

Before the  
Pennsylvania Public Utility Commission

**CUMBERLAND – WEST SHORE  
#3 & #4 138/69 kV TRANSMISSION  
LINE RECONSTRUCTION**

**ATTACHMENTS IN SUPPORT OF THE  
Letter of Notification**

Application Docket No. \_\_\_\_\_

Submitted by: PPL Electric Utilities Corporation



## SUMMARY

This filing is submitted by PPL Electric Utilities Corporation (PPL Electric) pursuant to the Pennsylvania Public Utility Commission's (PUC or the Commission) regulations at 52 Pa. Code §§ 57.71 through 57.77 for PUC approval to reconstruct approximately 1.6 miles of the existing double circuit Cumberland – West Shore #3 and #4 69 kV Transmission Line between the Mount Allen Tap Line and the Rossmoyne Tap Line to resolve identified transmission reliability criteria violations in central Pennsylvania and to ensure reliable long-term electric service to customers in Cumberland County. The reconstructed line segment will be replaced with higher capacity conductors that will be designed and constructed for future 138 kV operation, but initially will operate at 69 kV until load growth in the area makes it appropriate to increase the operating voltage. The transmission line segment to be reconstructed is located within Lower Allen Township and Upper Allen Township in Cumberland County, Pennsylvania.

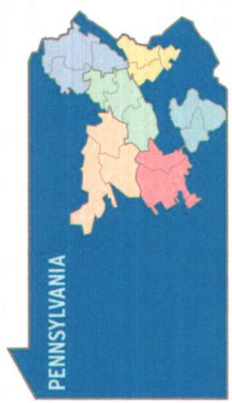
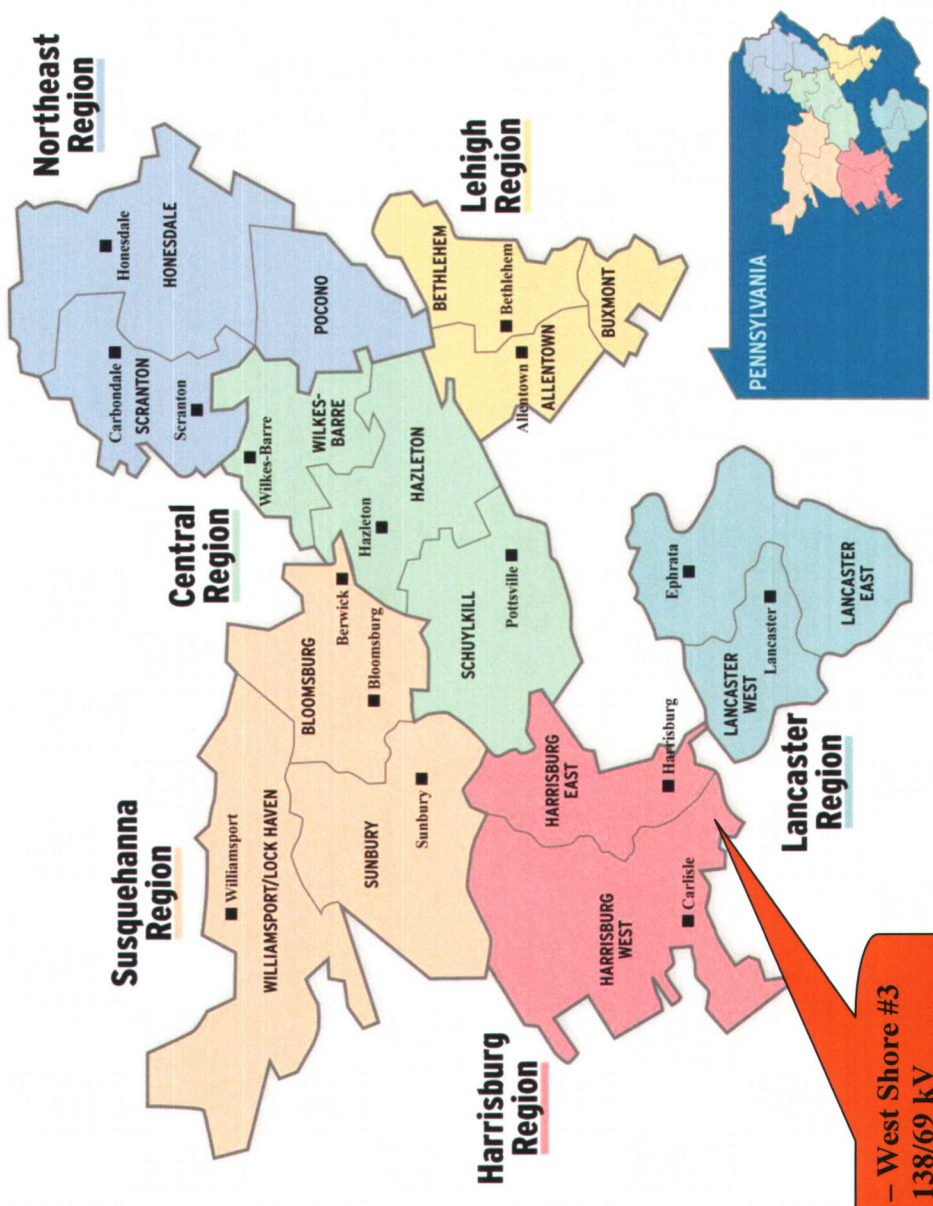
The Cumberland – West Shore #3 & #4 138/69 kV Reconstruction Project (Cumberland-West Shore Project) described herein will require rebuilding approximately 1.6 miles of existing Transmission Line largely within PPL Electric's existing right-of-way (ROW). This work will include replacing the existing wood pole structures with new steel monopole structures, installing a new conductor, and installing one Load Sectionalizing Air Break (LSAB) switch.

The estimated cost of the Cumberland-West Shore Project is \$2,314,900. Subject to Commission approval, construction is scheduled to begin in January 2013 to support the Project's in-service date of May 2013. The Attachments to the Letter of Notification describe the need, engineering, and environmental analysis for the proposed Cumberland-West Shore Project and provide additional information, including the following:

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Public Entities

# PPL ELECTRIC UTILITIES SERVICE TERRITORY



Cumberland – West Shore #3  
and #4 138/69 kV  
Transmission Line

**Attachment 1**

**ATTACHMENT 1**  
**CUMBERLAND – WEST SHORE #3 & #4 138/69 kV TRANSMISSION LINE**  
**RECONSTRUCTION**  
**NECESSITY STATEMENT**

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**ATTACHMENT 1**  
**CUMBERLAND – WEST SHORE #3 & #4 138/69 kV TRANSMISSION LINE**  
**RECONSTRUCTION**  
**NECESSITY STATEMENT**

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**A. INTRODUCTION**

This Necessity Statement describes the need for PPL Electric Utilities Corporation (“PPL Electric”) to reconstruct 1.6 miles of the existing double circuit Cumberland – West Shore #3 and #4 69 kV Transmission Line between the Mount Allen Tap Line and the Rossmoyne Tap Line in Upper and Lower Allen Townships, Cumberland County (Cumberland-West Shore Project). As explained below, PPL Electric proposes to replace this line segment with high-capacity conductors to resolve identified transmission reliability criteria violations in central Pennsylvania, and to ensure reliable long-term electric service to customers in Cumberland County.

PJM Interconnection, L.L.C. (“PJM”) is a Federal Energy Regulatory Commission (“FERC”) approved Regional Transmission Organization charged with ensuring the reliability of the electric transmission system under its functional control and coordinating the movement of electricity in all or parts of thirteen states and the District of Columbia, including most of Pennsylvania. PPL Electric, as an owner of transmission facilities in Pennsylvania, is a member of PJM and actively participates in the PJM transmission planning process. As explained in the sections that follow, the Cumberland-West Shore Project is required to resolve violations of PJM’s Reliability Planning Criteria as defined in “Manual 14B: PJM Region Transmission Planning Process” (PJM Manual 14B) and PPL Electric’s Reliability Principles and Practices (RP&P). After identifying this violation, through a coordinated effort, PPL Electric explored various solutions to address these violations. After extensive analysis, PPL Electric proposed the preferred solution to reconstruct the 1.6 mile long segment of the

existing double-circuit Cumberland – West Shore #3 and #4 69 kV Transmission Line for high-capacity 138 kV operation.

The rebuilt Cumberland – West Shore #3 and #4 138/69 kV Transmission Line will initially operate at 69 kV until load growth in the area makes it appropriate to increase the operating voltage to 138 kV. The preferred solution was reviewed and accepted by PJM. The proposed Cumberland-West Shore Project will eliminate the identified reliability criteria violation and will maintain reliable electrical service to customers served by PPL Electric in Cumberland County.

The estimated cost to rebuild this section of double circuit line is \$2,314,900. Construction is scheduled to begin in January 2013 to support a proposed in-service date of May 2013. The required in-service date is defined as the date that the proposed facility must be placed in service to prevent overloads that could potentially damage equipment and result in service interruptions to customers.

A PPL Electric system map showing existing transmission facilities with a design voltage of 69 kV or greater is included in the Attachment 1 map pocket. This filing addresses only the existing 69 kV and proposed 138/69 kV transmission system in Cumberland County.

## **B. SYSTEM PLANNING PROCESS AND GUIDELINES**

### **1. Transmission Reliability Standards**

The nation's interconnected transmission grid serves as the backbone for the safe and reliable delivery of large amounts of electricity from generating stations over substantial distances to customers served by transmission and local distribution systems. It is critically important that this interconnected transmission system (transmission grid) be planned and designed to be highly reliable so that reliable electric service can be provided under peak and all loading conditions and when certain elements of the system are out of service (system contingencies) due to

planned or forced outages.

On February 3, 2006, FERC certified the North American Electric Reliability Corporation (“NERC”) as the organization required to establish and enforce reliability standards for the bulk electric system. Thereafter, NERC develops and enforces reliability standards, which define the reliability requirements for planning and operating transmission systems in North America. The NERC Reliability Standards apply to all users, owners, and operators of the nation’s interconnected transmission grid, including PPL Electric. The NERC Reliability Standards are monitored and enforced by NERC and the regional reliability organizations that function under its auspices. NERC achieves compliance through monitoring, audits and investigations, the imposition of financial penalties, and other enforcement actions for non-compliance. These FERC-approved NERC Reliability Standards are mandatory and failure to comply can result in penalties of up to \$1 million per day per violation.

## **2. System Planning**

System Planning is the process which assures that the transmission system can supply electricity to all customer loads reliably and economically. The System Planning process assures that the transmission systems:

- Are able to accommodate the forecasted system flows during the summer peak load conditions
- Are constructed to adequately serve customers’ needs with regard to capacity, voltage, and reliability for all load levels throughout the daily load cycle;
- Can sustain probable contingencies and disturbances with no consequential loss of load; and
- Conform to the applicable transmission planning reliability principles, practices, and standards of PPL Electric, PJM, and NERC for all normal

and emergency operating conditions.

### **3. PJM Planning Process**

PJM is the FERC-approved Regional Transmission Organization (“RTO”) charged with ensuring the reliability of the electric transmission systems under its functional control (100 kV and above), and coordinating the movement of wholesale electricity in all or parts of thirteen states and the District of Columbia, including most of Pennsylvania. In order to ensure reliable transmission service, PJM prepares an annual Regional Transmission Expansion Plan (“RTEP”) to identify system reinforcements that are required to, among other things, meet the NERC Reliability Standards. The RTEP is a FERC-approved transmission planning process that undertakes a comprehensive analysis to identify existing and forecasted violations of the NERC Reliability Standards on the transmission systems within PJM’s service territory.<sup>1</sup>

PJM's RTEP is an annual process that encompasses a comprehensive series of detailed analyses to ensure power continues to flow reliably to customers under stringent reliability criteria set by NERC. The NERC reliability standards, transmission owner criteria, and PJM reliability planning criteria are used by PJM to analyze the system and to determine the specific transmission upgrade projects, as part of the overall reliability solution, that are needed to ensure long-term reliable electric service to customers and competitive power markets. Based upon this analysis, PJM determines the optimal transmission upgrades that are needed to meet NERC reliability standards.

