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STATE CORPORATION COMMISSION

December 1, 2014

The Honorable Terence R. McAuliffe
Governor of Virginia

The Honorable Thomas K. Norment, Jr.
Chairman, Commission on Electric Utility Regulation

The Honorable Thomas Davis Rust
Chairman, Joint Commission on Technology and Science

The State Corporation Commission is pleased to submit its final report on the pilot program to construct qualifying electric transmission lines underground, as required by Chapter 799 of the 2008 A cts of Assembly (House Bill 1319), as amended and reenacted.

Respectfully submitted,

Judith Williams Jagdmann
Chairman

Mark C. Christie
Commissioner

James C. Dimitri
Commissioner

REPORT OF THE
STATE CORPORATION COMMISSION

Final 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
2014

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GLOSSARY OF TERMS

Act	House Bill 1319 of the 2008 Acts of Assembly of the Virginia General Assembly, as amended and reenacted
APCo	Appalachian Power Company
CEUR	Commission on Electric Utility Restructuring
CPCN	certificate of public convenience and necessity
certificate	certificate of public convenience and necessity
Code	Code of Virginia
Commission	State Corporation Commission
DVP	Dominion Virginia Power
Delmarva	Delmarva Power & Light Company
FERC	Federal Energy Regulatory Commission
filing period	the time between the effective date of the Act and July 1, 2014
General Assembly	Virginia General Assembly
HB 1319	House Bill 1319
HDD	horizontal directional drilling
HPFF	high-pressure fluid-filled
JCOTS	Joint Commission on Technology and Science
JLARC	Joint Legislative Audit Review Commission
kcmil	one thousand circular mils
kV	kilovolts
MVA	megavolt amperes
Option 1	preferred underground alternative using two transmission circuits
Option 2	underground alternative using one transmission circuit
PVC	polyvinyl chloride
SCC	State Corporation Commission
Staff	Commission Staff
Staff Guidelines	Guidelines of Minimum Requirements for Transmission Line Applications Filed Under Code § 56-46.1 and the Utility Facilities Act
VDOT	Virginia Department of Transportation
W&OD	Washington and Old Dominion Trail
XLPE	cross-linked polyethylene

EXECUTIVE SUMMARY

House Bill 1319[1] ("HB 1319") of the 2008 Regular Session of the Virginia General Assembly ("General Assembly"), as amended and reenacted[2] (the "Act"), collectively established a pilot program to construct four *qualifying electrical transmission line projects* 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 SCC to submit a final report to the Commission on Electric Utility Restructuring ("CEUR"),[4] 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 of Virginia ("Commonwealth" or "Virginia").[5]

The Commission approved three[6] of Dominion Virginia Power's ("DVP") 230 kV transmission line projects for inclusion in the pilot program pursuant to the Act.[7] Although the primary focus of this final report is the pilot program relative to the Act (including both qualifying and non-qualifying electrical transmission line projects), the report also will address two experimental underground transmission line projects not directly encompassed by the Act, both of which were approved by the Commission prior to enactment of the Act. The Commission believes the 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.

With respect to the possible future placement of transmission lines underground in the Commonwealth, the Commission recommends that projects continue to be evaluated on a case-by-case basis to determine whether placing such lines underground would be both technically feasible and cost effective. In addition, given that (1) the Commission's Rules of Practice and Procedure allow any party to a transmission line proceeding to propose an underground alternative, (2) the Code of Virginia requires the Commission to consider environmental impacts and the public interest when considering transmission line applications, and (3) as a matter of practice, the Commission has stated its reasons for declining to impose underground transmission construction, the Commission recommends no change to the procedures under which it presently considers alternative transmission line routing pursuant to Title 56 of the Code of Virginia ("Code").

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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 CEUR, established pursuant to Chapter 885 of the 2003 Acts of Assembly, was continued, effective July 1, 2008, as the CEUR (Va. Code § 30-201).

[5] In addition, the Act directed the SCC to report annually to the CEUR, the Joint Commission on Technology and Science, and the Governor on the progress of the pilot program no later than December 1 of each year that the Act was in effect. The Commission submitted six annual reports from 2008 to 2013.

[6] In accordance with the Act and in order to justify approving fewer than four projects to be placed underground, this final report will document the failure of other projects to qualify for the pilot program.

[7] (1) a two-mile segment of the Pleasant View–Hamilton transmission line in Loudoun County previously approved as an overhead transmission line; (2) the 0.71-mile Beaumeade–NIVO transmission line in Loudoun County; and (3) the 3.7-mile Ballston–Radnor Heights Project in Arlington County. Appendix B provides the pilot status of all transmission line applications (230 kV or less) filed during the applicable period established by the Act, including those that did not qualify for the pilot program. Proceedings on three of these applications are still pending before the SCC.

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 on the placement of underground transmission lines 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 as amended and reenacted in 2011,[9] the General Assembly established a pilot program to construct four qualifying electrical transmission line projects of 230 kV or less, in whole or in part, underground. The Act directed the SCC to "report annually to the CEUR, 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 specified that the SCC "shall submit a final report to the CEUR, 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 directed 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 was qualified to be placed underground, in whole or in part, if it met the following criteria:

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[8] The JCOTS was created by the 1997 General Assembly as a permanent legislative commission to generally study all aspects of technology and science.

