
Division 2-14

Request:

Please: (A) state whether PPL or any of its affiliates has prepared and/or implemented any of the following plans, programs, or studies; and (B) if the answer is yes, provide at least one example of such plan or study and state the jurisdiction and utility system in which it was implemented:

a. System electrical long range plan;

b. Distribution system area study or equivalent;

c. Energy Efficiency program plan or equivalent;

d. Distribution capital investment plans similar to the Infrastructure, Safety and Reliability Plan developed in Rhode Island;

e. Non-wires studies;

f. System heat maps or other distributed energy resources (DER) tools;

g. System Reliability Procurement standards and studies; and

h. Power Sector Transformation standards and studies.

To the extent relevant, any example of a plan provided or a regulatory filing should include all models in original software and PDF formats, all tables in Excel format, and any associated regulatory docket information.

Response:

a. System electrical long range plan:

PPL's affiliates have submitted system electrical long range plans.

PPL Electric Utilities Corporation ("PPL Electric") supports PJM Interconnection ("PJM") in the creation of the Regional Transmission Expansion Plan ("RTEP") as laid out in PJM Manual 14 (https://www.pjm.com/-/media/documents/manuals/m14b.ashx). PPL Electric also conducts a series of independent studies on its transmission system based on the PPL Planning Criteria (https://www.pjm.com/-/media/planning/planning-criteria/ppl-planning-criteria.ashx). The results of these studies become part of the long range (5-year) transmission plan.

PPL Electric has prepared and implemented a long-range plan in terms of investment planning, referred to as PPL Electric's Long Term Infrastructure Improvement Plan ("LTIIP") for the period of January 1, 2018 through December 31, 2022. Under Pennsylvania Act 11 legislation, through the filing and approval of this plan, PPL Electric is able to implement a Distribution System Improvement Charge ("DSIC") to recover reasonable and prudent costs incurred to repair, improve, or replace distribution property. In 2017, PPL Electric's second LTIIP was filed and approved and is provided as Attachment PPL-DIV 2-14-1.

Additionally, PPL Electric also has prepared and implemented its Biennial Inspection, Maintenance, Repair and Replacement Plan which outlines its inspection and maintenance protocol in compliance with the Pennsylvania Public Utility Commission requirements. The current 2020-2021 Biennial Inspection, Maintenance, Repair and Replacement Plan is provided as Attachment PPL-DIV 2-14-2.

The Louisville Gas & Electric and Kentucky Utilities Corporation ("LG&E/KU") transmission department perform an annual system electrical long range plan called the Transmission Expansion Plan ("TEP"). The purpose of the TEP is to reliably plan the combined LG&E/KU transmission systems (69kV and above) to meet future transmission customer needs. The TEP process is detailed in LG&E/KU's Open Access Transmission Tariff, which is required and approved by the Federal Energy Regulatory Commission. An example of the TEP is provided as Attachment PPL-DIV 2-14-3 CONFIDENTIAL. This attachment includes Critical Energy Infrastructure Information.

b. Distribution system area study or equivalent:

PPL Electric performs Proactive Circuit Analyses ("PCA") of each distribution feeder/circuit on a four-year cycle. The review analyzes and addresses both the operational and the 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. Two example reports are provided as Attachment PPL-DIV 2-14-4.

LG&E and KU creates an annual non-coincidental forecast for both LG&E and KU delivery points. This data is used to develop our capacity expansions for new loads. It is based on the expected growth from the past 10 years of data and new loads under contract.

c. Energy Efficiency program plan or equivalent:

PPL Electric has prepared and implemented energy efficiency plans, programs and studies for the past 12 years in Pennsylvania. These programs cover the full spectrum of PPL Electric's customer base, which includes residential, low income, small and medium business, and commercial and industrial sectors. PPL Electric's current energy efficiency and conservation plan in Pennsylvania is provided as Attachment PPL-DIV 2-14-5. Additional information can be found at https://pplelectric.com/ways-to-save/for-act-129-stakeholders.

