF UNDERGROUND UTILITIES

Title of this Project: **Cost Considerations/Benefits OH vs UG** | Date: **7/9/2003** | Client: **Maryland SHA Contract No. SP208B4C Task 7**

Prepared By: **W H Albeck**

Description of the Build Area: Maryland Highway Right-Of-Way | Difficutly factor for this Build Area: 1.00

COMPANY D-RURAL OVERHEAD THREE PHASE INSTALLATION COSTS INCLUDING VERIZON AND CATV

Company D-This price includes all labor and material to install 27 poles (200' spans), all crossarms, insulators, down guys, 3-477 AL. primary with 2/0 neutral. **Note: all service area is considered rural.**
Verizon-This price includes all labor and material to install 1-1800, 1-1500 & 1-1200 pair copper wire to exisiting poles.
Telecommunications (fiber)-This price includes al labor and material to install 1-216 fiber to existing poles.

	Construction or Service	# of Units per Mile	Estimated Cost per unit/foot	Factored Cost per Unit	Description of the Work or Service; Include assumptions.	Cost per Mile
1	Company D-3-Phase 12kv 477AL. Pri. & 2/0 Neu.	5280.00	$30.00	$30.00	Labor & Material (poles, wire, crossarms, guys, insulators)	$158,400
2	Company D-69kv Transmission on ex. Poles	5280.00	N/A	N/A	No sub-transmission installed on distribution system poles	N/A
3	Company D-3-phase Urban Additive w/43 poles	5280.00	N/A	N/A	All areas are considered rural.	N/A
4	Verizon 1800 Pair Copper	5280.00	$25.00	$25.00	Labor & Material. Includes guys, anchors and splicing. Attach to ex. Poles.	$132,000
5	Verizon 1500 Pair Copper	5280.00	$18.00	$18.00	Labor & Material. Includes guys, anchors and splicing. Attach to ex. Poles.	$95,040
6	Verizon 1200 Pair Copper	5280.00	$16.00	$16.00	Labor & Material. Includes guys, anchors and splicing. Attach to ex. Poles.	$84,480
7	Verizon Urban Additive 20% of items 4-6	5280.00	$12.00	$12.00	Labor and Materials with 3 additional attachments per pole.	$63,360
8	Telecommunications 1-216 fiber	5280.00	$15.00	$15.00	Labor & Material. Includes guys, anchors and splicing. Attach to ex. Poles.	$79,200
9	Telecommunications Urban Additive 20% of item 8.	5280.00	$3.00	$3.00	Labor & Material For Additional Attachments	$15,840
			$119.00	$119.00	Per Mile SubTotal:	$628,320

COMPANY D-RURAL UNDERGROUND THREE PHASE INSTALLATION COSTS INCLUDING VERIZON AND CATV

Company D-This price includes trenching , 1000 MCM Al. underground three phase conductor, splicing, labor to install the conductor in trench, assumes 4 padmounted switches/mile. **Note:All cable is direct burried. No duct bank is used in their system. All service area is considered rural.**
Verizon-This price includes a 4" X 9 way concrete encased duct bank including trenching, with ten (10) 12'W x 6'L x 7' H manholes, 1800 pair copper wire, splices labor to install wire in conduit.
Telecommunications-This price includes 2 handholes/mile, 1-216 fiber cable, 3-1 1/2"concrete encased conduit, labot to install conduit in open trench, labor to pull fiber in conduit.

	Construction or Service	# of Units per Mile	Estimated Cost per unit/foot	Factored Cost per Unit	Description of the Work or Service; Include assumptions.	Cost per mile
1	Company D-3-Phase 12kv 1000 MCM AL. Pri.	5280.00	$66.29	$66.29	Trench, labor, materials, restoration (No duct bank used)	$350,011
2	Company D-Padmounted switches	5280.00	$18.94	$18.94	4/mile @$25,000 ea.Includes, labor, material, terminations	$100,003
3	Company D-Directional bore Additive	5280.00	$56.82	$56.82	Add to item 1 for directional bore ($200,000 (Trench) x 2.5 (bore)=$500,000-$200,000=$300,000	$300,010
4	Company D-Urban Duct Bank Additive	5280.00	N/A	N/A	All service area is considered rural. No duct bank or conduit is used.	N/A
5	Verizon 1800 Pair Copper	5280.00	$25.00	$25.00	Labor and Materials. Includes 10 Splices.	$132,000
6	Verizon 4" x 9 way duct bank w/12Wx6Lx7H MH's	5280.00	$230.00	$230.00	Trenching, conduit, concrete, 10 MH's @ $15k ea. , labor, material	$1,214,400
7	Verizon Directional Bore Additive 40% of item #6	5280.00	$138.00	$138.00	Add to item 7 for directional bore ($485,760 (Trench) x 2.5 (bore)=$1,214,000-$485,760.00=$728,640	$728,640
8	Verizon Urban Duct Bank Additive 30% of item #6	5280.00	$69.00	$69.00	Add to item 7 for urban areas for additional Labor, manholes & conduit	$364,320
9	Telecommunications Handholes	5280.00	$1.51	$1.51	2 per mile @ $4,000.00 ea., labor, materials	$7,973
10	Telecommunications 1-216 Fiber	5280.00	$5.00	$5.00	Materials, splices	$26,400
11	Telecommunications Conduit 3-1 1/2"	5280.00	$8.00	$8.00	Materials, including concrete encasement., Labor to install conduit in open trench	$42,240
12	Telecommunications Pull Fiber	5280.00	$1.00	$1.00	Labor to pull fiber in conduit	$5,280
13	Telecommunications Urban Additive 30% of items 9-12.	5280.00	$4.65	$4.65	Additional labor and material.	$24,552
14						
15						
16						
17						
18						
19						
			$624.21	$624.21	Per Mile SubTotal:	$3,295,829

Source: Verizon-Candy Pickett (301) 595-6848

3.3 Historical Data on Routine Maintenance Costs and Repair Costs for Both Overhead and Underground Facilities Under Comparable Baseline Conditions

The utility companies surveyed in this study have indicated that compilation of the requested data for maintenance and repair costs would require a significant amount of analysis and time. The companies have indicated that some of the data requested may be obtained from a report to the Public Service Commission Of Maryland on the Selective Undergrounding of Electric Transmission and Distribution Plant dated February 14, 2000, prepared by the Selective Undergrounding Working Group. The participants in the Selective Undergrounding Working Group included Allegheny Power, BG&E, Bell Atlantic, Choptank Electric Cooperative, Connectiv, PEPCO, Southern Maryland Electric Cooperative, Maryland Energy Administration, Power Plant Research Program, Office of People's Counsel and Commission Staff. The following presents the information found within this report.

3.3.1 Historical Data

The Maintenance information listed below was obtained from the February 14, 2000 report. The utilities were asked to provide reliability driven maintenance for a feeder and the total cost of the maintenance. The utilities were also asked to provide The System Average Interruption Frequency Index (SAIFI, see 3.4.1 for complete explanation) and The System Average Interruption Duration Index (SAIDI, see 3.4.1 for complete explanation) for the feeder for 12 months following the maintenance. The requested information from the utilities is as follows:

Allegheny Power – Wolfsville feeder was experiencing poor reliability in 1992. This feeder is a rural overhead line. Extensive tree trimming/removal was performed in 1993 at a cost of $750,000. SAIFI dropped from 2.66 to 0.26 and SAIDI was lowered from 563.85 to 100.42 in all weather conditions.

Baltimore Gas & Electric – Feeder number 7027 serving 2344 residential and small commercial customers had maintenance and tree trimming performed in 1996. The cost of the work was $26,000.00. SAIFI dropped from 1.31 to 0.08 and SAIDI was lowered from 267 to 10 in all weather conditions. The maintenance on this circuit included replacement of broken or defective equipment, fuse coordination, wildlife protection, fusing of unfused taps, lightning arrestors, and tree trimming.

Connectiv – Fruitland circuit number 2226 serving 3,478 customers had a 1.5 mile underground portion of the line converted to overhead. The existing 750 kcmil underground cable was 25 years old and not repairable. The overhead line construction cost was $90,000.00. SAIFI dropped from 3.274 to 1.43 and SAIDI was lowered from 213.16 to 54.90 ($60,000/mile).

Potomac Electric Power Company – Feeder number 14973 serving 827 customers overhead was converted to underground where 4,000 feet of underground cable was installed at a cost of $1,500,000. SAIFI was reduced from 3.55 in 1997 to 0.2250 in 1998 and SAIDI was lowered from 7.392 to 0.8540 ($1,980,000/mile).

Note: An explanation of SAIFI and SAIDI can be found in item 4 on historical data on reliability and dependability.

3.3.2 Additional Information

In addition to the information gathered from the aforementioned report, two of the sample companies provided a written response to the request for maintenance and repair costs.

Maintenance and Repair Costs – Company A

In a letter dated May 8, 2003 to Mr. Neil J. Pedersen, Company A identified that in years 2001 and 2002 the average expenditures for Operations & Maintenance of overhead and underground distribution facilities as follows:

Overhead – $6.2 million ($1.069/mile)
Underground – $1.5 million ($0.536/mile)

Company A has approximately 5,800 miles of overhead and 2,800 miles of underground distribution facilities in the state of Maryland.

Maintenance and Repair Costs – Company C

In a letter dated April 28, 2003 to Mr. Joseph Bissett, Company C reported that for the calendar year 2002, the maintenance and repair of overhead distribution facilities was $7,862,000. This cost includes the unreimbursed costs associated with the April 28, 2002 tornado. The total net cost for maintenance and repair of underground distribution facilities was $3,804,000.