[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 included 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, (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 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

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

Commission is authorized to issue its own rules and regulations to facilitate the implementation 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 content and completeness, and the Commission enters a procedural order for notice and comment/hearing that usually provides for a Hearing Examiner to initially consider the case. Subsequently, any respondents may file testimony on the application, the Staff develops a report or testimony on the application, rebuttal testimony may be filed by the applicant, and a formal regulatory proceeding ensues in accordance with the SCC's Rules of Practice and Procedure.[12] The Hearing Examiner then issues 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's content pursuant to the requirements of the Code and the Staff Guidelines, the Staff analyzed 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 analysis, the Staff requested additional technical and cost analyses not already included in the utility's application, as necessary. In its report on the application, the Staff commented on whether or not the proposed transmission line potentially met the criteria to be a qualified project in accordance with § 4 of the Act and recommended exclusion or inclusion of the transmission line in the pilot program. The Hearing Examiner's report also included findings and recommendations to the Commission, for or against inclusion of the line in the pilot program. Finally, if the proposed transmission line was granted a CPCN, the Commission also would decide for or against inclusion of the line in the pilot program.

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

III.
PILOT PROGRAM RESULTS

A. Introduction

As previously stated, the Act established a pilot program to construct four qualifying electrical transmission line projects 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 ("filing period"). However, only two other projects qualified for the pilot program. In accordance with the Act and in order to justify approving fewer than four projects to be placed underground, this final report documents the failure of other projects to qualify for the pilot program. 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.

During the filing period, the SCC received 30 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 nine applications for 138 kV overhead transmission lines. DVP submitted 16 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.

B. Transmission Lines Approved for the Pilot Program

DVP filed applications for approval and issuance of CPCNs to construct and operate the following three 230 kV transmission lines as pilot projects pursuant to the Act:

- DVP Pleasant View–Hamilton Project: 2-mile underground segment, 230 kV cross-linked polyethylene ("XLPE")[13] solid dielectric cable, mostly on the Washington and Old Dominion Trail ("W&OD Trail") in Loudoun County (Case Number PUE-2005-00018, modified in Case Numbers PUE-2008-00027 and

[13] Although the dominant underground transmission line technology in the United States for decades has been high-pressure fluid filled ("HPFF") pipe technology, XLPE cable technology 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 cable technology over HPFF pipe technology.

PUE-2008-00042). The Commission approved the request in accordance with the Act on May 28, 2008.[14] 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 January 26, 2009 (Case Number PUE-2008-00063).[15] The line was energized in July 2010.

- DVP Ballston–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 2.6-mile, HPFF section was energized on February 6, 2013. The 1.1-mile XLPE section was energized on March 6, 2014.[16]

Summaries of two other experimental underground transmission projects, approved separately from the Act, are provided in Appendix C.[17]

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[14] *Modified Request of Virginia Electric and Power Company, To participate in pilot project, and for approval of underground transmission line construction, under §2.A of HB 1319*, Case No. PUE-2008-00042, 2008 S.C.C. Ann. Rept. 537, Order Approving Modified Request (May 28, 2008).

[15] *Application of Virginia Electric and Power Company, For approval and certification of Beaumeade-NIVO 230 kV Underground Transmission line and 230-34.5 kV NIVO Substation under Va. Code § 56-46.1 and the Utility Facilities Act, Va. Code § 56-265.1 et seq., and as a pilot project pursuant to HB 1319*, Case No. PUE-2008-00063, 2009 S.C.C. Ann. Rept. 319, Final Order (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 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.

[16] *Application of Virginia electric and Power Company, For approval and certificates of public convenience and necessity for facilities in Arlington County: Glebe-Radnor Heights 230 kV Transmission Line; Davis-Radnor Heights 230 kV Transmission Line; Ballston-Radnor Heights 230 kV Transmission Line; and Radnor Heights Substation*, Case No. PUE-2010-00004, 2010 S.C.C. Ann. Rept. 443, Final Order (July 21, 2010).

[17] The Commission approved the two experimental 230 kV underground projects to enable DVP to gain experience with 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. To date, the Commission has approved approximately 39 miles of 230 kV underground transmission lines that employ HPFF pipe technology. These cables 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.

C. Justification for Approving Fewer Than Four Projects

Of the 30 applications received from public utilities during the filing period for CPCNs for electrical transmission lines of 230 kV or less, 27 projects failed to qualify for the pilot program based on one or more of the three qualifying criteria established under the Act. For example, with respect to 26 of the 27 non-qualifying projects, the governing bodies of the localities filed no resolutions indicating general community support for the lines to be placed underground. With respect to the only project (among the 27 that failed to qualify for the pilot program) in which the governing body did file a resolution, the SCC determined that underground construction was not technically viable.[18]

A number of projects also failed to qualify for the pilot program because they did not meet the Act's cost criterion since the estimated additional cost of placing the proposed lines, in whole or in part, underground exceeded 2.5 times the cost of placing the same lines overhead.[19] Documentation for the 27 projects that failed to qualify for the pilot program is provided in Appendix B.