In 2018, LG&E/KU received approval for their latest 2019-2025 Demand-Side Management and Energy Efficiency Program Plan from the Kentucky Public Service Commission (KPSC). The Plan was assigned to Case No. 2017-00441 and can be found on the KPSC website here: https://psc.ky.gov/PSC_WebNet/ViewCaseFilings.aspx?case=2017-00441.

d. Distribution capital investment plans similar to the Infrastructure, Safety and Reliability Plan developed in Rhode Island:

For PPL Electric, please see the response to subpart (a), above.

LG&E and KU recently filed the 2021-2025 Distribution Reliability and Resiliency Plan with the Kentucky Public Service Commission, which can be found on the KPSC website here: https://psc.ky.gov/pscecf/2020-00350/rick.lovekamp%40lge-ku.com/11252020085918/10-LGE_Testimony_1of4%28Thompson_Blake_Bellar_Sincliar_Wolfe_Saunders%29.pdf at Exhibit JKW-1

e. Non-wires studies:

PPL Electric's internal Transmission and Distribution planning process' incorporate evaluating non-wires alternatives as potential solutions in resolving system reliability concerns and issues. As an example, in 2019 PPL Electric installed and commissioned a distribution system battery to address a regional reliability concern on a specific circuit that has seen historical outages. Additional studies are currently underway in evaluating potential non-wires solutions on our distribution system as potential solutions for identified circuits for potential performance improvement.

PPL Electric is actively installing Dynamic Line Ratings ("DLR") sensors on 230 kV transmission lines to address the market congestion identified by PJM in the 2020-21 Market Efficiency window. The DLR sensors allow for updates to the transmission system rating based on real time ambient conditions, can provide a significant increase in rating during favorable weather conditions, and will allow the PPL Electric to forego investments in traditional projects that would have required re-conductoring of lines with higher capacity conductors to address the same congestion issue.

f. System heat maps or other distributed energy resources (DER) tools:

Beginning in 2017, PPL Electric executed the Keystone Solar Future pilot program which allowed us to remotely communicate with and manage customer DER systems on select feeders in our service territory. Expanding on this pilot, PPL Electric was approved to implement a three-year DER Management pilot program on 1/1/2021 to test and evaluate the costs and benefits of monitoring and actively managing inverter-based DER. This program, now system wide, leverages the Company's Advanced Distribution Management System ("ADMS") and the associated Distributed Energy Resource Management ("DERM") platform to communicate with DER's to improve the accuracy of planning and interconnection impact studies, hosting capacity, and masked or hidden load. Below are links to the details of this pilot program:

https://www.pplelectric.com/site/-/media/PPLElectric/At-Your-Service/Docs/Current-Electric-Tariff/rule12.ashx

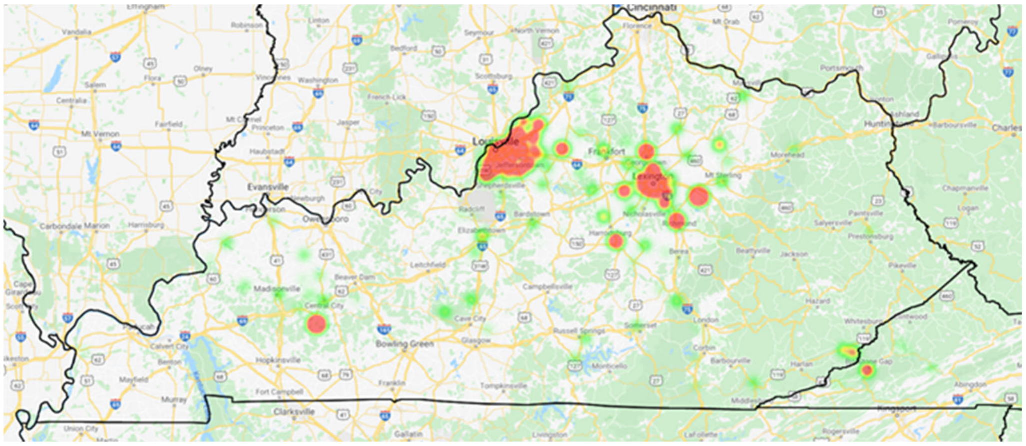
https://www.puc.pa.gov/pcdocs/1679576.pdf

