REPORT OF THE
STATE CORPORATION COMMISSION

Fifth Annual Report on the Pilot Program to Place Certain Transmission Lines Underground

TO THE GOVERNOR,
THE COMMISSION ON ELECTRIC UTILITY REGULATION, AND THE JOINT COMMISSION ON TECHNOLOGY AND SCIENCE

COMMONWEALTH OF VIRGINIA
RICHMOND
2012

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STATE CORPORATION COMMISSION

December 1, 2012

TO: The Honorable Robert F. McDonnell, Governor of Virginia
Commission on Electric Utility Regulation
Joint Commission on Technology and Science

The State Corporation Commission is pleased to submit its fifth annual report regarding progress on the pilot program to construct qualifying electric transmission lines underground, as required by Chapter 799 of the 2008 Acts of Assembly (House Bill 1319), as amended.

Respectfully submitted,

Mark C. Christie
Chairman

James C. Dimitri
Commissioner

Judith Williams Jagdmann
Commissioner

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GLOSSARY OF TERMS

APCo	Appalachian Power Company
CPCN	certificate of public convenience and necessity
certificate	certificate of public convenience and necessity
Code	Code of Virginia
DVP	Dominion Virginia Power
Delmarva	Delmarva Power & Light Company
FERC	Federal Energy Regulatory Commission
General Assembly	Virginia General Assembly
Staff Guidelines	Commission's Staff Guidelines of Minimum Requirements for Transmission Line Applications Filed Under Code § 56-46.1 and the Utility Facilities Act
HB 1319	House Bill 1319
HPFF	high-pressure fluid-filled cable technology
JCOTS	Joint Commission on Technology and Science
kV	kilovolts
OH	overhead transmission lines
Option 1	preferred underground alternative using two transmission circuits
Option 2	underground alternative using one transmission circuit
SCC	State Corporation Commission
Staff	Commission Staff
UG	underground transmission lines
XLPE	cross-linked polyethylene solid dielectric cable

EXECUTIVE SUMMARY

House Bill 1319[1] ("HB 1319") of the 2008 Regular Session of the Virginia General Assembly ("General Assembly"), as amended[2] (the "Act"), collectively established a pilot program to construct four qualifying electrical transmission lines of 230 kilovolts ("kV") or less in whole or in part underground.[3] Among other provisions, the Act established the criteria necessary for certain transmission line projects to qualify for the pilot program. In addition, the Act directed the Commission to "report annually to the Commission on Electric Utility Restructuring,[4] the Joint Commission on Technology and Science, and the Governor on the progress of the pilot program by not later than December 1 of each year that this Act is in effect."

As of the date of this report, the Commission has approved three of Dominion Virginia Power's ("DVP") 230 kV transmission line projects for inclusion in the pilot program pursuant to the Act: (1) a two-mile segment of the Pleasant View–Hamilton transmission line in Loudoun County previously approved as an overhead line; (2) the 0.71-mile Beaumeade–NIVO transmission line in Loudoun County; and (3) the 3.7-mile Radnor Heights Project in Arlington County.[5] One more qualified transmission line of 230 kV or less may be approved for inclusion in the pilot program from utility applications submitted before July 1, 2014.

As required by the Act, the Commission will continue to file annual reports on December 1 of each year until the pilot program has been completed and will file a final report no later than December 1, 2014. The final report will include an analysis of the entire pilot program and make recommendations about the continued placement of transmission lines underground in the Commonwealth of Virginia, as required by the Act.

Although the primary focus of this report is the pilot program relative to the Act, the report also will address two experimental underground transmission line projects not directly encompassed by the Act,[6,7] both of which were approved by the Commission prior to enactment of the Act. The Commission believes that all relevant experience gained from these two experimental projects should be considered in conjunction with the projects under the Act for making recommendations about the placement of transmission lines underground in the Commonwealth of Virginia.

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[1] 2008 Va. Acts ch. 799 (*see* Appendix A).

[2] 2011 Va. Acts ch. 244 (extending the program for two years) (*see* Appendix A).

[3] The Act specified one qualifying project and directed the State Corporation Commission ("SCC" or "Commission") to approve three additional qualifying projects.

[4] The Commission on Electric Utility Restructuring, established pursuant to Chapter 885 of the 2003 Acts of Assembly, was continued, effective July 1, 2008, as the Commission on Electric Utility Regulation (Va. Code § 30-201).

[5] Appendix B provides the pilot status of all transmission line applications (230 kV or less) filed since the effective date of the Act, including those that did not qualify for the pilot program.

[6] The Commission approved the two experimental 230 kV underground projects to enable DVP to gain experience with cross-linked polyethylene ("XLPE") solid dielectric cable. These two experimental projects include the 2200-foot Clarendon-Ballston project in Arlington County and the 5.5-mile Garrisonville project in Stafford County (see Appendix C for additional details and Appendix D for construction updates and photographs).

[7] To date, the Commission has approved approximately 39 miles of 230 kV transmission lines for underground construction that employ high-pressure fluid-filled ("HPFF") cable technology. These underground lines are located in various areas of DVP's service territory, including Alexandria, Arlington, Fairfax, Norfolk, and underneath the York River. In most cases the lines were located underground in highly congested urban areas because overhead construction was not feasible.

I. BACKGROUND AND INTRODUCTION

A. Historical Background

The placement of electric transmission lines has long been a topic of intense public interest. While the vast majority of transmission lines in the United States have been constructed overhead, a small portion of such lines have been located underground, including in Virginia. In recent years the feasibility of placing more lines underground has been a topic of interest within the General Assembly. In 2005, the Joint Commission on Technology and Science ("JCOTS")[8] first began to study the technological feasibility of burying transmission lines. In 2007 JCOTS created the Underground Transmission Lines Advisory Committee to produce a policy statement with possible legislative implications for 2008. As a result of their deliberations, JCOTS and its Transmission Lines Advisory Committee developed an outline for proposed legislation for a pilot program to study the construction of underground transmission lines.

B. Legislation Establishing the Pilot Program

By legislation enacted in 2008 and amended in 2011,[9] the General Assembly established a pilot program to construct four qualifying electrical transmission lines of 230 kV or less, in whole or in part, underground. The Act directs the SCC to "report annually to the Commission on Electric Utility Restructuring, the Joint Commission on Technology and Science, and the Governor on the progress of the pilot program by no later than December 1 of each year that this [A]ct is in effect." In addition, the Act now states that the SCC "shall submit a final report to the Commission on Electric Utility Restructuring, the Joint Commission on Technology and Science, and the Governor no later than December 1, 2014, analyzing the entire program and making recommendations about the continued placement of transmission lines underground in the Commonwealth."

Specifically, the Act directs the SCC to approve as a qualifying project, and part of the pilot program, an approximately 1.8-mile section of DVP's Pleasant View–Hamilton transmission line, which had been granted a certificate of public convenience and necessity ("certificate" or "CPCN") for overhead construction by the SCC prior to the effective date of the Act, and to approve three additional qualifying projects from among "applications submitted by public utilities for certificates of public convenience and necessity for the construction of electrical transmission lines of 230 kilovolts or less filed between April 2, 2008, and July 1, 2014." For purposes of the Act, a project is qualified to be placed underground, in whole or in part, if it meets the following criteria:

[8] The JCOTS was created by the 1997 Virginia General Assembly as a permanent legislative commission to generally study all aspects of technology and science. Each year, the JCOTS identifies technological issues of interest, develops a work plan, and creates advisory committees to study those issues. Once the studies have been concluded, advisory committees issue their final reports and recommendations, including legislative proposals.

[9] 2008 Va. Acts ch. 799; 2011 Va. Acts ch. 244 (extending the program for two years) (*see* Appendix A).

1. An engineering analysis demonstrates that it is technically feasible to place the proposed line, in whole or in part, underground;

2. The estimated additional cost of placing the proposed line, in whole or in part, underground does not exceed 2.5 times the cost of placing the same line overhead, assuming accepted industry standards for undergrounding to ensure safety and reliability. If the public utility, the affected localities, and the State Corporation Commission agree, a proposed underground line whose cost exceeds 2.5 times the cost of placing the line overhead may also be accepted into the pilot program; and

3. The governing body of each locality in which a portion of the proposed line will be placed underground indicates, by resolution, general community support for the line to be placed underground.

The Act also includes language relative to (1) a presumption of need for lines that will complete a network for qualifying underground projects that provide only radial service, (2) lines that would need to be completed within a specific amount of time to facilitate an economic development agreement, (3) qualifying projects chosen pursuant to the Act but not fully recoverable as charges for new transmission facilities pursuant to § 56-585.1 A 4 of the Code of Virginia ("Code"), (4) the placement of existing or future overhead facilities in the same area or corridor as a pilot project, (5) a requirement that utilities must seek low-cost and effective means to improve the aesthetics of new overhead transmission lines and towers, and (6) the necessary documentation required in the event four applications meeting the requirements of the Act are not submitted to the SCC.

II. PILOT PROJECT SELECTION PROCESS

A. Scope of SCC's Legislative Responsibilities

The General Assembly, through the legislative process, imparts certain responsibilities upon the SCC relative to the regulation of electric utility companies, including the certification of proposed electric transmission lines. The Commission's authority and responsibility with regard to the construction of transmission lines is established by Title 56 of the Code, primarily by §§ 56-265.2[10] and 56-46.1. Specifically, § 56-265.2 of the Code requires public utilities to obtain certificates from the Commission in order to construct facilities for use in public utility service.[11] Section 56-46.1 of the Code establishes certain procedural requirements and identifies specific factors to be considered in the approval process. Additionally, the Commission is authorized to issue its own rules and regulations to facilitate the implementation

[10] Section 56-265.2 is part of the Utilities Facilities Act, § 56-265.1 *et seq*. of the Code of Virginia.

[11] This requirement is applicable to transmission lines not considered ordinary extensions or improvements in the usual course of business, including all transmission lines capable of carrying 138 kV.

of its statutory responsibilities. Furthermore, pursuant to the Act (and as noted above), the Commission was directed to select a number of qualifying transmission lines to be placed underground as part of the pilot program established by the Act.

B. Synopsis of the Transmission Line Application and Certification Process

A utility's application for a certificate to construct and operate a transmission line typically includes supporting written testimony for the certificate and a map and sketch of the applicant's preferred route, as well as other alternative routes that have been considered. Each application also includes other information in accordance with the Commission's Staff Guidelines of Minimum Requirements for Transmission Line Applications Filed Under Virginia Code Section 56-46.1 and the Utility Facilities Act ("Staff Guidelines"). The Staff Guidelines direct that the applicant address four major categories: (1) the necessity for the proposed project, including estimated cost; (2) a description of the proposed project and alternatives considered; (3) the impact of the line on scenic, environmental, and historic features, including impacts on residences and businesses; and (4) the health aspects associated with the electric and magnetic fields that will be generated by the proposed line.

Typically, after an application is filed, the Commission Staff ("Staff") reviews the application for general content, and the Commission enters an order for notice and hearing that usually provides for a Hearing Examiner to consider the case. Subsequently, any respondents may file testimony, the Staff develops a report or testimony on the application, and a formal regulatory proceeding ensues in accordance with the SCC's Rules of Practice and Procedure.[12] After a hearing including an opportunity public comment and development of the evidentiary record, the Hearing Examiner enters a report summarizing the evidentiary record and making recommendations on the application to the Commission. The applicant, respondents, and the Staff may file comments on the Hearing Examiner's report. Then, after reviewing the case, the Commission makes a decision and issues a final order and, if the proposed transmission line is approved, a certificate for the line and route is issued.

C. Outline of Pilot Project Selection Process

In accordance with the Act and in addition to reviewing an application for general content, need and routing, the Staff analyzes the potential for any proposed transmission line of 230 kV or less to be constructed underground and included in the pilot program. As part of this determination, the Staff may request additional technical and cost analyses not already included in the utility's application. In its report on the application, the Staff will comment on whether or not the proposed transmission line potentially meets the criteria to be a qualified project in accordance with § 4 of the Act and will recommend for or against inclusion of the transmission line in the pilot program. After the hearing, the Hearing Examiner will enter a report summarizing the evidentiary record and making findings and recommendations to the Commission, including recommending for or against inclusion of the line in the pilot program. Finally, if the proposed transmission line is granted a CPCN, the Commission also will decide for or against inclusion of the line in the pilot program.

[12] 5 VAC 5-20-10 *et seq*.

III. PILOT PROGRAM PROGRESS

A. Introduction

As previously stated, the Act established a pilot program to construct four qualifying electrical transmission lines of 230 kV or less in whole or in part underground. For the first pilot project, the Act directed the SCC to approve an approximately 1.8-mile section of DVP's Pleasant View–Hamilton 230 kV transmission line, which originally had been granted a CPCN for overhead construction by the SCC prior to the effective date of the Act. In addition, the Act directed the SCC to approve three other qualifying projects from among applications submitted by public utilities for the construction of electrical transmission lines of 230 kV or less filed between the effective date of the Act and July 1, 2014.