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<sup>1</sup> PJM’s RTEP process is currently set forth in Schedule 6 of PJM’s Amended and Restated Operating Agreement (“Schedule 6”). Schedule 6 governs the process by which PJM’s members rely on PJM to prepare an annual regional plan for the enhancement and expansion of the transmission facilities to ensure long-term, reliable electric service consistent with established reliability criteria. In addition, Schedule 6 addresses the procedures used to develop the RTEP, the review and approval process for the RTEP, the obligation of transmission owners to build transmission upgrades included in the RTEP, and the process by which interregional transmission upgrades will be developed.

PJM conducts RTEP studies in conjunction with its transmission owners and applies NERC, regional, and transmission owner reliability criteria to specific conditions on the transmission system. When the studies show an inability of the transmission system to meet a specific reliability standard under these conditions, solutions such as construction of one or more new transmission lines or one or more upgrades to existing transmission facilities may be necessary.

NERC reliability standards require PJM to identify the “critical system conditions” against which the system must be evaluated to ensure that it meets the performance criteria specified in the standards. Specifically, the NERC reliability standards require PJM to test events which fall into the following categories:

- NERC Category A criteria require that, for all facilities in service, equipment thermal ratings and system voltage levels are within applicable limits and that the system is stable, referred to as “N minus zero” or N-0.
- NERC Category B criteria impose similar requirements with one facility removed from service. This is referred to as the “n minus 1” or “N-1” criteria. These criteria ensure that the system continues to remain within applicable limits and stable upon the outage of a transmission element.
- NERC Category C criteria require the system to be stable and within applicable equipment thermal ratings and system voltage limits for less probable contingency events. Such events include multiple facility outages such as bus, tower line, or circuit breaker failures. Also included are second contingencies involving the loss of one system element followed by manual system readjustments, and then the loss of a second system element. These second contingencies are referred to as the “N minus 1 minus 1” or “N-1-1” criteria.

PJM has developed the PJM Reliability Planning Criteria as set forth in the PJM

Manual 14B. The PJM Reliability Planning Criteria consist of multiple standards and applicable planning principles that include PJM planning procedures, NERC Planning Standards, NERC Regional Council planning criteria, Reliability First Corporation (RFC) Standards, and Transmission Owner-defined reliability criteria (in this case, the PPL Electric RP&P). PJM applies all applicable planning criteria when identifying reliability problems and determining the need for transmission system upgrades the PJM service territory. As a transmission owner in the PJM service territory, PPL Electric is required to follow the PJM Reliability Planning Criteria.

When a potential reliability violation is identified, PJM and the affected transmission owner develop specific solutions to resolve the identified violation. PJM presents the results of the analyses to its Transmission Expansion Advisory Committee (“TEAC”) to solicit comments on the violations and recommendations to resolve the identified reliability violations. The TEAC is open to participation by: (i) all transmission customers; (ii) all PJM members; (iii) state commissions and consumer advocates; (iv) any other entity proposing to build Merchant transmission facilities to be integrated into the PJM region; and (v) any other interested entities or persons. The TEAC reviews potential solutions to the identified reliability violations, including transmission line solutions. Where the solution requires construction of new or upgraded transmission facilities, PJM will direct the relevant transmission owner to undertake the required project.

### **3. The PPL Electric System Planning Process**

The reliable and economical operation of PPL Electric’s transmission system requires upholding PPL Electric’s planning guidelines for system expansion. The principles upon which these planning guidelines are based recognize that:

- The system expansion should be coordinated to achieve the most economical balance of construction and operating expenditures.
- It should maintain a proper balance between the degree of risk, amount

and type of load interrupted, and the cost of providing the needed expansion.

- System reliability should be maintained to prevent large scale, long term, or frequent service interruptions to avoid adverse effects and hazards to the public.

These principles are incorporated in PPL Electric's RP&P document.

PPL Electric undertakes an independent analysis of both its bulk electric system (BES) transmission facilities, which include transmission facilities operated at voltages of 100 kV or higher and are under the functional control of PJM, and its non-bulk electric transmission system facilities. The PPL Electric planning guidelines are outlined the RP&P, which was developed to ensure adequate and appropriate levels of electric service to its customers consistent with good utility practice. The PPL Electric RP&P for the bulk electric system is consistent with NERC Reliability Standards and PJM Reliability Planning Criteria.

In accordance with the RP&P guidelines, PPL Electric's transmission system is planned so that it can be operated at all projected load levels and during normal and scheduled outages to withstand specific unscheduled contingencies without exceeding the equipment capability, causing system instability or cascade tripping, or exceeding voltage tolerances. The transmission system is required to have adequate capability so that it can be operated normally and can withstand the following unscheduled contingencies and other system conditions:

- For the normal system operations, the system should remain stable, and both thermal and voltage limits should remain within the applicable ratings in order to prevent equipment damage, N-0 category.
- For the loss of any single element (single or double circuit transmission line, transformer, or generator, N-1 category), following the contingency,

the system should remain stable and both thermal and voltage limits should stay within the applicable ratings in order to prevent equipment damage and cascading outages.

- For the loss of a bus, double circuit transmission line, or the combination of a single line or three phase fault with stuck breaker, or a single line to ground fault with a failure of protection system (N-2 category), following the contingency, the system should remain stable and both thermal and voltage limits should stay within the applicable ratings in order to prevent equipment damage and cascading transmission outages.
- For the loss of a single element and subsequent loss of a second single element (N-1-1, a special category of N-2), after the initial loss, appropriate switching and/or starting of available generation, and load shedding procedures can be initiated to prevent damage to equipment and cascading outages.
- Load loss resulting from the loss of the non-bulk electrical transmission facilities should remain within the RP&P guidelines.

The planning process begins with development of a computer model of the future system. A specific study year is chosen and the future system model is developed using the existing system plus any planned modifications to the transmission system scheduled to be in service prior to the study year. Load levels used in the system model are based on the latest forecast prepared within the Transmission Planning section of PPL Electric. The load forecast used by Transmission Planning is based on the recent PJM summer peak forecast and on temperature and humidity indices.

Once the system model is complete, comprehensive power flow simulations are performed to determine the ability of the system to comply with the PPL Electric

Reliability Criteria. This is accomplished by simulating an outage of each non-BES and bulk power facility. All conditions where the system is not in conformance with the PPL Electric Reliability Criteria are identified and system reinforcements are added to bring the system into conformance. After that, system reinforcement projects are compiled, their cost and lead times for completion are estimated, and computer simulations of the system with the identified reinforcement alternatives are completed to identify the best overall reinforcement that will meet the needs of the region in a reliable and economic manner.

C. **EXISTING SYSTEM**

The Cumberland – West Shore #3 and #4 69 kV Transmission Lines extend 17.7 and 19.9 miles, respectively, between the Cumberland 230 – 69 kV Substation and the West Shore 230 – 69 kV Substation. Presently, twelve 69-12 kV substations are served from the Cumberland – West Shore #3 and #4 69 kV Transmission Lines: five are PPL Electric substations, and seven are large customer-owned substations. Under normal operating conditions, both the Cumberland 230 – 69 kV Substation and the West Shore 230 – 69 kV Substation supply the twelve 69 – 12 kV substations served by the Cumberland – West Shore #3 and #4 69 kV Transmission Line.

PPL Electric's Cumberland 230 – 69 kV Substation is supplied by two 230 kV transmission lines; the Juniata-Cumberland 230 kV Transmission Line and the Cumberland-West Shore 230 kV Transmission Line. The 1.6 mile section of the Cumberland – West Shore #3 and #4 69 kV Line between the Mount Allen Tap and Rossmoyne Tap currently uses low-capacity 336 kcmil<sup>2</sup> ACSR<sup>3</sup> conductors.

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<sup>2</sup> Kcmil stands for thousand circular mills. Kcmil wire size is the equivalent cross sectional area in thousands of circular mills. A circular mil is the area of a circle with a diameter of one thousandth (.001) of an inch.

<sup>3</sup> ACSR stands for aluminum conductor steel reinforced.

The basic functional arrangement of the existing transmission system in the region is shown in Figure 1 at the end of this Attachment 1.

**D. DEFINITION OF THE PROBLEM**

Applying the RTEP process as outlined above, the 2008 RTEP identified violations of the PJM Reliability Planning Criteria and PPL Electric RP&P. Specifically, the 2008 RTEP identified a load loss violation and a thermal overload for an N-1-1 event. The major violations identified in the 2008 RTEP are summarized below.

PPL Electric's Cumberland 230 – 69 kV Substation serves approximately 325 MW of load. The outage of both 230 kV sources to the Cumberland 230 – 69 kV Substation would cause all 325 MW of load to be lost. This load loss would be a violation of the PJM Reliability Planning Criteria identified in Manual 14B, which limits load loss to 300 MW for all criteria tests.

Further, the 1.6 mile section of the Cumberland – West Shore #3 and #4 69 kV Line between the Mount Allen Tap and Rossmoyne Tap will overload its current 336 kcmil ACSR conductors if it were used as a transmission path to reduce the amount of interrupted load at the Cumberland 230 – 69 kV Substation to within the PJM limit of 300 MW. Transmission lines have a maximum rated thermal capacity, which is the maximum electrical current they can safely carry. When a transmission line overloads, the conductor, the hardware securing the conductor and the line terminal equipment begin to overheat. Overheating the conductor may cause the line to sag. Under these conditions, the metal in the conductor may become brittle, rendering it useless. In addition, the line may break and fall to the ground causing a potentially dangerous situation for those near the line, as well as the crews required to respond to the event. Overloading transmission lines may

cause permanent damage to transmission infrastructure and catastrophic long duration power outages.

**E. PROPOSED SOLUTION**

To resolve the reliability problems explained above, PPL Electric proposes to rebuild 1.6 miles of the double circuit Cumberland – West Shore #3 and #4 69 kV Transmission Line between the Mount Allen Tap and the Rossmoyne Tap utilizing higher capacity 795 kcmil ACSR conductors. The Summer Emergency rating of 795 kcmil ACSR is 161 MVA compared to 92 MVA for 336 kcmil ACSR. While the standard for 138/69 kV line design usually calls for 556 kcmil ACSR conductors, 795 kcmil ACSR conductors will be used due to the greater load carrying capability of the larger conductor. As a result of the larger, heavier conductors, the existing wooden poles will be replaced with steel monopoles.

The reconstructed Cumberland – West Shore #3 and #4 138/69 kV Transmission Line initially will operate at 69 kV. Conversion to 138 kV will take place when load growth in the West Shore area approaches the limits of the 69 kV systems' capability. Reconstructing to 138 kV design standards now is to facilitate future conversion to 138 kV and minimize interruption to customers' electric service during the conversion.

With the reconstruction of this 1.6 mile section of the Cumberland – West Shore #3 and #4 Transmission Lines from 336 kcmil ACSR conductors to higher capacity 795 kcmil ACSR conductors, approximately 50 MW of load could be restored after the loss of both 230 kV sources into the Cumberland 230 – 69 kV Substation by transferring the load to the rebuilt Cumberland-West Shore #3 and #4 138/69 kV Transmission Line without overloading the rebuilt Transmission Line. The amount of load interrupted will then be below 300 MW limit and

remain within the PJM Reliability Planning Criteria.