https://www.puc.pa.gov/pcdocs/1694930.pdf

https://www.pplelectric.com/site/More/For-Construction/DER-Management

In addition, PPL Electric built and deployed the Renewable Energy Connection Web Portal, which provides customers with an easy method to apply for interconnection and receive a response from PPL Electric within a day and without manual intervention.

LG&E and KU have prepared a heat map showing the approximate location and capacity of DER connected in the LG&E and KU service area through the end of Q1 2021. The map shows that most of the DER interconnections are in the Louisville, KY and Lexington, KY areas with a few distributed throughout the more rural regions of the service area. This map is included below:



g. System Reliability Procurement standards and studies:

PPL Electric under the PA PUC requirements reports and evaluates system reliability performance and conducts studies to address circuit performance as required to improve reliability. This evaluation considers reliability trends and opportunities for system resiliency optimization. Capital investments to improve reliability are data driven and incorporate traditional and non-traditional system reinforcements. These also include non-wires alternatives solutions, automated sectionalizing and DER management solutions. In addition, PPL Electric evaluates and benchmarks its Transmission and Distribution system performance nationally to other similar sized utilities through IEEE Std 1366-2012. A copy of this IEEE standard is attached as Attachment PPL-DIV 2-14-6.

Pursuant to 807 KAR 5:058, LG&E and KU file integrated resource plans every three years with the Kentucky Public Service Commission which lay out their load forecasts and resource plans to meet future demand with an adequate and reliable supply of electricity at the lowest possible cost for all customers within their service areas. LG&E and KU's most recent IRP was assigned to Case No. 2018-00348 and can be found on the KPSC website here: https://psc.ky.gov/Case/ViewCaseFilings/2018-00348.

h. Power Sector Transformation standards and studies:

PPL Electric has not prepared or implemented any power sector transformation standards or studies as defined by the Power Sector Transformation Initiative undertaken by the Rhode Island Public Utilities Commission, the Office of Energy Resources, and the Rhode Island Division of Public Utilities and Carriers at the direction of the Rhode Island Governor. PPL Electric has, however, developed and implemented a self-healing distribution Smart Grid. Through systemwide studies, PPL Electric identified locations for and installed more than 5400 telemetered distribution sectionalizing devices on nearly all distribution circuits throughout the Company's entire service territory. Using the Company's Advanced Distribution Management System (ADMS), Fault Location Isolation and Service Restoration (FLISR) works with the data provided by the telemetered sectionalizing devices, without human intervention, to complete real-time power flow studies and reroute power to customers keeping the outage area contained to the smallest possible footprint. In 2020, PPL Electric surpassed more than 1 Million permanent customer outages avoided due to FLISR and Smart Grid technologies.

PPL Electric has also conducted studies of certain areas and circuits to determine the feasibility of converting the circuit to 100% renewable generation and storage. An example of such a study is provided as Attachment PPL-DIV 2-14-7.

Kentucky

LG&E and KU have not performed any Power Sector Transformation standards or studies. However, LG&E and KU are in the process of implementing smart grid technologies. Through studies and analysis, LG&E and KU have identified locations and installed approximately 1,500 SCADA connected reclosers throughout the Company's service territory which provides benefits to 78% of the Company's customers. At the end of May 2021, LG&E and KU surpassed more than 35.8 million outage minutes avoided and 230 thousand permanent customer outages avoided due to Distribution Automation. In the future, the Company's Advanced Distribution Management System (ADMS), Fault Location Isolation and Service Restoration (FLISR) will work with the data provided by the SCADA connected reclosers, to complete real-time power flow studies and keep outages to a minimal footprint.