From the effective date of the Act through November 1, 2012, the SCC received 24 applications from public utilities for CPCNs for the construction of electrical transmission lines of 230 kV or less. Delmarva Power & Light Company ("Delmarva") submitted one application and Appalachian Power Company ("APCo") submitted six applications for 138 kV overhead transmission lines. DVP submitted 13 applications for overhead transmission lines, one application for an overhead/underground hybrid, and three applications for 230 kV underground transmission lines, one of which, in accordance with the Act, was for a portion of a transmission line previously approved by the SCC as an overhead line. Brief summaries of the three transmission line applications approved for the pilot program are provided below. The pilot status of all transmission line applications (230 kV or less) filed since the effective date of the Act, including those that did not qualify for the pilot program, are provided in Appendix B.

B. Transmission Lines Approved for the Pilot Program

From the effective date of the Act through November 1, 2012, DVP filed three applications for approval and issuance of CPCNs to construct and operate the following 230 kV transmission lines as pilot projects pursuant to the Act:

- DVP Pleasant View–Hamilton Project: 2-mile underground segment, 230 kV XLPE[13] cable, mostly on the W&OD Trail in Loudoun County (Case Number PUE-2005-00018, modified by Case Numbers PUE-2008-00027 and PUE-2008-00042). The Commission approved the request in accordance with the Act on May 28, 2008. The transmission line was energized in October 2010.

- DVP Beaumeade–NIVO Project: 0.71-mile, 230 kV XLPE underground transmission cable in Loudoun County. DVP requested the line be included as a pilot project, and the Loudoun County Board of Supervisors approved a resolution on September 2, 2008, indicating general community support for the line to be placed underground. The Commission approved the request in accordance with the Act on

[13] Although the dominant underground transmission line technology in the United States for decades has been HPFF pipe, XLPE is considered by some as an emerging technology that is gaining in popularity and use at certain voltages. XLPE cable often is referred to as "extruded" cable because of the method used to apply the solid polyethylene insulation to the electrical conductor. Cost is often noted as an advantage of XLPE over HPFF.

January 26, 2009 (Case Number PUE-2008-00063).[14] The line was energized in July 2010.

- DVP Radnor Heights Project: 3.7-mile, 230 kV XLPE/HPFF hybrid underground transmission line in Arlington County. DVP requested the line be included as a pilot project, and the Arlington County Board approved a resolution on July 10, 2010, indicating general community support for the line to be placed underground. The Commission approved the request in accordance with the Act on July 21, 2010 (PUE-2010-00004). The transmission line's target in-service date is the 4th Quarter of 2012.

Summaries of two other experimental underground transmission projects, approved separately from the Act, are provided in Appendix C.

C. Related Developments

In March 2010, Old Dominion Electric Cooperative and North Carolina Electric Membership Corporation (later joined by several other cooperatives) filed a complaint at the Federal Energy Regulatory Commission ("FERC") against DVP, alleging, among other issues, that it was improper to include the costs of constructing certain facilities underground, including projects built as pilot projects pursuant to the Act because the facilities were placed underground for aesthetic reasons and not for reliability purposes. In September 2012, the parties submitted briefs to FERC regarding whether the incremental undergrounding costs should be included in the FERC rate or borne entirely by DVP's retail customers. The treatment of such costs will be determined by FERC. The parties negotiated a settlement for the remaining issues.

IV. CONCLUSIONS

The SCC has regulated a pilot program to construct four qualifying electrical transmission lines of 230 kV or less, in whole or in part, underground as required by the Act. This report primarily addresses the status of 24 transmission lines that either have been or are being evaluated for inclusion in the pilot program. The 24 transmission lines are identified in Appendix B.

As of the date of this report, three transmission lines have been approved for inclusion in the pilot program, two of which have been completed. As required by the Act, one more

[14] The SCC hearing convened on January 26, 2009, and the Commission issued its Final Order on May 29, 2009. In its Final Order, the Commission noted that if the cost to ratepayers was the overriding concern in this proceeding, the proposed transmission line would be constructed overhead at a total cost of $7.9 million. However, DVP proposed to install the line as an underground pilot project pursuant to HB 1319. The Staff examined the proposed project under HB 1319 and recommended that the project might qualify as a pilot project and that it would provide DVP with additional experience regarding use of XLPE cable. The Hearing Examiner concluded that (1) it is technically feasible to construct the line underground; (2) the cost of installing the underground line is 1.3 times the cost of installing an overhead line; and (3) the governing body of Loudoun County has expressed its support for undergrounding the line. The Commission agreed with the Hearing Examiner that DVP's proposal complied with the requirements of HB 1319 and approved construction of the line underground as a pilot project.

qualified transmission line may be approved for inclusion in the pilot program by 2014. Separate from the Act, the Commission also has approved the construction of two other experimental underground transmission line projects, one of which has been completed.

Experience gained from the analysis and construction of these projects will provide insight for evaluating the potential efficacy of placing transmission lines underground. Although construction of some of these projects is incomplete, it appears at this early stage that underground construction costs may be highly variable and project dependent, particularly with respect to topography and soil conditions.

A summary of the estimated costs for these experimental and pilot projects, as well as comparisons with overhead cost estimates, is provided in Table 1. In addition, attached as Appendix D to this report is an evaluation from DVP that presents a more detailed synopsis and construction photographs of DVP's underground transmission projects.

As provided by the Act, the Commission will continue to file annual reports on December 1 of each year and will file a final report no later than December 1, 2014. The final report will include an analysis of the entire pilot program and make recommendations about the continued placement of transmission lines underground in the Commonwealth.[15]

[15] The 2010 Virginia General Assembly enacted legislation addressing the undergrounding of transmission lines. *See* Chapter 392 of the 2010 Acts of Assembly for amendments to § 15.2-2404 F of the Code concerning localities' imposition of taxes related to underground transmission lines.

Table 1. Costs for Experimental and Pilot Underground ("UG") Transmission Projects and Comparisons with Overhead ("OH") Estimates

Project	Length (miles)	Estimated OH Cost		Actual or Estimated UG or Hybrid Cost		Ratio of UG to OH Costs
		Project	Line Mileage	Project	Line Mileage	Mileage Basis
Pilot Program for Underground Transmission Projects Pursuant to the Act						
Pleasant View–Hamilton	10 OH/ 2 UG	$69.6 million	$7 million per mile	$90.4 million (57.5 OH + 32.9 UG)(actual)	$12.1 million per mile (UG section)	1.7
Beaumeade–NIVO	0.71	$7.9 million	$4.2 million per mile	$9.8 million (actual)	$6.9 million per mile	1.6
Radnor Heights	6.3	$280 million	$39 million per mile	$81 million (est.)	$8.3 million per mile	<1
Experimental Underground Projects Unrelated to the Pilot Program						
Clarendon–Ballston	0.42	N/A	N/A	$24.9 million (actual)	$14.7 million per mile	N/A
Garrisonville	11	$14.16 million	$0.9 million per mile	$137.6 million (est.)	$10.8 million per mile	12

Table 1 Notes:

1. Total project costs include transmission work at substations, transition station costs for hybrid lines, and land acquisition costs (if applicable). Project costs do not include distribution work at substations.
2. Line mileage costs do not include transition stations or transmission work at substations, which could distort the mileage cost for short underground segments. DVP estimates the cost per mile for Pleasant View-Hamilton would have been $2 million higher but for the fact that DVP already owned the land on the W&OD Trail.
3. The OH estimate for Garrisonville assumes $10 million (2006) for overhead line construction and $4.76 million to construct the Garrisonville switching station. DVP reportedly indicated a willingness to mitigate visual impacts by using galvanized steel monopoles and routing the line down the center of the right-of-way, which would have changed the original estimate submitted with the application for the line from $9.4 million to $10 million (Hearing Examiner's Report, PUE-2006-00091, p.50).
4. The OH estimate for Radnor Heights is high due to the densely developed, urban nature of the area, which contains numerous national monuments and historic resources.
5. DVP did not analyze an overhead option for Clarendon–Ballston.
6. The breakdown of estimated underground project costs is provided as follows:
   (a) Pleasant View–Hamilton: $32.9 million; total includes $5.4 million for transmission work at Hamilton Substation and $3.3 million for terminal stations and land
   (b) Beaumeade–NIVO: $9.8 million; total includes $4.9 million in substation transmission work
   (c) Radnor Heights: $81 million; total includes $28.6 million in substation transmission work
   (d) Clarendon–Ballston: $24.9 million; total includes $18.7 million in substation transmission work
   (e) Garrisonville: $137.6 million; includes $11.9 million in substation transmission work
7. For purposes of estimating mileage costs, DVP notes that Radnor Heights (3.7 mile route) and Garrisonville (5.5 mile route) are effectively 6.3 and 11 miles long, respectively, given they consist partially or totally of networked transmission lines with two distinct underground paths.

APPENDIX A

HOUSE BILL 1319
(CHAPTER 799 OF THE 2008 ACTS OF ASSEMBLY)

HOUSE BILL 2027
(CHAPTER 244 OF THE 2011 ACTS OF ASSEMBLY)

CHAPTER 799

An Act to establish a pilot program to place certain transmission lines underground.

[H 1319]

Approved April 2, 2008

Be it enacted by the General Assembly of Virginia:

1. *§ 1. There is hereby established a pilot program to construct qualifying electrical transmission lines of 230 kilovolts or less in whole or in part underground. Such pilot program shall consist of a total of four qualifying electrical transmission line projects, constructed in whole or in part underground, as set forth in this act.*

§ 2. A. Notwithstanding any other law to the contrary, as a part of the pilot program established pursuant to this act, the State Corporation Commission shall approve as a qualifying project a transmission line of 230 kilovolts or less that has received a certificate of public convenience and necessity from the State Corporation Commission prior to the effective date of this act that approved construction of an electrical transmission line in a right of way located upon land owned by a regional park authority used by the general public for park and recreation purposes, provided that the construction of such electrical transmission line has not commenced prior to the effective date of this act. The project shall be constructed in part underground, and the underground portion shall consist of a double circuit.

The State Corporation Commission shall approve such underground construction within 30 days of receipt of the written request of the public utility to participate in the pilot program pursuant to this section. The Commission shall not require the submission of additional technical and cost analyses as a condition of its approval, but may request such analyses for its review. The Commission shall approve the underground construction of one contiguous segment of the transmission line that is approximately 1.8 miles in length that was previously approved for construction upon or immediately adjacent to the right of way of the regional park authority, provided that the underground construction shall be located within the boundaries of such existing right of way upon the land owned by the regional park authority, excluding any substation or transition locations which may be required as a part thereof. The Commission shall make a finding establishing the termini of the underground portion of the line. The remainder of the construction for the previously approved transmission line shall be aboveground pursuant to the terms of the certificate of public convenience and necessity. The Commission shall not be required to perform any further analysis as to the impacts of this route, including environmental impacts or impacts upon historical resources.

The approval for constructing the above-described portion of the previously approved electrical transmission line as a double circuit underground shall not impair or delay the implementation of the certificate of public convenience and necessity and no further notice, testimony, or hearings shall be required in connection with such approval. The electric utility may proceed to acquire right of way and take such other actions as it deems appropriate in furtherance of the construction of the approved transmission line, including acquiring the cables necessary for the underground installation. Approval of a transmission line pursuant to this section for inclusion in the pilot program shall be deemed to satisfy the requirements of § 15.2-2232 and local zoning

ordinances with respect to such transmission line and any substations or transition locations that may be required.

B. If the qualifying project approved in subsection A provides only radial, rather than networked, electric service, there shall be a presumption of need in applications filed for a certificate of public convenience and necessity for electrical transmission lines that will complete the network for such qualifying project. The State Corporation Commission shall give priority on its docket for any such application of a public utility. Upon written request of the public utility for participation in the pilot program pursuant to this section, the Commission shall approve the construction of such additional network facilities in whole or in part underground, and such additional network facilities shall be considered a qualifying project for purposes of this act. The Commission shall not require the submission of additional technical and cost analyses as a condition of such approval, but may request such analyses for its review.

§ 3. In reviewing applications submitted by public utilities for certificates of public convenience and necessity for the construction of electrical transmission lines of 230 kilovolts or less filed between the effective date of this act and July 1, 2012, the State Corporation Commission shall approve three applications for qualifying projects to be constructed in whole or in part underground, as a part of the pilot program. The three qualifying projects shall be in addition to the qualifying project described in subsection A of § 2. If a public utility submits an application for a certificate of public convenience and necessity for an electrical transmission line that completes the network for a qualifying project as set forth in subsection B of § 2, the approval of such application shall constitute one of the three additional projects to be approved pursuant to this section.

§ 4. For purposes of this act, a project shall be qualified to be placed underground, in whole or in part, if it meets all of the following criteria:

1. An engineering analysis demonstrates that it is technically feasible to place the proposed line, in whole or in part, underground;

2. The estimated additional cost of placing the proposed line, in whole or in part, underground does not exceed 2.5 times the cost of placing the same line overhead, assuming accepted industry standards for undergrounding to ensure safety and reliability. If the public utility, the affected localities, and the State Corporation Commission agree, a proposed underground line whose cost exceeds 2.5 times the cost of placing the line overhead may also be accepted into the pilot program; and

3. The governing body of each locality in which a portion of the proposed line will be placed underground indicates, by resolution, general community support for the line to be placed underground.

