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E-FILE

October 1, 2024

Rosemary Chiavetta, Secretary
Pennsylvania Public Utility Commission
Commonwealth Keystone Building
400 North Street
Harrisburg, Pennsylvania 17105-3265

Re: PPL Electric Utilities Corporation
Biennial Inspection, Maintenance, Repair and Replacement Plan
For the Period January 1, 2026 – December 31, 2027
Docket No. M-2009-2094773

Dear Ms. Chiavetta:

Enclosed for filing on behalf of PPL Electric Utilities Corporation ("PPL Electric") an original of PPL Electric's Biennial Inspection, Maintenance, Repair and Replacement Plan for the Period January 1, 2026 – December 31, 2027 ("I&M Plan"). PPL Electric's I&M Plan is being filed pursuant to the Commission's regulations at 52 Pa. Code §§ 57.198.

Pursuant to 52 Pa. Code § 1.11, the enclosed document is to be deemed filed on October 1, 2024, which is the date it was submitted electronically via the Commission's E-Filing system.

If you have any questions, please call me or Preston Walker, PPL Electric's Director – Transmission Planning & RTO Strategy at (484) 633-0996.

Respectfully submitted,

Kimberly A. Klock

Enclosures

cc via email: Paul Diskin
NazAarah Sabree
Patrick Cicero, Esquire

PPL Electric Utilities Corporation

Biennial Inspection, Maintenance, Repair and Replacement Plan of PPL Electric Utilities Corporation

For the Period of January 1, 2026 – December 31, 2027

Submitted by:

Preston Walker
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Dated: October 1, 2024

PPL Electric Utilities Corporation

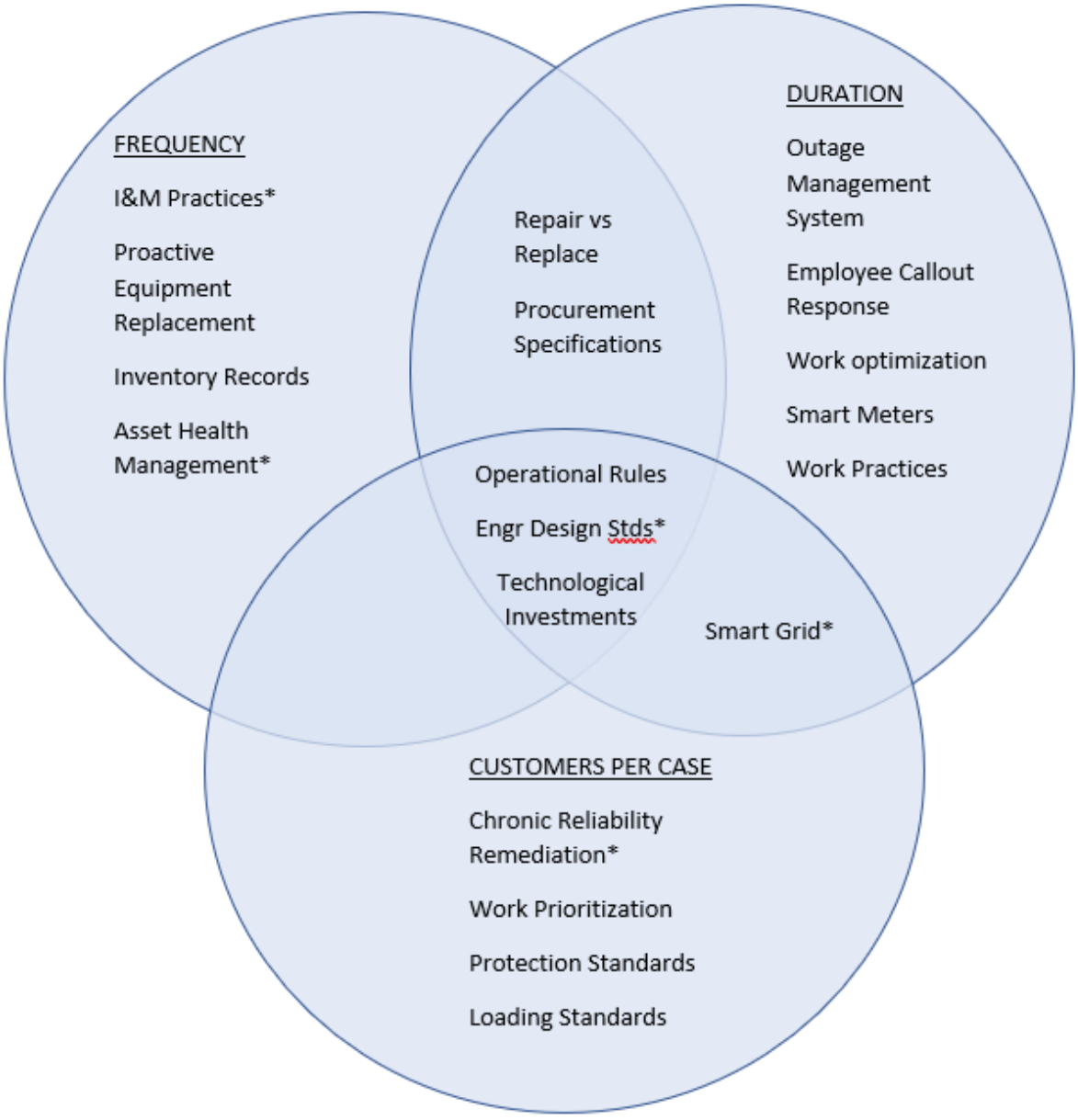
Table of Contents

Introduction

PPL Electric Utilities Corporation ("PPL Electric" or "Company") is firmly committed to attaining high levels of customer satisfaction. Customer surveys show that high levels of customer satisfaction are achieved by providing reliable performance at a reasonable cost. Despite recent storm performance and the increased number of storm events, our goal is to reach and maintain high levels of customer satisfaction and reliability.

Ultimately, the costs of maintaining reliability are borne by customers. Therefore, managing finite resources to produce optimal results is essential to deliver excellence in customer satisfaction. The criterion for program inclusion is not whether any single activity produces a positive reliability result, but rather, which portfolio of activities produces the best result for a given expenditure. PPL Electric carefully balances results with expenditures, with the goal of providing the reliability our customers expect and deserve while ensuring costs remain reasonable.

Reliability performance is driven by a mixture of manageable and unmanageable factors. The most impactful of the unmanageable factors is the frequency and severity of weather events, which can vary dramatically over time and geography as we have experienced in recent years. The manageable factors, as provided in the figure below, have an effect on service interruption frequency, duration, or number of customers affected, or a combination of all three. The figure below depicts a portfolio of manageable factors with inspection and maintenance ("I&M") practices being one of many.



Reliability Programs and Policies

PPL Electric's philosophy is that the first step in improving reliability is to prevent outages altogether. The primary focus is, therefore, on the manageable factors that reduce the frequency (number) of cases. Efforts are designed to minimize the number of customers affected should an outage occur. Realizing that not all outages are preventable, PPL Electric also directs efforts designed to reduce the duration of

the outages that do occur. Examples of the PPL Electric initiatives marked with an asterisk above are set forth below.