D. 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 be borne entirely by DVP's retail customers. On March 20, 2014, FERC issued an Order on Reserved Issue in which it found that customers outside Virginia should not bear any of the incremental underground costs, but that Virginia customers in the Dominion zone should share such costs. FERC set the allocation of the costs for hearing, but held the hearing in abeyance pending settlement discussions. This matter is presently pending before FERC.[20]

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[18] *See Application of Virginia Electric and Power Company For approval and certification of electric facilities: Surry-Skiffes Creek 500 kV Transmission Line, Skiffes Creek-Whealton 230 kV Transmission Line, and Skiffes Creek 500 kV-230 kV-115 kV Switching Station*, Case No. PUE-2012-00029, 2013 S.C.C. Ann. Rept. 240, Order (Nov. 26, 2013). *Appeal docketed, Nos. 140462, 141009, 141201, 141201, 140470 and 142010* (Va. Sup. Crt. Jul. 10, 2014).

[19] Section 4.2 of the Act authorized an exception to the cost criterion, stating that "[i]f the public utility, the affected localities, and the State Corporation Commission agree, a proposed underground line whose costs exceeds 2.5 times the cost of placing the line overhead may also be accepted into the pilot program"; however, this exception was never applied. Section IV.E. of this final report provides additional information on the relative costs of overhead and underground transmission line construction for certain non-qualifying projects.

[20] *Old Dominion Electric Cooperative and North Carolina Electric Membership Corporation v. Virginia Electric and Power Company d/b/a Dominion Virginia Power*, Docket No. EL10-49-000 (FERC Mar. 17, 2010).

IV.
ANALYSIS OF THE PILOT PROGRAM AND OTHER NON-PILOT EXPERIMENTAL UNDERGROUND PROJECTS

A. Introduction and Summary

This section provides a summary of the SCC's analysis of the pilot program's three qualifying projects, as well as two experimental non-pilot projects, and recounts lessons learned relative to the placement of transmission lines underground. These five projects (three pilot projects and two non-pilot experimental projects) consisted of DVP electrical transmission projects of 230 kV. A summary of the physical and electrical attributes, as well as the costs, of the five projects is provided in Table 1. Two of the pilot projects and both non-pilot experimental projects made use of XLPE technology, while the third pilot project used both XLPE and HPFF technologies. The five projects ranged in overall length from 0.71 mile to 5.5 miles. The underground line mileage costs for the five projects ranged from approximately $7 million to $15 million per mile. A summary of the actual costs for the five projects, as well as comparisons with overhead cost estimates, are provided in Table 2. We also will comment on underground-overhead cost comparisons for some of the non-qualifying projects.

For the purposes of this report, we have focused primarily on two projects: the Beaumeade–NIVO pilot project and the Garrisonville non-pilot experimental project. These two projects provided the most relevant opportunities for valid comparisons between overhead and underground construction. These projects also provided examples of the extreme range of possibilities for underground cable construction costs. The two projects were analyzed on a line mileage basis, as well as a total project basis. Total project costs include not only the overhead line or underground cable construction costs but also the costs of substation transmission work. A summary of the analysis for these two projects is provided in the following paragraphs.

B. Beaumeade–NIVO Pilot Project

The Beaumeade–NIVO pilot project involved the construction of a 0.71-mile, 230 kV, XLPE underground radial transmission line in Loudoun County, Virginia. The project consisted of one trench containing one concrete duct bank containing six power cables connected as two circuits (three cables per circuit). In general, radial underground transmission lines are required to have two circuits in order to provide redundant supply to the receiving end substation, which is supplied by no other substations. This is necessary because the repair of underground cable failures can take weeks to complete. The two circuits of the Beaumeade–NIVO line, in normal operation, would be separated at the NIVO end by a normally open circuit breaker, so that each underground transmission circuit would supply one of the two NIVO transformers to be initially installed. In the case of a cable failure on either circuit, all three cables of that circuit would be switched during the repairs, and the second circuit would be switched at the NIVO Substation to supply all installed transformers, thus carrying the full substation load.

The concrete duct bank enclosure installed in the trench is four feet wide with its top buried at a minimum depth of 3.5 feet. The duct enclosure contains a 2-row x 4-column array of 6-inch polyvinyl chloride ("PVC") ducts, each capable of carrying one power cable. Three ducts

in the top row carry the cables of one circuit, and three ducts in the bottom row carry the cables of the other circuit. Thus, two ducts are spares. There also is fiber optic cable for protective relaying that opens circuit breakers in the case of cable faults.

Each of the underground circuits has one cable per phase. Each cable is composed of a 3500 thousand circular mil ("kcmil") copper conductor at its core, surrounded by XLPE dielectric insulation, all encased in an aluminum and plastic sheath. The capacity of each circuit is 524 megavolt amperes ("MVA"). This far exceeds any expected load at the NIVO Substation. The reason for the 524 MVA capacity is to enable the two circuits to be operated as a double-cable-per-phase circuit with a capacity of 1047 MVA, which equals the Company's standard capacity for a 230 kV transmission circuit operating as a network circuit. While the Company's intent is to operate the line radially, the NIVO Substation could, in the future, be connected to a second substation, which would make the Beaumeade–NIVO line a network line subject to network power flows (*i.e.*, power flows through it and not just to it). Thus, the planners designed the line to be capable of network capacity.

The estimated total overhead cost of this project in 2008 was $7.9 million, while the actual total underground cost in 2010 was $9.8 million. Both of these cost figures include $4.9 million in substation transmission work. Using a line mileage basis comparison (excluding substation transmission work), underground cable construction was approximately 1.6 times the estimated cost for overhead line construction. However, the total underground project was only approximately 1.2 times the cost of the estimated total overhead project. The underground project experienced no major cost or schedule overruns.