3.4 Historical Data on Reliability or Dependability

Distribution systems of electric utilities are designed and operated to provide the highest degree of reliability to the customer. Power delivery is the most important aspect of reliability. Customers expect and demand that the power remain on all times. System reliability is adversely affected by vehicle collisions with utility poles, trees making contact with overhead conductors, climate, equipment failure, cable cuts or third party faults where cable is underground. Utilities measure reliability using reliability performance indices which track historical data on the causes of a fault, what specific equipment was involved, the total number of customers affected and the duration of the outage. There are two common customer oriented reliability indices. They are as follows:

3.4.1 Definitions

SAIFI-The System Average Interruption Frequency Index. This is the average number of interruptions per customer per year. When a customer experiences loss of service, the customer interruption event is recorded for that customer. Interruptions are then totaled and divided by the total number of customers to determine the utility average. A SAIFI of 4 would mean that there were an average of 4 interruptions per customer during a year. Some customers may experience more than 4 interruptions in service, while others may experience less than 4 interruptions in service.

SAIDI-The System Average Interruption Duration Index. This is the average number of minutes of interruption per customer per year. A SAIDI of 30 means that each customer averages 30 minutes of interruption per year.

It is important to note that utilities may track the data differently. Some utilities may only count outages in excess of five minutes while others may collect data on all outages. The SAIFI and SAIDI measure a utility's average for its distribution system. Extremes in these indices will occur where some customers experience a low number of interruptions, while other customers experience a large number of interruptions.

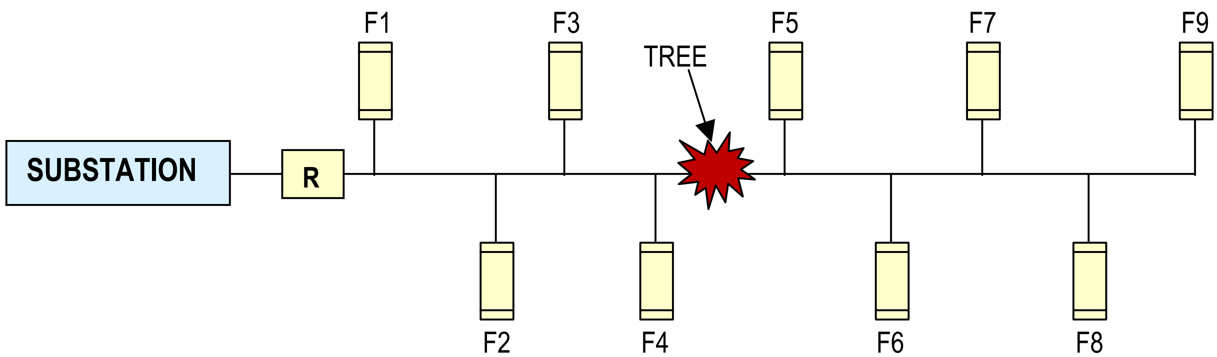
3.4.2 Example of SAIFI and SAIDI Calculation

An example of the calculations associated with SAIFI and SAIDI is illustrated below.

Assume that a tree falls on an overhead distribution line, which serves a total of 10,000 customers. See Figure 11. In an attempt to allow the fault to clear the line, an automatic reclosure opens the entire circuit and de-energizes the line for 5 seconds then closes and re-energizes the entire circuit. The fault remains and the reclosure operates a second time for another 5 seconds and again the fault remains. When the reclosure closes the second time, line fuses F5-F9 blow and half of the 10,000 customers lose service and experience a third interruption. The other half of the customers behind line fuses F1-F4 have their service restored. Five thousand customers are restored after two interruptions totaling ten seconds, while the remaining 5,000 customers experience a third interruption. Removing the tree from the line and repairing the line using a high tension splice takes two hours. The blown line fuses F5-F9 are replaced one by one every five minutes and service is restored to all the customers. SAIFI and SAIDI for this hypothetical event would be calculated as follows:

Figure 11. Sample SAIDI and SAIFI Calculations

TOTAL CUSTOMERS 10,000



R = Reclosure

FUSES F5-F9 – 1000 customers each

F1-F4	5,000 x 10 seconds=833.33 minutes
F5	1,000 x (10 seconds + 2 HOURS + 5 minutes)=125,166.66 minutes
F6	1,000 x (10 seconds + 2 HOURS + 10 minutes)=130,166.66 minutes
F7	1,000 x (10 seconds + 2 HOURS + 15 minutes)=135,166.66 minutes
F8	1,000 x (10 seconds + 2 HOURS + 20 minutes)=140,166.66 minutes
F9	1,000 x (10 SECONDS + 2 HOURS + 25 minutes)=145,166.66 minutes

TOTAL = 676,666.63 MINUTES

Two interruptions for 5,000 customers and 3 interruptions for 5,000 customers. 25,000 customer interruptions for a total of 676,666.63 minutes of interruptions.

SAIFI = 25,000/10,000 = 2.5 interruptions per customer

SAIDI = 676,666.63/10,000 = 67.66 average minutes of interruption/customer

3.4.3 SAIFI and SAIDI Data

The utilities surveyed in this study have indicated that compilation of the requested data for reliability and construction and maintenance costs would require a significant amount of analysis and time. The utilities have indicated that much of the data requested may be obtained from a report to the Public Service Commission Of Maryland on the Selective Undergrounding of Electric Transmission and Distribution Plant dated February 14, 2000, prepared by the Selective Undergrounding Working Group. The participants in the Selective Undergrounding Working Group include Allegheny Power, BG&E, Bell Atlantic, Choptank Electric Cooperative, Connectiv, PEPCO, Southern Maryland Electric Cooperative, Maryland Energy Administration, Power Plant Research Program, Office of People's Counsel and Commission Staff.

Reliability information contained in the table below was obtained from the February 14, 2000 report. The utilities were asked to select two feeders, one primarily overhead and one primarily underground in close geographic proximity to each other. They were then asked to provide SAIFI and SAIDI for the feeders for each of the past three calendar years. The requested information for four of the utilities is as follows:

Table 1. SAIFI and SAIDI Data

	Circuit	SAIFI				SAIDI				Circuit Type
Company	Name/Circuit Number	1996	1997	1998	1999	1996	1997	1998	1999	– Overhead/ Undergroung
Allegheny Power	Brigadoon Circuit	0.11	1.73	0.04		25.16	125	4.59		Overhead
Allegheny Power	McCain Circuit	0.28	0.91	1.29		49.4	569.9	91.07		Underground
BG&E	7075		3.43	0.45	7.96		65	242	680	Overhead
BG&E	7071		0.58	1.72	1.39		178	94	118	Underground
Connectiv	2254		2.935	0.328	0.4		230.8	24.18	47.81	Overhead
Connectiv	2284		1.333	1.465	0.205		18.16	129.6	18.59	Underground
PEPCO	14488		0.12	0.032	0.248		0.302	0.105	0.39	Overhead
PEPCO	14487		1.00	0.058	0.003		0.575	0.123	0.102	Underground

Source: Report to the Public Service Commission of Maryland on the Selective Undergrounding of Electric Transmission and Distribution Plant February 14, 2000.

Company A, in a letter dated May 8, 2003 to Mr. Neil J Pedersen, has identified reliability indices associated with underground versus overhead as follows:

	2002 SAIFI	2001 SAIFI
Underground	0.11	0.14
Overhead	0.96	0.96

In calendar year 2002, Company D experienced 123,000 customer-hours of interruptions on its overhead distribution facilities and 63,400 customer-hours on interruptions on its underground distribution facilities. Of the 123,000 customer-hours of interruptions on its overhead distribution facilities, approximately 75,000 customer-hours of interruptions were a result of weather or trees, which Company D includes with weather related outages. There were 700 customer-hours of interruptions on underground distribution facilities due to weather related events.

The utilities have indicated that they do not maintain data or have estimates as to the amount of "lost revenue" due to outages.

3.5 Lifecycle Cost Comparison of Overhead and Underground Utility Placements/Relocations Based on Similar Service Capacities

3.5.1 Model Approach

The approach used to develop the lifecycle cost-benefit model was to design a single system that could be used as a tool both for evaluating the general efficiency of undergrounding overhead utility lines and for decision–making regarding specific proposed undergrounding projects. Thus, the model provides the user with options to select inputs from various data sources, some of which have been filled with default assumptions and some of which allow the user to enter a custom set of model inputs.

Using the selected set of input assumptions, the model calculates the differential cost or benefit value in various component categories between rebuilding distribution lines in overhead or underground configurations. Overhead construction is the default method. The model sums the differentials in each category to estimate the total net present value of rebuilding in an underground configuration. The model's calculation incorporates the costs and benefits of relocating other utility wires along with electric lines. It also considers total lifecycle costs—first year and annually recurring costs are both elements of the formula. In addition to total net present value (NPV), as an aid to decision–making the model also provides subtotals of benefits and costs individually.

It is important to note that the model treats all dollars equally, whether they are costs or benefits. Further, all benefits, whether they accrue to the general public or specific parties, receive equal weight in the calculation of net present value. Nevertheless, we suggest that the user give further consideration to whether the impacts to individual property values should have the same weight in a public policy question as the expenditure of state funds for construction or the benefits of reducing traffic accident fatalities.

3.5.2 Model Functions

The lifecycle cost-benefit model is a Microsoft Excel spreadsheet file. In this file, two worksheets are of primary concern to the user—one manages input data assumptions from various sources and one performs the cost-benefit comparison calculation. Another worksheet holds data tables necessary for the mechanics of the model. Finally, Edwards and Kelcey's construction cost estimates are included in four additional worksheets (one each for Company A-D).