- **I&M Practices:** PPL Electric remains focused on equipment performance and service interruption avoidance through the application of effective inspection and maintenance practice and programs. A comprehensive discussion has been provided to the Pennsylvania Public Utility Commission ("PUC" or "Commission") via PPL Electric's I&M filing on a biennial basis since the initial report filed in 2010. The scope of these programs, procedures and activities covers all areas of the Company's electrical infrastructure including transmission, substations, distribution, and vegetation.

  Transmission
  Transmission inspection programs include aerial patrols conducted via helicopter. These patrols include both comprehensive inspections and routine "stop and go" inspections for identification of maintenance work. Inspections focus on all transmission line equipment, including poles, arms, line switches, interrupters, arresters, grounding, guying, anchors, and other key components. Proactive replacement programs are in place to target specific risk areas (e.g., wood poles, Corten lattice towers, copper conductor, etc.) and to apply data-driven approaches to mitigate known reliability risks (e.g., avian interference, lightning performance, etc.).

  Substation
  Substation maintenance programs include inspections and overhauls of equipment. Some equipment is maintained on a time basis; other equipment is condition-monitored. These two methods help ensure that maintenance work is performed in a cost-effective manner. Besides time and condition-based maintenance, thermo-graphic inspections are used to help ensure substation equipment does not operate at elevated temperature levels for an extended period of time, which helps prevent equipment failure.

  Distribution
  Distribution programs encompass many maintenance activities similar to those used on transmission and substations, but also include load surveys that help engineers determine peak load requirements and circuit analyses for the identification of lines requiring maintenance work, voltage relief, or other capital improvements. Overhead line inspections are also used to identify damaged or deteriorated equipment for proactive repair or replacement. In addition, distribution maintenance includes inspections of poles and other key distribution equipment.

  Vegetation
  The vegetation on PPL Electric's transmission and distribution rights-of-way ("ROWs") is maintained utilizing a combination of management techniques. These include tree pruning, tree removal, re-clearing, and herbicide application. Lines are field surveyed on a regular basis. Work performed on a routine cycle is scheduled and budgeted based on conditions observed and past performance. Outside of the ROW, hazard trees with the potential to fall into the ROW are removed when possible.

Each of these I&M programs is more fully described in Appendices A through D.

- **Asset Health Management**

  Asset Optimization Strategy ("AOS"): PPL Electric developed several data-driven failure probability models based on relevant failure modes. These data model projects were initiated to drive smarter, more targeted asset investment strategies throughout the portfolio and to address the challenges created by the Company's aging infrastructure. The Company continually evaluates these models and revises its investment strategy as needed.. PPL Electric conducts reviews of the various programs comprising this strategy to ensure that aging infrastructure continues to be appropriately addressed.

  Asset Health Assessment: PPL Electric is continually seeking opportunities to expand its use of data-driven decision making. Where feasible, asset health and criticality scores are captured and employed to refine programs to deliver the most effective reliability impact per dollar invested. PPL Electric continually monitors the accuracy and effectiveness of these asset health and criticality scores and, developed predictive failure models of vital assets with the intention of improving the accuracy and efficiency of these health and criticality scores. These continued health calculation efforts enable PPL Electric to mitigate risk and optimize reliability more effectively. Among the areas where health and criticality scores are employed are substation and Low-Tension Network equipment, reclosers, and underground cables.

  Long Term Infrastructure Improvement Plan: In September 2022, PPL Electric submitted its third Long Term Infrastructure Improvement Plan ("LTIIP"). This Plan was submitted pursuant to the requirements of Subchapter B, Distribution Systems, of the Public Utility Code, 66 Pa. C.S. §§ 1350-1360, and the PUC's Implementation Order for Establishment of a Distribution System Improvement Charge ("DSIC"). The Plan is a continuation of AOS infrastructure replacements in addition to prudent capital investments such as the proactive installation of animal guards, new sectionalizing devices, distribution automation, asset life extension methods, replacement of deteriorated equipment, and capital projects aimed at addressing reliability and customer experience. **I**n July 2024, the Commission approved major modifications to the Company's third LTIIP. Those major modifications were made due to developments affecting the design and funding of the LTIIP.

- **Chronic Reliability Remediation**

  Reliability Preservation Program: In 2019, the legacy Customers Experiencing Multiple Interruptions ("CEMI") and Momentary Average Interruption Frequency Index ("MAIFI") Programs were combined with the Reliability Preservation Program. This was strategically done to ensure all reliability-based projects were prioritized and addressed together for efficiency and timeliness of remediation. In 2024, PPL Electric began a new initiative to "harden" the Company's circuits, addressing those most impacted by weather events given

the increased number of storms PPL Electric has experienced over the past three years. All projects are vetted and prioritized using a common prioritization methodology to ensure consistency and systematic benefits are quantified across the portfolio. Reliability performance of PPL Electric's circuits is reviewed on a quarterly basis to ensure investment plans are optimized.

Proactive Circuit Analysis ("PCA"): PCAs are performed on each circuit on a four-year cycle. The review analyzes and addresses both operational and reliability characteristics of each circuit. Voltage support, phase balancing, protection coordination, power factor maintenance and loading issues are addressed from an operational perspective. Service outage analysis, exposure analysis and field checks address reliability and power quality.

- **Engineering Design Standards:** Reliability Principles and Practices ("P&P") sets forth a set of principles that PPL Electric follows to plan, protect, and operate the Electrical Distribution System ("EDS"). These principles are implemented through a set of standard practices that are used as guidelines in designing the EDS. These practices are reviewed regularly to ensure they remain reasonable and acceptable and align well in accordance with good utility practices.

- **Smart Grid:** In 2010, PPL Electric launched a "smart grid" pilot project that enables the Company to react rapidly to changes on the delivery system and to automatically re-route power around problems that occur. The project initially focused on the Harrisburg, Pa. area, but has since been expanded to cover all of the Company's service territory. The project included the implementation of an Advanced Distribution Management System ("ADMS"), which was a breakthrough technology enabling the Company's operators to see the status of PPL Electric's distribution network in real-time. In 2016, PPL Electric also completed a system wide rollout of Fault Isolation and Service Restoration ("FISR") technology. FISR identifies faulted sections and quickly develops an optimized restoration plan, then automatically executes that plan. Using FISR, PPL Electric can typically restore customers within five minutes from the start of the outage. This technology has saved over two million customer interruptions to-date. Over 8,800 automated smart devices have been installed, which has allowed for remote operation and monitoring of circuit sectionalizing equipment through the use of ADMS and FISR.

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PPL Electric Reliability Results

In recent years, PPL Electric's reliability performance has been declining largely due to the increased severity and number of storms as mentioned above. In light of the reduction in performance, reliability investments are increasing in the portfolio with an enhanced focus on circuit hardening and resiliency.