§ 5. A. If the State Corporation Commission identifies an application as a potentially qualified project for purposes of the pilot program, the Commission shall request that the public utility provide technical and cost analyses for placing the proposed line overhead and for placing the proposed line, in whole or in part, underground.

B. If any application relates to the construction of a proposed line to meet a specific and identifiable industry's needs, and the project must be completed by the public utility within a

specific amount of time to facilitate an economic development agreement, then such application need not include the two analyses, so long as the public utility provides documentation regarding the economic development agreement.

§ 6. The State Corporation Commission shall report annually to the Commission on Electric Utility Restructuring, the Joint Commission on Technology and Science, and the Governor on the progress of the pilot program by no later than December 1 of each year that this act is in effect. The State Corporation Commission shall submit a final report to the Commission on Electric Utility Restructuring, the Joint Commission on Technology and Science, and the Governor no later than December 1, 2012, analyzing the entire program and making recommendations about the continued placement of transmission lines underground in the Commonwealth.

§ 7. For any qualifying project chosen pursuant to this act (regardless of whether such project is chosen pursuant to § 2 or 3) and not fully recoverable as charges for new transmission facilities pursuant to subdivision A 4 of § 56-585.1, the State Corporation Commission shall approve a rate adjustment clause. The rate adjustment clause shall provide for the full and timely recovery of any portion of the cost of such project not recoverable under applicable rates, terms, and conditions approved by the Federal Energy Regulatory Commission and shall include the use of the fair return on common equity most recently approved in a Commission proceeding for such utility, as defined by subsection A of § 56-585.1. Such costs shall be entirely assigned to the utility's Virginia jurisdictional customers. The Commission's final order regarding any petition filed pursuant to this subsection shall be entered not more than three months after the filing of such petition.

§ 8. If a transmission line is included in the pilot program pursuant to § 3 that includes only radial, rather than networked, electric service, there shall be a presumption of need in applications for a certificate of public convenience and necessity for electrical transmission lines that will complete the network for such qualifying project. The State Corporation Commission shall give priority on its docket for any such application of a public utility.

§ 9. Approval of a proposed transmission line for inclusion in this program shall not preclude the placing of existing or future overhead facilities in the same area or corridor by other transmission projects.

§ 10. Public utility companies granted a certificate of public convenience and necessity for a proposed transmission line not included in this program or not otherwise being placed underground shall seek to implement low-cost and effective means to improve the aesthetics of new overhead transmission lines and towers.

§ 11. The provisions of this act shall not be construed to limit the ability of the State Corporation Commission to approve additional applications for placement of transmission lines underground.

§ 12. If four applications are not submitted to the State Corporation Commission that meet the requirements of this act, the State Corporation Commission shall document the failure of the projects to qualify for the pilot program in order to justify approving fewer than four projects to be placed underground, in whole or in part.

§ 13. Insofar as the provisions of this act are inconsistent with the provisions of any other law or local ordinance, the provisions of this act shall be controlling.

2. That an emergency exists and this act is in force from its passage.

Legislative Information System

CHAPTER 244

An Act to amend and reenact §§ 3 and 6 of the first enactment of Chapter 799 of the Acts of Assembly of 2008, relating to a pilot program to place certain electric transmission lines underground.

[H 2027]

Approved March 18, 2011

Be it enacted by the General Assembly of Virginia:

1. That §§ 3 and 6 of the first enactment of Chapter 799 of the Acts of Assembly of 2008 are amended and reenacted as follows:

§ 3. In reviewing applications submitted by public utilities for certificates of public convenience and necessity for the construction of electrical transmission lines of 230 kilovolts or less filed between ~~the effective date of this act~~ *April 2, 2008,* and July 1, ~~2012~~ *2014*, the State Corporation Commission shall approve three applications for qualifying projects to be constructed in whole or in part underground, as a part of the pilot program. The three qualifying projects shall be in addition to the qualifying project described in subsection A of § 2. If a public utility submits an application for a certificate of public convenience and necessity for an electrical transmission line that completes the network for a qualifying project as set forth in subsection B of § 2, the approval of such application shall constitute one of the three additional projects to be approved pursuant to this section.

§ 6. The State Corporation Commission shall report annually to the Commission on Electric Utility Restructuring, the Joint Commission on Technology and Science, and the Governor on the progress of the pilot program by no later than December 1 of each year that this act is in effect. The State Corporation Commission shall submit a final report to the Commission on Electric Utility Restructuring, the Joint Commission on Technology and Science, and the Governor no later than December 1, ~~2012~~ *2014*, analyzing the entire program and making recommendations about the continued placement of transmission lines underground in the Commonwealth.

APPENDIX B:
PILOT STATUS OF TRANSMISSION LINE APPLICATIONS (230 KV OR LESS)

This Appendix provides the status for all transmission line applications of 230 kV or less submitted since the effective date of the Act, including those that either did not qualify for the program or have yet to be evaluated. From the effective date of the Act through November 1, 2012, the SCC received 24 applications from public utilities for certificates for the construction of electrical transmission lines of 230 kV or less. Delmarva submitted one application and APCo submitted six applications for 138 kV overhead transmission lines. DVP submitted 13 applications for overhead transmission lines, one application for an overhead/underground hybrid, and three applications for 230 kV underground transmission lines, one of which, in accordance with the Act, was for a portion of a transmission line previously approved by the SCC as an overhead line. Brief summaries of these transmission line applications are provided below. Table 2 in this Appendix also summarizes the extent to which each transmission line meets the criteria necessary to qualify for the pilot program, as well as the status of each line.

DVP Transmission Lines

From the effective date of the Act through November 1, 2012, DVP filed 17 applications for approval and issuance of certificates to construct and operate the following 230 kV transmission lines:

- Pleasant View–Hamilton: 2-mile underground segment, 230 kV XLPE cable, mostly on the W&OD Trail in Loudoun County, Virginia (Case Number PUE-2005-00018, modified by Case Numbers PUE-2008-00027 and PUE-2008-00042). The Commission approved the request in accordance with the Act on May 28, 2008. The transmission line was energized in October 2010.

- Beaumeade–NIVO: 0.71-mile, 230 kV XLPE underground transmission cable in Loudoun County. DVP requested the line be included as a pilot project, and the Loudoun County Board of Supervisors approved a resolution on September 2, 2008, indicating general community support for the line to be placed underground. The Commission approved the request in accordance with the Act on January 26, 2009 (Case Number PUE-2008-00063). The line was energized in July 2010.

- Hayes–Yorktown: 8-mile, 230 kV overhead/underground hybrid transmission line in York County, Virginia, and Gloucester County, Virginia. HPFF underground construction is being proposed for 3.8 miles in order to cross the York River. The Commission determined the line should not be considered as an underground pilot project relative to the Act (Case Number PUE-2009-00049).

- Remington CT–Gainesville: 25-mile, 230 kV overhead transmission line in Fauquier County, Virginia, and Prince William County, Virginia. The line will be located on structures to be constructed for the new Meadowbrook–Loudoun 500 kV transmission line approved in Case Number PUE-2007-00031. The Commission determined the line should not be considered as an underground pilot project relative to the Act (Case Number PUE-2009-00050).

- Loudoun–New Road: 4-mile, 230 kV overhead transmission line in Loudoun County, Virginia, and Prince William County, Virginia. The Commission determined

the line should not be considered as an underground pilot project relative to the Act (Case Number PUE-2009-00134).

- Ballston–Radnor Heights: 3.7-mile, 230 kV underground transmission line project in Arlington County, Virginia. DVP requested the line be included as a pilot project, and the Arlington County Board approved a resolution on July 10, 2010, indicating general community support for the line to be placed underground. The Commission approved the request in accordance with the Act on July 21, 2010 (Case Number PUE-2010-00004). The transmission line's target in-service date is 4th Quarter 2012.

- Landstown–Virginia Beach: 11-mile, 230 kV overhead transmission line rebuild in Virginia Beach, Virginia. The Commission authorized the Company to rebuild an overhead transmission line (Case Number PUE-2010-00012).

- Hopewell–Prince George: 3-mile, 230 kV overhead transmission line in the City of Hopewell, Virginia, and Prince George County, Virginia. The Commission authorized the Company to construct an overhead transmission line on existing right-of-way (Case Number PUE-2010-00032).

- Cannon Branch–Cloverhill: 2-mile, 230 kV overhead transmission line in the City of Manassas, Virginia, and Prince William County, Virginia. The Commission determined that the project does not meet the criteria necessary for consideration as an underground pilot project relative to the Act (Case Number PUE-2011-00011).

- Hollymead Tap: 8-mile, 230 kV overhead transmission line in Albemarle County, Virginia. The Commission determined that the project does not meet the criteria necessary for consideration as an underground pilot project relative to the Act (Case Number PUE-2011-00015).

- Bremo–Dooms: 43-mile, 230 kV overhead transmission line in Albemarle County, Virginia, and Fluvanna County, Virginia. The Commission determined that the project does not meet the criteria necessary for consideration as an underground pilot project relative to the Act (Case Number PUE-2011-00039).

- Lakeside–Northwest: 12-mile, 230 kV overhead transmission line in Henrico County, Virginia, and Hanover County, Virginia. The Commission determined that the project does not meet the criteria necessary for consideration as an underground pilot project relative to the Act (Case Number PUE-2011-00082).

- Dahlgren: 9.4-mile, 230 kV overhead transmission line in King George County, Virginia. The Commission has yet to determine whether this proposal is a qualified underground pilot project relative to the Act (Case Number PUE-2011-00113).

- Waxpool and Brambleton–BECO: 1.5-mile and 11.2-mile, 230 kV overhead transmission lines in Loudoun County, Virginia. The Commission has yet to determine whether this proposal is a qualified underground pilot project relative to the Act (Case Number PUE-2011-00129).

- Surry–Skiffes Creek and Skiffes Creek–Whealton: 7.4-mile, 500 kV overhead transmission line and 20.2-mile, 230 kV overhead transmission line in Surry, James City, and York Counties and Cities of Newport News and Hampton, Virginia. The Commission has yet to determine whether this proposal is a qualified underground pilot project relative to the Act (Case Number PUE-2012-00029).

- Cloverhill–Liberty and Liberty Loop: 5.6-mile and 2-mile, 230 kV overhead transmission lines in Prince William County, Virginia, and City of Manassas, Virginia. The Commission has yet to determine whether this proposal is a qualified underground pilot project relative to the Act (Case Number PUE-2012-00065).

- Harrisonburg–Endless Caverns: 19.8-mile, 230 kV overhead transmission line in Rockingham County, Virginia. The Commission has yet to determine whether this proposal is a qualified underground pilot project relative to the Act (Case Number PUE-2012-00095).

APCo Transmission Lines

From the effective date of the Act through November 1, 2012, APCo filed six applications for approval and issuance of certificates to construct and operate the following 138 kV transmission lines:

- Sunscape: 1.4-mile, double-circuit 138 kV overhead transmission line in an urbanized area of southwestern Roanoke County (Case Number PUE-2008-00053).

- Matt Funk: 4.5-mile, double-circuit 138 kV overhead transmission line in southwestern Roanoke County (Case Number PUE-2008-00079).

- Huntington Court–Roanoke: 6-mile, double-circuit 138 kV overhead transmission line in the Roanoke area (Case Number PUE-2008-00096).

- Lockhart Extension: 138 kV overhead transmission line and associated substation in Dickenson County, Virginia (Case Number PUE-2008-00116).

- Saltville–Kingsport: 138 kV overhead transmission line rebuild in Washington County and the City of Bristol, Virginia (Case Number PUE-2009-00137).

- Falling Branch–Merrimac: 7.5-mile (6.25 miles single-circuit, 1.25 miles double circuit), 138 kV overhead transmission line in Montgomery County and the Town of Christiansburg, Virginia (Case Number PUE-2012-00007.

APCo did not request that any of the above proposed projects be considered as underground pilot projects relative to the Act. The Commission Staff, after reviewing the applications, concluded that constructing the proposed transmission lines underground would not be reasonable. The governing localities did not indicate, by resolution, general community support for the lines to be placed underground. After convening evidentiary hearings for Sunscape, Matt Funk, Huntington Court–Roanoke, and Saltville–Kingsport, including public

comment and expert testimony, and reviewing the Hearing Examiners' reports summarizing the evidentiary record in the cases, the Commission did not identify APCo's applications as qualified projects for purposes of the pilot program, and the Commission approved these five projects for overhead construction. The Commission has yet to determine whether Falling Branch–Merrimac is a qualified underground pilot project relative to the Act.

Delmarva Transmission Line

From the effective date of the Act through November 1, 2012, Delmarva filed one application for approval and issuance of a certificate to construct and operate the following 138 kV transmission line:

- Oak Hall–Wattsville: 4-mile, 138 kV overhead transmission line in Accomack County. Delmarva proposed to install the line adjacent to an existing 69 kV line and operate both lines as a double circuit. Existing wooden poles would be replaced with taller steel poles. The Commission authorized the Company to construct an overhead transmission line (Case Number PUE-2009-00106). Delmarva did not request that this project be considered as an underground pilot project relative to the Act.