The worksheet named "Model" contains the cost-benefit comparison calculation. For each of five categories—construction, O&M, automobile accidents, power outages, and aesthetics—the model calculates the differential cost or benefit of undergrounding. Note that all cost components are expressed in dollars per mile in first year dollars. Also, positive dollar values indicate a benefit of undergrounding, negative values indicate a cost of undergrounding. The net present values of total benefits, costs, and the balance are displayed at the bottom of the calculation, along with a notice in red indicating whether benefits exceed costs or costs exceed benefits.

At the top of the Model worksheet are five cells for the user to select data sources and enter values for analytical variables:

- A box to select the data source for utility costs—Company A-D, or a user input data set ("custom"). This allows the user to choose the source of construction and O&M cost estimates.
- A box to select a description for the environment surrounding the undergrounding project—urban, rural, or custom. This selection will affect whether the model uses the default urban property value, the default rural property value, or a user specified property value. It also affects whether the urban adder will be incorporated into the construction costs.
- Cells to enter nominal inflation and discount rates. The difference between the two is the real discount rate used in the net present value calculations.
- A cell to enter the time horizon for the analysis.

The worksheet named "Data" organizes the model input data from various sources. It is divided into three sections, one each for static, environment–varying, and utility–varying components. Static components are those input assumptions that probably do not change from project to project. They are:

- Collision frequency reduction—the number of automobile accidents eliminated each year because of the undergrounding project.

- Collision severity factor—the average equivalent lives saved per automobile accident eliminated.
- Value of life—the equivalent economic benefit of each life saved.
- Incremental interruption hours—the number of power interruption hours eliminated each year because of the undergrounding project.
- Energy usage rate—the average hourly power consumption of the customers experiencing fewer interruption hours after the undergrounding project.
- Cost of unserved energy—the value of energy demand not served.
- Property value improvement—the average percentage increase in value of the properties affected by the undergrounding project.

The only environment–varying component, i.e., an input assumption that depends on the nature of the project's surroundings, is the value of affected property, which represents the total value of properties affected by the undergrounding project.

Default urban and rural assumptions are provided for the environment varying components. The user can also enter a project specific (custom) assumption. Additionally, a check box in this section of the worksheet enables the user to indicate if the custom environment is urban. If the box is checked, the model will incorporate the urban adder into construction costs.

Utility–varying components are those input assumptions where the default values depend on the utility in whose service territory the undergrounding project is taking place. They are:

- Rural overhead electric, telecom, and cable construction costs—the cost per mile of constructing electric, telecom, and cable systems in a rural setting in an overhead configuration.
- Urban overhead construction cost adder—the increase in costs of constructing overhead electric, telecom, and cable systems in an urban setting.
- Rural underground electric, telecom, and cable construction costs—the cost per mile of constructing electric, telecom, and cable systems in an underground configuration.
- Urban underground construction cost adder—the increase in costs of constructing underground electric, telecom, and cable systems in an urban setting.
- Overhead O&M cost—the annual cost per mile of maintaining overhead electric, telecom, and cable systems.
- Underground O&M cost—the annual cost per mile of maintaining underground electric, telecom, and cable systems.

Default values for these components are provided for Companies A-D. The user can also enter a custom set of construction and O&M cost estimates in the custom column.

3.5.3 Model Inputs and Assumptions

Construction

Basis for construction cost input assumptions provided by Edwards and Kelcey for Companies A-D.

Operations and Maintenance

Basis for O&M cost input assumptions provided by Edwards and Kelcey for Companies A-D.

Automobile Accidents

The impact of undergrounding utility lines on the cost of automobile accidents is equal to the product of the collision frequency reduction, the collision severity factor, and the value of life.

Collision Frequency Reduction

Data collected by the Maryland State Highway Administration for the years 1994 through 2002 indicates that there is an average of 2,163 automobile accidents per year involving utility poles. If one assumes that accidents with utility poles are distributed evenly along the approximately 35,000 miles of primary and distribution lines in the state, then burying a mile of distribution lines will eliminate 0.062 collisions each year.

Collision Severity Factor

Collisions with utility poles can result in damage to property, injury, and death. Maryland State Highway Administration data on collisions with utility poles records the number and cost of each result. Though the method used for determining costs is unknown, the reported values were used to calculate an equivalent number of fatalities per accident, 0.02. This number is then used as a severity factor to convert value of life into total cost per accident.

Value of Life

We believe that for the purposes of this assessment, the appropriate value of life assumption is the $3.0 million recommended by the U.S. Department of Transportation (value of statistical life in Revision of Departmental Guidance on Treatment of the Value of Life and Injuries).1 The DOT describes its measure of value of statistical life (VSL) as representing, not the value placed on a particular life, but society's willingness to pay for safety measures

[1] http://ostpxweb.dot.gov/VSL_background.htm

that are expected to reduce the number of accidental fatalities by one. This measurement was selected for two reasons:

- It is categorically relevant in that the U.S. Department of Transportation's (DOT's) purpose for measuring VSL is similar to the need of the Maryland State Highway Administration.
- When comparing the U.S. DOT's VSL to other studies and government agencies' recommended value of life measurements, the DOT measure is neither at the high end nor the low end of the range of VSL values that have been proposed.

The DOT's VSL measure, originally published in the 1993 guidance memorandum Treatment of Value of Life and Injuries in Preparing Economic Evaluations, was based on two independent studies. One, by Dr. Ted R. Miller, was a meta–analysis of sources that addressed consumer purchases and the use of safety enhancing devices,2 as well as the additional compensation workers demand to accept risky jobs. Dr. Miller concluded from his analysis that the value of statistical life was equal to $2.2 million (1998 dollars). The other study, by Dr. W. Kip Viscusi, found VSL to lie in a range of $3 to $7 million. Referring to these studies, the U.S. DOT originally recommended using a VSL of $2.5 million. Since then, it has adjusted its VSL recommendation by the Gross Domestic Product implicit price deflator, resulting in the current value of $3.0 million.

A later (2000) meta–analysis of 68 studies by Dr. Miller estimated VSL at $3.67 million (1995 dollars). However, in this analysis Miller used the wage and salary component of the employment cost index, which grew more rapidly than the GDP implicit price deflator used by the U.S. DOT. A U.S. DOT memorandum released in January 2002 commented:

> "Recent years have seen a considerable expansion in the number of studies published and refinement in analytical techniques. However, it does not appear that newer estimates converge on a consensus value or range that would justify modification of our established standard, and some significant estimates continue to lie well below it. Therefore, for the present, we will continue to use the procedure adopted in the 1993 guidance."

[2] the systematic analysis of a set of existing evaluations of similar programs in order to draw general conclusions

Other federal agencies support the use of different VSL measures. For example, the current FDA Consumer Product Safety Commission uses a VSL of $5 million that is based on Viscusi's study, and the EPA has recommended an increase in its VSL from $6.4 million to $7.9 million.

Power Outages

The effect on power outages of undergrounding utility lines is modeled in the cost-benefit calculation as the product of reliability improvement (reduction in MWh of interrupted consumption) and the value of unserved energy.

Reliability Improvement

Information on the reliability impacts of undergrounding has been hard to come by, and where available, has been inconsistent. Maryland utility responses to a 1999 survey provided just six examples of comparable overhead and underground circuits. For each circuit a measure of reliability was reported. However, that measure only allows us to estimate the average benefit to a customer, in terms of interruption–hours reduced, of being fed by an underground circuit instead of an overhead circuit. The data do not provide any basis for estimating the reliability benefit of undergrounding a mile of line. Nor, in fact, are the data consistent. Of the six pairs of circuits reported on, five showed underground to be more reliable, while one showed overhead to be more reliable. Even within the five showing a benefit to undergrounding, the quantity of that benefit was highly variable. Thus, we were unable to reach a conclusion regarding the reliability benefit of undergrounding and recommend that data be developed on a case–by–case basis. Factored into this assessment would be the historical reliability of the circuit containing the section to be undergrounded, the section's share of total circuit overhead length, and the number, type, and consumption patterns of customers fed by the circuit. The model is structured to receive data on the change in the number of hours of interruption and the rate of energy consumption during those hours by the customers no longer interrupted.

Value of Unserved Energy

The value of unserved energy represents the value to consumers of avoiding incremental power supply interruptions. This value may be greater than the average price consumers are willing to pay for all their electricity requirements. In fact, we recommend that, for the analysis of undergrounding projects, the SHA assume a value of unserved energy of $3.00 per kWh. This is the number used by the Energy Information Administration (EIA) of the U.S. Department of Energy in its National Energy Modeling System.3 The National Energy Modeling System is used by EIA to develop its forecasts published in the Annual Energy Outlook and to answer specific policy–related questions posed by the U.S. Congress.

EIA bases its $3.00 per kWh assumption both on more direct studies of consumers willingness to pay for reliability and on its analysis of historical utility planning criteria and reserve margins. In the latter approach, the value of unserved energy is the market price of power required to support enough new generating plants to provide the desired level of reliability.

Aesthetics

The contribution of aesthetic improvements to the overall cost-benefit balance of undergrounding is a function of property values and the impact on property values.