PPL Electric Reliability Planning Process

PPL Electric's reliability planning process is forward-looking and proactive. It consists of the following:

- Analyzing and identifying the drivers of historical trends of causes of service outages and other power service problems.
- Forecasting future reliability metrics System Average Interruption Duration Index ("SAIDI"), System Average Interruption Frequency Index ("SAIFI"), and Customer Average Interruption Duration Index ("CAIDI") given existing mitigation programs' effect on the identified drivers.
- Identifying new programs, policies, and activities to enhance or accelerate existing mitigation programs to avoid forecasted gaps between future reliability and benchmark targets.
- Identifying, evaluating, and implementing new technologies that enhance the Company's condition monitoring strategy.
- Evaluating and adjusting existing programs, policies, and activities to produce the desired future results.
- Performing targeted data analytics against the Company's aging infrastructure utilizing real-time, or near real-time, operational data to further improve reliability performance.
- Incorporating the resulting portfolio of existing and new programs, policies, and activities in PPL Electric's five-year business plan and I&M plan.

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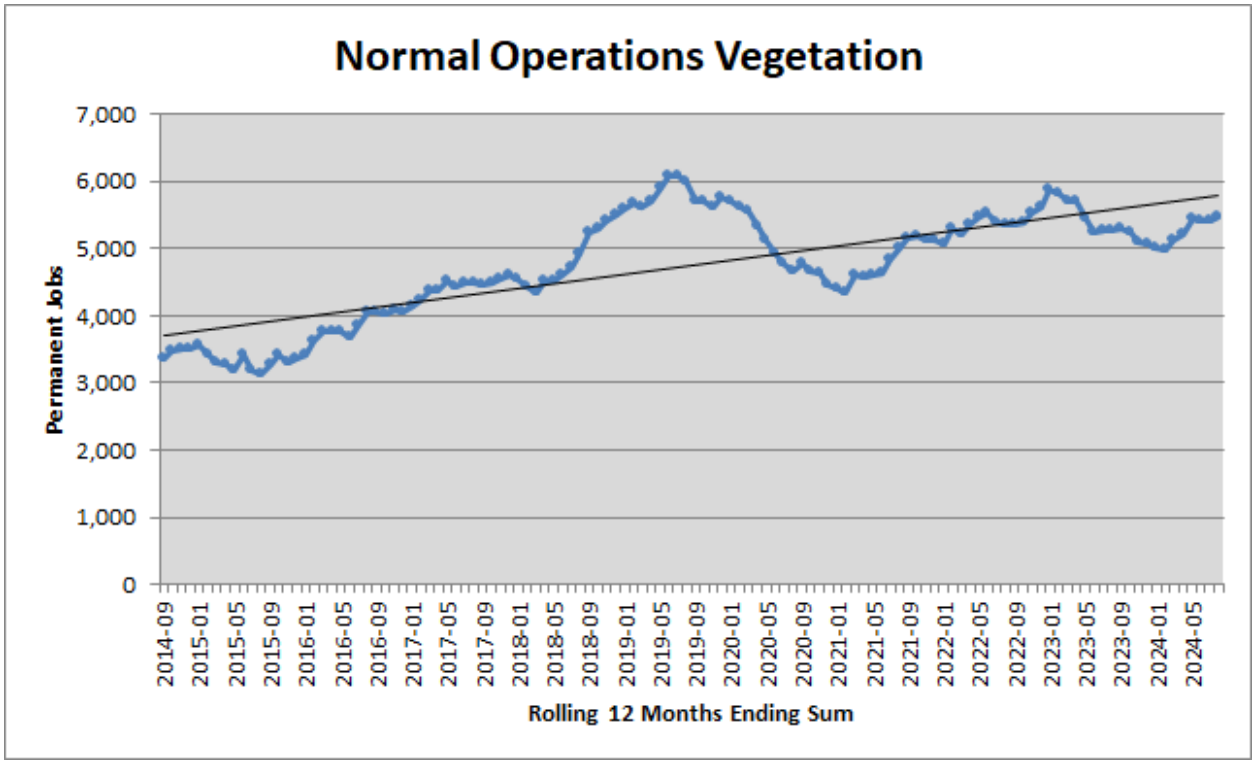
PPL Electric Reliability Analysis

Identifying and understanding trends creates the opportunity for PPL Electric to plan programs that mitigate undesirable trends. Most of the year-to-year variation in service interruptions is explained by differences in storm experience. Therefore, PPL Electric generally removes all declared storm-caused service outages (though not all weather-related outages) for internal analysis to identify other causal trends affecting reliability. Each data point in the following charts represents a rolling 12-month ending value through August 2024 to eliminate the effect of seasonal variation.



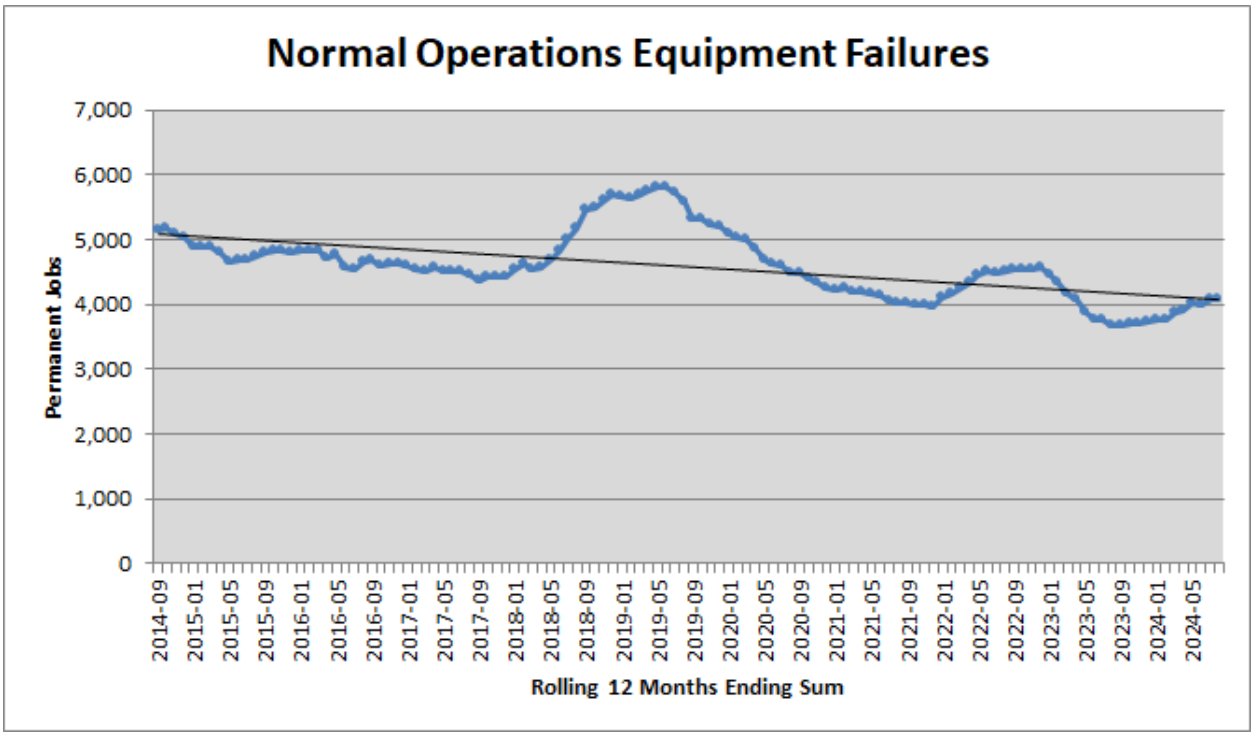
Vegetation Related Service Interruption Cases

PPL Electric is committed to a Vegetation Management program that addresses the threat of tree-related outages. It is worth noting that even when excluding major and PUC reportable storm events, approximately 85% of vegetation related customer interruptions occur during adverse weather conditions. The more frequent and intense storms in recent years resulted in higher-than-normal occurrences of vegetation outages, including healthy trees toppling into overhead conductors.