Table 2. Pilot Status of Transmission Line Applications (230 kV or Less)
(pilot projects are shaded)

TRANS. LINE / SCC CASE No.	FEASIBILITY TEST	COST TEST*	RESOLUTION BY LOCALITY	PILOT STATUS
DVP 230 kV Transmission Lines				
Pleasant View–Hamilton PUE-2008-00027 Filed 4/21/2008	Technically Feasible	Not Required	Not Required	Required by Act
Beaumeade–NIVO PUE-2008-00063 Filed 7/21/2008	Technically Feasible	1.4 times the cost of OH for the total project	Approved 9/2/2008	Requested by DVP; Approved by SCC
Hayes–Yorktown PUE-2009-00049 Filed 7/1/2009	Detailed UG engineering analysis not completed for OH portion of line	Cost analysis not applicable	None Filed	Did not qualify
Remington CT–Gainesville PUE-2009-00050 Filed 6/15/2009	Detailed UG engineering analysis not completed	25 times the cost of OH for the total project	None Filed	Did not qualify
Loudoun–New Road PUE-2009-00134 Filed 12/28/2009	Detailed UG engineering analysis not completed	3.3 times the cost of OH for the total project	None Filed	Did not qualify
Ballston–Radnor Heights PUE-2010-00004 Filed 2/9/2010	Technically Feasible	Less than the cost of OH for the total project	Approved 7/10/2010	Requested by DVP; Approved by SCC
Landstown–Va. Beach PUE-2010-00012 Filed 3/1/2010	Detailed UG engineering analysis not completed	4.7 times the cost of OH for the total project	None Filed	Did not qualify
Hopewell–Prince George PUE-2010-00032 Filed 4/26/2010	Detailed UG engineering analysis not completed	2.4 times the cost of OH for the total project	None Filed	Did not qualify

Table 2 (cont'd). Pilot Status of Transmission Line Applications (230 kV or Less)

DVP 230 kV Transmission Lines (cont'd.)				
TRANS. LINE / SCC CASE No.	**FEASIBILITY TEST**	**COST TEST***	**RESOLUTION BY LOCALITY**	**PILOT STATUS**
Cannon Branch–Cloverhill PUE-2011-00011 Filed 2/7/2011	Detailed UG engineering analysis not completed	1.8 times the cost of OH for the total project	None Filed	Did not qualify
Hollymead Tap PUE-2011-00015 Filed 2/18/2011	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	Did not qualify
Bremo–Dooms PUE-2011-00039 Filed 4/29/2011	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	Did not qualify
Lakeside–Northwest PUE-2011-00082 Filed 7/20/2011	Detailed UG engineering analysis not completed	4.6 times the cost of OH for the total project	None Filed	Did not qualify
Dahlgren PUE-2011-00113 Filed 10/26/2011	Detailed UG engineering analysis not completed	5.5 times the cost of OH for the total project	None Filed	To be determined
Waxpool and Brambleton–BECO PUE-2011-00129 Filed 12/16/2011	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	To be determined
Surry–Skiffes Creek and Skiffes Creek–Whealton PUE-2012-00029 Filed 6/11/2012	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	To be determined
Cloverhill–Liberty and Liberty Loop PUE-2012-00065 Filed 6/29/2012	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	To be determined
Harrisonburg–Endless Caverns PUE-2012-00095 Filed 8/13/2012	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	To be determined

Table 2 (cont'd). Pilot Status of Transmission Line Applications (230 kV or Less)

TRANS. LINE / SCC CASE No.	FEASIBILITY TEST	COST TEST*	RESOLUTION BY LOCALITY	PILOT STATUS
APCo 138 kV Transmission Lines				
Sunscape PUE-2008-00053 Filed 6/20/2008	Detailed UG engineering analysis not completed	3 times the cost of OH for undergrounding the total route	None Filed	Did not qualify
Matt Funk PUE-2008-00079 Filed 8/18/2008	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	Did not qualify
Huntington Court–Roanoke PUE-2008-00096 Filed 10/10/2008	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	Did not qualify
Lockhart Extension PUE-2008-00116 Filed 12/19/2008	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	Did not qualify
Saltville–Kingsport PUE-2009-00137 Filed 12/16/2009	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	Did not qualify
Falling Branch–Merrimac PUE-2012-00007 Filed 2/9/2012	Analysis completed by APCo Consultant	6 times the cost of OH for undergrounding an alternative route	None Filed	To be determined
Delmarva 138 kV Transmission Line				
Oak Hall–Wattsville PUE-2009-00106 Filed 9/24/09	Detailed UG engineering analysis not completed	3.9 times the cost of OH for undergrounding the total route	None Filed	Did not qualify

The estimated cost of placing the proposed line in whole or in part underground should not exceed 2.5 times the cost of placing the same line overhead unless otherwise agreed to by the public utility, the affected localities, and the Commission.

APPENDIX C:
EXPERIMENTAL UNDERGROUND TRANSMISSION LINE PROJECTS SEPARATE FROM THE ACT

This Appendix provides a summary of two experimental underground transmission line projects not undertaken relative to the Act. These projects are included in this report for the purpose of aggregating and tracking all ongoing underground transmission line projects in one document. The experience gained from the analysis and construction of these two projects, in addition to the pilot projects under the Act, should be useful in making recommendations about the continued placement of transmission lines underground in the Commonwealth. A summary of these two projects is included in Table 3 in Appendix C.

Clarendon-Ballston 230 kV Transmission Line

On February 2, 2007, DVP filed its application with the SCC for the 2200-foot Clarendon-Ballston 230 kV transmission line in Arlington County. The utility proposed the construction of the line under streets in the highly urbanized area because there was no practical overhead route for the line.

In addition, the utility proposed the use of a different underground construction technology, XLPE, than in past projects. Previous underground transmission projects in urban areas employed HPFF cable. DVP argued that the proposed facility would provide the utility an opportunity to gain experience with XLPE lines operating at 230 kV. The utility noted that any failures could be managed with limited service disruption since the proposed facility would be located in an urban area with significant transmission facilities already in place. To date, DVP has not experienced any service disruptions with regard to this underground transmission line. The utility also noted that the cost of underground urban construction for an XLPE line is reasonably comparable to HPFF construction.

The Commission approved the line by its Final Order of May 25, 2007, in Case Number PUE-2006-00082. In approving the line, the Commission commended DVP's decision to use a different technology for the project and encouraged the utility to investigate and employ new technologies while also considering the reliability of its system and financial impact on all ratepayers. The Commission also directed the utility to inform the Commission's Division of Energy Regulation of the progress of this installation and to provide information on cost, engineering, construction, and future operation.

The actual cost of the 230 kV underground transmission line was $6.2 million ($14.7 million per mile equivalent). The 230 kV substation transmission work cost an additional $18.7 million.[16] The utility did not perform comparable cost estimates for either HPFF technology or overhead construction. The utility also expected construction to require nine months, with an anticipated completion date of May 2008; however, the completion date was extended primarily due to unforeseen difficulty in obtaining local permits. The line was energized in February of 2010.

[16] In its application, DVP estimated the cost of the proposed underground 230 kV transmission line to be $4 million with an additional $11 million for substation transmission work.

Garrisonville 230 kV Transmission Line

On August 30, 2006, DVP filed its application with the SCC for the five-mile Garrisonville 230 kV overhead transmission line in Stafford County. On February 27, 2007, DVP filed a Motion for Leave to File Underground Alternative Supplement. The utility attached to its Motion an Underground Alternative Supplement which presented the underground alternative as part of the utility's direct case to be considered along with its other proposals.[17]

To address the cost and visual impact issues, the utility proposed treating the Garrisonville project as an underground XLPE pilot project, which would allow the cost to be recovered through the ratemaking process. The utility stated that the prospect of gaining further experience and familiarity with the construction, operation, and performance of XLPE technology through a much larger underground project could justify incurring the additional cost of underground construction and recovering it from the broad range of the utility's customers. According to the utility, apportioning the costs across the utility's entire rate base would add approximately 10 cents to every DVP residential customer's monthly bill. On a percentage basis, bills would increase approximately one-tenth of one percent.

The Commission approved the underground line by its Final Order of April 8, 2008, in Case Number PUE-2006-00091. In approving the line, the Commission emphasized that the approval of this project as an underground pilot project, and the rate treatment afforded thereto, in no way established a precedent for future transmission lines, either in the subject right-of-way or elsewhere.

DVP originally estimated the cost of the proposed 230 kV underground transmission line to be $70.4 million. This correlates to approximately $6.4 million per mile. The 230 kV substation work was expected to cost an additional $11.9 million, for a total project cost of $82.3 million. The total cost for the overhead alternative was estimated to be $14.16 million, a $68.14 million difference. Thus, the underground option was expected to cost approximately six times the cost of the overhead alternative. The utility also expected preconstruction activities and construction to require a total of thirty-six months,[18] with an anticipated completion date of June 2009. The overhead alternative was expected to require twenty-four months, including six months for preconstruction and eighteen months for construction.

[17] The preferred underground alternative ("Option 1") will consist of two transmission circuits and be constructed with a spare conduit to add an additional cable in the event the rating needs to be increased in the future. Constructing two underground double circuits will assure that service to the Garrisonville Switching Substation would be maintained in the event of a fault on the new line and will provide transfer capability and redundancy equivalent to the proposed overhead line. From a transmission planning perspective, Option 1 of the underground alternative provides an electrically acceptable alternative to the proposed overhead line. Option 1 would assure continued service to Garrisonville substation, at a higher cost, by providing transfer capability and redundancy equal to the proposed double circuit overhead line configuration. In the event of an extended outage on one underground circuit, the Garrisonville station could continue to receive service from the other until the outage is repaired. The utility recommended against using an underground alternative that consisted of only one circuit ("Option 2") built in a radial configuration. Although less expensive at $48.44 million (still 3.4 times the overhead alternative), Option 2 would have been less reliable.

[18] The thirty-six month estimate included eighteen months for preconstruction activities (acquiring underground rights and clearing right-of-way) and eighteen months for construction.

The project was divided into three phases. The first phase of the project was energized in 2010. Phases two and three of the project were completed in July 2012.

Adverse soil conditions, large amounts of rock in the right-of-way, unfavorable topography, and interstate road crossings have resulted in significant increases in the cost estimates for this project. As opposed to conventional trenching, these difficult conditions necessitate directional drilling to depths in the range of sixty to seventy feet. Additional costs will also be incurred for larger gauge cable due to poorer thermal dissipation at such depths. The latest cost estimate is $137.6 million ($11.9 million per mile *excluding* land acquisition costs) or approximately nine times the project cost using overhead construction.

Table 3. DVP Experimental Transmission Line Projects Separate from the Act

PROJECT	**LENGTH/ ACTUAL COST**	**CONSTRUCTION STATUS**	**APPLICATION**
Clarendon – Ballston 230 kV (Arlington County) PUE-2006-00082 Filed: 2/2/2007 Approved: 5/25/2007	2,200 feet $15 million for 230 kV work (incl. $11 million for substation work)	Construction completed	Initiated by DVP, approved by Commission (OH option not feasible, and to gain experience with XLPE technology)
Garrisonville 230 kV (Stafford County) PUE-2006-00091 Filed: 8/30/2006 Approved: 4/8/2008	11 miles[19] $137.6 million (incl. $11.9 million for substation work)	Phases 1, 2, and 3 energized.	Initiated by DVP, approved by Commission (to gain experience with XLPE technology on a longer project)

[19] DVP notes that the new underground transmission line is effectively eleven miles long when considering it is a networked transmission line. The line will run approximately 5.5 miles from the existing "252 Line" into Garrisonville substation and then approximately 5.5 miles back to the 252 Line along the same 5.5 mile right-of-way but creating two distinct 5.5-mile double-circuit underground paths.

APPENDIX D:
DOMINION VIRGINIA POWER REPORT TO THE SCC

Underground Transmission Line Projects Update

October 27

2012

This report presents a synopsis of underground transmission line projects within the Dominion Virginia Power footprint.

HB 1319

R. Matthew Gardner, Ph.D.
Electric Transmission Planning and Marketing
Dominion Virginia Power

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Executive Summary

Dominion Virginia Power has an obligation to provide a strong and reliable source of electricity to all its customers and is committed to doing so in a safe, responsible, and economical manner. Within this decade, Dominion is projected to experience an increase in customer demand for electricity of nearly 28 percent. This pace is the fastest projected growth rate in a 13-state region stretching across the Mid-Atlantic, reaching from the District of Columbia to Chicago. Dominion plans to meet the increased demand in Virginia and North Carolina through a balanced program of infrastructure improvements. The focus of this report is Dominion's involvement in underground electric transmission line construction projects – specifically those projects pertinent to Virginia Acts of Assembly House Bill 1319 approved in 2008 entitled "*An Act to establish a pilot program to place certain transmission lines underground.*" Since the passage of House Bill 1319 in 2008, Dominion has been involved in five underground electric transmission line construction projects of relevance to the pilot program. Three of the five underground projects are approved pilot projects. The other two projects are discussed in this report for their similarity in scope and nature to the three pilot projects. This report is aimed at discussing the technical, financial, and project management/scheduling issues that Dominion has encountered in the construction of underground electric transmission lines since 2008. The following points are constructed and discussed within the report:

- The process of constructing underground electric transmission lines is generally less predictable than the process of constructing overhead lines – even the best surveying and soil analysis techniques often fail to identify significant underground obstacles.