Property Values

For our life-cycle cost-benefit model, we assumed that the value of properties lining 1 mile of road in an urban area is $9.5 million and in a rural area is $2.5 million. However, it should be noted that these values are highly speculative. The value of real property along any mile of roadway in the state of Maryland is very much location-specific. Further, users of the model should know that the values of specific properties are generally available to the public through a state-managed database of assessments for property taxes. This database may be accessed through the Internet at http://sdatcert3.resiusa.org/rp_rewrite. To arrive at our rough assumptions for urban and rural environments, we made use of housing density data published by the U.S. Census Bureau and average property sale price data published in the Maryland Department of Assessment and Taxation's 2003 Annual Report.

Property Value Improvement

It is our judgment that a figure of 2.5 percent represents a reasonable estimate for the potential improvement to the value of adjacent properties as a result of the undergrounding of utilities. Though there are no studies of the impact on property values of proximate distribution lines, several studies have investigated the impact of high voltage transmission lines. According to these studies, buyers and sellers adjust their valuation of property near transmission lines because of concerns regarding electromagnetic fields (EMFs) and because of the aesthetic impact of large transmission poles and towers. Since distribution lines require much smaller poles and produce much less intense electromagnetic fields than transmission lines, the impact of transmission lines on property values should represent an upper bound for the impact of distribution lines.

[3] Telephone conversation with staff member Lori Aniti (3/18/2003). See also pages 15 and 39 of *Electricity Prices in a Competitive Environment*, Energy Information Administration, 1997.

For our analysis of transmission line impacts, we relied primarily on two sources, a 2001 article by Mr. Thomas A. Jaconetty and a 1998 presentation by Ms. Cheryl Mitteness and Mr. Steve Mooney.[4,5] The Jaconetty article reviewed the results of at least six studies completed between 1967 and 1999 and covering widely divergent geographic regions. It concluded that a value loss of less than 10 percent "may be a reasonable expectation for residential properties." According to the Mitteness and Mooney presentation, a survey of owners, buyers, sellers, and appraisers in Minnesota and Wisconsin found that the effects on property value diminished when located more than 200 yards from power lines. In fact, only 66 percent of surveyed buyers believed that power lines had any impact on property values. And while 83 percent of appraisers believed that the proximity of transmission lines affected property values, the average impact was thought to be just 4.1 percent.

One factor that may have affected the range of impacts found in the various studies is the emergence of media attention to the purported cancer–causing effects of EMFs. The first high profile studies addressing the carcinogenic impacts of EMFs were published in 1987 and 1990. Though their conclusions were later disputed, these studies found that exposure to transmission wires resulted in an increased risk of childhood cancers. EMF risks also received widespread attention in December 1990, when it was discovered that the U.S. Environmental Protection Agency was delaying the release of an EMF study. Therefore, since EMF risks were not generally recognized before the late 1980s, earlier studies—which generally reported much smaller transmission line property value impacts—should better represent the potential impact of overhead distribution lines where EMF risks are also less recognized.

Based on the transmission data, one might consider assuming that distribution lines have no impact on property values. However, this seems unlikely given the willingness of communities across the country to pay for the significant cost of undergrounding. In fact, when Maryland utilities were charged with undertaking a sample undergrounding project for cost and impact research purposes in connection with a governor's Task Force on underground if overhead distribution lines, Task Force members received calls from several neighborhoods requesting to be the test case for the effort.

3.5.4 Model Report

Sample outputs of the Lifecycle Cost Benefit Model have been included in the Appendix of this report.

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[4] Jaconetty, Thomas A. "Do you want your children playing under those things?: The continuing controversy about high voltage electromagnetic fields, human health, and real property values." Assessment Journal; Chicago; May/June 2001.
[5] Mitteness, Cheryl M.B.A. and Steve Mooney Ph.D. "Power Line Perceptions: Their Impact on Value and Market Time". For presentation at the 1998 ARES Annual Meeting.

3.6 Thresholds at Which the Cost Benefit of Undergrounding Utilities Is More Advantageous Compared to Installing Utilities Overhead

There are no known thresholds, e.g. voltage type of service or otherwise at which the cost benefit of under grounding is more advantageous compared to installing utilities overhead.

Cost comparisons for pole-mounted and pad-mounted transformers can be found in Table 2 on the following page. Company B did not provide the requested transformer cost data.

The State Of Maryland requires that all new commercial and residential utilities are installed underground. Existing overhead utilities may be replaced in kind if necessary. This will include but not be limited to reconductoring, replacing, or repairing the existing overhead utilities.

Table 2. Transformer Cost Comparison

UTILITY	SINGLE PHASE OVERHEAD TRANSFORMER 120/240V	SINGLE PHASE UNDERGROUND TRANSFORMER 120/240V	THREE PHASE OVERHEAD TRANSFORMER 120/240V, 120/208V	THREE PHASE PADMOUNT TRANSFORMER 120/240V, 120/208V	THREE PHASE PADMOUNT TRANSFORMER 277/480V
Company A	25kva-$1,100 50kva-$1,400 100kva-$2,800 167kva-$5,000	25kva-$1,100 50kva-$1,400 100kva-$2,000 167kva-$2,500	75kva-$2,900 225kva-$5,600 300kva-$6,500 500kva-$13,700	150kva-$4,300 300kva-$6,100 500kva-7,600	750kva-$11,000 1000kva-$13,000 1500kva-$15,000 2000kva-N/A 2500kva-$27,000
Company B	NO COST DATA PROVIDED				
Company C	15kva-$500 25kva-$925 50kva-$1,350 100kva-$1,775 167kva-$2,200	25kva-$800 50kva-$1,267 100kva-$1,734 167kva-$2,200	45kva-$1,500 75kva-$2,775 150kva-$4,050 300kva-$5,325 500kva-$6,600	150kva-$3,500 300kva-$5,143 500kva-6,786 750kva-$8,429 1000kva-$10,072 1500kva-11,715 2000kva-$13,358 2500kva-15,000	150kva-$3,500 300kva-$5,714 500kva-7,928 750kva-$10,142 1000kva-$12,356 1500kva-14,570 2000kva-$16,784 2500kva-19,000
Company D	25kva-$475 50kva-$762 100kva-$1,190	25kva-$613 50kva-$821 100kva-$1,262 167kva-$1,680	150kva-$2,449 300kva-$3,570	75kva-$2,620 150kva-$3,231 300kva-4,110 500kva-$5,837 1000kva-$14,191	75kva-$2,755 150kva-$3,383 300kva-4,102 500kva-$7,109 1000kva-$9,203 1500kva-13,261 2000kva-$19,178 2500kva-18,080

3.7 Survey of Local Maryland Jurisdictions

3.7.1 Cost Responsibility

The cost of undergrounding utility lines requires a significant amount of capital outlay. The costs of the undergrounding can be borne in three ways: 1) full cost responsibility being borne by the utility; 2) cost responsibility being shared by the utility and a third party; and 3) full cost responsibility being borne by a third party. Under the scenario where full cost responsibility is borne by the utility, the traditional method of financing utility construction is followed. The utility would bear the cost of the project and have total control over the design and construction of the plant. The utility will begin to recover its investment in the plant when its rates are adjusted as a result of a rate case that included those costs. In the cost sharing scenario, the utility and a third party share in the total cost of project. Generally, this is done either by each of the parties being responsible for different aspects of design and construction of the plant, or where one or more party is responsible for the design and construction and a the other party is billed for it share of the construction costs. In the scenario where a third party is responsible for the design and construction of the project, a third party designs and constructs (to the utility's standards) the entire plant and transfers ownership and operation of the plant to the utility. The utility does not participate in the cost expenditures and therefore it does not have a direct investment in the plant. As a result, the plant is carried on the utility's books as contributed plant on which it does not earn a return.

Each of the methods of assigning cost responsibility entails specific concerns on the part of the utilities that must be addressed in order to get their cooperation. With respect to the scenario where the utility is responsible for the full costs, there is likely to be opposition from utility companies for two primary reasons. First, the electric utilities in Maryland are currently operating under rate freezes, and consequently, they are unable to recover any investment associated with undergrounding until the rate freezes expire. The rate freezes expire at different times for different utilities and at different times for different classes of customers within the same utility. All rate freezes expire no later than 2008 and some expire as early as 2004. Second, in order to underground utility lines, overhead lines must be removed from service. However, the investment in some overhead lines may not be fully recovered by the utilities. Therefore, they are not likely to favor undergrounding utility lines unless there is a means of compensation for the unrecovered investment in the overhead lines.

Even though the utility would be receiving contributed plant under the scenario where full cost responsibility is borne by third party, there are still concerns on the part of the utilities. Utilities generally oppose this method because they are concerned about losing control over the project, which could result in problems with system planning, as well as plant not being built to their standards. The second concern of utilities with respect to receiving contributed plant is that the value of contributed plant is taxed, for federal tax purposes, as revenue to the utility. Therefore, receiving contributed plant can trigger a significant increase in federal income taxes because utility plant is capital intensive.

In this cost sharing scenario, the concern of the utilities is a combination of both the scenario where cost responsibility is borne by the Company and the scenario where cost responsibility is borne by a third party. Under this scenario the utilities desire to have an arrangement where the cost being borne by the third party is not associated with an asset which will be transferred, and thus subject the utility to the tax on contributed property. The utility would also want to maintain an investment level that it can absorb given its cost recovery limitations. At the same time, the utility would want to keep a certain level of control over the part of the project being borne by the third party for reasons stated above.