Equipment Failure Service Interruption Cases

A significant risk to PPL Electric's ability to meet reliability benchmarks is the large portion of distribution facilities, which were installed in the 1960's and 1970's, that are now beyond or nearing the end of their design lifetime. The resultant effect on non-storm-related equipment failure is illustrated by the chart below.

The number of no-light cases due to equipment failures is trending slightly downward due to investments made by the Company over the past five to ten years. The need to remediate or replace equipment that is at or near end-of-life remains in order for PPL Electric to maintain or improve this favorable trajectory. Components contributing the most significantly to distribution equipment failures include poles/arms/attachments, overhead and underground conductors, switches, and substation equipment.



Initiatives contributing to the reversal of the failed equipment trend include equipment replacements identified through Proactive Circuit Analysis of 25% of circuits annually, aggressive circuit remediation and hardening, implementation of PPL Electric's Asset Optimization Strategy, enhanced pole inspection and treatment, distribution automation, and infrared inspections.

Although these programs have successfully leveled equipment failure growth rates in the short-term, PPL Electric faces a long-term challenge regarding aging infrastructure. PPL Electric is committed to mitigating the aging infrastructure challenge through effective use of proactive replacement programs and data-driven failure probability models. Scheduled replacement of that infrastructure is necessary to avoid accelerating failure rates due to end-of-life fatigue.

52. Pa. Code § 57.198(b) Plan Consistency *The plan must be consistent with the National Electrical Safety Code, Codes and Practices of the Institute of Electrical and Electronic Engineers, Federal Energy Regulatory Commission Regulations and the provisions of the American National Standards Institute, Inc.*

PPL Electric's I&M Plan is consistent with the National Electric Safety Code ("NESC"), Codes and Practices of the Institute of Electrical and Electronic Engineers ("IEEE"), Federal Energy Regulatory Commission Regulations ("FERC") and the provisions of the American National Standards Institute, Inc. ("ANSI").

52. Pa. Code § 57.198(c) Requested Deviations *The plan must comply with the inspection and maintenance standards in subsection (n). A justification for the inspection and maintenance time frames selected shall be provided, even if the time frame falls within the intervals prescribed in subsection (n). However, an EDC may propose a plan that, for a given standard, uses intervals outside the Commission standard, provided that the deviation can be justified by the EDC's unique circumstances or a cost/benefit analysis to support an alternative approach that will still support the level of reliability required by law.*

PPL Electric is again requesting acceptance of the following deviations from the intervals in the Commission standard as were included in the seven previous I&M reports (2012-2013, 2014-2015, 2016-2017, 2018-2019, 2020-2021, 2022-2023, and 2024-2025):

- Section 57.198(n)(2). Pole Inspections. (vi) A load calculation.
- Section 57.198(n)(4). Distribution overhead line inspections.
- Section 57.198(n)(6). Distribution transformer inspections.

PPL Electric is again requesting acceptance of the following deviations from the intervals in the Commission standard as were included in the five previous I&M reports (2016-2017, 2018-2019, 2020-2021, 2022-2023, and 2024-2025):

- Section 57.198(n)(7). Recloser inspections.

PPL Electric is again requesting acceptance of the following deviation from the intervals in the Commission standard as were included in the four previous I&M reports (2018-2019, 2020-2021, 2022-2023, and 2024-2025):

- Section 57.198(n)(8). Substation inspections.

52. Pa. Code § 57.198(m) Recordkeeping *An EDC shall maintain records of its inspection and maintenance activities sufficient to demonstrate compliance with its distribution facilities inspection, maintenance, repair and replacement programs as required by subsection (n). The records shall be made available to the Commission upon request within 30 days. Examples of sufficient records include: (1) Date-stamped records signed by EDC staff who performed the tasks related to inspection. (2) Maintenance, repair and replacement receipts from independent contractors showing when and what type of inspection, maintenance, repair or replacement work was done.*

Inspection and maintenance activities performed by PPL Electric employees are tracked by electronic work requests in the Company's work management platform which date-stamps transactions and captures an electronic signature of the employee certifying completion.

Inspection and maintenance activities performed by PPL Electric contractors are documented with itemized records which identify when and what type of work was performed before invoices for the work are paid.

52. Pa. Code § 57.198(n)(1). Vegetation Management *The Statewide minimum inspection and treatment cycle for vegetation management is between 4-8 years for distribution facilities. An EDC shall submit a condition-based plan for vegetation management for its distribution system facilities explaining its treatment cycle.*

Program Description

PPL Electric employs a condition based five- to eight-year inspection and maintenance cycle for its distribution circuits where trimming, hazard tree removals, and brush control are performed. All transmission lines have two complementary condition-based maintenance programs performed on four-year cycles. One focuses on herbicide application to manage vegetation on the floor of the corridor and the other focuses on trimming along the edge of the corridor. Inspections for and removals of hazard trees occur on both cycles. Each program is offset by two years, so each line receives a physical inspection and maintenance every two years. Additionally, to verify clearances of vegetation from transmission facilities, an aerial Light Detection and Ranging ("LiDAR") inspection is performed every other year for low kV lines. Based on conditions, the cycle schedule may be modified but not beyond established regulations.

- Purpose:

  To safeguard the reliability of its electric distribution system, PPL Electric has developed a comprehensive program to manage vegetation around power lines. Keeping trees and other vegetation away from high-voltage lines is vital, as tree contacts can result in short-circuits and subsequent service outages.

Taller species of trees grown under power lines eventually will contact the wires if not managed, causing service interruptions and unsafe conditions. It is necessary for PPL Electric to trim or remove these trees to continue safe and reliable electric service.

- Process:

Distribution

Trees within 10 feet of multi-phase lines will be pruned to the full extent of the established tree line, not to exceed 25 feet from centerline and ground to sky pruning will be utilized.

Trees within 10 feet of single-phase lines will be pruned to the full extent of the established tree line, not to exceed 15 feet from centerline and to a distance of 15 feet above the line. All dead or structurally weak limbs that could fall or blow into the conductor are removed regardless of their distance above the conductor.

Exceptions: Trees on the opposite side of any thoroughfare, where normal line construction exists (not alley arms), are considered for proper lateral pruning using the centerline of the thoroughfare as a guideline. Fast growing tree species may need more aggressive pruning.

"Hazard trees" are trees outside the right of way (ROW) that may be leaning, diseased, or otherwise pose a threat of falling on a distribution line. PPL Electric conducts the removal either based on ROW agreements or with the property owner's permission.