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August 31, 2017

VIA ELECTRONIC FILING

Rosemary Chiavetta, Secretary
Pennsylvania Public Utility Commission
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Harrisburg, PA 17105-3265

Re: Petition of PPL Electric Utilities Corporation for Approval of its Long-Term Infrastructure Improvement Plan for the Period January 1, 2018 through December 31, 2022 - Docket No. P-2017

Dear Secretary Chiavetta:

Enclosed for filing is the Petition of PPL Electric Utilities Corporation for Approval of a Long-Term Infrastructure Improvement Plan. Copies are being served on the statutory advocates and all parties of record to the Company's most recent base rate proceeding at Docket No. R-2015-2469275 as indicated on the Certificate of Service.

Respectfully submitted,

Christopher T. Wright

CTW/jl
Enclosures

cc: Certificate of Service

CERTIFICATE OF SERVICE

I hereby certify that a true and correct copy of the foregoing has been served upon the following persons, in the manner indicated, in accordance with the requirements of 52 Pa. Code § 1.54 (relating to service by a participant).

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Date: August 31, 2017

Christopher T. Wright

15976006v1

**BEFORE THE
PENNSYLVANIA PUBLIC UTILITY COMMISSION**

Petition of PPL Electric Utilities Corporation for Approval of its Long-Term Infrastructure Improvement Plan for the Period January 1, 2018 through December 31, 2022	: : : :	Docket No. P-2017-____________

PETITION OF PPL ELECTRIC UTILITIES CORPORATION FOR APPROVAL OF A LONG-TERM INFRASTRUCTURE IMPROVEMENT PLAN

TO THE PENNSYLVANIA PUBLIC UTILITY COMMISSION:

Pursuant to 66 Pa.C.S. § 1352(a) and 52 Pa. Code §§ 121.1 *et seq*, PPL Electric Utilities Corporation ("PPL Electric" or the "Company") hereby requests approval of its second Long-Term Infrastructure Improvement Plan ("LTIIP") for the period January 1, 2018 through December 31, 2022. A copy of the Company's proposed second LTIIP is provided as "**Attachment 1**" to this Petition. This second LTIIP replaces the Company's current LTIIP that was approved on January 10, 2013 at Docket No. P-2012-2325034, which is set to expire on December 31, 2017. Under the second LTIIP, the Company proposes to continue its accelerated repair, improvement, and replacement of aging infrastructure as described below an in further detail in the proposed LTIIP.

PPL Electric respectfully requests that the Pennsylvania Public Utility Commission ("Commission") approve the second LTIIP, as further described in this Petition for the period January 1, 2018 through December 31, 2022.

I. INTRODUCTION

1. This Petition is filed by PPL Electric, a public utility subject to the regulatory jurisdiction of the Commission.

2. PPL Electric's address is PPL Electric Utilities Corporation, Two North Ninth Street, Allentown, Pennsylvania 18101.

3. PPL Electric's attorneys are:

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PPL Electric's attorneys are authorized to receive all notices and communications regarding this filing.

4. PPL Electric furnishes electric distribution, transmission and default supply services to approximately 1.4 million customers throughout its certificated service territory, which includes all or portions of twenty-nine counties and encompasses approximately 10,000 square miles in eastern and central Pennsylvania.

5. PPL Electric is a "public utility," an "electric distribution company" ("EDC"), and a "default service provider" as defined in Sections 102 and 2803 of the Pennsylvania Public Utility Code, 66 Pa.C.S. §§ 102, 2803.

6. On February 14, 2012, Governor Corbett signed into law Act 11 of 2012 ("Act 11"), which amended Chapters 3, 13 and 33 of Title 66 of the Code to allow, among other things, EDCs, natural gas distribution companies, water utilities, wastewater utilities and city natural gas distribution operations to establish a distribution system improvement charge ("DSIC").