3.7.2 Contributions In Aid of Construction

The value of plant contributed to a utility is recorded and classified as contribution in aid of construction (CIAC). Under Section 118(b) of the Internal Revenue Code (IRC) Section 118(b), the value of property transferred to a utility for provision of utility service is taxed as income to the utility receiving the property. Even if the property is sold to the utility at a below-market price, the amount by which the fair market price exceeds the sales price is considered CIAC. Water and sewer utilities are the only utilities not subject to the CIAC tax rules. IRC Section 118(b) allows water and sewer utilities to treat contributed plant as contributed capital, and therefore they are not taxed on the value of the contributed plant. According to one of the utilities operating in Maryland, another instance where the utility is not subject to CIAC tax on contributed plant is when plant is transferred by the Maryland State Highway Administration as a result of utility plant relocation related to work on the roadway. Such relocation work is not taxable because it generally involves moving existing utility plant from a previous right-of-way to a newly designated right-of-way to accommodate road construction. This relocation is considered a public convenience and necessity. As long as the plant was properly located within the previous right-of-way, the relocation to the newly designated right-of-way is not the fault of the utility and the utility is entitled to reimbursement for the relocation. In certain instances, the relocation of the plant is done by the state, and ownership of the relocated plant is then transferred to the utility. This arrangement is tantamount to the utility doing the relocation and being reimbursed by the transportation department. However, for projects that are conducted for purely aesthetic reasons, there is no public convenience and necessity. Thus, the utility would be subject to the CIAC tax if it accepts contributed plant from the SHA.

The tax burden created by the CIAC is a disincentive for utilities to accept contributed plant because the value of the plant investment can easily add up to several hundred million dollars. Typically, utilities pass on the CIAC tax to property contributors, rather than absorb the taxes. In other words, when a utility accepts contributed property, the property contributor transfers ownership of the property and also provides funds to compensate the utility for the CIAC tax. As a result, the utility is not put into a position where accepting the contributed property would be costly but the cost to the contributor associated with transferred property can be as high as 35 percent of the value of the property transferred.

3.7.3 Application of CIAC Tax on Recent Undergrounding Projects in Maryland

The towns of Ocean City and Elkton are two municipalities in Maryland that have recently engaged in projects to underground utility lines. According to both towns, they did not have to compensate the utilities for the CIAC tax.6 This was possible because the projects were both cost-sharing projects, as opposed to projects where the towns completed the project and transferred the assets to the utility.

The Ocean City project was undertaken for aesthetic reasons. The town was responsible for trenching and labor, while the utilities were responsible for the conduit, manholes, spacers and other material. At completion of the project, the utilities were left with only the investment they made in the project. There were no physical assets to be transferred. The other potential disincentive, the unrecoverd investment in existing plant, was eliminated because the town paid the utilities the value of the unrecovered investments.

The Elkton project differed from the Ocean City in that it was part of a larger project that included new road and sidewalk design. The project was a pilot that was funded by the State Highway Administration. The first two phases of the project, which involved design and construction of the utility infrastructure, are complete. The third phase, which involves removing overhead poles, wires, cross arms, splicing all new cable, etc., is currently in progress. The third stage will involve the utilities who will be responsible for the final tasks.

According to Elkton, the tax on CIAC has not been an issue, since no asset is expected to be transferred between the parties.[7] Hence there is no contributed plant that will subject the utilities to being taxed.

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[6] Based on meetings held during February and March 2003 involving the towns, the Maryland State Highway Administration, Edwards & Kelcey, and Exeter Associates.
[7] Ibid.

3.7.4 Comparison of Elkton and Ocean City Project Costs

The cost-per-mile of overhead distribution line converted to underground line differed markedly between the project undertaken in Ocean City and the project undertaken in Elkton. The fundamental reason underlying the much higher cost per mile incurred by Elkton relative to Ocean City was the fundamental difference in the scope of these two projects. The Elkton project was a revitalization effort that involved the undergrounding of overhead lines in the downtown area. The undergrounding effort entailed streets and sidewalks being torn up and replaced (as part of the revitalization/beautification goal). Additionally, the project was undertaken in stages to minimize disruption to downtown businesses. The Ocean City effort, in contrast, did not entail nearly as extensive an effort. The differential in cost, therefore, is not attributable to financing, management, or the relative efficiency of the contractors. Rather, it relates to the nature of the work performed.

3.7.5 Utility Undergrounding in Other States

According to a report on utility pole safety prepared by University Transportation Center for Alabama, the states of Florida, Georgia, New York and Pennsylvania each have utility pole safety programs. There are two observations with respect to the programs in the four states listed that should be mentioned. One is that the programs in these states are utility pole relocation programs rather than conversion of overhead lines to underground lines. The decision to relocate utility poles is generally governed by automobile accident statistics and transportation safety concerns.

The New York pole relocation program operates by tabulating traffic accidents involving utility poles during a seven-year period along each 0.1-mile road increment. Increments with more than five incidents or at least one death plus another accident in seven years is considered to be a pole targeted for removal.

The Florida program checks traffic accident histories for poles along road construction routes. An inspection is conducted to determine if the poles are in the clear zone (i.e., six feet behind the curb for a less than 35 mph speed zone or eight feet behind the curb for a greater than 35 mph speed zone). A pole that is closer to the curb than those parameters is placed on a relocation list if replacing that pole has a benefit:cost ratio of 2:1 or greater.

Georgia has a clear zone that is the same as Florida's. However, Georgia's program has a goal of relocating 250 poles per year over a 30-year period. Traffic accidents involving utility poles are tabulated over a three-year period and relocation priority is given to those poles with the highest traffic accident involvement rates.

The Pennsylvania program will target for relocation those poles that have been involved in three or more accidents within a 0.5 mile range over a five-year period. The state calls such poles "hit pole clusters." However, poles will be moved only when a substantial gain (five feet or more) is achievable.

In addition, we note that the utilities are generally responsible for the costs of relocating the poles, except in Pennsylvania, where the state shares the costs of relocation or undergrounding on a roughly equal basis with the utilities. With the exception of Pennsylvania, the states' programs are designed to move poles during highway construction, while Pennsylvania targets poles characterized by a significant number of automobile accidents. In other words, in Florida, Georgia and New York, when roadwork is being conducted, a data base of poles that are considered to be situated in a dangerous location is searched, and if they are in the area of the construction, they are targeted for relocation. However, Pennsylvania seeks to relocate poles that are involved in multiple automobile accidents whether or not there is roadway work being conducted in the area of the poles.

3.8 Summary of How Others Have Reduced the Costs Associated with Undergrounding Utilities

3.8.1 Town Of Ocean City, Maryland

The following information was obtained in a meeting with the Town Of Ocean City, Maryland on February 26, 2003.

Meeting Attendees:

Hal O. Adkins–Director, Town Of Ocean City, Public Works Administration – (410) 524-7715, Hadkins@ococean.com
J. David Vitchock, Whitman, Requardt And Associates, LLP – (410) 235-3450, dvitchock@wrallp.com
Milan Shah – SHA Assistant Utility Engineer – (410) 667-4095, mshah1@sha.md.us
Joseph Bissett – SHA Statewide Utility Engineer – (410) 545-5546, jbissett@sha.md.us
William H Albeck, Jr., Edwards & Kelcey – (703) 669-2180, balbeck@ekmail.com

The Project –Description

The purpose of the meeting was to determine how the Town Of Ocean City, Maryland is converting its overhead utilities to underground with lower than average construction costs.

The Town Of Ocean City, Maryland has incorporated utility conversions from overhead to underground into their planning projects. The town recognizes that the best time to convert utilities underground is in conjunction with proposed roadway work. Planning projects include replacement/repair of waterlines, san sewer lines, storm drains and any roadway improvements.

These projects typically encompass several blocks within the downtown area. The projects will be performed in the off-season between October and May. Ocean City, Maryland is a resort community where the town population increases substantially in the summer months.

When the scope of a planning project is defined and the limits of the geographic area have been determined, the Town Of Ocean City, Maryland Public Works Administration will utilize the services of a sub consultant to coordinate the conversion of all existing overhead utilities to underground. The sub consultant will coordinate with the utilities and obtain all proposed engineering drawings from the utilities. The sub consultant will then look at the proposed cable routes for each utility and make recommendations to the utilities to move their proposed cable routes in order to maximize one common trench for all utilities while maintaining the necessary horizontal and vertical separation as required by the National Electric Safety Code (NESC). Utilizing one common trench by all utilities results in substantial savings in trenching and construction costs.

It should be noted that a contractor hired by the Town Of Ocean City performs any paving or concrete work.

Costs

The general fund and General Obligation Bonds are used to pay for the conversion of utilities underground. General Obligation Bonds are sold and principle and interest payments are made over a 20-year period. Once the utilities have been converted underground, property values rise resulting in larger assessments for Ocean City. It is estimated that the aesthetics effects of underground utilities may increase the adjacent properties by two 2.5%. The additional monies collected through assessments are then put back into the General Fund and can be applied to the next utility conversion project.

The average cost to Ocean City to convert one block (approximately 300') of overhead utilities underground is approximately $150,000 for electric, telephone and CATV. This price includes all labor and material from the Town Of Ocean City and the utilities.

Labor

When the final cable routes, manholes, and above ground devices (switches, transformers, and pedestals) have been determined, the Town Of Ocean City installs the conduit system including manholes for all of the utilities utilizing its own work crews. Each utility has a representative on site to make decisions concerning field changes if they become necessary. The Town Of Ocean City supplies the trenching equipment and all labor for this task. Manholes, conduit, spacers and any other material are provided by the utilities. The conduit system is not required to be concrete encased. This work is performed in the off-season.

The following off-season, cable is installed into the conduit system, above pad mounted equipment is installed and all terminations completed by each utility.

Contribution in Aid of Construction

Hal O. Adkins–Director, Public Works Administration has indicated that the CIAC tax has not been assessed by any utility for work performed by the Town Of Ocean City.