Transmission

PPL Electric operates thousands of miles of high-voltage transmission lines. The Company's vegetation management program is designed to promote the safe and reliable operation of the electric grid, while considering the concerns of property owners and obligations to electric customers. Low-growing grasses and other compatible species are permitted within the wire zone. In the remainder of the ROW, certain compatible trees and shrubs are allowed if they do not pose a reliability risk.

52. Pa. Code § 57.198 (n)(2). Pole Inspections *Distribution poles shall be inspected at least as often as every 10-12 years except for the new southern yellow pine creosoted utility poles which shall be initially inspected within 25 years, then within 12 years annually after the initial inspection. Pole inspections must include:*

(i) Drill tests at and below ground level.
(ii) A shell test.
(iii) Visual inspection for holes or evidence of insect infestation.
(iv) Visual inspection for evidence of unauthorized backfilling or excavation near the pole.
(v) Visual inspection for signs of lightning strikes.

(vi) A load calculation.

Program Description

- Cycle:

  Every PPL Electric-owned pole will be inspected within the 2020-2031 time period, resulting in no more than 12 years between inspections.

- Purpose:

  Distribution poles are inspected to identify and measure the extent of decay and defects that may adversely affect safety or service reliability.

- Process:

  PPL Electric conducts an inspection process that includes the tests and visual inspections referenced in Section 57.198(n)(2) of the PUC's regulations. Poles are drilled to test for interior and exterior (shell) decay and are visually inspected for insect infestation, lightning strikes, backfilling and excavation. Pole conditions, including pole top conditions and crossarm defects, are also inspected. Poles younger than 25 years are visually inspected upon first inspection and subjected to a full inspection upon subsequent inspections.

  Based on the inspection and testing results, the pole is treated with a preservative, reinforced (by truss or fiber wrap), or replaced.

- Justification for Waiver:

  PPL Electric's pole inspection program generally complies with the intervals set forth in 52 Pa. Code § 57.198(n)(2), complies with NESC rules, and is consistent with industry practices.

  PPL Electric proposes a continuance of the deviation from the requirement for a load calculation to be performed for each pole inspected. The design of PPL Electric's lines is based on its Distribution Engineering Instructions, which are based upon NESC heavy loading conditions. These instructions provide adequate safety factors such that the allowable percentage of strength reduction does not compromise the ability of the pole to support the load. PPL Electric requires entities attaching facilities to its poles to perform their own load calculations before making the attachment. PPL Electric performs load calculations on every pole where new third-party attachments are requested.

  PPL Electric does not track service outages caused by pole equipment failure as a discrete category. Outages caused by pole equipment failure are included within a category of

outage causes that also includes failure of poles arms, brackets, guys, push braces, pole top extensions and any other mounting hardware. In 2023, equipment failures requiring replacement in this category amounted to 110 cases, of which only a small fraction are poles. Excluding pole fires, only four cases suggest broken PPL Electric-owned poles contributed to an outage. Four poles represent 0.0005% of PPL Electric's roughly 890,000 wood distribution pole inventory. Most of the limited number of pole failures are aggravated by weather conditions, such as trees being blown into lines, so the potential risk reduction through a load calculation is likely to be insignificant.

52. Pa. Code § 57.198 (n)(3). Pole inspection failure *If a pole fails the groundline inspection and shows dangerous conditions that are an immediate risk to public or employee safety or conditions affecting the integrity of the circuit, the pole shall be replaced within 30 days of the date of inspection.*

Corrective Maintenance

- Critical poles, those that pose an immediate safety concern or have a condition affecting the integrity of the circuit, are reinforced or replaced as soon as possible, and not later than 30 days after notification of a critical condition by the inspector at the time of inspection. Pole strength is provided for each rejected pole to assist reinforce versus replace decisions and schedule prioritization. The method of reinforcement is determined by the circumstances and/or location of the pole.

52. Pa. Code § 57.198 (n)(4). Distribution overhead line inspections *Distribution lines shall be inspected by ground patrol a minimum of once every 1-2 years. A visual inspection must include checking for:*

(i) Broken insulators.
(ii) Conditions that may adversely affect operation of the overhead transformer.
(iii) Other conditions that may adversely affect operation of the overhead distribution line.

Program Description

- Cycle:

  Infrared inspection: Every two years for multi-phase overhead lines adjacent to roadways.

  Visual inspection: Condition based – selected line segments. Inspections are scheduled under various conditions to include CEMI and Worst Performing Circuits (WPCs), if warranted based on Proactive Circuit Analyses, and/or if power quality issues are experienced. Additional patrols are conducted to ensure continued reliability including those in support of distribution construction projects and summer and winter readiness patrols.

- Purpose:

The objective of an overhead line inspection is to identify and correct equipment defects that may lead to a future service interruption or pose a safety hazard. Defects are identified by inspection, prioritized, and scheduled for repair.

- Process:

  Infrared: Multi-phase distribution lines adjacent to roadways are scanned from vehicles. A roof-mounted infrared camera is employed to capture a thermal image of components carrying electrical current. Heat emission measurements are compared to reference temperatures. Probability of failure is estimated based on the magnitude of temperature difference from reference. The method detects problems in current carrying components such as transformers, connections, splices, hot line clamps, disconnects, switches, lightning arresters, terminators, etc., whether or not there are visible defects. A detailed report of findings is prepared and at-risk items are prioritized and mitigated by repair or replacement.

  Visual: An analysis of actual service interruptions is conducted on selected circuits (e.g., poor performing circuits as measured by PPL Electric's WPC process, circuits with higher CEMI customers, and circuits undergoing proactive circuit analysis.) If an analysis indicates a pattern of equipment failure exists, a visual line inspection is scheduled. In addition to looking for visible defects in current-carrying components, visual inspection looks for mechanical defects in anchors, guys, crossarms, insulators, offset brackets, grounding systems, and poles.

- Justification for Waiver:

  PPL Electric hereby proposes a continued deviation from the one- to two-year inspection cycle on the basis of an effectiveness evaluation and cost-benefit analysis in favor of the program described herein. Resources that would be required to perform more frequent visual cycles than this proposal would reduce the amount of resources that could be applied to other more cost-effective reliability programs described in this plan.

  PPL Electric conducted a trial of infrared inspections of multi-phase lines in 2006. The trial inspections cost $122,500 and identified repairs costing $100,000, saving an estimated 1,460,000-2,600,000 Customer Minutes Interrupted ("CMI"), at a cost of $0.09 to $0.15 per CMI saved. PPL Electric restructured the infrared service contract, gaining further efficiencies in 2014. The cost benefit as calculated by the 2018 program effectiveness review suggested that the two programs, at a yearly cost of $327,000, save an estimated 719,000 CMI, at a cost of $0.45 per CMI saved.