7. Act 11 provides utilities with the ability to implement a DSIC to recover reasonable and prudent costs incurred to repair, improve, or replace certain eligible distribution property that is part of the utility's distribution system. Eligible property for EDCs is defined in Section 1351 of the statute. *See* 66 Pa.C.S. § 1351(1). As a precondition to the implementation of a DSIC, a utility must file an LTIIP with the Commission that is consistent with the provisions of Section 1352 of the statute. *See* 66 Pa.C.S. § 1352(a).

8. On August 2, 2012, the Commission issued an Implementation Order establishing procedures and guidelines necessary to implement Act 11. *Implementation of Act 11 of 2012*, Docket No. M-2012-2293611 (Order entered August 2, 2012) ("*Implementation Order*"). The *Implementation Order* adopted the requirements established in Section 1352, provided additional standards that each LTIIP must meet, and gave guidance to utilities for meeting the Commission's standards.

9. On January 10, 2013, the Company's current LTIIP was approved by the Commission at Docket No. P-2012-2325034. The Company's current LTIIP expires on December 31, 2017.

10. On January 15, 2013, PPL Electric filed a petition seeking approval of a DSIC. By Orders entered May 23, 2013 and April 9, 2015, the Commission approved PPL Electric's DSIC.

11. On December 20, 2014, the Commission's LTIIP regulations became effective. *See* 52 Pa. Code §§ 121.1 *et seq*. The LTIIP regulations provide the elements that an LTIIP must include to be approved. Specifically, an LTIIP must include the following eight major elements:

> (a) Identification of types and age of eligible property owned and operated by the utility for which it is seeking DSIC recovery;
>
> (b) An initial schedule for planned repair and replacement of eligible property;
>
> (c) A general description of location of the eligible property;
>
> (d) A reasonable estimate of quantity of eligible property to be improved or repaired;
>
> (e) Projected annual expenditures and means to finance the expenditures;
>
> (f) A description of the manner in which infrastructure replacement will be accelerated and how repair, improvement or replacement will ensure and maintain adequate, efficient, safe, reliable and reasonable service;
>
> (g) A workforce management and training program designed to ensure that the utility will have access to a qualified workforce to perform work in a cost-effective, safe and reliable manner; and
>
> (h) A description of a utility's outreach and coordination activities with other utilities, Department of Transportation and local governments regarding the planned maintenance/construction projects and roadways that may be impacted by the LTIIP.

52 Pa. Code § 121.3.

12. The Commission's LTIIP regulations further provide that a utility seeking to continue its DSIC mechanism after the expiration of its LTIIP must file a new LTIIP with the

Commission at least 120 days prior to the expiration of the currently-effective LTIIP. 52 Pa. Code § 121.5.

13. PPL Electric's proposed LTIIP addresses each of the eight elements listed in the LTIIP regulations, as summarized in this Petition.

II. PROPOSED LONG-TERM INFRASTRUCTURE IMPROVEMENT PLAN

A. PROPERTY TO BE IMPROVED, REPAIRED AND REPLACED

14. In accordance with the Commission's *Implementation Order*, the LTIIP regulations and statute, PPL Electric has focused its LTIIP on distribution plant that is DSIC eligible. *Implementation Order*, p. 18; 52 Pa. Code § 121.3(b).

15. All of the property PPL Electric has included in its LTIIP meets the definition of eligible property found in Section 1351(1), which includes the following items: poles; overhead conductors; distribution substation equipment; fixtures and devices related to the eligible property such as circuit breakers, fuses, reclosers, and crossarms; unreimbursed costs related to highway relocation projects; and other related capitalized costs.

16. Nearly half of PPL Electric's distribution system was constructed 40 or more years ago as a result of the economic expansion and building boom of the 1960's and 1970's. As this equipment deteriorates due to age, environmental exposure, and added load, it has become increasingly critical to plan for the repair, upgrade, and/or replacement of these assets.