Right-of-Way

Any required easements are negotiated with the affected property owners prior to any construction by the Town Of Ocean City and not by the utilities. It is the opinion of those in Town Of Ocean City that property owners are more receptive to them than the utility representatives. The majority of easements are granted. If an easement agreement cannot be negotiated with a property owner, then a modification is made to one of the public parallel parking spaces so that it can accommodate the necessary above ground equipment. The easement document is modified and prepared by a single utility to include all utilities. This allows for a single easement document to be recorded in the courthouse.

Underground Meter Bases

Electricians from the Town Of Ocean City install at the Towns expense new underground electric meter bases for each residence or business. For commercial businesses this may include a trough or CT cabinet. In some cases the underground cable is installed in a conduit vertically up the side of the home or business and connected at the weather head. This method is performed in about 40% of the existing services where major upgrades to the customers service panel would be necessary. This scenario requires no electrical inspection.

In other services not requiring a panel upgrade, new load-side conductor is pulled from the meter base to the customer's service panel box. A third party performs the electrical inspections. This work again is performed in one off-season if possible.

Reasons for Undergrounding

Burying the overhead utilities in Ocean City was done for purely aesthetic reasons. There were no reliability-outage related reasons for under grounding the utilities.

Advantages and Disadvantages of the Project

By incorporating utility conversions with roadway improvement projects Ocean City, Maryland is reducing construction costs and eliminating redundant work.

Maintenance costs of those utilities such as water lines may increase as a result of the placement of other utilities in the roadway. Replacement or repair of the water lines, storm drains or sanitary sewer lines could be slowed as a result of all the utilities located within the roadway.

Public Opinion

Hal O. Adkins–Director, Public Works Administration has stated that public opinion for these types of projects has been very positive. Property values as realized through assessments have risen significantly once the work is completed. Once overhead utilities have been removed the focus of those traveling along the roadway is now shifted to the homes and buildings. Property owners have taken those steps necessary for beautification of their property through landscaping, painting, etc.

3.8.2 Town Of Elkton, Maryland

The following information was obtained in a meeting with the Town Of Elkton, Maryland on March 18, 2003.

Meeting Attendees:

Joseph Bissett – SHA Statewide Utility Engineer – (410) 545-5546, jbissett@sha.md.us

Barry Clothier – SHA Dist. 2 – (410) 778-3061, bclothier@sha.state.md.us

Derek Cloud – Comcast const. coord. – (410) 398-3818 ext.108, derek_cloud@cable.comcast.com

Angel Collazo – Conectiv – (302) 454-4370

Joseph Enrico – Elkton Dir. of Public Works – (410) 392-6636

Beryl Gore – Town of Elkton – (410) 392-6636

Pat Hynes – Comcast – (302) 632-8072, pat_hynes@cable.Comcast.com

Chase Kappel – Exeter Associates, Inc. – (301) 622-4500, ckappel@exeterassociates.com

Scott Riddle – KCI Technologies – (410) 316-7912, sriddle@kci.com

Michael Rothenheber – JMT – (410) 410-316-2260

Dennis Schaefer – Verizon – (410) 224-6647

Stanford E. Sutphin – Corman Construction Inc. – (301) 925-0900

Robert Tucker – SHA – (410) 778-3061

The Pilot Project -Description

The Elkton pilot project was, a State Highway Administration (SHA) funded project. The Town of Elkton, MD was responsible for $600,000 in costs associated with the installation of new water lines, which were funded with a state grant. The existing overhead electric, cable and telephone were buried in conjunction with the proposed water lines. The sanitary sewer line was not replaced or modified. The Elkton project is not limited to the under grounding of overhead utility lines. It is part of a larger downtown renovation project called Streetscape that included a new road and sidewalk design and more attractive street lighting.

The project consists of three phases. The first phase included the design by KCI Technologies to create a conceptual design plan for the construction of the backbone infrastructure required for the under grounding of the utilities. This included the proposed duct bank including spares to accommodate the proposed cable routes of all utilities. Both parallel and joint trench were utilized. Minimal boring was required. At the completion of this phase, the conceptual plans were sent out for bidding by Design Build teams. The successful bidding team was Corman Construction and JMT Engineering. This second phase of work included finalizing of the construction plans by JMT and the actual construction of the utility infrastructure and streetscape features by Corman Construction. This work took approximately one year and is now complete. The third phase consists of the utilities removing overhead poles, wires, cross arms, down guys, transformers, protective devices etc. and terminating or splicing all new cables, switches, and transformers. Phase three could not commence until phase two was complete. This phase is projected to take in excess of a year and is in progress.

Streetscape and utility improvements included 3 blocks along Main Street for a distance of approximately 2200'. The underground infrastructure and other aesthetic improvements were completed in one-block segments, at a duration of four months for each segment. During the phase two year, traffic was shut down on the affected portion or roadway and traffic was detoured. This did have an impact on local businesses, as discussed below.

Costs

KCI Technologies was hired to do the initial infrastructure design; JMT finalized this design and provided construction-engineering services during the construction as Corman Construction installed the backbone for the system. KCI's design cost was $219,000, and KCI consulted on design changes during construction at an additional cost of approximate $75,000. JMT/Corman won the contract for the implementation of the infrastructure design at a total cost of $8,435,000, and this bid has been broken down by utility. See cost summary below. Corman Construction supplied most of the materials and labor to install the infrastructure. The gas utility (NUI Elkton Gas) supplied the gas line materials needed. Corman Construction installed all conduit, manholes, and pads to utility specifications.

Phase three final costs still outstanding, will come from Conectiv, Verizon and Comcast.

According to a Maryland Department of Transportation Press Release dated October 28, 2002, the cost of the Elkton "Neighborhood Conservation Program" is $12.4 million. A breakdown of all known costs is provided in a cost summary below.

Labor

The utilities involved in the relocation indicated that the use of non-utility labor to install the duct bank was unique to Elkton. The utilities provided an approved contractors list of who would be acceptable to install the infrastructure. It was proposed for this project to have one contractor install the conduit system for all utilities. Utilities typically install their own system using their own labor. For the Elkton project, the utilities had to grant permission to the Corman Construction Company to install the infrastructure. Once the infrastructure is completed, the utility companies utilizing their labor will pull all the proposed conductor, install all pad mounted equipment, make any necessary terminations or splices which may be required.

Contribution in Aid of Construction

The CIAC tax is not an issue since SHA paid for the project and no asset is considered to be changing parties.

Right-of-Way

There were 77 property owners on the three blocks of Main Street. The town negotiated any required rights-of-way from individual property owners, which allowed for the placement of facilities in private property. Conectiv required additional rights-of-way for seven pad sites (transformers, switches). These easements were again negotiated by Elkton. For those property owners who objected to any pad sites, the SHA acted as a mediator. All necessary easements were granted with only one property owner monetarily compensated by SHA in the amount of $3,000.00.

Underground Meter Bases

The conversion of electric utility lines underground requires the replacement of the existing overhead meter base to an underground meter base. Typically, the meter base is the responsibility of the customer, therefore the customer would bear all costs associated with the installation of an underground meter base by a private electrician including an electrical inspection. Customers on the Elkton project were given the option to replace the existing overhead meter base with an underground meter base at their expense or the utility would simply install conduit along the outside of the house to a point near the existing weather head where terminations can be made by the utility thus eliminating the need for a new meter base or an electrical inspection. The majority or customers on this project opted to utilize their existing overhead meter bases.

Reasons for Undergrounding

Burying the overhead utilities in Elkton was done for purely aesthetic reasons. There were no reliability-outage related reasons for under grounding the utilities. Mr. Collazo of Conectiv expressed his doubt that the conversion of the electric utilities to underground would result in fewer outages or improved reliability.

Advantages and Disadvantages of the Project

The utilities expressed concern that placing their facilities underground may result in longer outages due to troubleshooting the underground faults and safety hazards associated with the use of manholes.

Joseph Enrico, Elkton Director of Public Works who is responsible for the maintenance of the water lines in Elkton, expressed his concern that any future water line replacement costs would double as a result of the placement of other utilities in the roadway and any abandoned utilities located in the roadway. Replacement or repair of the water lines would be slowed as a result of all the utilities located within the roadway.

Public Opinion

A site visit was performed to speak with local business owners. Two businesses indicated that they were seriously affected by the construction because there was no sidewalk in front of their stores and parking was limited. Other businesses located in the initial block of construction again indicated there businesses were affected because the construction removed the existing sidewalk for a long period of time. Mr. Larry Drummonds, who runs a paintball store, said traffic in his store dropped by at least 80 percent during the time his block was under construction. On another block, the construction company removed the existing sidewalk towards the end of the construction period and put planks down so that people could walk and have access to the businesses.

Although many of the businesses were adversely affected during the time of the construction on Main Street, others were not. Colonial Jewelers had a record month in March 2002. Colonial Jewelers, a big proponent of Streetscape, said they strategically offered sales and did more advertising. Colonial Jewelers acknowledged that they were not as affected by not having a sidewalk as some other businesses.