C. Garrisonville Non-Pilot Experimental Project

The Garrisonville non-pilot experimental project involved the construction of two 5.5-mile, 230 kV, XLPE underground transmission lines in Stafford County, Virginia. In certain areas, the project consisted of two trenches 20 feet apart, each containing one concrete duct bank containing six power cables connected as two circuits (three cables per circuit). In other areas, difficult terrain conditions necessitated horizontal directional drilling ("HDD"). In the case of a cable failure on either circuit, all three cables of that circuit would be switched during the repairs.

In areas where trenching was possible, the concrete duct bank enclosure installed in each trench is 4.5 feet wide with its top buried at a minimum depth of 3.5 feet. The duct enclosure contains a 2-row x 4-column array of 6-inch PVC ducts, each capable of carrying one power cable. Three ducts in the top row carry the cables of one circuit, and three ducts in the bottom row carry the cables of the other circuit. Thus, two PVC ducts are spares. There also is fiber optic cable for protective relaying that opens circuit breakers in the case of cable faults. Where HDD was necessary, four 42-inch diameter holes 10 feet apart were necessary to accommodate the four circuits, each of which contained four PVC conduits, including one spare.

Each of the proposed underground circuits has one cable per phase. Each cable is composed of a 3500 kcmil copper conductor at its core, surrounded by XLPE dielectric insulation, all encased in an aluminum and plastic sheath. The capacity of each circuit is 763 MVA.

The estimated total overhead cost of this project in 2006 was approximately $14 million, while the actual total underground cost in 2012 was $137.6 million. Both of these cost figures include $11.9 million in substation transmission work. Using a line mileage basis comparison (excluding substation transmission work), underground cable construction was approximately 12 times the estimated cost for overhead line construction. The total actual underground project was approximately 9.7 times the cost of the estimated total overhead project. This actual final cost represented a 62% cost overrun. The estimated schedule to complete the overhead project was 24 months whereas the estimated underground schedule was 36 months. The actual schedule required approximately 50 months, nearly a 40% overrun. According to DVP, adverse soil conditions, large amounts of rock in the right-of-way, unfavorable topography, and interstate road crossings resulted in significant increases in the cost estimates for the project. As opposed to conventional trenching, these difficult conditions necessitated directional drilling to depths in the range of 60-70 feet. Additional costs were incurred for larger gauge cable due to poorer thermal dissipation at such depths. Additional information is provided in Attachment C.

D. Other Pilot and Non-Pilot Experimental Projects

The Pleasant View–Hamilton and Ballston–Radnor Heights pilot projects and the Clarendon–Ballston non-pilot experimental project involved some unique circumstances that prevented straightforward overhead-underground comparative analyses. For example, the Act designated an approximately 1.8-mile section of the Pleasant View–Hamilton project as a qualifying project, and part of the pilot program, after the SCC had granted a CPCN for overhead construction. This created an overhead/underground hybrid project that necessitated two overhead/underground transition stations which created additional costs and viewshed impacts. However, the successful completion of the Pleasant View–Hamilton project confirms that hybrid overhead/underground construction might be a technically feasible option in certain circumstances.

The Clarendon–Ballston and Ballston–Radnor Heights projects in Arlington County had no reasonable overhead alternatives due to the densely developed, urban nature of the area, which contains numerous national monuments and historic resources. Because a Clarendon–Ballston overhead route was impractical, DVP provided no overhead cost estimate for that non-pilot experimental project. However, DVP did provide a cost estimate for the Ballston–Radnor Heights pilot project for the purpose of comparison as part of the pilot program, but the overhead option necessitated a different, much longer route than the underground route, and this impractical overhead option was estimated to cost more than three times as much as the underground option. The Ballston–Radnor Heights pilot project exceeded cost and schedule estimates due to numerous underground obstructions encountered during the trenching work done along the entire route.[21] There were multiple tunnels that had to be excavated because open trenching was not allowed by the Virginia Department of Transportation ("VDOT") and the County of Arlington.

[21] In addition, because most of the trenching was performed in the streets, working hours were limited to weekdays from 9:30 a.m. to 3 p.m., resulting in a longer period of construction.

E. Lessons Learned

Underground cable systems can be a viable alternative to overhead transmission lines in extraordinary situations when proper consideration is given to the many details of using these types of systems. However, as a result of the knowledge gained over the last seven years from evaluating 30 transmission line applications for transmission lines of 230 kV or less for potential inclusion in the pilot program, as well as the experience gained from two non-pilot experimental projects, the SCC has learned that underground construction of transmission lines can be beneficial in very densely populated areas with monuments and other culturally significant structures, though these projects take longer to construct due to traffic constraints. The SCC has further learned that underground construction is inherently subject to unpredictable circumstances and, therefore, both underground transmission line construction costs and project schedules are highly variable, project dependent and more likely to exceed estimates. Likewise, the potential aesthetic, reduced maintenance and enhanced reliability benefits can be highly variable and project dependent.