PPL Electric Utilities Corporation

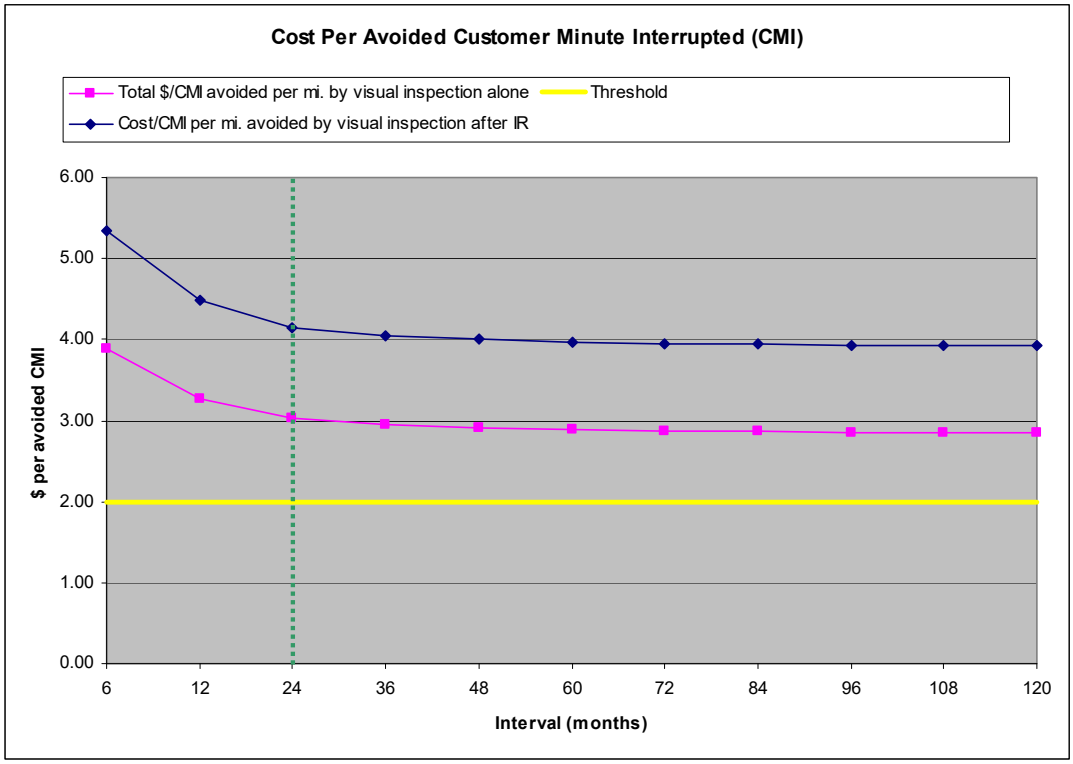
PPL Electric employs a $2.00 per CMI saved cost threshold[1] as a principal criterion for evaluating new projects for inclusion in the portfolio of reliability programs. Costs below that threshold are generally considered to be prudent investments, while those above typically provide less benefit for the cost. The cost threshold assists in applying finite resources to programs to produce better results, thus enabling the most effective portfolio of programs. Because infrared costs per CMI saved are well below the threshold, PPL Electric instituted a two-year infrared cycle for accessible multi-phase lines.

PPL Electric also conducted an overhead line visual inspection cost-benefit study in 2010. The study calculated a reliability benefit as a probability that inspections and the associated repairs would reduce equipment failure service interruptions. The overall probability is the product of (a) the probability that an equipment failure service outage is preceded by a visible condition, (b) the probability that the visible condition exists at the time of inspection, (c) the probability that an existing condition is detected, and (d) the probability that the condition is repaired before a service interruption occurs. For seven of the 13 overhead distribution component codes, actual inspection data established little likelihood of visible conditions preceding failure. For the remaining six component codes, subject matter experts were surveyed. The resulting probability estimates were applied to actual service outage data to estimate avoided CMI per mile. The inspection and repair cost per mile divided by CMI avoided per mile yielded an estimate of cost per CMI avoided. The graph below shows these costs per CMI for various inspection intervals.

The study also estimated avoided CMI/mile for visual inspections that follow infrared inspections because there is significant overlap between the two methods; infrared identifies both visible and hidden defects in current carrying components, while visual inspection detects only visible defects in electrical and mechanical components. The second graph below shows these costs per CMI for various inspection intervals.

As the graphs below depict, given PPL Electric's reliability parameters, there is no interval for visual overhead inspections that meets the established cost threshold, particularly when performed in conjunction with infrared inspections. Visual inspections alone at two-year intervals are 50% above the threshold; two-year visuals done in conjunction with infrared are 100% above the threshold.

[1] Cost threshold recommended by Richard E. Brown, Sr. Vice President and co-founder of Quanta Technology, a firm specializing in technical and management consulting for utilities. Dr. Brown has provided consulting services to most major utilities in the U.S. Dr. Brown has published more than 90 technical papers related to asset management and is the author of Electric Power Distribution Reliability, CRC Press, 2009.



Overhead Line Inspection Cost per Avoided CMI

Although universal overhead visual inspections are not found to be cost-effective, targeted visual inspections by PPL Electric have provided greater reliability benefit. For the period 2022 to 2023, 30% of circuits were responsible for 80% of equipment failure CMI.

As shown in the charts on pages 8 and 9, the majority of customer interruptions are due to vegetation related events during storms, rather than equipment failures during normal operations. Equipment failures are decreasing due to the many proactive initiatives and programs in place, including the line inspection program. This trend provides further justification to continue with PPL Electric's current inspection process.

In addition to the condition-based visual inspection approach described above, PPL Electric has many other efforts to review circuits, including: Proactive Circuit Analyses, deployment of new sensor technology, field checks and overhead inspections in conjunction with pole inspections.

52. Pa. Code § 57.198 (n)(5). Inspection failure *If critical maintenance problems are found that affect the integrity of the circuits, they shall be repaired or replaced no later than 30 days from discovery.*

Corrective Maintenance Description

- Infrared

  Priorities for corrective maintenance are determined by the magnitude of the variance from normal operating temperature as shown below.

Distribution Overhead Infrared Inspections Corrective Maintenance		
	Variance from Normal Operating Temp.	**Maximum Days Allowed After Report Receipt for Service**
3-Phase Backbone	+20-60° C	2 weeks
	> +60° C	Immediate
Multiphase	+20° C	8 weeks
	> +100° C	Immediate
Secondaries and Single-Phase	+30° C	16 weeks
	> +100° C	Immediate

- Visual

  The urgency for repairs is determined and an appropriate order of priority is assigned as described in the table below.

Distribution Overhead Visual Inspections Corrective Maintenance	
Definition	**I&M Standard**
Emergency; Defects which: (1) Threaten the safety of the public or employees; or (2) Will cause a service interruption at any moment Scheduling Priority: 1	Corrective Action taken Immediately
Priority; Defects with a high probability of causing a service interruption if not corrected promptly. Scheduling Priority: 2	Corrective Action must be taken within 30 days.

52. Pa. Code § 57.198 (n)(6). Distribution transformer inspections *Overhead distribution transformers shall be visually inspected as part of the distribution line inspection every 1-2 years. Above-ground pad-mounted transformers shall be inspected at least as often as every 5 years and below-ground*

transformers shall be inspected at least as often as every 8 years. An inspection must include checking for:

(i) Rust, dents or other evidence of contact.
(ii) Leaking oil.
(iii) Installation of fences or shrubbery that could adversely affect access to and operation of the transformer.
(iv) Unauthorized excavation or changes in grade near the transformer.