Cost Summary

The following table summarizes the costs associated with this project:

Table 3. Elkton Pilot Project Costs

JMT Phase One	
Detail Build	$4,640,000
Comcast	$365,000
Conectiv	$1,170,000
Verizon	$625,000
Gas	$530,000
Water	$1,095,000
JCI total	$8,425,000
City of Elkton Water	$600,000
KCI Total Charges	$294,000
Right of Way	$3,000
Current Total	9,322,000
Phase Three estimates	Pending
Maryland DOT Total	**$12,400,000**

Differences Between Ocean City and Elkton Projects

There are many reasons for the differences in cost between Ocean City (OC) and Elkton. The city streets in Ocean City are almost twice as wide as Main Street in Elkton. Soil conditions in Ocean City make trenching much easier. More common trench between utilities was shared in Ocean City. Ocean City utilized its own labor to install the duct back thus reducing the installation costs. Main Street in Elkton is a one-lane, one-way street, while the Ocean City streets have at a minimum twice the width. Less space results in a "spaghetti effect" of under grounded utilities that is more costly to construct. Additionally, in Elkton, utilities that existed underground prior to construction were simply abandoned and not removed thus contributing to the underground congestion.

3.8.3 Proposed Town Run Utilities Project, Winchester, Virginia

The following information was obtained from a website for the City Of Winchester, Virginia and a phone conversation with Mr. Frank Sanders, Director Of Public Utilities on March 17, 2003.

Contact/Reference Information

Frank Sanders – Director Of Public Utilities City Of Winchester, Virginia – (540) 667-1815

Website address – www.ci.winchester.va.us/utilities/townrun.html

The Project -Description

The City Of Winchester, Virginia has a proposed Town Run Sewer Utilities Project. The proposed project will include the replacement of the existing 70-year-old sanitary sewer main, replacement of existing water mains and the construction of new storm drain facilities. This work will encompass an area from 844 Amherst Street to Boscawen Street and along Boscawen Street to Cameron Street, a distance of approximately .96 miles (5069'). Additionally, the project will include removing the existing overhead utilities and placing them underground. The overhead utilities include electric, telephone and cable TV. The overhead utility portion of the relocation will be along Boscawen Street from the intersection of Amherst Street to the intersection of Kent Street, a distance of approximately .580 miles (3062'). The relocated overhead utilities will be placed in an underground conduit system along Boscawen Street. Decorative streetlights will also be installed. The project is planned to take approximately one year to complete.

The proposed water improvements will eliminate multiple smaller pipes and replace them with a new 10" water main.

Costs

Anderson & Associates, consulting engineers were hired by the City Of Winchester to coordinate the utility relocation with the utilities. The affected utilities include Allegheny Power, Verizon Communications and Adelphia Cable. A breakdown of the estimated project cost by utility is listed below. The fees paid to Anderson & Associates have been dispersed among all the utilities and are included in the estimated project cost below. The total cost of the project including Sanitary Sewer improvements, Water System improvements, Drainage System Construction, Street Reconstruction and Burying of the Overhead Utilities is estimated at $5,609,000.00.

Labor

The utility conduit system, including manholes and pad locations will be installed by the sewer contractor to the utility specifications. The sewer contractor will provide all materials including manholes per utility specifications. A majority of the conduit will be installed utilizing one common trench. The necessary vertical and horizontal separation of each utility in the trench as required by the NEC and the utilities will be maintained. The projected progression of work will be installation of the gas lines followed by sewer then conduit for the utilities and finally sidewalk and roadway work. Once the backbone is completed, the utility companies utilizing their labor and will pull all the proposed conductor, install all pad-mounted equipment, make any necessary terminations or splices which may be required.

Contribution in Aid of Construction

The CIAC tax is not an issue. The utilities have not requested any CIAC tax from the Town Of Winchester.

Right-of-Way

This project required only one easement. The required easement has not been negotiated as of 3/27/03. All other conduit, cable, manholes and pad-mounted equipment will be located within the right-of-way. Pavement and parking areas will be used for the placement of proposed utility pad mounted equipment.

Underground Meter Bases

The conversion of electric utility lines underground requires the replacement of the existing overhead meter base to an underground meter base. Typically, the meter base is the responsibility of the customer, therefore the customer would bear all costs associated with the installation of an underground meter base by a private electrician including an electrical inspection. The Town Of Winchester has agreed to pay for the installation of new underground meter bases and the required electrical inspection. If the customer wishes to upgrade their existing service when the new underground meter base is installed , the Town Of Winchester has notified those customers that the Town Of Winchester will not bear any of the costs associated with the upgrade.

Reasons for Undergrounding

Burying the overhead utilities in Winchester, Virginia was done for purely aesthetic reasons. There were no reliability-outage related reasons for under grounding the utilities.

Advantages and Disadvantages of the Project

Mr. Frank Sanders-Director Of Public Utilities believes that by placing utilities underground you eliminate any opportunity for "wires down". In addition, the buried utilities will improve the aesthesis of the neighborhood for generations to come.

There is considerable concern by the Town Of Winchester that the project duration of one year, the blocking of streets, the removing of sidewalks and the everyday disruption to pedestrians may have a negative impact on project perception. Repairs may be more difficult because of the number of utilities in the roadway.

Public Opinion

The general comments of the community have been mixed. The public generally feels that the project will be painful while in the construction phase and will be widely appreciated when work is completed. The Town Of Winchester will have a hotline, website and will have flyers and mailers in an attempt to inform the public of the project as it progresses.

Estimated Project Cost

The following table summarizes the costs associated with this project:

Table 4. Winchester, Virginia Project Costs

Sanitary Sewer	$2,045,000
Water	$488,000
Drainage	$327,000
Streets	$711,000
Bury Utilities	$2,038,000
Total	**$5,609,000**

APPENDIX

Lifecycle Cost Benefit Comparisons

Incremental Benefit of Undergrounding Utilities

Table A.1. Lifecycle Cost Benefit Comparison – Company A, Urban

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Company A
Environment	Urban
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	**NPV**	**First Year Impact**	**Annually Recurring Impact**
Total Overhead Construction		949,344	
Total Underground Construction		4,961,933	
Construction Increment	-4,012,589	-4,012,589	
Overhead O&M			0
Underground O&M			0
O&M Increment	0		0
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		9,500,000	
Aesthetics Increment	237,500	237,500	
Total	-3,704,276	-3,775,089	3,720

NPV of Total Benefits	308,313
NPV of Total Costs	-4,012,589

NPV of Costs Exceeds NPV of Benefits

Table A.2 Lifecycle Cost Benefit Comparison – Company A, Rural

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Company A
Environment	Rural
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	**NPV**	**First Year Impact**	**Annually Recurring Impact**
Total Overhead Construction		691,680	
Total Underground Construction		4,350,139	
Construction Increment	-3,658,459	-3,658,459	
Overhead O&M			0
Underground O&M			0
O&M Increment	0		0
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		2,500,000	
Aesthetics Increment	62,500	62,500	
Total	-3,525,146	-3,595,959	3,720
NPV of Total Benefits	133,313		
NPV of Total Costs	-3,658,459		

NPV of Costs Exceeds NPV of Benefits

Table A.3. Lifecycle Cost Benefit Comparison – Company A, Custom

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Company A
Environment	Custom
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	NPV	First Year Impact	Annually Recurring Impact
Total Overhead Construction		691,680	
Total Underground Construction		4,350,139	
Construction Increment	-3,658,459	-3,658,459	
Overhead O&M			0
Underground O&M			0
O&M Increment	0		0
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		6,000,000	
Aesthetics Increment	150,000	150,000	
Total	-3,437,646	-3,508,459	3,720

NPV of Total Benefits	220,813
NPV of Total Costs	-3,658,459

NPV of Costs Exceeds NPV of Benefits

Table A.4. Lifecycle Cost Benefit Comparison – Company B, Urban

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Company B
Environment	Urban
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	**NPV**	**First Year Impact**	**Annually Recurring Impact**
Total Overhead Construction		947,707	
Total Underground Construction		4,712,189	
Construction Increment	-3,764,482	-3,764,482	
Overhead O&M			0
Underground O&M			0
O&M Increment	0		0
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		9,500,000	
Aesthetics Increment	237,500	237,500	
Total	-3,456,169	-3,526,982	3,720

NPV of Total Benefits	308,313
NPV of Total Costs	-3,764,482

NPV of Costs Exceeds NPV of Benefits

Table A.5 Lifecycle Cost Benefit Comparison – Company B, Rural

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Company B
Environment	Rural
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	**NPV**	**First Year Impact**	**Annually Recurring Impact**
Total Overhead Construction		690,730	
Total Underground Construction		4,006,517	
Construction Increment	-3,315,787	-3,315,787	
Overhead O&M			0
Underground O&M			0
O&M Increment	0		0
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		2,500,000	
Aesthetics Increment	62,500	62,500	
Total	-3,182,474	-3,253,287	3,720

NPV of Total Benefits	133,313
NPV of Total Costs	-3,315,787

NPV of Costs Exceeds NPV of Benefits

Table A.6. Lifecycle Cost Benefit Comparison – Company B, Custom

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Company B
Environment	Custom
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	**NPV**	**First Year Impact**	**Annually Recurring Impact**
Total Overhead Construction		690,730	
Total Underground Construction		4,006,517	
Construction Increment	-3,315,787	-3,315,787	
Overhead O&M			0
Underground O&M			0
O&M Increment	0		0
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		6,000,000	
Aesthetics Increment	150,000	150,000	
Total	-3,094,974	-3,165,787	3,720
NPV of Total Benefits	220,813		
NPV of Total Costs	-3,315,787		

NPV of Costs Exceeds NPV of Benefits

Table A.7. Lifecycle Cost Benefit Comparison – Company C, Urban

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Company C
Environment	Urban
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	**NPV**	**First Year Impact**	**Annually Recurring Impact**
Total Overhead Construction		1,015,238	
Total Underground Construction		8,314,627	
Construction Increment	-7,299,389	-7,299,389	
Overhead O&M			0
Underground O&M			0
O&M Increment	0		0
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		9,500,000	
Aesthetics Increment	237,500	237,500	
Total	-6,991,076	-7,061,889	3,720