In addition, underground construction costs are significantly higher than overhead construction costs. For example, the Pleasant View–Hamilton and Beaumeade–NIVO underground pilot projects cost 2.0 and 1.6 times overhead estimates, respectively, on a line mileage basis excluding substation transmission work.[22] The Garrisonville non-pilot experimental underground project cost 12 times overhead project estimates on a line mileage basis excluding substation transmission work. One component of the higher line mileage costs of underground construction can be attributed to the construction of separate duct banks for duplicate circuits and the installation of spare cable conduits as a hedge against potentially slow restoration following infrequent but inevitable cable failures. Substation costs increase when there is a need to install special electrical devices to protect against the voltage instabilities inherent in underground cable systems.[23]

Furthermore, with respect to the non-qualifying projects, underground cost estimates were significantly higher than overhead cost estimates for the 12 non-qualifying projects for which underground estimates were available. For example, for the nine non-qualifying DVP projects for which underground cost estimates were available, underground project estimates ranged from approximately 1.4 times (for the Warrenton–Wheeler project) to 25 times (for the Remington CT–Gainesville project) overhead project cost estimates. Excluding the Remington CT–Gainesville and Warrenton–Wheeler extremes, underground project estimates for DVP's other seven non-qualifying projects exceeded overhead project estimates by an average factor of 3.6. APCo completed detailed cost estimates for the Sunscape and Falling Branch–Merrimac non-qualifying transmission line projects. APCo estimated these two underground projects would cost three and six times the overhead projects, respectively. For the sole Delmarva non-qualifying transmission line project, the underground project estimate exceeded the overhead project estimate by a factor of 3.9.

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[22] The underground costs would have been higher but for the fact that DVP did not have to pay for easements on these two projects.

[23] Shunt reactors may be needed to compensate for potential over-voltage situations as a consequence of the higher capacitance of underground cables.

Therefore, with respect to the continued placement of transmission lines underground, the SCC believes proposed transmission lines should be evaluated on a case-by-case basis to determine whether placing such lines underground would be both technically feasible and cost effective. The SCC believes that such a policy is consistent with the conclusions expressed in a recent report conducted by the Joint Legislative Audit and Review Commission ("JLARC") and described in the following section.

V.
ADDITIONAL INSIGHTS FROM THE 2006 JLARC STUDY OF UNDERGROUNDING ELECTRIC TRANSMISSION LINES IN VIRGINIA

In 2006, House Joint Resolution 100 enacted by the 2006 General Assembly directed JLARC to study the criteria and policies used by the SCC in evaluating the feasibility of undergrounding transmission lines in Virginia. The JLARC Report (2006 House Document No. 87) was submitted December 27, 2006.

The JLARC Report addressed, in part, (1) types of underground transmission systems and extent of use, (2) underground and overhead transmission line costs, (3) SCC policies relative to transmission line cases, (4) reliability concerns relative to underground transmission lines, (5) environmental, health, and historic resource concerns, (6) the impacts of the cost of underground transmission lines on ratepayers and relevance to SCC decision making, (7) the impact of overhead transmission lines on property values and the feasibility of allowing surrounding property owners to pay for underground lines, and (8) the need for improved information availability and planning transmission line cases.[24]

While the JLARC report identified some recommendations to enhance transmission line decision-making, the report concluded, in part, that the SCC and Virginia utilities do seek to address aesthetic, environmental, and property value concerns associated with overhead lines. JLARC noted that the estimated cost of a new line is also given a prominent role in transmission line proceedings under current statutes and that the SCC Commissioners are routinely required to balance these competing criteria in transmission line cases. The Report indicated that the SCC often uses alternate routes or adjustments in the type or size of overhead towers to address potential impacts. JLARC found that technologies are available to enable certain electric transmission lines to be placed underground but that an underground line is likely to be about four to ten times more expensive than an overhead line.[25]

VI.
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The SCC has completed the regulation of a pilot program designed to construct four qualifying electrical transmission lines of 230 kV or less, in whole or in part, underground as required by the Act. The SCC approved three of DVP's 230 kV transmission line projects for inclusion in the pilot program pursuant to the Act, all of which have been completed: (1) a two-mile segment of the Pleasant View–Hamilton transmission line in Loudoun County

[24] JLARC Report Table of Contents
[25] JLARC Report Summary, In Brief (inside cover), at i, and at v.

previously approved as an overhead line; (2) the 0.71-mile Beaumeade–NIVO transmission line in Loudoun County; and (3) the 3.7-mile Ballston–Radnor Heights Project in Arlington County. In accordance with the Act and in order to justify approving fewer than four projects to be placed underground, this final report documents the failure of other projects to qualify for the pilot program. Separate from the Act, the Commission also approved the construction of two other experimental underground transmission line projects, both of which have been completed and were considered in conjunction with the projects under the Act for making recommendations. The experience gained from the analysis and construction of both the pilot and non-pilot experimental projects, as well as the consideration of DVP's applications for these projects, provided valuable insight for evaluating the potential efficacy of placing transmission lines underground, as well as the procedures under which the Commission presently considers alternative transmission line routing.

As provided by the Act, this final report analyzes the entire pilot program and makes recommendations about the continued placement of transmission lines underground in the Commonwealth.[26] Included as part of this final report is an independent analysis of underground transmission line technology and applications provided by DVP (*see* Appendix D). It is generally understood that underground cable systems may be a feasible, or even a necessary, alternative to overhead transmission lines where the use of cable is warranted because of right-of-way constraints or other extraordinary conditions. However, based on the experience gained from the analysis and construction of these pilot projects it is evident that underground construction costs are highly variable and project dependent, particularly with respect to topography and soil conditions. Whenever underground cable systems are being evaluated as a possible alternative to overhead transmission lines, proper consideration must be given to the many factors related to the design, specification, manufacturing, installation, and cost of such systems.