PPL Electric submitted the proposed Cumberland-West Shore Project to PJM on April 13, 2007. PJM accepted the solution and presented the upgrade to TEAC on September 17, 2008, and the PJM Board approved the Cumberland-West Shore Project in December 2008. The Cumberland-West Shore Project was included in the PJM 2008 RTEP report as a baseline load growth reliability upgrade, PJM baseline project number b0625.

**F. FUNCTIONAL ALTERNATIVES**

No other reasonably economical functional alternatives were identified that would resolve the problem outlined above. Further, load transfers to the Cumberland 230 – 69 kV Substation on the 138/69 kV system are not possible due to the limited capacity of that system. Rebuilding the limiting section of the Cumberland – West Shore #3 and #4 69 kV Lines will resolve the violation of PJM Transmission Planning criteria.

**Attachment 2**

**ATTACHMENT 2**  
**CUMBERLAND – WEST SHORE #3 & #4 138/69 kV TRANSMISSION LINE**  
**RECONSTRUCTION**  
**ENGINEERING DESCRIPTION**

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**MAP**

MAPS	PROJECT LOCATION MAP AND AERIAL EXHIBIT.....	END OF ATTACHMENT 2
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**ATTACHMENT 2**  
**CUMBERLAND – WEST SHORE #3 & #4 138/69 kV TRANSMISSION LINE**  
**RECONSTRUCTION**  
**ENGINEERING DESCRIPTION**

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**A. DESCRIPTION OF THE PROPOSED LINE**

PPL Electric Utilities proposes to reconstruct a segment of the existing Cumberland-West Shore #3 and #4 69 kV Transmission Line between the Mount Allen Tap Line and the Rossmoyne Tap Line. The Line segment is 1.6 miles and is currently a double-circuit 69 kV line designed for, and operating at, 69 kV. The reconstructed Line will be designed for double-circuit 138 kV operation, but will operate initially at 69 kV. The line will be converted to 138 kV operation when load growth in the area makes this increase appropriate. The proposed Project is located in Upper and Lower Allen Townships, Cumberland County. Refer to the Aerial Exhibit at the end of Attachment 2 which depicts the location of these facilities.

The Line must be reconstructed because the existing wood poles are at the end of their useful lives, cannot support the heavier conductor required for this Project, and are not high enough to allow sufficient ground clearance. The 50 existing wood poles, which average 65 feet high (see Figure 1), will be replaced in approximately the same location with 50 steel poles averaging 75 feet high (see Figure 2). Span lengths will average 200 feet. Each steel pole will be equipped with six steel upswept conductor support arms. Angle structures will be guyed, and tangent structures will be direct embedded. A steel High-Low Tap structure will replace the existing wood pole tap structure. The high pole will be 97 feet high, and the low pole will be 60 feet high (see Figure 3). Six power conductors and one overhead groundwire will be installed. The power conductors will be 795 kcmil 30/19 stranding ACSR. The overhead ground wire will be 3/8 high strength steel and will provide lightning protection for the reconstructed section of

Line. In addition to the above, one Load Sectionalizing Air Break (LSAB) switch will be installed (see Figure 4).

The proposed Line will be designed to, and generally exceed, National Electrical Safety Code minimum standards. Design specifications and safety rules practiced by PPL Electric Utilities are included in Attachment 4. The minimum conductor to ground clearance for the proposed Line will be 30 feet which occurs at a maximum conductor temperature of 125°C. The designed minimum conductor clearances and conductor thermal ratings are as follow:

**TABLE 1**  
**DESIGN MINIMUM CONDUCTOR CLEARANCES**  
**FOR 795 KCMIL 30/19 STRANDING ACSR\***

<u>Condition</u>	<u>Double-Circuit Design Clearance to Ground</u>
Normal load, average weather (16°C ambient temperature)	31.17 feet
Predicted extreme thermal load (125°C conductor temperature)	30.00 feet
Predicted NESC extreme wind load (16°C ambient temperature)	31.06 feet
Predicted extreme weather conditions (1-inch ice, 4 lbs. wind, -10°C)	31.40 feet

*Clearances based on a maximum tension of 3000 lbs. at 1 inch ice, 4 lbs. wind, -10°C and a ruling span of 200 feet.*

**TABLE 2**  
**CONDUCTOR THERMAL RATING**  
**795 KCMIL 30/19 STRANDING ACSR**  
**125°C MAXIMUM CONDUCTOR TEMPERATURE**

<u>Condition</u>	<u>Ambient Temperature</u> <u>°C</u>	<u>Wind Speed</u> <u>Knots</u>	<u>Ampacity</u> <u>Amps</u>
Summer Normal	35	0	1058
Winter Normal	10	0	1220
Summer Emergency	35	1.5	1350
Winter Emergency	10	1.5	1521

**B. MAGNETIC FIELD MANAGEMENT**

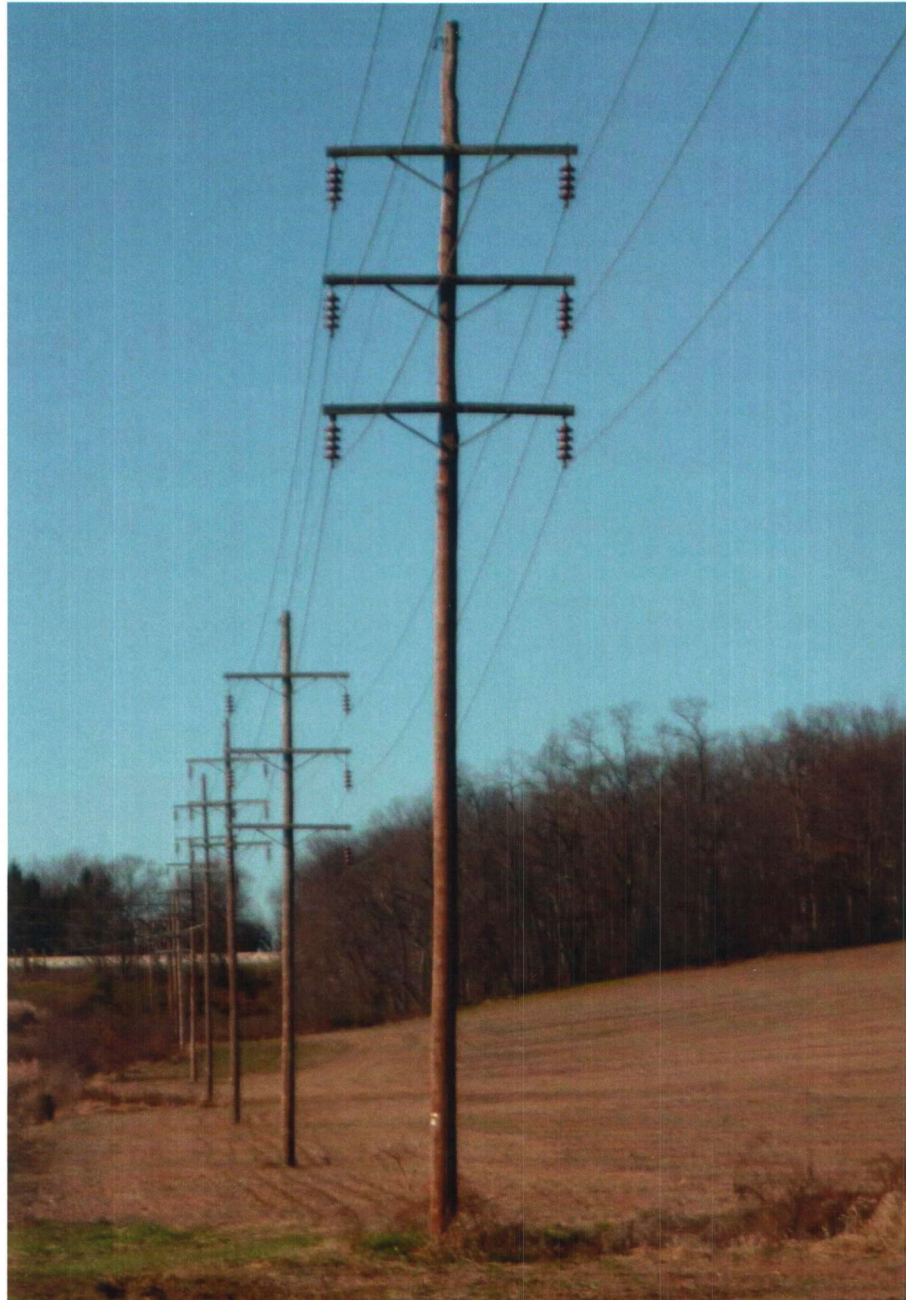
PPL Electric’s Magnetic Field Management Program is summarized in Attachment 5 and applied to reconstruction and new line projects. In order to lower magnetic field exposures, the program generally prescribes the use of line design that provides 5 feet higher ground clearances and reverse phasing new double-circuit lines where it is feasible to do so at low or no cost. The implementation of additional modifications will be considered, provided those modifications can be made at low or no cost and do not interfere with the operation of the facility.

For this Project, reverse phasing can be utilized to reduce magnetic field levels because we are rebuilding an existing line that is currently reverse phased. A further reduction of the magnetic field will be achieved through the use of taller poles resulting in increased ground clearance.

C. **RIGHT-OF-WAY STATUS**

PPL Electric does not require any additional right-of-way (“ROW”) for the rebuild of the Cumberland – West Shore #3 and #4 138/69 kV Transmission Line. In order to facilitate the rebuild of the Line without using custom-designed structures, however, PPL Electric is attempting to widen its ROW across one property. PPL Electric has approached the Dunkard Brethern Church for an additional 0.05 acres of ROW for the installation of guy wires on an angle structure. If the church declines, PPL Electric will install a custom-designed steel pole on a concrete foundation within the existing ROW. The Aerial Exhibit at the end of Attachment 2 shows existing property lines and current ownership along the right-of-way as well as the expanded ROW on Dunkard Brethern Church property. Attachment 6 identifies the property owners within the proposed right-of-way.

**FIGURE 1**  
**EXISTING 69 kV DOUBLE CIRCUIT WOOD POLES**



Average Height High Pole – 65 Feet  
Arm Spacing – 7 Feet  
Length of Arms – 12 Feet

**FIGURE 2**  
**PROPOSED 138/69 kV DOUBLE CIRCUIT**  
**STRUCTURE**



Average Height – 75 Feet

Length of Steel Arms – 7 Feet

**FIGURE 3**  
**NEW 138/69 kV DOUBLE CIRCUIT**  
**HIGH – LOW TAP WITH STEEL POLES**



High Pole Height – 97 Feet

Low Pole Height – 60

**FIGURE 4**  
**PROPOSED TWO POLE X-BRACED LSAB SWITCH**  
**STRUCTURE**



Height – 75 Feet

Switch Spacing – 9 Feet

Width of Structure – 16 Feet

**Attachment 3**

**ATTACHMENT 3**  
**CUMBERLAND – WEST SHORE #3 & #4 138/69 kV TRANSMISSION LINE**  
**RECONSTRUCTION**  
**ENVIRONMENTAL ASSESSMENT**

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**ATTACHMENT 3**  
**CUMBERLAND – WEST SHORE #3 & #4 138/69 kV TRANSMISSION LINE**  
**RECONSTRUCTION**  
**ENVIRONMENTAL ASSESSMENT**

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**D. INTRODUCTION**

PPL Electric is requesting PUC approval to reconstruct approximately 1.6 miles of the existing Cumberland – West Shore #3 & #4 69 kV Transmission Line between the Mount Allen and Rossmoyne Taps. The proposed Project will be designed and constructed for future 138 kV operation, but initially will operate at 69 kV until load growth in the area makes it appropriate to increase the operating voltage.