NPV of Total Benefits	308,313
NPV of Total Costs	-7,299,389

NPV of Costs Exceeds NPV of Benefits

Table A.8. Lifecycle Cost Benefit Comparison – Company C, Rural

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Company C
Environment	Rural
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	NPV	First Year Impact	Annually Recurring Impact
Total Overhead Construction		835,718	
Total Underground Construction		7,102,075	
Construction Increment	-6,266,357	-6,266,357	
Overhead O&M			0
Underground O&M			0
O&M Increment	0		0
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		2,500,000	
Aesthetics Increment	62,500	62,500	
Total	-6,133,044	-6,203,857	3,720

NPV of Total Benefits	133,313
NPV of Total Costs	-6,266,357

NPV of Costs Exceeds NPV of Benefits

Table A.9. Lifecycle Cost Benefit Comparison – Company C, Custom

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Company C
Environment	Custom
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	**NPV**	**First Year Impact**	**Annually Recurring Impact**
Total Overhead Construction		835,718	
Total Underground Construction		7,102,075	
Construction Increment	-6,266,357	-6,266,357	
Overhead O&M			0
Underground O&M			0
O&M Increment	0		0
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		6,000,000	
Aesthetics Increment	150,000	150,000	
Total	-6,045,544	-6,116,357	3,720
NPV of Total Benefits	220,813		
NPV of Total Costs	-6,266,357		

NPV of Costs Exceeds NPV of Benefits

Table A.10. Lifecycle Cost Benefit Comparison – Company D, Urban

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Company D
Environment	Urban
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	NPV	First Year Impact	Annually Recurring Impact
Total Overhead Construction		628,320	
Total Underground Construction		3,295,829	
Construction Increment	-2,667,509	-2,667,509	
Overhead O&M			2,122
Underground O&M			791
O&M Increment	25,337		1,331
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		9,500,000	
Aesthetics Increment	237,500	237,500	
Total	-2,333,859	-2,430,009	5,051

NPV of Total Benefits	333,650
NPV of Total Costs	-2,667,509

NPV of Costs Exceeds NPV of Benefits

Table A.11. Lifecycle Cost Benefit Comparison – Company D, Rural

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Company D
Environment	Rural
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	**NPV**	**First Year Impact**	**Annually Recurring Impact**
Total Overhead Construction		549,120	
Total Underground Construction		2,906,957	
Construction Increment	-2,357,837	-2,357,837	
Overhead O&M			2,122
Underground O&M			791
O&M Increment	25,337		1,331
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		2,500,000	
Aesthetics Increment	62,500	62,500	
Total	-2,199,187	-2,295,337	5,051
NPV of Total Benefits	158,650		
NPV of Total Costs	-2,357,837		

NPV of Costs Exceeds NPV of Benefits

Table A.12. Lifecycle Cost Benefit Comparison – Company D, Custom

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Company D
Environment	Custom
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	NPV	First Year Impact	Annually Recurring Impact
Total Overhead Construction		549,120	
Total Underground Construction		2,906,957	
Construction Increment	-2,357,837	-2,357,837	
Overhead O&M			2,122
Underground O&M			791
O&M Increment	25,337		1,331
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		6,000,000	
Aesthetics Increment	150,000	150,000	
Total	-2,111,687	-2,207,837	5,051

NPV of Total Benefits	246,150
NPV of Total Costs	-2,357,837

NPV of Costs Exceeds NPV of Benefits

Table A.13. Lifecycle Cost Benefit Comparison – Custom, Urban

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Custom
Environment	Urban
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	NPV	First Year Impact	Annually Recurring Impact
Total Overhead Construction		885,152	
Total Underground Construction		5,321,144	
Construction Increment	-4,435,992	-4,435,992	
Overhead O&M			2,122
Underground O&M			791
O&M Increment	25,337		1,331
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		9,500,000	
Aesthetics Increment	237,500	237,500	
Total	-4,102,342	-4,198,492	5,051
NPV of Total Benefits	333,650		
NPV of Total Costs	-4,435,992		

NPV of Costs Exceeds NPV of Benefits

Table A.14. Lifecycle Cost Benefit Comparison – Custom, Rural

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Custom
Environment	Rural
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	**NPV**	**First Year Impact**	**Annually Recurring Impact**
Total Overhead Construction		885,152	
Total Underground Construction		5,321,144	
Construction Increment	-4,435,992	-4,435,992	
Overhead O&M			2,122
Underground O&M			791
O&M Increment	25,337		1,331
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		2,500,000	
Aesthetics Increment	62,500	62,500	
Total	-4,277,342	-4,373,492	5,051
NPV of Total Benefits	158,650		
NPV of Total Costs	-4,435,992		

NPV of Costs Exceeds NPV of Benefits

Table A.15. Lifecycle Cost Benefit Comparison – Custom, Custom

Lifecycle Cost Benefit Comparison
Incremental Benefit of Undergrounding Utilities

Utility Cost Data Source	Custom
Environment	Custom
Inflation Rate	2.5%
Discount Rate	6.0%
Study Years	30

All cost components are $/mile in first year dollars.
Positive dollar values are benefits, negative values are costs.

Component	NPV	First Year Impact	Annually Recurring Impact
Total Overhead Construction		885,152	
Total Underground Construction		5,321,144	
Construction Increment	-4,435,992	-4,435,992	
Overhead O&M			2,122
Underground O&M			791
O&M Increment	25,337		1,331
Collision Frequency Reduction			0.06
Severity Factor			0.02
Value of Life			3,000,000
Automobile Accidents Increment	70,813		3,720
Interruption Hours Reduction			0
Energy Usage Rate			0
Cost of Unserved Energy			3.00
Power Outages Increment	0		0
Property Value Improvement		0.025	
Value of Affected Property		6,000,000	
Aesthetics Increment	150,000	150,000	
Total	-4,189,842	-4,285,992	5,051

NPV of Total Benefits	246,150
NPV of Total Costs	-4,435,992

NPV of Costs Exceeds NPV of Benefits

Table A.16. Lifecycle Cost Benefit Comparison Data – Custom Urban Environment

Static Components

Collision Frequency Reduction	0.06	collisions
Collision Severity Factor	0.02	equivalent lives/collision
Value of Life	3000000	$/life
Incremental Interruption Hours		hrs
Energy Usage Rate		kWh/hr
Cost of Unserved Energy	3.00	$/kWh
Property Value Improvement	2.5	%

Environment Varying Components

	Urban	Rural	Custom
Value of Affected Property	9,500,000	2,500,000	6,000,000

Utility Varying Components

	Row	Company A	Company B	Company C	Company D	Custom	
Rural Overhead Electric Construction	2	300,960	300,010	444,998	158,400	301,092	$
Rural Overhead Telecom Construction	3	311,520	311,520	311,520	311,520	311,520	$
Rural Overhead Cable Construction	4	79,200	79,200	79,200	79,200	79,200	$
Urban Overhead Construction Adder	5	257,664	256,978	179,520	79,200	193,340	$
Total Overhead Construction	6	949,344	947,707	1,015,238	628,320	885,152	$
Rural Underground Electric Construction	7	2,193,206	1,849,584	4,945,142	750,024	2,434,489	$
Rural Underground Telecom Construction	8	2,075,040	2,075,040	2,075,040	2,075,040	2,075,040	$
Rural Underground Cable Construction	9	81,893	81,893	81,893	81,893	81,893	$
Urban Underground Construction Adder	10	611,794	705,672	1,212,552	388,872	729,722	$
Total Underground Construction	11	4,961,933	4,712,189	8,314,627	3,295,829	5,321,144	$
Overhead O&M	12				2,122	2,122	$/yr
Underground O&M	13				791	791	$/yr

Table A.17. Lifecycle Cost Benefit Comparison Data – Non-customized Urban Environment

Static Components

Collision Frequency Reduction	0.06	collisions
Collision Severity Factor	0.02	equivalent lives/collision
Value of Life	3000000	$/life
Incremental Interruption Hours		hrs
Energy Usage Rate		kWh/hr
Cost of Unserved Energy	3.00	$/kWh
Property Value Improvement	2.5	%

Environment Varying Components

	Urban	Rural	Custom
Value of Affected Property	9,500,000	2,500,000	6,000,000

Utility Varying Components

	Row	Company A	Company B	Company C	Company D	Custom	
Rural Overhead Electric Construction	2	300,960	300,010	444,998	158,400	301,092	$
Rural Overhead Telecom Construction	3	311,520	311,520	311,520	311,520	311,520	$
Rural Overhead Cable Construction	4	79,200	79,200	79,200	79,200	79,200	$
Urban Overhead Construction Adder	5	0	0	0	0	193,340	$
Total Overhead Construction	6	691,680	690,730	835,718	549,120	885,152	$
Rural Underground Electric Construction	7	2,193,206	1,849,584	4,945,142	750,024	2,434,489	$
Rural Underground Telecom Construction	8	2,075,040	2,075,040	2,075,040	2,075,040	2,075,040	$
Rural Underground Cable Construction	9	81,893	81,893	81,893	81,893	81,893	$
Urban Underground Construction Adder	10	0	0	0	0	729,722	$
Total Underground Construction	11	4,350,139	4,006,517	7,102,075	2,906,957	5,321,144	$
Overhead O&M	12				2,122	2,122	$/yr
Underground O&M	13				791	791	$/yr

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