The Commission's authority and responsibility relative to the construction of new transmission lines is established primarily by §§ 56-46.1 and 56-265.2 of the Code. Section 56-46.1 A of the Code directs the Commission to consider several factors whenever the Commission is required to approve the construction of any electrical utility facility, including (1) the effect of the proposed facility on the environment, (2) the effect of the proposed facility on economic development, and (3) any improvements in service reliability that may result from the construction of such facility. In addition, § 56-46.1 B states that the Commission shall determine that the line is needed and that the corridor or route the line is to follow will reasonably minimize adverse impact on the scenic assets, historic districts, and environment of the area concerned. Another section of the Code that the Commission considers when comparing transmission alternatives is § 56-235.1, which requires the Commission to assure that utilities make the maximum effective use of capital resources in rendering utility service. In adjudicating transmission line applications, the Commission considers and weighs the evidence submitted in the record by the applicant, respondents, Staff, and public witnesses; considers and weighs the factors set forth in the Code; reviews and considers the benefits and adverse impacts of

[26] 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.

all alternative proposals; and makes a final decision, including reasons for declining to impose an underground alternative.[27]

Given that (1) the Commission's Rules of Practice and Procedure allow any party to a transmission line proceeding to propose an underground alternative, (2) the Code of Virginia requires the Commission to consider environmental impacts and the public interest when considering transmission line applications, and (3) as a matter of practice the Commission has stated its reasons for declining to impose underground transmission construction, the Commission recommends no change to the procedures under which it presently considers transmission line routing pursuant to Title 56 of the Code. With respect to the possible future placement of transmission lines underground in the Commonwealth, the Commission recommends projects continue to be evaluated on a case-by-case basis to determine whether placing such lines underground would be both technically feasible, cost effective, and in accord with the relevant provisions of the Code.

[27] For example, in its October 8, 2004 Final Order in Case No. PUE-2002-00702, the Commission stated the following: "Our explanation for rejecting an underground proposal in a previous proceeding is applicable here as well: 'There is no evidence that benefits will accrue to the Company or its ratepayers which outweigh the increased costs and risk of reliability problems associated with the underground installation of the proposed transmission line.'" In response to the Commission's Final Order in that case, a party to the proceeding appealed the Commission's decision to the Supreme Court of Virginia, claiming, in part, that the Commission erred in rejecting the recommendation that a portion of the transmission line be placed underground. In its Order of November 4, 2005, the Supreme Court ruled that there was "no reversible error" in the Final Order of the State Corporation Commission. *Application of Virginia Electric and Power Company d/b/a Dominion Virginia Power, For a certificate of public convenience and necessity for facilities in Loudoun County: Brambleton-Greenway 230 kV Transmission Line*, Case No. PUE-2002-00702, SCC. Ann. Rept. 347 (Oct. 8, 2004) *affd*; *Dulles Gateway Associates, LLC, et. al., v. State Corporation Commission, et. al.*, Record No. 050273, Memorandum Opinion (Nov. 4, 2005). *In* affirming the Commission's Final Order, the Court held that the Commission considered and applied the governing statutory criteria to all of the evidence, and that the Commission's findings were fully supported by the evidence.

Table 1. Physical and Electrical Attributes and Costs for Pilot and Non-Pilot Experimental Projects

	Three-Phase 230 kV Pilot Projects					Three-Phase 230 kV Non-Pilot Experimental Projects		
	Pleasant View-Hamilton		Beaumeade-Nivo	Ballston-Radnor Heights		Clarendon-Ballston	Garrisonville	
	Duct Bank 1	Duct Bank 2	Single Duct Bank	Single Duct Bank	Trench/HDD	Single Duct Bank	Duct Bank 1*	Duct Bank 2*
Cable Technology	XLPE	XLPE	XLPE	XLPE	HPFF	XLPE	XLPE	XLPE
Length (miles)	2	2	0.71	1.1	2.6	0.42	5.5	5.5
Circuits	1	1	2	1	2	1	2	2
Capacity	524 MVA	524 MVA	524 MVA/circuit	524 MVA	354 MVA/circuit	240 MVA	763 MVA/circuit	763 MVA/circuit
Cu Cable area	3500 kcmil	3500 kcmil	3500 kcmil	3500 kcmil	2500 kcmil	1500 kcmil	3500 kcmil	3500 kcmil
PVC Conduits	(8) 6-inch	(8) 6-inch	(4) 6-inch/circuit)	(8) 8-inch	(2) 8-inch steel	(4) (6 - inch)	(8) 6-inch	(8) 6-inch
Cables/phase	1	1	2	1	2	1	2	2
Spare Conduits	5	5	2	5	0	1	2	2
Cable Miles per mile of ROW (or mile of duct bank)	3	3	6	3	6	3	6	6
Project Cable Miles	12		4.26	3.3	15.6	1.26	66	
UG Project Cost ($M)	$32.9 M		$9.8 M	$92.5 M		$24.9 M	$137.6 M	
Cost excl. SS work	$27.50		$4.9 M	$16.5 M	$45.7 M	$6.2 M	$125.7 M	
Cost excl. SS & TS	$24.20		N/A	N/A	N/A	N/A	N/A	
Project land mileage cost	$16.45 M/land mile		$13.8 M/land mile	$25 M/land mile		$59.2 M/land mile	$25 M/land mile	
Project cable mileage cost	$2.7 M/mile of cable		$2.3 M/mile of cable	$4.9 M/mile of cable		$19.8 M/mile of cable	$11.5 M/mile of cable	
Project circuit mileage cos	$8.2 M/ckt. mi.	$8.2 M/ckt. mi	$6.9 M/circuit mile	$25 M/circuit mile	$12.5 M/circuit mile	$59.2 M/circuit mile	$12.5 M/ckt mi	$12.5 M/ckt mi

SS = Substation

TS = Transition Station

* In certain areas 2 directionally drilled holes were used in place of a single duct bank.