The proposed Project is located in Lower Allen Township and Upper Allen Township, Cumberland County. The proposed Project was reviewed with representatives of both Townships, and the County. Neither the Townships nor the County has any objection to the proposed reconstruction. A list of involved governmental agencies, municipalities, and other public entities is presented in Attachment 7.

**E. LAND USE**

The existing Transmission Line begins on the north side of Route 15 and traverses in a southeasterly direction, crossing Route 15, the Rossmoyne Industrial Park and the Pennsylvania Turnpike (I-76). The Transmission Line parallels I-76 for a short distance before turning south through an agricultural field and into the West Shore Substation. The closest residential development is located in between the Rossmoyne Industrial Park and the Pennsylvania Turnpike. With one exception (see Right-of-Way Status on page 2-4) the proposed rebuild will be constructed entirely within the existing right-of-way (“ROW”) for the Cumberland – West

Shore #3 & #4 69 kV Transmission Line. While the new transmission structures will be somewhat taller, visual impacts to existing and future homes in the area will be minimal as the Project consists of reconstructing within an existing transmission ROW that presently contains a double-circuit transmission line.

No communication towers, pipelines, or other utilities will be affected by the proposed Project. The closest airport is the Capital City Airport, located approximately 5 miles east of the Project. The proposed reconstruction is not expected to impact airport operations. PPL Electric will file the appropriate documentation with both the Federal Aviation Administration and the PennDOT Bureau of Aviation to ensure the proposed line rebuild will not be a hazard to the airport's flight operations.

**F. CULTURAL RESOURCES**

Historic Architectural Assessment

PPL Electric completed a desktop survey of historic architectural resources within the project area. The survey consisted of accessing the Pennsylvania Historical and Museum Commission ("PHMC"), Bureau for Historic Preservation ("BHP") Cultural Resources Geographic Information System ("CRGIS") to review available information on previously recorded historic architectural sites along and in the vicinity of the transmission line alignment.

Two National Register of Historic Places ("NRHP") eligible historic architectural resources are located within 1 mile of the proposed Project. The first NRHP-eligible resource, the Pennsylvania Turnpike (key number 122695), is located within the existing Cumberland – West Shore ROW. The turnpike is crossed once by the existing transmission Line. The second is the Harrison Farm (key number 077113), located approximately 0.5 mile from the Project. In addition to the two properties mentioned above, the Philadelphia and Reading Railroad is

traversed by the existing transmission Line. This resource (key number 155708) is currently listed as an “aggregate file”<sup>1</sup> that traverses multiple counties, and its NRHP-eligibility is undetermined. Because the Project involves reconstructing an existing transmission Line, the Project will not have any material impact on any architectural sites.

#### Archaeological Assessment

Review of the PHMC CRGIS reveals that no recorded archaeological sites are located within 1 mile of the proposed Project.

PPL Electric consulted with the PHMC to determine whether surveys are required given the limited earth disturbance involved. A response letter from the PHMC dated March 21, 2012<sup>2</sup> indicates that the activities associated with this Project should have no effect on existing or potential historic buildings, structures, and/or archaeological resources in the project area. No further investigations are required. PPL Electric will notify the PHMC should any unidentified historic buildings, structures or archaeological resources be discovered during the course of this Project.

### **G. NATURAL FEATURES**

The Project will not affect any recreational areas or natural landmarks. No recreational areas are traversed by the Project. The closest local recreation area, Vernon C. Wass Park, is located approximately 0.7 mile northeast of the Project. Other local recreation areas located over 1 mile from the Project include Mt. Allen Park, Spring Run Park, Lower Allen Community Park, and Yellow

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<sup>1</sup> “Aggregate files” are digital files that were created as a means of bringing together - and displaying in the CRGIS - any previously surveyed components of a particular railroad line, noted in the details report as “Associated Resources.”

<sup>2</sup> File No. ER 2012-1134-041-A.

Breeches Park. According to the Natural Areas Inventory (NAI)<sup>3</sup> of Cumberland County, the closest natural area is the Yellow Breeches-Rabold NAI Site. This natural community is located approximately 1.5 miles northeast of the Project within the floodplain of the Yellow Breeches Creek and supports a plant species of concern. Based on the distance from the proposed Project, no impacts are expected on this natural area.

The Project will not traverse or affect any other unique geological, scenic or natural areas. PPL Electric conducted a wetland delineation of the Line on December 15, 2011. One palustrine emergent (PEM) wetland approximately 0.7 acre in size and one perennial unnamed tributary of Cedar Run were observed within the ROW. The unnamed tributary is designated as a cold water fishery (CWF). PPL Electric will acquire all required environmental permits and adhere to all of their terms and conditions. Some minimal tree clearing may be required, and PPL Electric will apply its “Specification for Initial Clearing and Control of Vegetation On or Adjacent to Electric Line Right-of-Way Through Use of Herbicides, Mechanical and Hand Clearing Techniques” to minimize any impacts. PPL Electric will employ its “Specification for Soil Erosion and Sedimentation Control on Transmission Line Rights-of-Way” as appropriate. PPL Electric will acquire any required soil erosion and sedimentation control permits, and PPL Electric will comply with any conditions placed on those permits.

#### **H. THREATENED AND ENDANGERED SPECIES**

PPL Electric conducted an online Pennsylvania Natural Diversity Inventory (PNDI) database review on January 25, 2012. Based on this review, the Pennsylvania Game Commission (PGC), Pennsylvania Fish and Boat Commission (PFBC), and the Pennsylvania Department of Conservation and Natural Resources (DCNR) all report that, except for occasional transient species

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<sup>3</sup> The Nature Conservancy. (2005). *A Natural Areas Inventory of Cumberland County*.

of wildlife, no threatened or endangered plant or animal life is known to exist in the project area.<sup>4</sup>

The Project is located within the known range of the federally threatened bog turtle (*Glyptemys muhlenbergii*). Therefore, a Phase I bog turtle survey was conducted on April 5, 2012 for the wetland observed within the ROW. Based on the Phase I survey, the wetland is considered to be a potential bog turtle habitat. PPL Electric retained a qualified bog turtle surveyor to conduct a Phase II survey to determine the presence or absence of bog turtles onsite. That survey was completed on May 21, 2012, and no bog turtles were encountered. PPL Electric will submit the results of the Phase II survey to the U.S. Fish and Wildlife Service (USFWS) and will continue to consult with the USFWS to obtain clearance.

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<sup>4</sup> Pennsylvania Natural Diversity Inventory (PNDI) Search ID: 20120125335761

**Attachment 4**

**ATTACHMENT 4**  
**CUMBERLAND – WEST SHORE #3 & #4 138/69 kV TRANSMISSION LINE**  
**RECONSTRUCTION**

**PPL ELECTRIC DESIGN CRITERIA AND SAFETY PRACTICES**

The National Electrical Safety Code (NESC) is a set of rules to safeguard people during the installation, operation, and maintenance of electric power lines. The NESC contains the basic provisions considered necessary for the safety of employees and the public. Although it is not intended as a design specification, its provisions establish minimum design requirements. PPL Electric Utilities Corp. (PPL Electric) has developed design specifications and safety rules which meet or surpass all requirements specified by the NESC.

Engineering Design Criteria and Parameters

The NESC includes loading requirements and clearances for the design, construction, and operation of power lines. The "loads" on conductors and supporting structures are the mechanical forces that develop from the weight of the conductors, the weight of ice on the conductors, plus wind pressure on the conductors and supporting structures. Loading requirements are the loads on the conductors and structures that are anticipated assuming certain ice and wind conditions. Loading requirements always contain "safety factors" to allow for unknown or unanticipated contingencies. The clearances and loading requirements contained in the NESC were developed to ensure public safety and welfare.

PPL Electric transmission line design standards meet or surpass the NESC standards. For example, the relative order of grades of construction for conductors and supporting structures is B, C, and N; Grade B being the highest. According to the NESC standards, construction Grades B, C, or N may be used for transmission lines (except at crossings of railroad tracks and limited access highways where Grade B construction is specified). However, PPL Electric designs all of its transmission lines for Grade B construction. The use of Grade B design and

construction specifies enhancements such as larger-minimum crossarm dimensions, larger-minimum conductor size, and increased safety factors.

Another example is the design parameters utilized to account for ice and wind loadings on the overhead ground wire (OHGW) and power conductors. The NESC standard ice and wind design magnitudes for the PPL Electric territory are 0.5 inch thickness of radial ice combined with four pounds per square foot horizontal wind pressure (equivalent to 40-mile per hour wind velocity). The conductor sags and tensions used in line designs are the result of various ice and wind combinations, depending on the elevation at the line location and line design voltage. The conductor sags and tensions used in the design of all PPL Electric transmission lines are at least 0.5-inch ice combined with eight pounds wind pressure (equivalent to 57 miles per hour wind velocity). This means that PPL Electric lines are designed to operate safely and reliably during inclement weather even more severe than assumed by the NESC. In addition, PPL Electric transmission lines are designed with more clearance to the ground than required by the NESC. The tables below compare PPL Electric and NESC ground clearances for lines of various voltages.

**138 kV**

<u>Surface Underneath Conductors</u>	<u>Vertical Clearance to Ground</u>	
	<u>NESC Standard</u>	<u>PPL Electric Design</u>
Roads, streets, alleys	21 Ft.	30 Ft.
Other land traversed by vehicles (such as cultivated field, forest, etc.)	21 Ft.	30 Ft.
Spaces accessible to pedestrians only	17 Ft.	30 Ft.
Railroad tracks	31 Ft.	35 Ft.

**230 kV**

<u>Surface Underneath Conductors</u>	<u>Vertical Clearance to Ground</u>	
	<u>NESC Standard</u>	<u>PPL Electric Design</u>
Roads, streets, alleys	23 Ft.	32 Ft.
Other land traversed by vehicles (such as cultivated field, forest, etc.)	23 Ft.	32 Ft.
Spaces accessible to pedestrians only	19 Ft.	32 Ft.
Railroad tracks	31 Ft.	36 Ft.

**500 kV**

<u>Surface Underneath Conductors</u>	<u>Vertical Clearance to Ground</u>	
	<u>NESC Standard</u>	<u>PPL Electric Design</u>
Roads, streets, alleys	28 Ft.	53 Ft.
Other land traversed by vehicles (such as cultivated field, forest, etc.)	28 Ft.	53 Ft.
Spaces accessible to pedestrians only	24 Ft.	53 Ft.
Railroad tracks	38 Ft.	53 Ft.

A relay protection system is used to protect the public safety and welfare as well as equipment and the transmission system. Relay protection is installed for all transmission lines to automatically de-energize the line in the unlikely event that the line or supporting structure fails and the line contacts the ground.

### Periodic Maintenance Program on All Transmission Lines

To ensure continued public safety and integrity of service, a periodic maintenance and inspection program is implemented for every transmission line. The program is administered through the use of helicopter patrols, with supplemental foot and structure climbing patrols. A number of helicopter patrols are performed on all lines annually. The two-man helicopter crew flies parallel, to the left, and above the line so that the observer can look for signs of line damage or deterioration and observe clearances between vegetation and conductors. The observations are included in a report that is forwarded to the appropriate department for corrective action.

Foot and structure climbing patrol programs for a transmission line begin approximately three to five years after the line is energized, unless a helicopter patrol reports a need for earlier action. The frequency of foot patrols varies from once every year to once every several years depending on line type and age.

An assigned foot patroller checks right-of-way conditions, including access roads, bridges, pole washouts, tower footers, vegetation height and clearance to conductors, pole and tower deterioration and, with the use of binoculars, insulators, and condition of hardware. Identified problems are included in a report that is forwarded to the appropriate department for corrective action.