- Underground lines are often more expensive to construct in comparison to overhead facilities. Industry experience has proven that the cost of building underground lines generally ranges from six to greater than ten times the cost of the overhead alternative. The exception to the rule does occur in settings where existing infrastructure practically precludes an overhead option. Some of the projects delineated in this report are illustrative of these scenarios; scenarios in which insufficient space is available for overhead transmission lines. Establishing a sufficient right-of-way with such space constraints would require the impractical removal of significant amounts of existing infrastructure (utilities, roads, buildings, etc.).

- While the long term reliability of underground lines is still being proven, current experience clearly indicates that the duration of underground outages can easily far exceed the duration of overhead outages.

- Underground line construction is a much more environmentally intensive and disturbing process than overhead line construction. In both cases, a cleared right-of-way is needed. At times, proponents of underground transmission lines attempt to construct a scaling analogy to relate underground transmission infrastructure in similitude to underground distribution infrastructure. The report discusses the misguided nature of such an analogy as the relationship is not linear.

Introduction

This report presents an overview of Dominion Virginia Power's ("DVP" or the "Company") ongoing underground transmission line projects. This document also contains a summary of energized projects that were previously discussed in "Underground Transmission Line Projects Update" reports submitted between 2008 and 2010. Projects both directly related to House Bill 1319 ("HB 1319") and others not related to HB 1319 are included for the purpose of gaining a complete perspective on Dominion's latest experiences with the design and construction of underground transmission lines. Table 1 provides a list of projects discussed in this report along with their respective designations and statuses.

Table 1: Underground electric transmission projects discussed.

Project	Designation	Status
Radnor Heights 230 kV Substation/Lines	Approved HB 1319 Project	Target Date Q4 2012
Pleasant View – Hamilton 230 kV Hybrid Line	Approved HB 1319 Project	Energized
Beaumeade—NIVO 230 kV Line	Approved HB 1319 Project	Energized
Garrisonville 230 kV Line	Other Significant	Energized
Clarendon—Ballston 230 kV Substation/Lines	Other Significant	Energized

House Bill 1319 Pilot Program Progress – Dominion Projects

Radnor Heights 230 kV Substation and Underground Transmission Lines

On February 9, 2010 in PUE-2010-00004, the Company filed an application with the Virginia State Corporation Commission (hereafter referred to as the "Commission") for the approval and certification of electric transmission facilities in Arlington County, Virginia. DVP proposed to construct two new 230 kV underground transmission lines by cutting into the existing 230 kV "Glebe—Davis" underground transmission line (DVP line number 2036).

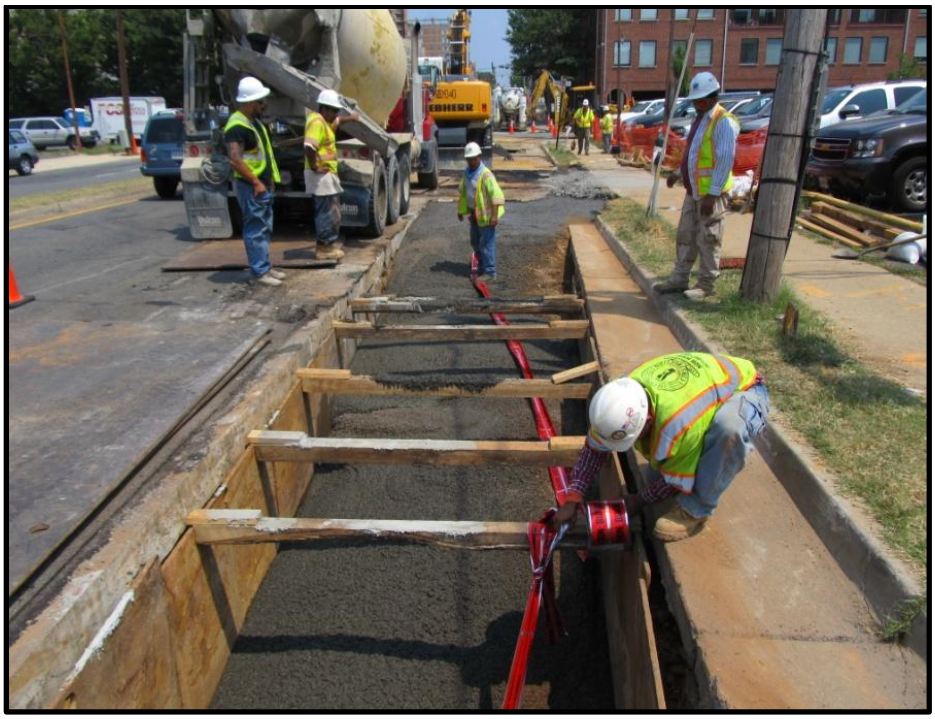

Figure 1: Crews utilize right lane of traffic to underground line.

These new lines would extend approximately 2.6 miles from the splice point to a new station called "Radnor Heights Substation." These two lines, the new Radnor Heights Substation, and a new 230 kV underground transmission line extending approximately 1.1 miles from the Company's existing Ballston Substation to interconnect the new Radnor Heights Substation, compose the axiomatic structure of this project. The estimated cost to construct the project, which is scheduled for completion by the 4th quarter of 2012, is approximately $81 million, of which approximately $52.4 million is for transmission line construction and approximately $28.6 million is for substation work.

Figure 2: Completed Radnor Heights Substation is consistent with community aesthetics.

On July 21, 2010, the Commission issued a Certificate of Public Convenience and Necessity ("CPCN") authorizing the Company to construct and operate the aforementioned three new 230 kV underground transmission lines and an accompanying substation in Arlington County. The Commission also authorized the Company to construct the proposed transmission lines underground as part of a pilot program pursuant to HB 1319.

The Commission ruled the evidence in this case is undisputed that there is a need to construct the proposed transmission lines and substation in order to prevent violations of mandatory North American Electric Reliability Corporation (NERC) reliability standards. The Commission also found that the project both meets the state requirements for the underground pilot program, and provides the Company with opportunity to gain additional experience testing technology and methods used to install underground transmission facilities.

The new lines will be located predominately within existing rights-of-way belonging to the Virginia Department of Transportation ("VDOT"), Arlington County, and on federal properties. The Commission also ruled that the Company's proposed route reasonably minimizes adverse environmental impact.

This project is advantageous for the HB 1319 underground pilot program because it involves both currently available underground technologies: high-pressure fluid-filled ("HPFF") pipe type cable and cross-linked polyethylene ("XLPE") solid dielectric cable. This project further complements the Company's progressing experience and familiarity with the construction, operation, and performance of XLPE technology. The project also enhances and expands the Company's experience and familiarity with

the construction of HPFF underground lines by way of Horizontal Directional Drilling ("HDD"). The proposed underground construction will provide the Company its first experience installing HPFF cable using HDD on land. To date, a submarine crossing of the Elizabeth River in Norfolk, Virginia is the Company's only experience installing HPFF cable using HDD construction. The proposed project involves the installation of HPFF cable utilizing HDD along the proposed route between the 2036 Line splice point and Radnor Heights Substation. The use of this construction method in the urban setting of the Washington D.C. metropolitan area shall serve as an informative comparison to the prior river crossing project, thereby advancing the Company's experience and familiarity with HDD installation of HPFF underground transmission lines. Construction activities for the projects constituting the Radnor Heights 230 kV substation and underground transmission lines began in early January 2011. The line is scheduled to be completed and energized by 4th quarter 2012.

Pleasant View—Hamilton 230 kV Underground/Hybrid Transmission Line (Energized)

On April 14, 2005 in PUE-2005-00018, DVP filed an application with the Commission for the approval and certification of electric transmission facilities in Loudoun County, Virginia consisting of a new overhead 230 kV single circuit transmission line from the Company's existing Pleasant View Substation to a new 230 kV-34.5 kV substation ("Hamilton Substation") to be constructed at a location east of the Town of Purcellville. On February 15, 2008, the Commission issued a Final Order in Case No. PUE-2005-00018 approving the proposed overhead transmission facilities along a route identified in that proceeding as the "Modified D Route." The Modified D Route is located, in part, on existing Company right-of-way along the Washington & Old Dominion Trail, which is owned by the Northern Virginia Regional Park Authority and used by the general public for park and recreational purposes ("W&OD Trail").

On April 21, 2008 pursuant to § 2.A of HB 1319 (2008), DVP requested to construct a portion of the transmission line previously approved by the Commission in PUE-2005-00018 underground, and sought approval to construct associated terminal stations as part of the pilot program. In accordance with HB 1319 §2.A and to mitigate concerns over the visual impact of overhead lines along the W&OD Trail, the Company proposed to construct underground an approximately 1.7-mile section of the previously approved overhead Pleasant View – Hamilton transmission line. In order to transition from the overhead line to the underground cables, two terminal stations were located proximate to the W&OD Trail. This project required the purchase of land on which to construct the two terminal stations (approximately 1.2 acres for the fenced area of each terminal station, plus additional acreage for screening) and the acquisition of a new 40-foot wide right-of-way between the terminal stations and W&OD Trail. The underground transmission line is located primarily within existing Company-owned right-of-way along the W&OD Trail, except for the short distances where the underground line leaves the trail to enter the two terminal stations. On May 6, 2008 the Commission approved the request to place 1.8 miles (the original 1.7 miles along the Trail plus the incremental sections to connect to the transition stations) of the line underground as a part of HB 1319.

On May 21, 2008, as a result of cooperation with local residents and officials to further minimize the potential impacts of the line and the unexpected terminal stations on private property, DVP proposed a Modified Request to move the North terminal station further from the Trail. This resulted in a revised total underground section of approximately 2 miles in length. On May 28, 2008, the Commission approved the Modified Request.

The total capacity of the line is 1,047 MVA in order to provide network transfer capability equivalent to the previously approved overhead line and redundancy in the event of an outage on one of the underground cables comprising the underground circuit. This transmission line is a radial transmission line and therefore not as reliable as a networked line since there is only a single source feeding the substation. If there were only one set of underground cables, the new substation could be out of service for many days; whereas with a second set of cables installed, an outage of the line due to a cable, cable termination, or underground splice failure should last only a few hours at most. By initially installing a second set of cables in accordance with the overall network capacity design requirements, the line will be able to be restored to service much faster if there is a cable, cable termination, or splice failure on one set of cables.

The underground transmission line uses XLPE solid dielectric underground cable encased in concrete duct bank (for protection) with two cables per phase; conduit for communications and shield wires; and spare cable conduits for additional underground transmission facilities if needed in the future. The XLPE cable system consists of two parallel duct banks, each with three (3) cables installed for a total of six (6) cables.

The cost estimate of the hybrid line project amounts to approximately $106.6 million with roughly $69.6 million associated with the cost of the 10-mile overhead portion of the line (approximately $7 million per mile *including* land acquisition costs) and roughly $37M million associated with the cost of the 2-mile underground segment of the line (approximately $18.5 million per mile *excluding* land)[1].

The new 230 kV hybrid transmission line from Pleasant View to Hamilton was successfully placed in service on October 28, 2010. The Hamilton Substation was energized October 29, 2010. Nearly 23,000 feet of trenching excavation was completed to install the parallel duct banks for the underground conductors. Fourteen splice vaults, or manholes, were installed, and more than 17 miles of cable plus additional miles of fiber lines were pulled into position in the conduits underground for splicing. The two terminal stations, where the cables safely transition back to overhead wires, were built and tested. The completion of the 2 mile underground portion was coordinated with the completion of 10 miles of overhead conductor for the line which was energized, on schedule.

[1] Excluding land acquisition costs: The underground line segment is located along existing company right-of-way and therefore no land purchase was required for the UG portion other than the short sections of underground right-of-way required to reach the two transition stations. An appropriate per-mile cost comparison of the underground portion versus the overhead portion should include land acquisition costs duly prorated and scaled for the underground segment. These costs would add approximately $2 million per mile to the underground line for a total of $20.5M per mile.

The actual cost for the project was slightly lower than the original estimate. The total cost for the project was approximately $90.4 million. $57.5 million associated with the cost of the 10-mile overhead portion of the line (approximately $5.75 million per mile *including* land acquisition costs) and roughly $32.9 million associated with the cost of the 2-mile underground segment of the line (approximately $16.5 million per mile *excluding* land).