Table 2. Costs for Experimental and Pilot Underground ("UG") Transmission Projects and Comparisons with Overhead ("OH") Estimates

Project	Length (miles)	Estimated OH Cost		Actual 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)	$13.75 million per mile (UG section)	2.0
Beaumeade–NIVO	0.71	$7.9 million	$4.2 million per mile	$9.8 million	$6.9 million per mile	1.6
Ballston–Radnor Heights	5.2 HPFF 1.1 XLPE	$280 million	$39 million per mile	$92.5 million (XLPE + HPFF)	$15 million per mile (XLPE section only)	<1
Experimental Underground Projects Unrelated to the Pilot Program						
Clarendon–Ballston	0.42	N/A	N/A	$24.9 million	$14.7 million per mile	N/A
Garrisonville	11	$14.16 million	$0.9 million per mile	$137.6 million	$11.4 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. 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. In addition, DVP did not have to pay for easements on the Beaumeade–NIVO project.
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 at 50).
4. The OH estimate for Ballston–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 actual 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) Ballston–Radnor Heights: $92.5 million; total includes $30.3 million in substation transmission work;
   (d) Clarendon–Ballston: $24.9 million; total includes $18.7 million in substation transmission work; and
   (e) Garrisonville: $137.6 million; includes $11.9 million in substation transmission work.
7. For purposes of calculating mileage costs, DVP notes that Ballston–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.

Legislative Information System

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

This Appendix provides the status for the 30 transmission line applications of 230 kV or less filed with the SCC during the filing period. Delmarva submitted one application and APCo submitted nine applications for 138 kV overhead transmission lines. DVP submitted 16 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 3 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 project.

DVP Transmission Lines

DVP filed 20 applications during the filing period 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 line was energized March 6, 2014.

- 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 determined that the project does not meet the criteria necessary for consideration as an underground pilot project relative to the Act (Case Number PUE-2011-00113).

- Waxpool and Brambleton–BECO: 1.5-mile and 11.2-mile, 230 kV overhead transmission lines in Loudoun 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-2011-00129).

- 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 authorized the Company to construct an overhead transmission line (Case Number PUE-2012-00029). The ruling has been appealed.

- 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, respectively. The Commission authorized the Company to construct an overhead transmission line on existing right-of-way (Case Number PUE-2012-00065).

- Harrisonburg–Endless Caverns: 19.8-mile, 230 kV overhead transmission line in Rockingham County, Virginia. The Commission authorized the Company to construct an overhead transmission line on existing right-of-way (Case Number PUE-2012-00095).

- Brambleton–Beaumeade: 1.2-mile, 230 kV overhead transmission line relocation in Loudoun 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-2013-00002).

- Dooms–Lexington: 39.1-mile, 230 kV overhead transmission line to be underbuilt on existing 500/230 kV structures in Rockbridge and Augusta Counties, Virginia. The Commission has yet to rule on this application; however, underground construction is not a feasible option given the 230 kV line is to be built on existing towers under an existing 500 kV line (PUE-2013-00118).

- Remington CT–Warrenton, Wheeler–Vint Hill: 12-mile and 6-mile, 230 kV overhead transmission lines in Fauquier and Prince William Counties, Virginia. The Commission has yet to rule on this application (PUE-2014-00025).

<u>APCo Transmission Lines</u>

APCo filed nine applications during the filing period 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).

- Wythe Area Improvements: 17.6-mile (5.1 miles single-circuit, 12.5 miles double-circuit), 138 kV overhead transmission line in Wythe County and the Town of Wytheville, Virginia (Case Number PUE-2012-00132).

- South Lynchburg Improvements: 9.3-mile, 138 kV overhead transmission line in Campbell County, Virginia (Case Number PUE-2013-00126).

- Richlands–Whitewood: 8.4-mile, 138 kV overhead transmission line in Buchanan and Tazewell Counties, Virginia (Case Number PUE-2014-00040).

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, including public comment and expert testimony, and reviewing the Hearing Examiners' reports summarizing the evidentiary record in the cases, the Commission approved eight of the nine proposed projects for overhead construction. The Commission has yet to rule on the Richlands–Whitewood application.

Delmarva Transmission Line

Delmarva filed one application during the filing period 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 3. 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
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

Table 3 (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**
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	Did not qualify
Waxpool and Brambleton–BECO PUE-2011-00129 Filed 12/16/2011	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	Did not qualify
Surry–Skiffes Creek and Skiffes Creek–Whealton PUE-2012-00029 Filed 6/11/2012	Not viable	2.3–2.8 times the cost of OH for the total project	Approved 4/24/2012	Did not qualify; Certificate granted for OH line but decision on appeal
Cloverhill–Liberty and Liberty Loop PUE-2012-00065 Filed 6/29/2012	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	Did not qualify
Harrisonburg–Endless Caverns PUE-2012-00095 Filed 8/13/2012	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	Did not qualify
Brambleton–Beaumeade PUE-2013-00002 Filed 1/17/2013	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	Did not qualify
Dooms–Lexington PUE-2013-00118 Filed 11/07/2013	Detailed UG engineering analysis not completed	Cost analysis not applicable	None Filed	Did not qualify
Remington CT–Warrenton; Wheeler–Vint Hill PUE-2014-00025 Filed 3/31/2014	Detailed UG engineering analysis not completed	1.4–2.2 times the cost of OH for the total project	None Filed	Proceeding pending before SCC