A scheduled line outage is required to perform an overhead patrol because of "hands-on" inspection of hardware. Overhead patrols are conducted on a schedule determined by line age, operating record, and observed general condition. The necessary repairs are also done during the inspection outage.

### Personnel Safety Rules

The following are a few of the PPL Electric safety rules that demonstrate the Company's concern for employee safety:

- Work procedures have been developed to allow work to be performed on energized facilities in a safe manner. When lines or apparatus are removed from service to be worked on, the Energy Control Process system is applied. This system provides that a red tag must be physically placed on the control handle of the de-energized equipment. The red tag may be removed only after proper authorization to energize the equipment. Various other tags are used for limited operations and informational purposes. Employees will not apply or remove a tag or change the status of tagged equipment unless authorized.
- Temporary safety grounds are used on de-energized facilities for employee safety during maintenance, construction, or reconstruction work. Safety grounds are wires connecting the de-energized facility to an electrical ground. If the facility should be energized, the safety grounds will divert the current directly to ground and reduce the likelihood of personal injury. The conductor size and attachment clamps of temporary safety grounds must be capable of conducting anticipated fault currents. Rubber gloves, rubber sleeves, and additional rubber protective equipment are used as required when applying or removing temporary safety grounds to or from the lines or apparatus to be grounded. An approved nonconductive working stick of sufficient length to allow workers to maintain the following required minimum clearances is used to test that the line has been de-energized and to apply temporary safety grounds:

<u>Voltage-kV</u>	<u>Minimum Clearance</u>
138	3'-7"
230	5'-3"
500	11'-3"

- Before applying grounds, a test is done to confirm that the line is de-energized. The voltage test device is checked before and after use to assure reliability. When ground pins are used to establish proper ground points, they are driven to a depth of not less than four feet as near vertical as possible.

- Poles or structures are inspected and examined for structural integrity before climbing. If there is any reason to believe that a pole is unsafe, it is stabilized before work is performed. Appropriate safety gear in the form of body belts, safety straps, hard hats, gloves, etc., is worn by linemen during line work activity.

**Attachment 5**

**ATTACHMENT 5**  
**CUMBERLAND – WEST SHORE #3 & #4 138/69 kV TRANSMISSION LINE**  
**RECONSTRUCTION**  
**PPL ELECTRIC MAGNETIC FIELD MANAGEMENT PROGRAM**

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**MAGNETIC  
FIELD  
MANAGEMENT  
PPL Electric Utilities  
Corporation**

**DECEMBER 2004**

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# INTRODUCTION

At PPL Electric Utilities Corp. (PPL EU), magnetic field management means investigating and implementing methods at low or no cost to reduce magnetic fields in new or rebuilt transmission and distribution lines. This document explains PPL EU's Magnetic Field Management Program, which is part of PPL EU's larger Electric and Magnetic Fields (EMF) policy.

## **PPL EU's View**

Some people are worried that electric and magnetic fields are harming their health. Others think the scientific research does not show a problem at all, and still others believe there's just too much scientific uncertainty to draw any conclusions.

Here's what we do know now. Various panels of scientists that have reviewed the EMF research generally have drawn two main conclusions. First, the large body of evidence does not demonstrate that EMF are harmful. Second, additional research is recommended to explore questions raised in some studies.

Given these conclusions, PPL EU is taking a reasoned approach in responding to the EMF issue. PPL EU's approach to the EMF issue consists of five elements:

- Providing EMF information to customers and employees
- Providing magnetic field measurements
- Establishing and implementing a magnetic field management program to reduce magnetic fields in new or rebuilt facilities when it can be done at no, or low, cost
- Integrating EMF in the public involvement process that PPL EU undertakes in the siting of transmission lines
- Have supported additional research

## **EMF Are All Around Us**

Electric and magnetic fields occur in nature and in all living things. The earth, for instance, has a magnetic field, which makes the needle on a compass point north.

Electric fields and magnetic fields of a different type also surround every wire that carries electricity. In everyday life, these EMF arise from several basic sources, including power lines, electrical appliances, home and building wiring, other utility lines and cables, and currents flowing on water pipes. Though they often occur together, EMF are made up of two separate components:

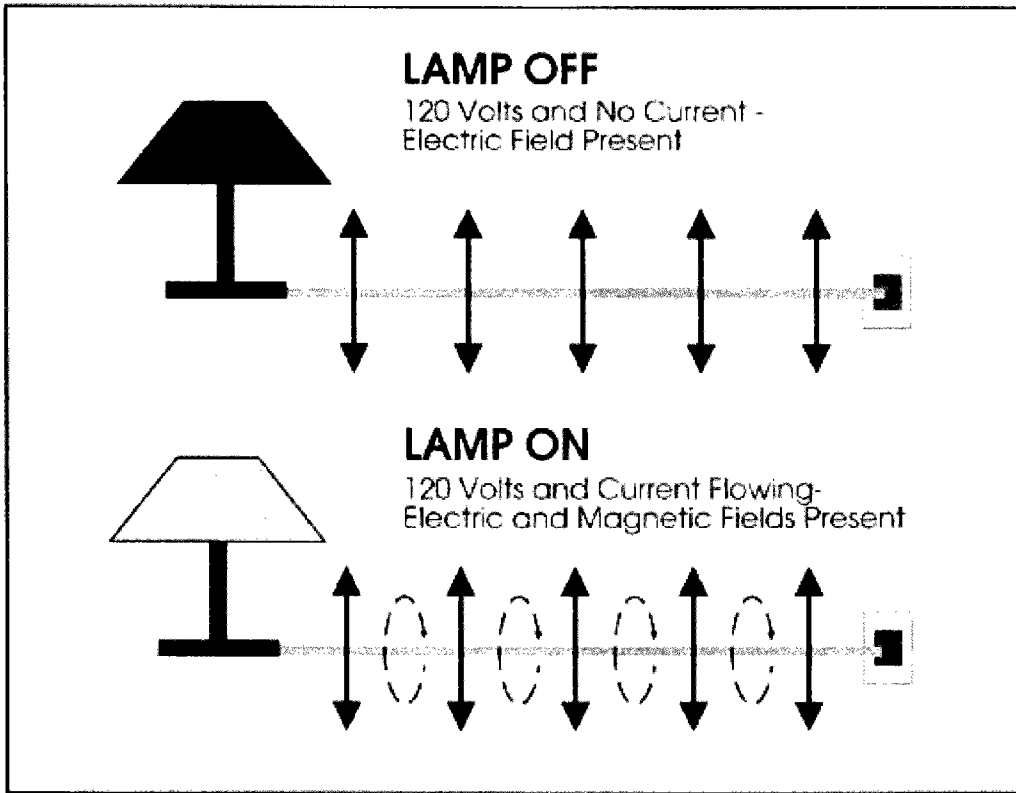
### **Electric Fields**

Electric fields are produced by the voltage—or electrical pressure—on a wire. The higher the voltage, the higher the electric field. As long as a wire is energized—has voltage present—an electric field is present (see Figure 1). In other words, an appliance, or an electric power line, doesn't actually have to be turned on to create an electric field. It just has to be plugged in. Electric fields diminish with distance and can be blocked or partially shielded by objects such as trees and houses.

### **Magnetic Fields**

Magnetic fields are created by the current or flow of electricity through a wire. Generally speaking, the higher the current, the higher the magnetic field. Because they only occur when current is flowing, magnetic fields are present only when the power is turned on (see Figure 1). Magnetic fields also diminish with distance, but—unlike electric fields—are not blocked by common objects. In recent years, public and scientific interest has turned toward the magnetic field component of EMF because of some scientific studies regarding these fields.

Figure 1



**Figure 2**




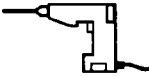




Magnetic field strengths decrease with distance Magnetic fields are measured in milligauss		Source: "EMF In Your Environment", U.S. Environmental Protection Agency 1992		
		At 6 inches	At 1 foot	At 2 feet
Clothes dryer		2 to 10	* to 3	*
Microwave oven		100 to 300	1 to 200	1 to 30
Toaster		5 to 20	* to 7	*
Power drill		100 to 200	20 to 40	3 to 6
Can opener		500 to 1500	40 to 300	3 to 30
Mixer		30 to 600	5 to 100	* to 10
Hair dryer		1 to 700	* to 70	* to 10
Color television		Data not available	* to 20	* to 8

FIGURE 2 \* The magnetic field measurement at this distance from the operating appliance could not be distinguished from background measurements taken before the appliance had been turned on.

### Measuring Magnetic Fields

Magnetic fields usually are measured in a unit called a milligauss. Magnetic field levels found in the living areas of homes typically range from less than 1 milligauss to about 4 milligauss according to the U.S. Environmental Protection Agency. They can be higher in some cases. The levels next to appliances can exceed 1,000 milligauss (1 gauss). Figures 2 and 3 show how the strength of the field falls off as you move away from the source, just as the heat of a campfire grows weaker as you walk away from it. For overhead power lines, the strength of the magnetic fields is dependent upon a number of factors that will be explained later. Those factors produce a magnetic field that drops off rapidly as you move away from the power line.

Figure 3

<b>Sample Magnetic Field Levels in Milligauss</b>				
<b>Type of Overhead Power Line</b>	<b>Distance from the line</b>			
	<b>Under the line</b>	<b>50 ft.</b>	<b>100 ft.</b>	<b>200 ft.</b>
220 kV and 500 kV	5-400	5-250	1-75	0.5-20
69 kV and 138 kV	3-80	0.5-2.5	0.1-10	0.1-3
12 kV and below	0.4-20	0.1-1	-	-

The magnetic field values provided in this table represent a general range of values associated with the types of overhead power lines listed and are provided for illustration. There will be circumstances in which there will be magnetic field levels above or below the range of values provided due to variations in such factors as height of the wires, current flow and so on.

## **DEVELOPMENT OF PPL EU's MAGNETIC FIELD MANAGEMENT PROGRAM**

One element of our response to EMF concerns expressed by some of our customers is PPL EU's Magnetic Field Management Program. The program was initiated in March 1991 because PPL EU believes it makes good sense, as a matter of policy, to respond to the concerns expressed by some of our customers and to reduce magnetic fields in new and rebuilt facilities where it can be done with either no-cost or low-cost design changes.

This document updates the original program which has been revised several times since 1991. These guidelines were developed by PPL EU's EMF Working Group.

### **VARIABLES THAT AFFECT MAGNETIC FIELDS**

Magnetic fields from transmission and distribution lines are a function of a number of design variables. The following parameters affect the magnetic field levels produced by transmission and distribution lines:

- Current
- Height of conductors above ground
- Configuration of conductors
- Distance from the line

### **EFFECT OF PHASE CURRENT ON MAGNETIC FIELDS**

At power frequencies (i.e., 60 hertz), the magnetic field level is a function of the current or flow of electricity through a wire. Keeping all other parameters the same, the magnetic field is proportional to the current. Hence, if the current increases by 25 percent, the resulting magnetic field level will increase by 25 percent.

The overall load current on any line varies with the demand for power. It's usually highest during daytime hours and lowest at night. There also are weekly, monthly, seasonal and yearly variations.

The difference in the currents between each phase in a multiphase line also can affect the magnetic field. This difference is called phase unbalance. For a constant load, a statistical analysis of this phase unbalance can be made to determine its effect on the magnetic field. Close to the line, there is very little effect. However, the phase unbalance slows the rate at which the magnetic field decreases with distance from the line.