Project Challenges

Sharing a very small corridor with the Northern Virginia Regional Park Authority's W&OD Trail proved to be one of the greatest challenges of the project. The 100-foot-wide W&OD Trail is 45 miles of paved trail for walking, running, bicycling and skating with 32 miles of adjacent gravel trail for horseback riding. Built on the roadbed of the former Washington & Old Dominion Railroad, the multi-use W&OD Trail runs through the urban heartland and countryside of Northern Virginia and is heavily used for recreation as well as commuting. Through this hilly project area west of Leesburg, the former railroad used significant amounts of cut and fill to create a level surface for the old railroad. Unfortunately, this did not leave much surface area for large construction equipment.

Detour Trail

Dominion retains a permanent easement along the 100-foot-wide property that is now owned by the Park Authority. This easement allowed Dominion the right-of-way to construct the new line, but made no provision for the displacement of trail users. The corridor was too narrow to safely conduct construction activities on a massive scale (see figures below), while sharing the space with pedestrians and other recreational traffic. With a mutual understanding that the W&OD Trail would have to be closed completely for 8-12 months during construction, testing and energizing, DVP and the Park Authority worked together to find an alternate route for trail traffic.

With no easy or obvious alternative route readily available in the area, DVP and the Park Authority turned to private property owners in the neighboring Shenstone and Ketocktin Farm Estates. Agreements were secured with 4 private property owners, the Loudoun County Fairgrounds, and Loudoun County for shared use of Canongate Drive in the Shenstone neighborhood, to complete the detour route. At a cost of approximately $700,000, DVP was able to design and construct a suitable detour path to keep trail users safely out of the construction area. Now that the line is energized and the original W&OD Trail is fully restored, the detour path has been dismantled and removed and those properties restored to their original conditions.

Figure 3: Paving the Detour Trail; before construction began in January 2010.

Narrow Workspace

DVP made considerable efforts to minimize any impact of the new underground lines on the usability or enjoyment of the W&OD Trail. To that end, the design engineers met with the Park Authority on multiple occasions to discuss the construction and the final disposition of the manhole lids, in particular.

Figure 4: Manholes "6A" and "6B." Once restored, the W&OD Trail will thread between the four manhole lids on the surface.

DVP was able to arrange each of the manhole locations so that the two lids for each manhole were off the newly paved trail. However, these shifts had to be balanced against the overall constraints of the narrow corridor. The manholes generally had to be staggered, as they would not fit side-by-side. Consideration was also given to the size of the equipment that would be needed to deliver and lower the 24' by 12' concrete manhole/vaults into position, and the ingress and egress of these large vehicles. Access to the trail is extremely limited along the narrow, windy Dry Mill Road. DVP purchased temporary and permanent easements for construction access to the trail.

Many trees had to be removed from the lush, shady canopy that made this section of the trail so enjoyable, to make room for the equipment that was necessary to excavate through layers of dense rock. In several areas, crews had to excavate into the cut sidewalls of the narrow sections of the trail in order to maneuver the excavating equipment. Additional measures were then necessary to stabilize the newly carved rock slopes along the trail.

Figure 5: A pre-construction view of the W&OD Trail west of Leesburg.

Erosion and Sediment Control

With the sheer volume of excavation and magnitude of the construction effort, combined with uncharacteristic amounts of snow and rain in western Loudoun, controlling run-off from the site became an ongoing challenge that absorbed manpower and project dollars. Old, unattended drainage systems along Dry Mill Road exacerbated the problem, turning an overnight storm into a two-day, three-mile long cleanup effort. Again, the amount of ground disturbance, compared to an overhead project, is significant and generally requires time and resources to address throughout the project.

Cost Drivers

There are four main cost drivers associated with the underground segment of the Pleasant View – Hamilton project.

1. *Manpower* – Unlike an overhead installation, the underground segment of this line required excavation from end to end, and a multi-step, labor-intensive installation process that could only be completed in series. The underground work involved approximately 145 personnel.

2. *Cable Costs* – The cost of underground cable can be more than 100 times that of overhead wire. The cost for cable for the two-mile underground segment of the Pleasant View – Hamilton project is approximately $5.7M million.

3. *Real Estate* – Additional parcels needed to be acquired for the transition stations and access. Despite agreements for underground easements that were acknowledged in the Commission's Modified Final Order in May of 2008, DVP was still negotiating for underground rights with property owners in December of 2009. Extra crews were utilized throughout the project to make up for lost time.

4. *Community Relations* – Initial efforts included creation of a detour path; coordination of activities during the 75th annual Loudoun County Fair; notification of road closure for Dry Mill Road crossing; coordinating efforts with the Park Authority; managing livestock in fields where cables had to be installed; and, a full-time communications manager assigned to project. Ongoing community relations activities are highlighted by sponsorship of an annual celebration of the W&OD Trail called the Dominion TrailMix.

Figure 6: Layers of dense rock below and beside the original trail (top right). Stacks of conduit (pipe) also visible.

Beaumeade—NIVO 230 kV Underground Transmission Line (Energized)

On July 21, 2008, in PUE-2008-00063, DVP filed a case with the Commission to build two new 230 kV underground transmission lines in Loudoun County, Virginia. These underground transmission lines are both approximately 0.71 miles long; extending from an expansion of DVP's existing Beaumeade Substation to a 230/34.5 kV substation ("NIVO Substation") constructed on land owned by DuPont Fabros. On May 29, 2009 the Commission issued a Final Order approving the construction of the transmission line as an HB 1319 underground pilot project.

The underground transmission lines were built primarily on a combination of existing DVP right-of-way within the W&OD Trail and existing VDOT right-of-way along Smith Switch Road, south of Beaumeade Substation. Both of the new lines occupy the same concrete encased duct bank consisting of eight 6-inch conduits. Each line comprises three XLPE solid dielectric cables with a rating of 524 MVA.

While it may have been feasible to construct these transmission lines overhead, the Company built the Beaumeade–NIVO 230 kV transmission lines underground as a pilot project under HB 1319. Although

the project is electrically configured as two transmission lines, this project was considered to be a single project for the purposes of HB 1319. As part of the HB 1319 pilot program, the project expanded the Company's experience with the construction, operation, and performance of XLPE technology. Further, the additional costs of placing these lines underground met the requirements of HB 1319. DVP has worked closely with Loudoun County officials during the project's planning phase and enjoyed general community support for the placement of these transmission lines underground.

The route for the project was approximately 0.71 miles long with a new 30-foot wide right-of-way for only a small portion of its length.

The Beaumeade—NIVO project was completed and energized on July 28, 2010. The cost of the project was $9.8 million. This represents a 25% higher cost than the equivalent overhead solution.

Key Attributes of Dominion Underground Pilot Projects

Each of the previous three underground transmission line projects are designed and implemented differently. In the case of Pleasant View – Hamilton, the underground transmission line was constructed in two duct banks; whereas the Beaumeade – NIVO underground transmission lines were constructed in a single duct bank. Underground transmission lines associated with the Radnor Heights project will employ conventional open-trench duct bank construction as well as both HDD and *tunnel* construction. These design differences stem from an individual consideration of the following factors for each of the underground transmission lines: anticipation of future capacity demands, demands of varying terrain, and proximity to other utilities in dense metropolitan areas. For example, a two duct bank design is useful in the long term when future networking of an underground transmission line is anticipated. The inherent redundancy helps ensure enhanced reliability.

A networked transmission line can potentially be more heavily loaded than can a radial transmission line. This distinction occurs because a networked transmission line serves any load tapped off of the line in addition to its service as a conduit or corridor for the transfer of bulk power across the bulk electric power system. While future networking of the Beaumeade – NIVO line is technically feasible, it is not anticipated that this line will need to be networked in similar fashion to the Pleasant View – Hamilton line. Thus the upfront construction of the Beaumeade – NIVO line is most accommodating to the immediate radial nature of the line's loading demands.

Table 2: Underground Transmission Line Project Attributes (Pilot-related)

Transmission Line	Case Number	Date Filed	Feasibility	Cost Test	Pilot Status
Pleasant View—Hamilton 230 kV	PUE-2008-00027 PUE-2008-00042	April 21, 2008	N/A	N/A	Included in Act
Beaumeade—NIVO 230 kV	PUE-2008-00063	July 21, 2008	Feasible	Less than 2.5 times the cost of overhead (1.25 times total cost)	Initiated by DVP
Radnor Heights 230 kV Lines and Station	PUE-2010-00004	February 9, 2010	Feasible	Less than 2.5 times the cost of overhead (0.33 times total cost)[2]	Initiated by DVP

[2] For the purposes of the HB 1319 cost comparison of the proposed underground project to the overhead equivalent, the estimated cost of placing the same lines overhead is approximately $245.4 million. In this case, the underground alternative is significantly less costly than the overhead option.

Other Significant Underground Transmission Line Projects

This section provides a summary of two other significant underground transmission line projects. These projects are included in this report solely for the purpose of aggregating and tracking all ongoing underground transmission line pilot projects in one document. A summary of these two projects is included in Table 4.

Garrisonville 230 kV Transmission Line (Energized)

On August 30, 2006, Dominion Virginia Power filed its application with the Commission for the 5.5-mile Garrisonville 230 kV overhead transmission line in Stafford County. On February 27, 2007, DVP filed a Motion for Leave to File Underground Alternative Supplement. The company attached to its Motion an Underground Alternative Supplement which presented the underground alternative as part of the Company's direct case to be considered along with its other proposals.[3] This new transmission line was designed to extend approximately 5.5 miles from an existing 230 kV overhead transmission line (DVP line number 252) into Garrisonville Substation and then back to the 252 Line along the same 5.5 mile right-of-way. This line is effectively 11 miles long when considering it is a networked transmission line.

The Commission approved the underground line by its Final Order of April 8, 2008, in PUE-2006-00091. In approving the line, the Commission emphasized that their approval of this project as an underground pilot project, and the rate treatment afforded thereto, in no way established a precedent for future transmission lines, either in the subject right-of-way or elsewhere.

The Garrisonville project was proposed as an underground XLPE project. The project continues to expand the Company's experience and familiarity with the construction, operation, and performance of XLPE technology.

Initial Estimates

The Company originally estimated the cost of the proposed 230 kV transmission line to be $70.4 million. This correlates to approximately $14 million per mile equivalent. The 230 kV substation work was expected to cost an additional $11.9 million, for a total project cost of $82.3 million. The total cost for the overhead alternative was estimated to be $14.16 million, a $68.14 million difference. Thus, the underground option was expected to cost approximately 5.8 times the cost of the overhead alternative.

[3] The preferred underground alternative ("Option 1") comprises two transmission circuits constructed with a spare conduit to add an additional cable in the event the rating needs to be increased in the future. Constructing two underground circuits assures that service to Garrisonville Substation is maintained in the event of a fault on the new line and provides transfer capability and redundancy equivalent to the proposed overhead line. From an electric transmission planning perspective, Option 1 provided an electrically acceptable alternative to the proposed overhead line. Option 1 assures continued service to Garrisonville Substation by providing transfer capability and redundancy equal to the proposed double circuit overhead line configuration. In the event of an extended outage on one underground circuit, the Garrisonville Substation could continue to receive service from the other line until the outage is repaired. The Company recommended against using an underground alternative that consisted of only one circuit ("Option 2") built in a radial configuration. Although less expensive at $48.44 million (still 3.4 times the overhead alternative), Option 2 would have offered less reliability.

The company also expected preconstruction activities and construction to require a total of 36 months[4], with an anticipated completion date of June 2009. The overhead alternative was expected to require 24 months, including 6 months for preconstruction and 18 months for construction.

Project Update

The first phase of the Garrisonville project was energized in June 2010 and consisted of the following activities: open cut trenching, HDD, duct bank installation, cable pulling, splicing, testing, and construction site refurbishment. This first phase completed the installation of a single set of cables – enough to energize the new Garrisonville Substation and carry initial load. The last two phases were complete in July of 2012, and included required double-circuit configuration. During these phases, crews utilized existing access roads to reach manhole locations along the right-of-way, minimizing any additional impact to the community.

Project Challenges

Adverse soil conditions, large amounts of rock in the right-of-way, and unfavorable topography contributed to significant increases in both the costs and construction duration for this project. As opposed to conventional trenching, these difficult terrain conditions necessitated HDD to depths in the range of up to 125 feet. For the sections of the line that required drilling, conventional concrete encased construction was untenable. In those cases, conduit was pulled after the drilling was completed. Conduit was necessary to facilitate the pulling of the XLPE cables. Additional costs were also incurred due to significant increases in cable costs that occurred with the commodity price escalation of 2008. The cost of the completed project was $137.6 million – a more than 45% overage and a multiple of nearly 9.3 times the cost of the equivalent overhead solution. The challenges addressed in this section have also contributed to construction delays.

Construction Challenges

As mentioned, the adverse terrain and road crossings (namely, Interstate 95) along the Garrisonville right-of-away necessitated the use of HDD methods as opposed to the conventional trenching methodology. For the portions of the line which were placed underground via the trenching methodology, the configuration in Figure 7 was used. However, where HDD was required, the configuration of Figure 8 was necessary.