Table 3 (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	Did not qualify
Wythe Area Improvements PUE-2012-00132 Filed 11/15/2012	Feasibility/cost inferred from similarity with Falling Branch–Merrimac	6 times the cost of OH for undergrounding an alternative route	None Filed	Did not qualify
South Lynchburg Improvements PUE-2013-00126 Filed 11/21/2013	Feasibility/cost inferred from similarity with Falling Branch–Merrimac	6 times the cost of OH for undergrounding an alternative route	None Filed	Did not qualify
Richlands-Whitewood PUE-2014-00040 Filed 6/12/2014	Detailed UG engineering analysis not completed	To be determined	None Filed	Proceeding pending before SCC
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.

*The County of Roanoke County Attorney did file a letter with Mr. Joel H. Peck, Clerk, SCC, on December 3, 2008, notifying the SCC that the Board of Supervisors requested the line be placed underground at its December 2, 2008 board meeting.

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, was 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 4 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.[1] 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.

[1] 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.[2]

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 $0.10 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, or 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 36 months,[3] with an anticipated completion date of June 2009. The overhead alternative was expected to require 24 months, including six months for preconstruction and 18 months for construction.

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[2] The preferred underground alternative ("Option 1") consisted of two transmission circuits and was designed 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.

[3] The 36-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 resulted in significant increases in the cost estimates for the project. As opposed to conventional trenching, these difficult conditions necessitated directional drilling to depths in the range of 60-70 feet. Additional costs were incurred for larger gauge cable due to poorer thermal dissipation at such depths. The cost was estimated to be $137.6 million ($11.9 million per mile *excluding* land acquisition costs), or approximately nine times the project cost using overhead construction.

Table 4. 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[4] $137.6 million (incl. $11.9 million for substation work)	Construction Completed	Initiated by DVP, approved by Commission (to gain experience with XLPE technology on a longer project)

[4] DVP notes that the new underground transmission line is effectively 11 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
DVP ANALYSIS OF UNDERGROUND TRANSMISSION LINE TECHNOLOGY AND APPLICATIONS

DVP ANALYSIS OF UNDERGROUND TRANSMISSION LINE TECHNOLOGY AND APPLICATIONS[1]

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 significantly smaller and 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, boring, and directional drilling. In some cases, drilling depths can extend downwards to 70 feet. Conversely, overhead transmission lines have a comparatively superficial impact at distinct points corresponding to tower locations which can typically range from 200 to 900 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 severe.

Transmission lines are typically built overhead throughout the country for reasons of economic expedience, technical feasibility, and environmental stewardship. Therefore, 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. For these reasons, utilities in the Commonwealth of Virginia have little experience with underground transmission line technology compared to overhead transmission line technology.

Underground transmission lines, though designed to replace 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 on the line. Therefore, as is the case in the Pleasant View – Hamilton line, shunt reactors are necessary to mitigate damaging over-voltage situations which would occur at almost any loading level – heavy or light. While other underground transmission lines in a networked configuration may be taken out of 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.

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. To ensure adequate reliability, underground transmission lines are typically constructed as double circuits in separate duct banks and require significantly different protection schemes. For safety reasons, duplicate underground circuits must occupy separate duct banks allowing for repairs on either circuit while allowing the other to remain energized and at a certain distance. "Dig-in" is an example of both a hazard associated with underground lines and also a cause of underground outages.

Ultimately, the construction, operation, and maintenance costs of underground transmission lines compared to those of conventional overhead transmission lines pose

[1] Analysis provided by DVP in response to a Staff request for input to the report.

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 material acquisition, construction, and maintenance/repair phases. Drastic increases in the costs of copper have resulted in similarly drastic increases in costs of XLPE cable. Copper commodity prices play a large part in determining the cost of large transmission cables. For instance, Dominion's typical 230kV cable (3500kcmil) contains approximately 10.79lb/ft of copper in the conductor portion (not including the concentric/shield layer). This is the equivalent of approximately 341,827 lbs of copper per mile for the cable system[2]. Over the past six years, the price of copper has fluctuated widely from a low of around $1.50/lb in late 2008 to a high of around $4.50/lb in early 2011, resulting in over $1M/mile cost difference just in raw material.

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 cost of the Garrisonville 230 kV Transmission Line project (reference Appendix C) exceeded original project estimates by over 67%[3] due largely to unforeseen adverse rock and terrain issues.

All of the pilot projects identified in this report have been completed and energized. Appendix C provides a summary of two experimental underground transmission line projects unrelated to HB1319 for the purpose of presenting issues likely to be relevant to the pilot program. Experience to date indicates that cost and potential cost variance continues to drive concerns associated with the construction of underground transmission lines. 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 number of citizens. The results of the pilot project have not altered Dominion's approach and preference for siting and designing transmission lines as overhead lines where feasible.

[2] Typical 230kV cable system consisting of 2 cables per phase
[3] Actual project cost $137.6M compared to original estimate of $82.3M