### **EFFECT OF CONDUCTOR CONFIGURATION ON MAGNETIC FIELDS**

In the transmission and distribution of power, utilities like PPL EU presently use both three-phase and single-phase lines. Each phase on a three-phase power line has either a single conductor or a bundle of two or more conductors. In a three-phase system, the ground-level magnetic field is a result of the fields produced by the currents in each of the phases. Placing the three phases as close together as possible (compaction) creates some field cancellation, and the ground-level magnetic field is reduced. However, appropriate phase separation is required for the reliable operation of the line. In addition, the arrangement of the phases can create some; field cancellation and reduction of the ground-level magnetic field.

### **EFFECT OF DISTANCE FROM THE MAGNETIC FIELD SOURCE**

Magnetic field strength diminishes with the vertical and lateral distances from the magnetic field source. Increasing the height of the conductors above ground is useful for magnetic field reduction at ground level, but may result in increased structure costs and increased aesthetic impact of the structures. Another possible method of increasing the distance to the magnetic field source is to increase the right-of-way requirements. By keeping buildings off increased rights of way, thereby requiring the public to live and work further away from lines, exposure to magnetic fields produced by the lines can be reduced. Increases in right of way are not always practical and may increase costs significantly, however.

## **SUMMARY OF PPL EU's MAGNETIC FIELD MANAGEMENT PROGRAM**

Under its Magnetic Field Management Program, PPL EU has changed the way it builds and rebuilds some of its transmission and distribution lines. These design changes reduce magnetic field levels (assuming balanced circuit loadings and phase currents) by up to 69 percent in most of the company's new transmission lines. These guidelines now are being applied to new and reconstructed transmission facilities, based on this program.

The distribution component of the program focuses on 12 kV lines, the company's standard distribution voltage. It concentrates on the three-phase, primary 12 kV lines, since these are the most heavily loaded facilities and often are located in densely populated areas. The guidelines in this program are being applied to these three-phase, primary 12 kV lines.

A maximum 3-5 percent change in estimated cost was used as the limit for the guidelines since this value is consistent with low cost, is within estimating accuracy and is likely to have little impact on overall line costs.

The magnetic field calculations used in this document for the design of PPL EU's overall magnetic field management plan assume balanced load conditions among the phases and a fixed level of current, not necessarily representative of specific transmission or distribution lines. These levels were calculated using the Electric Power Research Institute's ENVIRO computer program. Under actual operating conditions, the magnetic field levels that result may vary due to such things as actual load per circuit, overall current on each phase conductor and the electrical configuration and operation of each line.

# MAGNETIC FIELD MANAGEMENT PROGRAM GUIDELINES

The guidelines for magnetic field management are noted below, with discussion points for each.

## OVERHEAD LINES

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### NEW OR REBUILT TRANSMISSION LINES

1. **Balance transmission circuit loads and phase currents as much as possible.**
  - PPL EU should continue to make every effort to balance loadings between the two circuits of a double circuit line when planning new or rebuilt facilities to maximize the effects of reverse phasing.
  - PPL EU should continue the practice of balancing single-phase loads across the three phases of the distribution system. (Unbalanced phase currents on the distribution system are reflected through to the transmission system.)
    - Unbalanced phase currents result in higher magnetic fields that do not drop off as quickly with distance as do the fields resulting from balanced phase currents.
    - For a 5 percent phase current unbalance, the magnetic field 50 feet from the centerline of a single circuit 138 kV line could be more than twice the value than if the same line had balanced phase circuits.
  - Balanced phase currents on each three-phase distribution circuit also reduce magnetic fields from the distribution circuits themselves. In addition, they reduce magnetic fields on the transmission system from which the distribution system circuits are supplied and connected through substations.
  - Apart from magnetic field considerations, balanced phase currents on each three-phase distribution circuit also reduce line losses and improve the system voltage.

**2. Continue with the present practice of using long-span construction as the PPL EU 138/69 kV standard**

- Structure designs for short-span and long-span construction are illustrated on Charts I and II, respectively.
  - Short-span design does not significantly reduce magnetic fields when compared to long-span design even though it is more compact than long-span design. Comparison of the magnetic field values from Chart III indicates essentially the same values. Therefore, short-span design should not be used solely to reduce magnetic fields.
  - PPL EU will continue to use long-span construction for 138/69 kV double-circuit lines and for single-circuit/future-double-circuit lines.
  - For single-circuit/future-double-circuit lines, PPL EU will continue to install two conductors on the top positions and one in the middle position as shown in Chart IV.
    - This arrangement minimizes magnetic fields as shown in Chart V by placing the three initial conductors higher on the structure, which increases the ground clearances, and by placing the conductors in a triangular configuration.

**3. Compact design structures are not a low-cost alternative and should be used for magnetic field reduction only in special applications.**

Chart VI illustrates the compact design structure.

- The compact design increases the initial installation costs by 79 percent when compared to the long-span design but reduces the magnetic field from 9 mG to 3 mG (about 67 percent) at the edge of the 100-foot-wide right of way as shown on Chart III.

**4. Reverse phase new or rebuilt double-circuit transmission lines for all voltage levels.**

- Reverse phasing was adopted by PPL EU in March 1991 for double-circuit 138/69 kV transmission lines and in April 1992 for all other double circuit transmission lines. Reverse phasing is shown in Chart VII. Reverse phasing will reduce the magnetic fields when the current flow on both circuits is in the same

direction. Calculated values contained here are based on balanced and equal phase currents on both circuits.

- Reverse phasing reduces the magnetic field of a double circuit 138 kV single pole transmission line from 29 mG to 9 mG (about 69 percent) at the edge of the 100-foot-wide right of way as shown on Chart III.
- Reverse phasing reduces the magnetic field of a double circuit 230 kV single pole transmission line from 49 mG to 16 mG (about 67 percent) at the edge of the 150-foot-wide right of way as shown on Chart VIII.
- Reverse phasing reduces the magnetic field of a double-circuit 500 kV single pole transmission line from 37 mG to 21 mG (about 43 percent) at the edge of the 200-foot-wide right of way as shown on Chart IX.
- When new or rebuilt double-circuit lines require tapping existing double-circuit lines, PPL EU will review the existing lines to determine if reverse phasing can be provided at low cost.
- Computer modeling is required to develop the optimum phasing and overall conductor arrangements for lines added to, or rebuilt in, multiple-line corridors.
  - Merely adding a reverse-phase double-circuit line to an existing transmission line corridor or reverse phasing a rebuilt line in the multiple-line corridor will not necessarily produce lower magnetic field levels at the edge of the corridor right of way.
  - The corridor must be computer modeled with all the lines, existing phase conductor locations and currents. Then, magnetic field calculations must be made varying the phase arrangements of the new or reconstructed line to determine the appropriate phasing arrangement.
  - Current flow direction on a line also must be considered. For example, a reverse-phased line should have the current flowing in the same direction on both circuits. If the current flow is in the opposite direction for one circuit, reverse phasing will not produce the lowest magnetic field and another phase arrangement that produces lower fields may need to be utilized.

## 5. Increase the minimum ground clearance for all new transmission lines.

### 138/69 kV Transmission Lines

- Increasing the minimum line design ground clearance from 25 feet to 30 feet may add up to about 5 percent to the installed cost of a new double-circuit single pole 138/69 kV line. For a given project, such cost may be substantially less, however. In fact, PPL EU frequently uses higher-than-minimum ground clearances due to such features as road crossings, line crossings and site-specific terrain. With long-span reverse-phase design, the magnetic field is reduced from 9 mG to 7 mG (about 22 percent) at the edge of a 100-foot-wide right of way as shown in Chart X.
  - In the actual design of transmission lines to include higher minimum ground clearances, there may be limited segments (such as highway crossings, severe slopes and transmission line crossing locations) where National Electrical Safety Code (NESC) minimum ground clearances may need to be used. The NESC minimum ground clearances are less than the increased ground clearance discussed previously.

### 230 kV Transmission Lines

- Increasing the minimum line design ground clearances from 27 feet to 32 feet may add up to about 5 percent to the cost of a single-circuit single-pole line (current standard). For a given project, such cost may be substantially less, however. In fact, PPL EU frequently uses higher-than-minimum ground clearances due to such features as road crossings, line crossings and site-specific terrain. By increasing the clearances, the magnetic field is reduced from 30 mG to 28 mG (about 7 percent) at the edge of a 150-foot-wide right of way.
- Increasing clearances from 27 feet to 32 feet could theoretically add up to about 2.8 percent to the cost of a double-circuit single-pole line (current standard) and reduce the magnetic field of a reverse-phase line from 16 mG to 15 mG (about 6 percent) at the edge of a 150-foot-wide right of way. Chart XI is a summary of this data.
- Studies are required for each new 230 kV line to determine optimum structure types, ground clearances, configurations and designs to reduce field levels. Such

studies could include analysis of reduction measures such as additional minimum ground clearances, increasing conductor tensions, using reduced phase spacing (a "Delta" configuration on a single-circuit line), installing the second circuit initially, and/or adding a second set of conductors that are reverse phased and operated in parallel with the first set (bundled/split phase).

#### **500 kV Transmission Lines**

- Increasing ground clearances from 33 feet to 53 feet may add up to about 4.5 percent to the cost of a single-circuit "H-frame" line (current standard). For a given project, such cost may be substantially less, however. In fact, PPL EU frequently uses higher-than-minimum ground clearances due to such features as road crossings, line crossings and site-specific terrain. By increasing the clearances, the magnetic field is reduced from 42 mG to 35 mG (about 17 percent) at the edge of a 200-foot-wide right of way.
- Increasing ground clearances from 33 feet to 53 feet could theoretically add up to 2.8 percent to the cost of a double-circuit "H-frame" line (current standard) and reduces the magnetic field of a reverse-phase line from 21 mG to 16 mG (about 24 percent) at the edge of a 200-foot-wide right of way. Chart XII is a summary of this data.
- Studies are required for each new 500 kV line to determine optimum structure types, ground clearances, configurations and designs to reduce field levels. Such studies could include analysis of reduction measures such as additional minimum ground clearances, increasing conductor tensions, using reduced-phase spacing (a "Delta" configuration on a single circuit line), installing the second circuit initially, and/or adding a second set of conductors that are reverse phased and operated in parallel with the first set (bundled/split phase).

## **RECONDUCTORING OR ADDING ADDITIONAL CIRCUITS TO EXISTING TRANSMISSION LINES**

**When reconductoring or adding additional circuits to existing transmission lines, PPL EU will evaluate low-cost or no-cost options for magnetic field management on a case-by-case basis.**

When reconductoring existing transmission lines or adding additional circuits, low-cost alternatives may not exist; however, the following steps will be taken:

- For a single-circuit line, the use of a Delta arrangement or other modifications on the existing structure, with reduced-phase spacing, will be evaluated.
- For double-circuit lines, application of reverse phasing may reduce the magnetic field under the line and within the right of way and will be evaluated.
- For single- and double-circuit lines, evaluate using higher conductor tensions that can increase the minimum line design ground clearance.

## **DISTRIBUTION LINES**

**At the 12 kV distribution level, new main three-phase lines will continue to be constructed with five feet of additional ground clearance.**

- Main lines are the most heavily loaded sections of a distribution line and therefore have the highest magnetic fields associated with them.
- Increasing the ground clearance by five feet reduces the magnetic field under the line from 14 mG to 11 mG using the standard eight-foot crossarm design. These values are based on increasing pole heights from 45 feet to 50 feet and a typical operating current of 300 amps per phase.
- Chart XIII is a summary of this data. Increasing ground clearance by five feet could theoretically add about 5 percent to the cost of a typical distribution line.