Program Description

- Cycle:

  Overhead: Overhead transformers are inspected as part of overhead visual line inspections, infrared inspections, and pole inspections. Additionally, load profiles are analyzed to identify and remedy overhead transformer locations that have consistent load demands exceeding design parameters.

  Pad-mount and Below-Ground: Inspections are scheduled when indicated by circuit performance and are confirmed by an analysis of actual service interruptions that identifies underground failures addressable by visual inspection. Pad-mount and below-ground transformers may be inspected as part of the underground residential development cable testing or replacement programs.

- Purpose:

  The objective of a transformer inspection is to identify and correct hardware or equipment defects that may lead to a future service interruption or pose a safety hazard. Defects are identified by inspection, prioritized and scheduled for repair.

- Process:

  Overhead and underground transformers are visually inspected for damage (rust, dents, cracks, locking devices, broken bushings, etc.), integrity of connections, and leaks. In addition, pad-mounts and below-ground transformers have cables and elbows inspected for deterioration, foundations and covers inspected and animals, nests, cobwebs, and vegetation removed.

- Justification for Waiver:

  PPL Electric hereby proposes a continued deviation from the fixed inspection cycle for transformers in favor of the condition-based inspection program described herein.

The overhead line inspection cost-benefit study described previously estimated that about 20,000 CMI annually could be saved via visual overhead transformer inspections. In 2024, the estimated cost to inspect those transformers every two years was $1.7 million or $85 per CMI avoided, well above the threshold employed by PPL Electric of $2.00 per CMI saved for identifying prudent reliability investments.

Similarly, pad-mount transformers only contribute 438,000 CMI on average to overall system reliability. An inspection and maintenance program for transformer condition would cost millions in expense for little improvement in reliability over other underground reliability improvement programs.

Resources that would be applied to shorter cycles than this proposal would reduce the resources applied to other more cost-effective reliability programs described in this plan.

52. Pa. Code § 57.198 (n)(7). Recloser inspections *Three-phase reclosers shall be inspected on a cycle of 8 years or less. Single-phase reclosers shall be inspected as part of the EDC's individual distribution line inspection plan.*

Program Description

- Cycle:

  Three-phase vacuum circuit reclosers ("VCRs") are subjected to infrared inspection on the same two-year cycle as oil circuit reclosers ("OCRs").

  Three-phase OCR: Infrared inspection performed on a two-year cycle.

  Single-phase OCRs: Inspected as part of PPL Electric's distribution line inspection program.

- Purpose:

  The purpose of the recloser inspection program is to ensure the reliable operation of reclosers by replacing deteriorated equipment with new installations.

- Process:

  Three-phase oil and vacuum reclosers are included in the two-year infrared line inspection program.

- Justification for Waiver:

  PPL Electric proposes a continued deviation for reclosers in favor of the program described herein.

A recloser's function is to isolate faults while minimizing the number of customers affected by permanent service outages. Visual inspection of an OCR provides relatively little useful information about the unit's capability to perform its function compared to testing. Testing in place would require almost all of the same steps that are involved in replacement. Bench testing is preferable to testing in place and refurbishment requires the unit's removal from service.

PPL Electric is engaging in the replacement of OCRs with VCRs on a condition-based proactive cycle. PPL Electric proposes to continue replacements on a condition-based cycle accounting for the age and condition of the OCRs, so that available funds are used in the most optimal fashion for the continued reliable delivery of electric service.

When PPL Electric began the process of replacing OCRs, there were approximately 5,000 multiphase OCRs on-system. Currently, there are 202 remaining, with an average age of 12 years and an expected lifespan of 30 years. The Company believes it would be imprudent to replace these remaining OCRs with VCRs before the condition of such OCRs warrants such replacement.

As PPL Electric has been replacing older oil reclosing three phased units, reliability has held steady with the number of failed units. In the last 12 months, 13 outages were caused by equipment failure of OCR and VCRs that were fixed with repairs or replacement consistent with the average of 13 in the past two years. Seventy percent of the legacy outage causing equipment has been upgraded to the latest VCR standard aligning with the condition-based replacement strategy in PPL Electric's plan as stated above.

52. Pa. Code § 57.198 (n)(8). Substation inspections *Substation equipment, structures and hardware shall be inspected on a cycle of 5 weeks or less.*

Program Description

- Cycle:

Visual	Infrared
Quarterly	Annual

- Purpose:

  Periodic substation inspections verify the integrity of station physical security, record and correct any security breaches, visual inspection of essential station equipment, identify any leaks and initiate any necessary corrective actions.

- Process:

Inspection of substation equipment, yard and perimeter and recording abnormal conditions of the equipment. Infrared inspections of substation equipment are performed on an annual basis.

- Justification for Waiver:

  In 2017, PPL Electric was granted a deviation from the five-week inspection cycle for substations in favor of the quarterly inspection cycle described herein.

  PPL Electric employs SCADA at every substation which provides real-time telemetry of potential issues. The relay packages provide advanced health information about the breakers and signal when maintenance is required, negating the need for visual inspections of these assets. PPL Electric implemented an upgrade to the data historian software that allows the Company to be automatically alerted when substation abnormalities are detected and automatically calculates remaining life on smart assets when operations occur.

  Over the last four years, none of the repairs scheduled as a result of the quarterly inspections have been critical repairs due to imminent failure risk. Any repairs have been minor in nature.

  Resources that would be applied to shorter cycles than this proposal would reduce the resources applied to other more cost-effective reliability programs described in this plan.

Appendix A: Transmission Programs and Procedures

Program	Activity
Helicopter Inspections – Routine	Aerial linemen perform annual routine transmission line patrols from a helicopter. They identify damaged or deteriorated equipment. Engineers review the findings and develop plans for repair or replacement.
Helicopter Inspections – Comprehensive	Aerial linemen perform an overhead comprehensive inspection of transmission line facilities on a four-year or eight-year cycle. Detailed condition reports with close-up digital photos are prepared for each specific component problem found along the transmission line and right-of-way. Engineers review the findings and schedule corrective maintenance as needed.
Helicopter Inspections – Emergency	Aerial linemen perform patrols of transmission lines that operate abnormally. This inspection focuses on identifying damage that may have been caused by lightning, inclement weather, equipment failure or vandalism. Because of the nature of this work, corrective actions generally are expedited.
Field Inspections – Emergency	Line personnel perform emergency foot patrols to inspect transmission lines that operated abnormally. This inspection focuses on identifying damage that may have been caused by lightning, inclement weather, equipment failure or vandalism. Due to the nature of this damage, corrective actions are generally expedited.
Steel Structure Inspection/Repair	Personnel inspect steel structures at the ground line for corrosion, mechanical damage and foundation degradation. Structural components are coated, and repairs are made based on the findings of the inspections as necessary.
Equipment Maintenance	During helicopter and foot patrols, equipment and facilities are identified that require repairs. Based on need and criticality, repairs are either scheduled or completed as soon as possible.
Planned Replacement Programs	Proactive replacement programs in place to address high risk assets such as wood poles, COR-TEN lattice towers and copper conductor. Lightning arresters and avian guards are installed on targeted 69kV and 138kV facilities based on a data-driven risk analysis to improve reliability of worst performing circuits.
Line Switches – Maintenance & Inspection	Line personnel inspect, maintain, and perform operational tests on 138kV and 69kV transmission line switches to assure proper operation.