[4] 18 months for preconstruction activities (acquiring underground rights and clearing right-of-way) and 18 months for construction

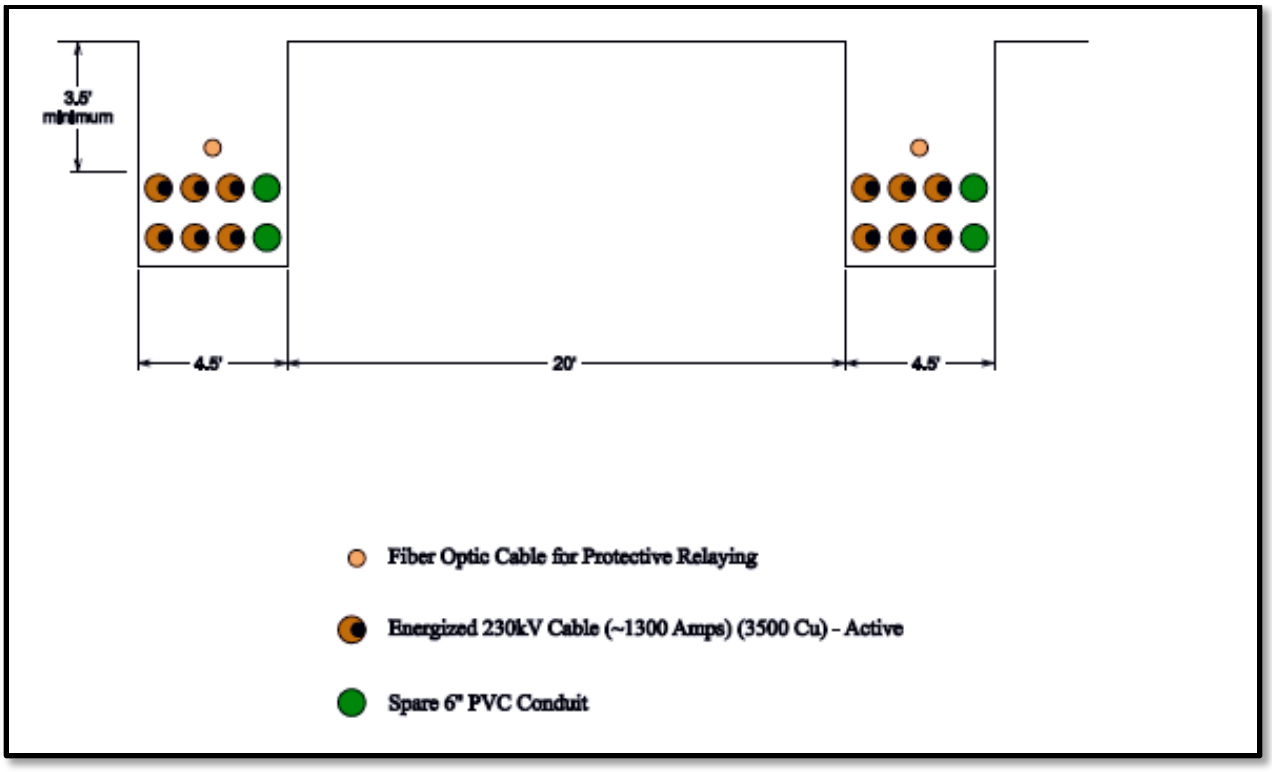

Figure 7: Garrisonville Project -- Trenching Configuration.

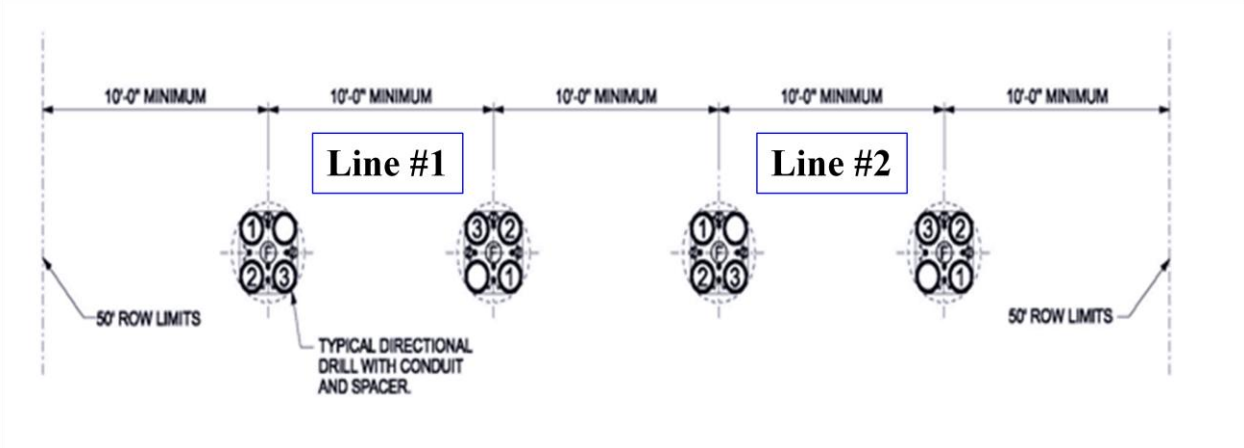

Figure 8: Garrisonville Project – Drilled-Hole Configuration.

Drilling and trenching are very different methods of placing a cable underground. Trenching is, in general, a less intensive surface operation compared to drilling. Drilling, especially to depths of 125 feet or more as required in this project, can get far more complex and expensive than trenching.

Drilling Equipment

First, drilling requires specialized drill rigs as seen in Figure 9 (often transported and operated mounted on a semi-trailer) and other large, heavy equipment.

Figure 9: Horizontal Directional Drill Rig.

Drilling Process

Second, the drilling process is iterative. Each of the four holes in Figure 8 must have a diameter of 42 inches in order to properly accommodate four properly-sized conduits. These 42-inch holes are impossible to drill in a single step. Therefore, a reaming process is used. A pilot hole, followed by successively larger reams of 28 inches and 42 inches in diameter, respectively, are drilled. Figure 10 shows a drill bit, or reamer, used in the final stage of drilling a 42-inch hole.

Figure 10: 42-Inch Drill Bit (Reamer).

Drilling Progress

Third, the drilling progress is highly dependent on the soil conditions through which the drill must advance. In some cases drilling is extremely slow and can be as slow as 6 inches per hour. Some spans (drilled underground between manholes) have presented completely untenable drilling conditions. In these spans, drilling was abandoned and re-attempted in hopes of hitting different soil conditions. The first four holes spanning Interstate 95 took three months to complete.

In order to prevent the newly drilled holes from losing form or collapsing altogether after the reamer advances, a bentonite-based drilling mud was used to provide hydrostatic pressure. The fluid was also used to keep the drill bit cool and "clean" during cutting. Depending on the soil conditions through which the hole was cut, the pressurized drilling mud can escape the intended bored hole and erupt into the surrounding environment. This eruption of drilling mud is referred to as a "frac-out."

Drilling Challenges

Because of the impact on the environment, frac-outs were treated very seriously and drilling was stopped upon finding a frac-out until all material was recovered and the frac-out site was properly

cleaned. Nearly 300 frac-outs were found during the drilling stages of the project and quantity of the lost drilling mud was estimated in the hundreds of thousands of gallons. These frac-outs have been up to 260 feet from the nearest approach of the bore's centerline and upwards of 100 feet above the centerline. Figure 11 shows a site of a frac-out. Note that two straw bale barriers were required for containment. Figure 13 shows the consistency of the drilling mud at one end of a drilling site.

Figure 11: Site of frac-out showing containment measures for the protection of the environment.

The drilling was also associated with the manifestation of sink holes. The noise and vibration of drilling equipment was reported to be problematic by some residents and businesses. Drilling operations activities required the usage of drill rigs, pipe stems, excavators, three reamers, water trucks, diesel generators, and large mud processing equipment. Drilling operations (which typically ran 12 hours per day, six days per week) generated concerns from some residents living close to drilling sites – concerns of foundations cracking and discomfort from the constant vibration. Mitigation efforts to reduce the side effects of drilling included the use of costly sound insulating walls as seen in Figure 12.

Figure 12: View of sound-insulating wall proximate to drilling site near Garrisonville underground line.

Underground Blasting

Due to the challenging terrain, directional drilling and conventional duct bank installation were not feasible in every location resulting in the use of underground rock blasting. Small holes were drilled and explosives were used to fragment rocks and clear obstacles for duct bank installation.

Weather

Rain adversely affected the drilling and trenching processes and required those processes to be halted. Each significant rain event set the construction process back two or three days.

Cost Drivers

There are five main cost drivers associated with the Garrisonville project

1. *Complexity* – The complexity of constructing an underground line is far more extensive than that of an overhead line. These complexities demand more time and personnel. The Garrisonville project involved, on average, 150 personnel.

2. *Cable Costs* – The price of underground cable can be more than 100 times that of overhead conductor. The cost of cable for the Garrisonville project is running about $850/line foot or $4.5 million per mile for each line.

3. *Terrain* – The severe grade variation required HDD which added significant costs to the project.

4. *Soil Conditions* – Adverse soil conditions reduced the drilling rate, allowed for environmentally hazardous frac-outs, and contributed to the creation of sink holes.

5. *Underground easement acquisition (Right-of-Way)* – The previously purchased easements were for an overhead line. These easements did not provide underground rights which required Dominion to initiate new agreements with each landowner along the designated transmission line route.

Community Challenges

1. *Works hours* – Set backs from project challenges resulted in extended working hours for construction crews (12 hours shifts, Monday through Saturday). Hours have been adjusted in some locations due to community concerns.

2. *Drilling* – Complaints from residents regarding noise levels, vibration, and traffic.

3. *Schools* - Provided morning and afternoon crossing guards to multiple school locations adjacent to construction thoroughfares.

4. *Restoration* – Extensive restoration throughout transmission line corridor; three athletic fields, tot-lots, street repaving, street cleaning, resident landscaping, etc.

5. *Community Outreach* - Communications Manager assigned full-time to project to address community issues and concerns.

Figure 13: A picture of drilling mud at one termination of a drilling span.

Project Comparisons

Table 3 compares the underground (UG) versus overhead (OH) options for the Garrisonville project.

Table 3: Underground vs. Overhead Cost Comparison.

	Reliability: Line Outage Duration	Life Cycle (years)	Construction Time (months)	Personnel Required	Conductor and Cable Prices ($/line foot)	Total Costs per Line Mile ($)	Total Costs ($)
OH	Hours	70	18-24	20	$8.10	$1.3 million	$14 million
UG	Days	35	36+	150	$850	$11 million	$137.6 million

Clarendon—Ballston 230 kV Underground Transmission Line (Energized)

On February 2, 2007, the Company filed an application with the SCC for the 2200-foot Clarendon-Ballston 230 kV transmission line in Arlington County. The company proposed the construction of the line under streets in the highly urbanized area because there was no practical overhead route for the line.

In addition, the company proposed the use of a different underground construction technology, XLPE, than in past projects. Previous underground transmission projects in urban areas employed HPFF cable. The Company argued that the proposed facility would provide the company an opportunity to gain experience with XLPE lines operating at 230 kV. The company noted that any failures could be managed with limited service disruption since the proposed facility would be located in an urban area with significant transmission facilities already in place. The company also noted that the cost of underground urban construction for an XLPE line is reasonably comparable to HPFF construction.

The Commission approved the line by its Final Order of May 25, 2007, in PUE-2006-00082. In approving the line, the Commission commended DVP's decision to use a different cable technology for the project and encouraged the company to investigate and employ new technologies while also considering the reliability of its system and financial impact on all ratepayers. The Commission also directed the company to inform the Commission's Division of Energy Regulation of the progress of this installation and to provide information on cost, engineering, construction, and future operation.

In February of 2010, the Clarendon—Ballston underground transmission line was energized. The installation of the underground line cost $6.2 million and the work at the terminal substations cost an additional $18.7 million.[5] The company did not perform comparable cost estimates for either HPFF technology or overhead construction. The company also expected construction to require nine months, with an anticipated completion date of May 2008. However, certain delays pushed project completion back almost two years to February of 2010. These delays were due both to unforeseen difficulty in obtaining local permits and the challenges of coordinating with existing underground infrastructure and rocky terrain in the area. Figure 14 shows the metropolitan nature of the area in which the underground transmission line was constructed.

[5] These cost figures comprise costs associated with inextricable 69kV substation and underground transmission line work.

Figure 14: Excavation for Clarendon -- Ballston underground transmission line.