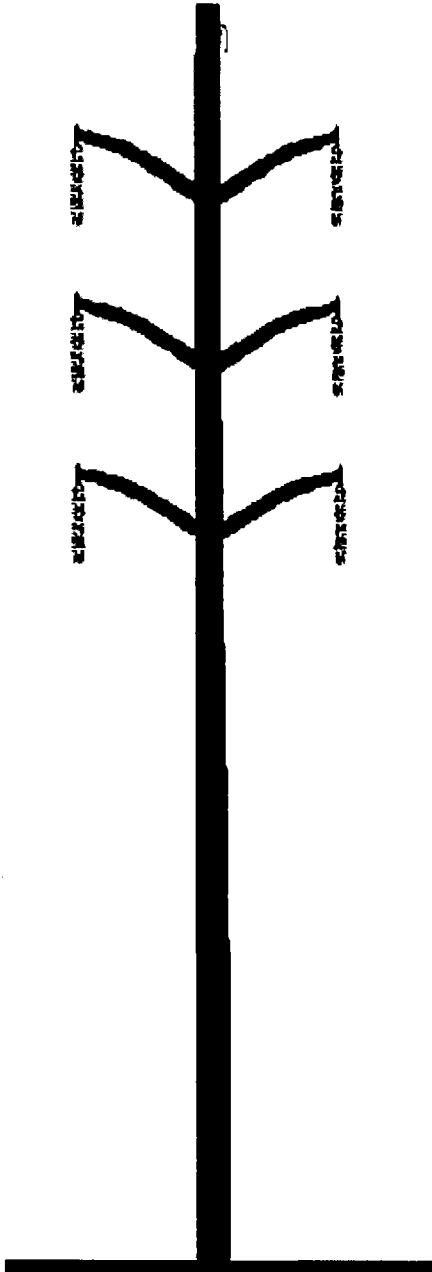
## **UNDERGROUND TRANSMISSION LINES**

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**Underground transmission lines are required due to environmental or land use factors or restrictions on available clearances, PPL EU will evaluate options for magnetic field management techniques on a case-by-case basis.**

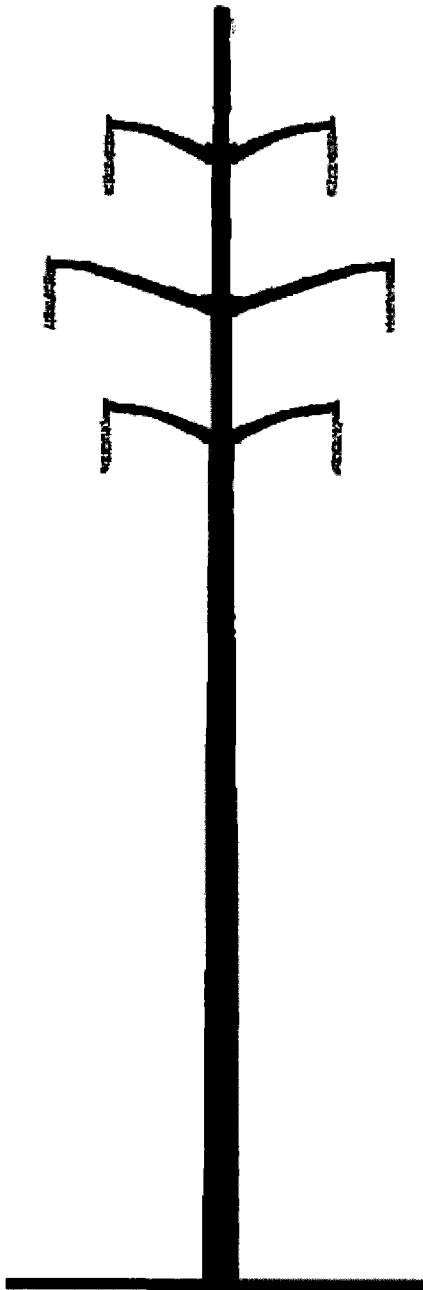
- The phase arrangement that produces the lowest field will be determined.
- The depth of burial of the line will be determined considering the cost of excavation and the location of other buried utilities in the area.
- The use of steel pipe ferromagnetic shielding that reduces magnetic fields will be evaluated.

# Short-Span Construction



- **More compact design**
- **Should not be used solely to reduce magnetic fields**
- **Typical conductor data:**
  - 1 3/8" HS steel overhead ground wire - 7.3 feet sag
  - 6-556.5 KCMIL 24/7 ACSR power conductors - (PARAKEET) 10.0 feet sag
  - Average span - 400 feet

# Long-Span Construction Remains PPL EU 138 kV Standard



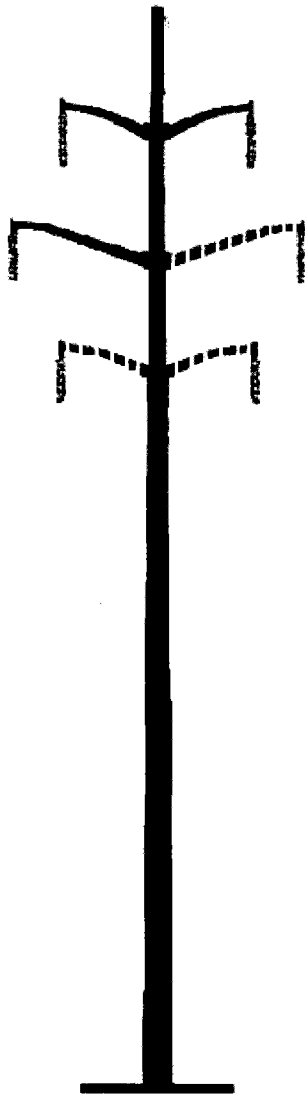
- Lower cost alternative
- Reduces magnetic fields due to higher structures
- Typical conductor data:
  - 1 3/8" HS steel overhead ground wire - 17.3 feet sag
  - 6-556.5 KCMIL 24/7 ACSR power conductors - (PARAKEET) 23.0 feet sag
  - Average span - 600 feet

**138/69 kV REVERSE-PHASE TRANSMISSION LINES  
CALCULATED MAGNETIC FIELDS AT 400 AMPERES**

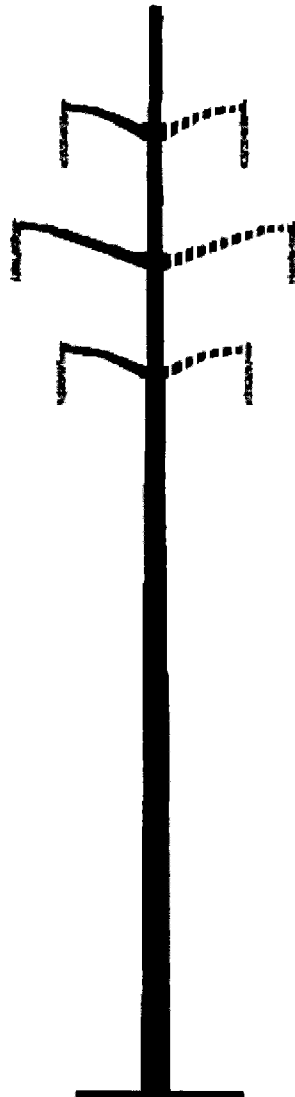
TYPE CONSTRUCTION	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
SHORT SPAN (CHART I)	30
SHORT SPAN (REVERSE PHASE)	8
LONG SPAN (CHART II)	29
LONG SPAN (REVERSE PHASE)	9
COMPACT (CHART VI)	14
COMPACT (REVERSE PHASE)	3

The edge of right of way is 50 feet from the line centerline.  
 The 400 ampere phase current is balanced between phases.  
 Calculations are based on a minimum ground clearance of 25 feet.  
 LONG SPAN, SHORT SPAN and COMPACT are double-circuit lines.

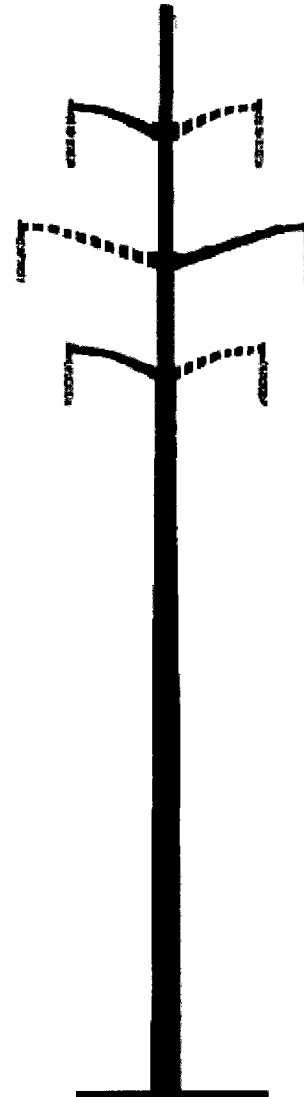
# Typical Single-Circuit Structure Designs



Top/Middle



Vertical



Top/Middle/Bottom

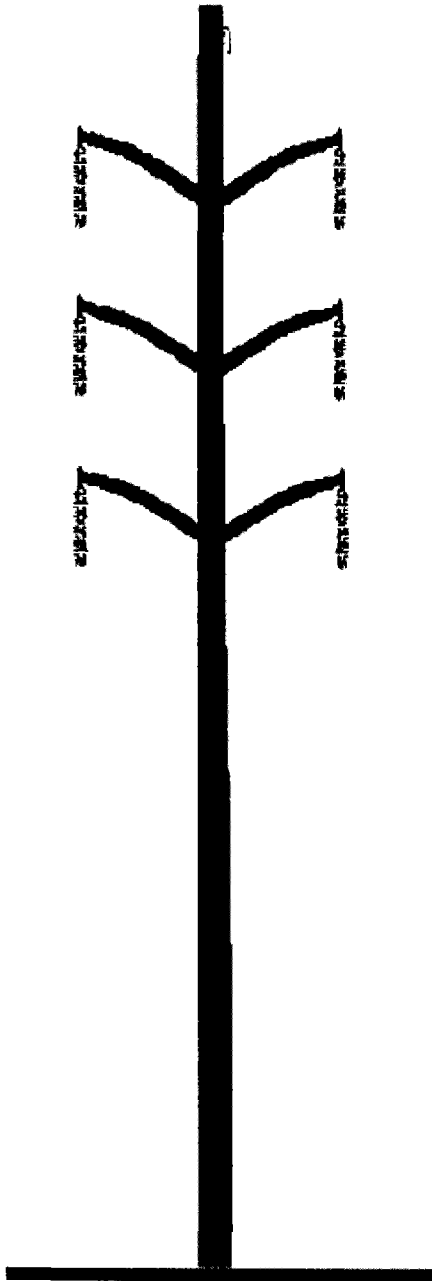
——— initial single circuit  
- - - - - future second circuit