PPL Electric Utilities Corporation

Program	Activity
Line Switch Upgrades	Transmission line switches are being programmatically upgraded to include motor operators and protection capabilities, as applicable, to allow for remote sectionalizing that substantially improves switching times during outages.
Circuit Analysis	Engineers analyze circuit loading and performance to identify areas needing increased line capacity or improved line reliability. Circuits are also reviewed based on operational performance and ranked yearly in a WPC list, with appropriate circuits identified for targeted reliability improvements.
Line Monitoring	Transmission line monitoring devices are being programmatically installed to provide real time data on line conditions to allow for accurate locating of faults, identification of conductor deficiencies, and load optimization to maintain the safe and reliable operation of the grid.

Appendix B: Substation Programs and Procedures

Program	Activity
Load Survey	Automatic monitoring devices such as Supervisory Control and Data Acquisition (SCADA) provide continuous, real-time loading information. Engineers review equipment loading and identify facilities and transfer capabilities approaching capacity limits. A portion of the load may be supplied from a different source, the existing facilities may be upgraded, new lines and equipment may be added, or a new substation may be built to address capacity deficiencies.
Substation Inspection/Repair	Electricians inspect substations for security and equipment reliability on a time-based maintenance cycle. They attempt to identify and correct potential equipment problems before a failure or interruption of service occurs.
Equipment Service	Electricians perform operational tests on power transformers, load tap changers ("LTCs"), voltage regulators, circuit breakers, circuit switchers, vacuum switches, air break switches and transformer protective switches on a time-based maintenance cycle to assure that equipment is operating within established parameters. Equipment serviced includes batteries, battery chargers, protective relays, HV fuses and high-speed automatic grounding switches. Depending on the type of equipment, "service" can include actions other than operational testing.
Inspection & Overhaul	Electricians inspect and overhaul circuit breakers, wave traps, ground switches, stick-operated disconnects, gang-operated disconnects and motor-operated disconnects on a time-based maintenance cycle to assure proper operation.
Insulation Testing	Technicians perform power factor testing on power transformers, potential transformers, lightning arresters, current transformers, select circuit breakers and power cables on a time-based maintenance cycle. Testing also includes other instrument transformers (capacitance coupled voltage transformer, coupling capacitors, potential devices, etc.). They also perform high-potential testing on12kV oil, air and vacuum circuit breakers to assure proper operation.

PPL Electric Utilities Corporation

Program	Activity
Condition Monitoring of Station Equipment	Technicians perform dissolved gas-in-oil, dielectric, oxygen, and oil acidity tests for oil in power transformers and impedance and capacity tests on station batteries to assure equipment is within normal parameters. Periodically, AC power factor tests, hi-potential tests, contact resistance tests and motion tests are performed on circuit breakers. Oil dielectric testing is conducted for oil circuit breakers.
Thermographic Inspections	Technicians perform thermography surveys of substation facilities to identify components operating at elevated temperature. Based on the findings, engineers develop plans to repair or replace the component(s) prior to failure.
Minor Improvements	Maintenance activities may identify conditions where additions or upgrades are needed to assure reliability. Engineers evaluate the need and develop action plans and schedules to complete the work.
DC Station Service Improvements	Repairmen identify deteriorated station batteries, battery chargers and battery components. Engineers schedule repair or replacement as necessary.
Capacitor Bank Protection	Engineers monitor the need for synchronous closing schemes on vacuum switches on 69kv capacitor banks. They plan and schedule installations as needed.
Area/Regional Supply	Engineers develop specific projects aimed at improving capacity shortfalls or replacing deteriorated or substandard station equipment.
SCADA Replacement	Engineers identify deteriorating substation SCADA equipment and develop plans to repair or replace it.

Appendix C: Distribution Programs and Procedures

Program	Activity
Load Survey – of equipment that is not continuously monitored	Line personnel measure the loading of facilities during peak periods. Engineers use this data for system studies.
Load Survey – by automatic monitoring devices	Automatic monitoring devices such as SCADA provide continuous, real-time loading information. Operators use this data to assure that loads do not exceed design limits. Engineers use this data for system studies.
Circuit Analysis	Engineers analyze circuit voltage profiles to balance loads and to identify areas requiring voltage support to maintain required voltage at the customer's facility.
Transformer Replacements	Engineers analyze customer usage data to identify overloaded transformers. Transformers that are heavily loaded are replaced with higher capacity units or portions of the load are transferred to other nearby transformers.
Wood Pole – Inspection, Maintenance, Reinforcement, Replacement	Wood poles are examined for deterioration and the degree of decay is measured. Based on the results, the pole may be treated with preservative to extend its life, treated and reinforced for extended life or replaced.
Overhead Line Inspection	Line inspection personnel examine overhead facilities to identify damaged, deteriorated or substandard equipment. Equipment examines include but is not limited to capacitors, regulators, switches, and reclosers. Line personnel repair or replace defective equipment likely to cause safety or reliability issues.
Circuit Performance Review	Engineers use PPL Electric's WPC score to ascertain the need for additional circuit reviews or inspections. The improved index looks at a circuit's overall impact to system SAIFI and circuit SAIDI. Actual service interruption history is analyzed to identify causal or geographic patterns.
LTN Maintenance	Electricians inspect, service, maintain and overhaul LTN vaults, manholes, cables, transformers, low-voltage network protectors and primary transformer disconnect switches. Based on results, defective equipment is either repaired or replaced.

PPL Electric Utilities Corporation

Program	Activity
Vulnerable Facilities Review	A program aimed at identifying the locations of facilities that have been damaged by public contact more than once. Technicians evaluate those installations and, if relocation is deemed appropriate, schedule work to move the facilities.
Underground Service Cable	Engineers resolve customer service problems that are due to deteriorated underground service conductors.
Capacitor and Voltage Regulator Installation	Engineers perform voltage profiles to determine the need, location and size of any new voltage support equipment required to maintain adequate service voltage levels at customer facilities and provide needed reactive support for system stability. Line personnel install the required equipment.
Upgrade System Facilities	Engineers determine the need for additional capacity and design new and upgraded facilities to assure system reinforcements are constructed by the time they are needed.

Appendix D: Vegetation Applications

Program	Activity
Tree Pruning	Tree pruning is scheduled based on field conditions observed and/or a system prioritization process. Pruning is done in accordance with American National Standard for Tree Care Operations-Tree, Shrub and Other Woody Plant Maintenance – Standard Practices (ANSI A300).
Hazard Tree Removal	Trees located outside the right-of-way that represent a threat to line performance/ safety are removed, when feasible.
Herbicide Application	Tall-growing, undesirable vegetation growing within the right-of-way corridors is selectively treated with herbicides. Low-growing vegetation that does not represent a hazard to the safe, reliable operation of PPL Electric's facilities is preserved wherever practicable.
Reclearing	Tall-growing, undesirable vegetation growing within the right-of-way corridors is selectively removed in those situations where herbicides cannot be utilized. Low-growing vegetation that does not represent a hazard to the safe, reliable operation of PPL Electric's facilities is preserved wherever practicable.