Key Attributes of Other Significant Transmission Line Projects

Table 4: Experimental Underground Transmission Line Project Attributes

Transmission Line	Case Number	Date Filed	Date Approved	Length	Estimated Cost
Clarendon—Ballston 230 kV *(Energized)*	PUE-2006-00082	February 2, 2007	May 25, 2007	2,200 feet	$24.9 million *(including $18.7 million for substation work)*[5]
Garrisonville 230 kV	PUE-2006-00091	August 30, 2006	April 8, 2008	11 miles total *(two 5.5-mile double-circuit underground paths)*	$137.6 million *(including $11.9 million for substation work)*

Analysis of Underground Transmission Line Technology and Applications

The use of underground transmission lines as an alternative to conventional overhead transmission lines addresses common public concerns associated with overhead transmission line aesthetics. The visual impact (or "above-ground profile") of underground lines compared to that of overhead lines is smaller and typically more publicly acceptable than that of overhead lines. However, the aesthetic advantages of underground lines are only made possible via invasive and continuous trenching, excavation, blasting, boring, and directional drilling. In some cases, drilling depths have extended downwards to 125 feet. Conversely, overhead transmission lines have a comparatively superficial impact at distinct points corresponding to structure locations which can typically range from 400 to 1,200 feet apart depending on the terrain and routing. Thus, the impact of underground transmission lines compared to overhead transmission lines on historic districts (such as burial grounds and other buried artifacts) and the environment is relatively severe. Figure 15 and Figure 16 depict the right of way clearing associated with the Garrisonville project.

Figure 15: Right of way being cleared for Garrisonville underground project.

Figure 16: Cleared right of way for Garrisonville project.

Figure 17 and Figure 18 present a good contrast between the environmental severity of overhead transmission line construction (Figure 17) and underground transmission line construction (Figure 18).

Figure 17: Construction of an arbitrary overhead transmission line.

Figure 18: Construction of a portion of the Garrisonville line (trenched portion).

Electric transmission lines are typically built overhead throughout the country for reasons of economic expedience, technical feasibility, reliability, operability, and environmental stewardship. Table 5 presents an international comparison of percentages that relate the proportions of underground infrastructure to overhead electrical infrastructure (cited from CIGRÉ 2010 underground data). Clearly, underground transmission lines are generally considered as an alternative to overhead lines in the very limited cases where no viable overhead line routes are available. Examples include highly urbanized areas (e.g., certain areas in Northern Virginia) or where customers have agreed to pay for the underground service and the service was of a radial configuration.

Table 5: International comparison of percentages of electrical infrastructure underground.

Country	110V – 219kV	220kV – 314kV	315kV – 500kV
United States	0.9%	0.6%	0.4%
Australia	1.5%	0.2%	0.9%
Austria	6.9%	0.1%	2.2%
Canada	1.6%	0.8%	0.8%
China	27%	8.6%	0%
Denmark	12.4%	0%	3.8%
France	0.1%	3.4%	0%
Germany	6.1%	0.2%	0.4%
Italy	2.3%	1.8%	0.3%
Japan	4.8%	6.5%	0.8%
Netherlands	16.3%	0.9%	0.3%
Sweden	2.3%	0.6%	0.1%
Switzerland	25.3%	0.9%	0%
United Kingdom	11.3%	7.3%	1.5%
Worldwide	2.9%	1.7%	0.5%

As of July 1, 2010, the laws regarding approval and funding for underground transmission lines in Virginia have changed. Senate Bill 645, which was passed by the General Assembly and signed by the Governor in April of 2010, "prohibits the State Corporation Commission from approving an agreement between a local governing body and an electric utility for the underground installation of an electric transmission line of at least 150 kilovolts if a feasible overhead alternative exists, unless all localities in which the line passes request that the line be installed underground." Further, "if the agreement is approved by the State Corporation Commission, the locality shall impose such tax or assessment on

electric utility customers within the district" to pay the additional costs of constructing that portion of the line underground rather than overhead.

Underground electric transmission lines, though designed to provide a viable alternative for overhead transmission lines, intrinsically possess technically challenging attributes that must be addressed in order to serve as an adequate substitute for overhead lines. The most pervasive attribute inherent to underground transmission lines is higher capacitance which leads to voltage rise along the line. Therefore, as is the case in the Pleasant View – Hamilton and Garrisonville lines, shunt reactors are necessary to mitigate damaging over-voltage situations that would occur at almost any loading level – heavy or light. While other underground transmission lines in a networked configuration may be removed from service as a last resort during periods of light loading when voltage rise problems occur, radial lines such as the Pleasant View – Hamilton line are not afforded such a luxury.

Underground electric transmission lines, like overhead lines, comprise multiple line segments. Each segment is "spliced" to the adjoining segment(s). A limiting factor to the maximum distance between splices of underground cable (or overhead line) is the size of the reel on which the cable (or line) is initially wound. Underground cable has a much larger diameter than overhead wire. The diameter of underground cable is larger than the diameter of overhead wire because it is insulated with thick dielectric material. Therefore, compared to conventional overhead wire, a shorter linear length of underground cable can be wound on a reel. Transportation infrastructure and equipment constraints then further constrain the size of the reel that can be used (weight limits, underpass/overpass dimensions, etc.). During installation of the cable, pulling tensions imposed on the cable and friction between the cable and conduit[6] also limit the amount of cable that can be pulled through conduit between vaults (also not a consideration for overhead lines). Cable splices are physically and electrically the weakest points of an underground transmission line. They must be immobilized so that they are not stressed by tensions resulting from thermal expansion and contraction. The vaults that are used to house and immobilize the underground cable splices are substantial and the walls of the vaults must also be reinforced so as to withstand the thermally induced forces that work to stretch and compress the cable. Conversely, because overhead wires do not have the shielding, insulating, dielectric layers surrounding the wire, overhead wire splices can be formed to withstand the normal tensions associated with thermal expansion and contraction, the weight of the line, and other environmental factors.

[6] This friction is somewhat mitigated by applying a lubricant to the cable as it is pulled through the conduit.

Figure 19: View of vault interior and cable splice along Garrisonville underground transmission line.

Whereas underground transmission lines may not be subject to the temporary/momentary outages associated with overhead transmission lines, it is generally accepted that underground outages are of longer duration than overhead outages. When an underground transmission line fails or is damaged, the time required to locate and repair the line can range from weeks to months, while overhead transmission lines can be repaired in hours or days.

When a fault occurs on an underground line, the fault energy is contained by the duct bank or conduit surrounding the line. Containing this energy in turn damages the conduit or duct bank necessitating further repairs. In the case of overhead lines, the fault energy is dissipated into open space around the conductor, thus minimizing the amount of damage.

Locating and accessing underground damage is difficult. The science is not exact. Whereas a broken conductor or a damaged insulator may be plainly visible on an overhead line, the same is not true for an underground line. Special equipment must be used to find the location of an underground cable fault. Once located, the damaged section needs to be accessed, possibly via excavation, for repair and/or replacement. Underground repairs are by nature more complicated, often requiring the installation of expensive splices.

To ensure adequate reliability, underground transmission lines are typically constructed as double circuits in separate duct banks and require significantly different protection schemes. To ensure safety,

duplicate underground circuits are located in separate duct banks. This redundant design allows for repairs on either circuit while allowing the other to remain energized. "Dig-in" is an example of both a hazard associated with underground lines and also a cause of underground outages.

Underground transmission lines are hardly similar in design, size, or operation to underground distribution lines. Figure 20 shows a size comparison between the size of underground 230 kV transmission line cable (same type as used in Garrisonville) and typical 35 kV underground residential distribution (URD) cable. Further, an entire typical neighborhood can be fed by the single URD cable pictured below. However, the electric AC transmission network is necessarily operated in three phases – requiring three of the larger cables pictured (at 230 kV).

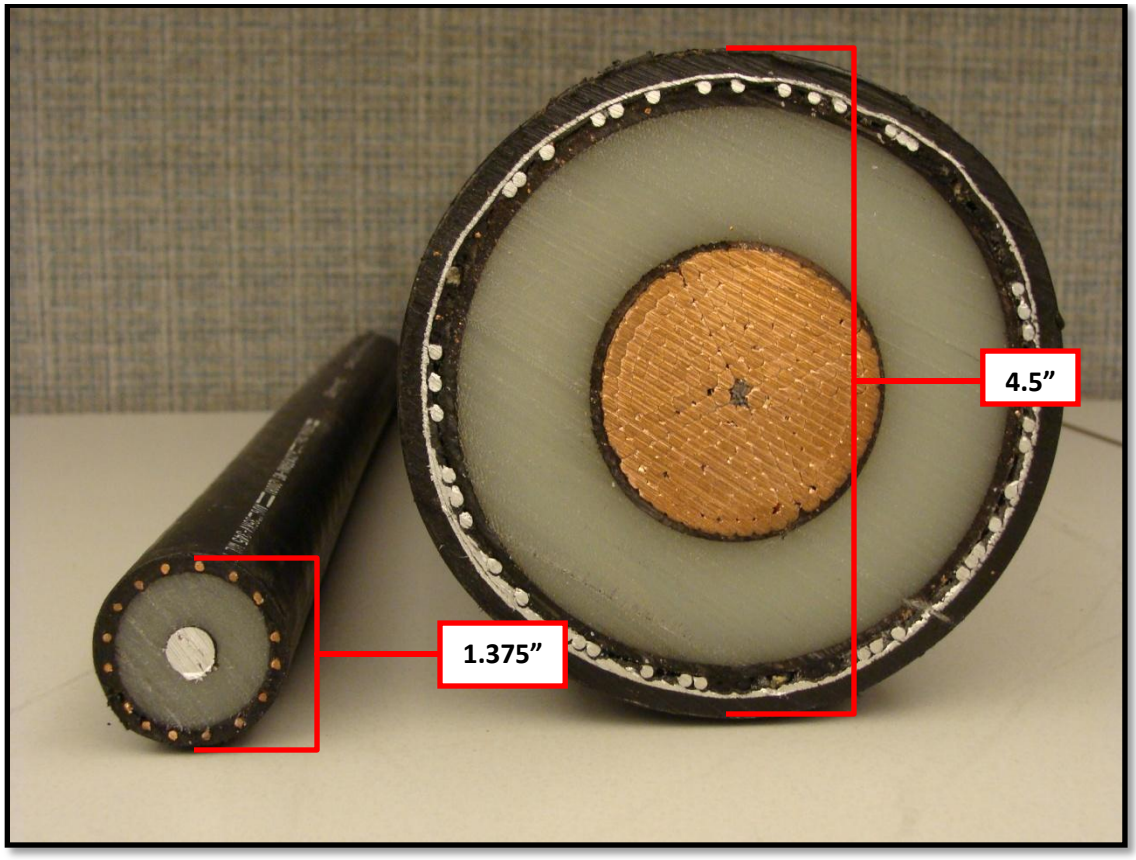

Figure 20: Comparison between underground residential distribution 35 kV cable (LEFT) and underground 230 kV transmission cable (RIGHT).

Ultimately, the construction, operation, and maintenance costs of underground transmission lines compared to those of conventional overhead transmission lines pose significant concerns. While some additional costs can be identified in the design and engineering phases of underground transmission line projects as identified above, the potential for significant additional costs arises in the land and material acquisition, construction, and maintenance/repair phases.

Overhead transmission lines can be constructed using aluminum conductor. Aluminum conductor has many favorable attributes that make it the conductor of choice for overhead line construction. Aluminum is an excellent conductor and highly resistant to weathering. However, copper is much more conductive than aluminum. In fact, standard electrical conductor grade aluminum has a conductivity of only 61% of that of copper. Therefore, copper conductors are used in underground transmission line construction for purposes of improved heat dissipation.

Drastic fluctuations in the costs of copper throughout the projects have resulted in drastic increases in costs of XLPE cable. While aluminum (the primary component in overhead conductors) costs have increased, the per-mile cost increases of aluminum pale in comparison to the per-mile cost increases of copper. In the past three years, the cost per mile of aluminum that would be used in the overhead conductors has increased by approximately $7,000 per mile whereas the cost of copper used in XLPE cable has increased well over $1.8 million per mile during the same time period. Also, the costs of boring and trenching are estimated based upon geological surveys that may not reveal unfavorable ground conditions until encountered after construction of underground lines are well underway. For example, the costs associated with the Garrisonville 230 kV Transmission Line project (reference Table 4) are currently expected to exceed original project estimates by over 45% due to the factors discussed in this report.

Conclusions

The purpose of this report is to provide a basic description of projects participating in the pilot program established by HB 1319 along with an analysis of the key issues facing the projects. Three approved underground transmission line projects have been identified in this update: Radnor Heights Substation and Underground Transmission Lines, Pleasant View—Hamilton 230 kV Hybrid Transmission Line and Beaumeade—NIVO 230 kV Underground Transmission Line. The Radnor Heights project is near completion and continues to illustrate the issues and impacts of underground line projects. Pleasant View—Hamilton and Beaumeade—NIVO are complete. These projects have been quite educational to the Company as it expands its experience with underground transmission line construction and technology (such as XLPE cable). The report also provides a summary of two experimental underground transmission line projects unrelated to HB1319 for the purpose of presenting issues likely to be relevant upon further development of projects participating in the pilot program. Experience to date indicates that cost and potential cost variance continue to drive concerns associated with the construction of underground transmission lines. There are additional concerns related to outages on underground cables and the potential for lengthy line outages due to the complexity of finding the cable damage and making repairs. The already high costs of energy induce additional trepidation over further financially burdening a broad base of utility customers to recover costs from undergrounding transmission lines for the aesthetic benefits of a relative few.