**138/69 kV SINGLE CIRCUIT TRANSMISSION LINES  
CALCULATED MAGNETIC FIELDS AT 400 AMPERES**

TYPE CONSTRUCTION	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
TOP/MIDDLE/BOTTOM	20
VERTICAL	17
TOP/MIDDLE	12

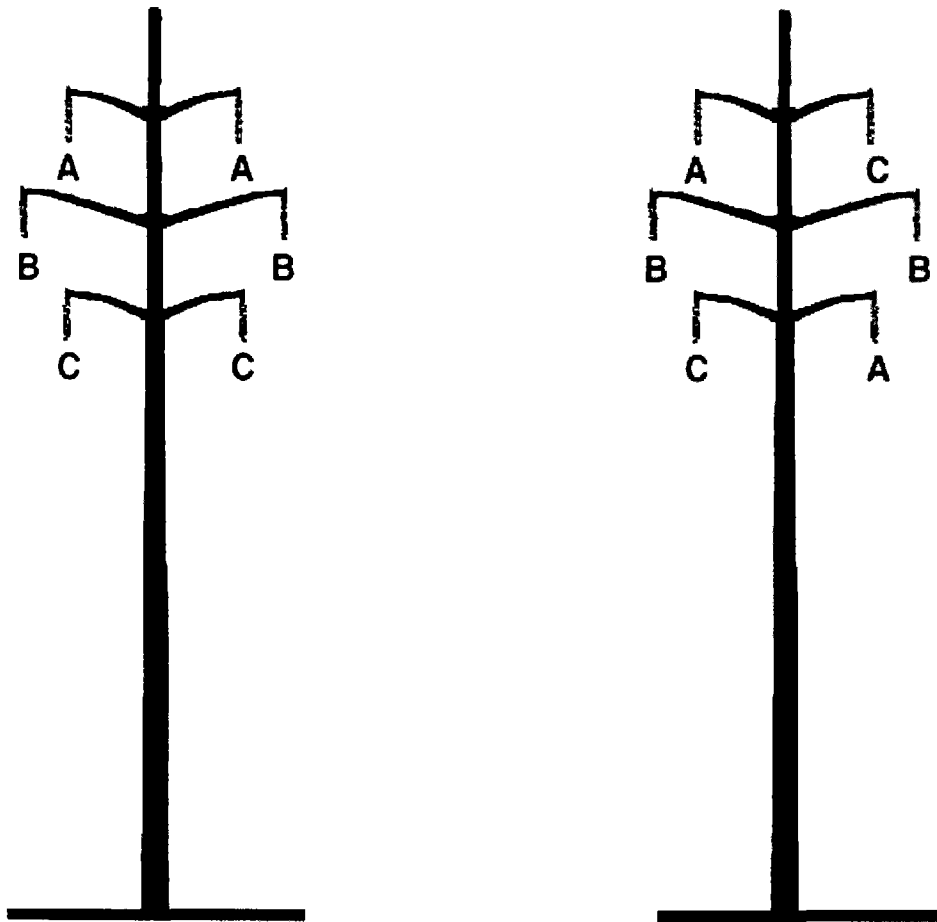
The edge of right of way is 50 feet from the line centerline.  
The 400 ampere phase current is balanced between phases.  
Calculations are based on a minimum ground clearance of 25 feet.

# Compact Design Structure



- **Minimize magnetic fields due to compact design**
- **Not a low-cost alternative**
- **Typical conductor data:**
  - 1 3/8" HS steel overhead ground wire - 9.0 feet sag
  - 6-556.5 KCMIL 24/7 ACSR power conductors - (PARAKEET) 9.0 feet sag
  - Average span - 300 feet

# Reverse Phasing of Double-Circuit Transmission Lines



From: → → → → To:

Reverse phasing also can be one of the following phase arrangements:

A	B		B	A		B	C		C	A		C	B
C	C	or	C	C	or	A	A	or	B	B	or	A	A
B	A		A	B		C	B		A	C		B	C

**230 kV REVERSE-PHASE TRANSMISSION LINES  
CALCULATED MAGNETIC FIELDS AT 800 AMPERES**

TYPE CONSTRUCTION	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
DOUBLE CIRCUIT POLE	49
DOUBLE CIRCUIT POLE (REVERSE-PHASE)	16

The edge of right of way is 75 feet from the line centerline.  
The 800 ampere phase current is balanced between phases.  
Calculations are based on a minimum ground clearance of 27 feet.

**500 kV REVERSE-PHASE TRANSMISSION LINES  
CALCULATED MAGNETIC FIELDS AT 1100 AMPERES**

TYPE CONSTRUCTION	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
DOUBLE CIRCUIT POLE	37
DOUBLE CIRCUIT POLE (REVERSE PHASE)	21

The edge of right of way is 100 feet from the line centerline.  
The 1,100 ampere phase current is balanced between phases.  
Calculations are based on a minimum ground clearance of 33 feet.

**INCREASED 138/69 kV MINIMUM GROUND CLEARANCE  
CALCULATED MAGNETIC FIELDS AT 400 AMPERES**

TYPE CONSTRUCTION	MINIMUM GROUND CLEARANCE FEET	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
SINGLE CIRCUIT TOP/MIDDLE	25	12
SINGLE CIRCUIT TOP/MIDDLE	30	10
LONG SPAN	25	29
LONG SPAN	30	26
LONG SPAN (REVERSE PHASE)	25	9
LONG SPAN (REVERSE PHASE)	30	7

The edge of right of way is 50 feet from the line centerline.  
The 400 ampere phase current is balanced between phases.

**INCREASED 230 kV MINIMUM GROUND CLEARANCE  
CALCULATED MAGNETIC FIELDS AT 800 AMPERES**

TYPE CONSTRUCTION	MINIMUM GROUND CLEARANCE FEET	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
SINGLE CIRCUIT TOP/MIDDLE	27	30
SINGLE CIRCUIT TOP/MIDDLE	32	28
DOUBLE CIRCUIT POLE	27	49
DOUBLE CIRCUIT POLE	32	46
DOUBLE CIRCUIT POLE (REVERSE PHASE)	27	16
DOUBLE CIRCUIT POLE (REVERSE PHASE)	32	15

The edge of right of way is 75 feet from the line centerline.  
The 800 ampere phase current is balanced between phases.

**INCREASED 500 kV MINIMUM GROUND CLEARANCE  
CALCULATED MAGNETIC FIELDS AT 1,100 AMPERES**

TYPE CONSTRUCTION	MINIMUM GROUND CLEARANCE FEET	MAGNETIC FIELD IN MILLIGAUSS AT THE EDGE OF THE RIGHT OF WAY
SINGLE CIRCUIT "H" STRUCTURE	33	42
SINGLE CIRCUIT "H" STRUCTURE	53	35
DOUBLE CIRCUIT POLE	33	37
DOUBLE CIRCUIT POLE	53	31
DOUBLE CIRCUIT POLE (REVERSE PHASE)	33	21
DOUBLE CIRCUIT POLE (REVERSE PHASE)	53	16

The edge of right of way is 100 feet from the line centerline.  
The 1,100 ampere phase current is balanced between phases.

**12 kV DISTRIBUTION LINES  
CALCULATED MAGNETIC FIELDS AT 300 AMPERES**

TYPE CONSTRUCTION	POLE HEIGHT FEET	MAGNETIC FIELD IN MILLIGAUSS*	
		AT CENTERLINE	AT 30 FEET FROM CENTERLINE
STANDARD CROSSARM	45	14	7
STANDARD CROSSARM	50	11	6

\* Field level under the line at mid-span based on 300 amps, balanced loading, one meter above ground level.

**Attachment 6**

**ATTACHMENT 6**  
**CUMBERLAND – WEST SHORE #3 & #4 138/69 kV TRANSMISSION LINE**  
**RECONSTRUCTION**  
**LIST OF OWNERS OF PROPERTY WITHIN THE RIGHT-OF-WAY**

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<u>Property Owner/Address</u>	<u>Parcel Number</u>
Frank M Bingman 2063 Harbour Links Drive #6 Longboat Key, FL 34228	1
Asbury Atlantic, Inc. 201 Russell Avenue Gathersburg, MD 20877	2
Dunkard Brethern Church 168 Wolfs Bridge Road Carlisle, PA 17013	3
Laurel Pipeline Company Buckeye Pipeline Company 5002 Buckeye Road Emmaus, PA 18049-0368	4
Clarence E Asbury 1355 Armitage Way Mechanicsburg, PA 17050	5
Ritter Hoberman Family et al 1072 Madison Avenue Lakewood, NJ 08701	6
PIA Services Incorporated Insurance Agents & Brokers 5050 Ritter Road Mechanicsburg, PA 17055	7
High Properties, High Gen Corp. 1853 William Penn Way Lancaster, PA 17601	8, 10, 16
Members 1st Federal Credit Union 5000 Louise Drive Mechanicsburg, PA 17055	9

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<u>Property Owner/Address</u>	<u>Parcel Number</u>
Rolleston Corporation 1705 North Front Street Harrisburg, PA 17012	11
Hanuman Two Lodging LLC 2845 Lebanon Road Manheim, PA 17545	12
Margaret R D'arcangelo 5159 Kylock Road Mechanicsburg, PA 17055	13
Peter D & Carol A Kirk 5155 Kylock Road Mechanicsburg, PA 17055	14, 15
Donald R Steele Jr 5153 Kylock Road Mechanicsburg, PA 17055	17
Eugene H Castle Jr 5149 Kylock Road Mechanicsburg, PA 17055	18
Ryan M & Jessica S Green 5145 Kylock Road Mechanicsburg, PA 17055	19
Robert M & Shari R Staiger 5141 Kylock Road Mechanicsburg, PA 17055	20
David B & Tracy L Morgan 5137 Kylock Road Mechanicsburg, PA 17055	21
Daniel R McIntyre 833 Flintlock Ridge Road Mechanicsburg, PA 17055	22
Menaughton Properties LP 4400 Deer Path Road Harrisburg, PA 17110	23, 25
Mark S & Lisa J Barnhardt 832 Flintlock Ridge Road Mechanicsburg, PA 17055	24

<u>Property Owner/Address</u>	<u>Parcel Number</u>
Strong & Detweiler Partnership 1340 Rossmoyne Road Mechanicsburg, PA 17055	26, 29
Emerson L & Ruth D Leshar 1340 Rossmoyne Road Mechanicsburg, PA 17055	27
Ruth D Leshar 1340 Rossmoyne Road Mechanicsburg, PA 17055	28, 31
PPL Electric PPL-Real Estate Taxes (GENTW2) 2 North Ninth Street Allentown, PA 18101	30

**Attachment 7**

**ATTACHMENT 7**

**CUMBERLAND – WEST SHORE #3 & #4 138/69 kV TRANSMISSION LINE  
RECONSTRUCTION**

**LIST OF INVOLVED GOVERNMENTAL AGENCIES, MUNICIPALITIES AND  
OTHER PUBLIC ENTITIES RECEIVING APPLICATIONS**

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1. Pennsylvania Historical and Museum Commission  
Bureau for Historic Preservation  
Commonwealth Keystone Building, Second Floor  
400 North Street  
Harrisburg, Pennsylvania 17120-0053  
Attn: Mr. Douglas C. McLearn, Chief
2. Pennsylvania Department of Transportation  
Honorable Barry Schoch, P.E., Secretary  
c/o Office of Chief Counsel  
Commonwealth Keystone Building  
400 North Street, 9th Floor  
Harrisburg, PA 17120  
Attn: Andrew Gordon
3. Department of Environmental Protection  
P.O. Box 2063  
Market Street State Office Building  
Harrisburg, Pennsylvania 17105-2063  
Attn: Office of Field Operations
4. Cumberland County Planning Commission  
1 Courthouse Square  
Carlisle, Pennsylvania 17013  
Attn: Mr. Kirk Stoner, AICP, Director of Planning
5. Cumberland County Board of Commissioners  
1 Courthouse Square  
Carlisle, Pennsylvania 17013  
Attn: Ms. Barbara Cross, Chair
6. Upper Allen Township  
100 Gettysburg Pike  
Mechanicsburg, Pennsylvania 17055  
Attn: Mr. Lou Fazekas, Township Manager

7. Upper Allen Township Planning Commission  
100 Gettysburg Pike  
Mechanicsburg, Pennsylvania 17055  
Attn: Ms. Amanda Parrish, Chair
  
8. Lower Allen Township  
2233 Gettysburg Road  
Camp Hill, Pennsylvania 17011  
Attn: Mr. Thomas Vernau, Jr., Township Manager
  
9. Lower Allen Township Planning Commission  
2233 Gettysburg Road  
Camp Hill, Pennsylvania 17011  
Attn: Mr. Brett McCreary, Chairman