17. The LTIIP covers a broad spectrum of distribution related equipment and facilities, which have been separated into two asset categories. These two categories are (1) distribution assets and (2) substation assets. A description of the items classified as distribution assets can be found on page 17 of the LTIIP, while a description of those items included in the LTIIP as substation assets is found on page 43. (*See* Attachment 1, pp. 17, 43) Within each of these categories, PPL Electric has identified specific programs to address the various elements,

equipment, and facilities that make up each of the two asset classes. Each program is described individually, with an estimated replacement schedule and estimated costs as applicable or appropriate.

18. For each individual program included in the LTIIP, PPL Electric has provided the following information: a description of the program and its purpose; a description of how PPL Electric identifies equipment for replacement within each program and the appropriate course of action to improve identified equipment; the scope of the program, including a reasonable estimate of the quantity of property to be improved where applicable; the location of planned replacements where applicable; and the total amount projected to be spent by the Company annually and over the life of the five-year plan. These detailed profiles of the individual programs are provided in the LTIIP. (*See* Attachment 1, pp. 17-42 for distribution assets, pp. 43-53 for substation assets)

19. Appendix A to the LTIIP provides a summary of the types and average age of eligible property to be replaced. (*See* Attachment 1, p. 54)

B. SCHEDULE FOR REPAIR AND REPLACEMENT

20. The proposed LTIIP covers the five-year period January 1, 2018 through December 31, 2022.

21. The estimated schedule for each individual LTIIP program has been included in the program descriptions. (*See* Attachment 1, pp. 17-42 for distribution assets, pp. 43-53 for substation assets)

22. PPL Electric has estimated the number of replacements in a variety of distribution asset categories over the five-year LTIIP period. In estimating its replacement schedule, a number of factors were considered. Some of the initiatives, such as animal guarding, clearly have implied end-points, where no further opportunities for improvement remain. Others, such

as System Average Interruption Duration Index ("SAIDI") improvements, eventually experience diminishing returns over time. Finally some programs, such as pole reinforcement and replacement, will be ongoing.

23. In addition, the programs implemented by PPL Electric are subject to change, as additional analysis is done on the effectiveness of individual programs, or as new issues arise. Some programs may become obsolete, while new programs may become desirable as a result of the evolution of new technologies.

24. The effectiveness of LTIIP programs will be reviewed on a regular basis and programs will be added, deleted, and/or modified, as necessary, to ensure that the expenditures are providing the desired benefits to customers at a reasonable cost. Therefore, while PPL Electric has provided an estimated schedule for when certain replacements will take place, that schedule is subject to change as a result of PPL Electric's ongoing review process and emergent resource requirements.

C. LOCATION OF ELIGIBLE PROPERTY

25. A description of the location of eligible property to be repaired and replaced has been provided on an individual program basis, and is included in the section of the LTIIP that provides individual program descriptions. (*See* Attachment 1, pp. 17-42 for distribution assets, pp. 43-53 for substation assets)

D. REASONABLE ESTIMATE OF THE QUANTITY OF PROPERTY TO BE IMPROVED

26. An estimate of the quantity of eligible property to be improved or repaired, as well as the Company's basis for these estimates, have been provided on an individual program basis, and are included in the section of the LTIIP that provides individual program descriptions. (*See* Attachment 1 pp. 17-42 for distribution assets, pp. 43-53 for substation assets)

E. PROJECTED ANNUAL EXPENDITURES AND MEANS TO FINANCE THE EXPENDITURES

27. The LTIIP provides the Company's projected expenditures on a yearly basis for each of the individual programs for the five-year period, the total projected expenditures for each program at the conclusion of the five-year period, and the overall projected annual and total expenditures for all DSIC eligible distribution property. (*See* Attachment 1, p. 16) In addition, individual program expenditure information is included in the sections describing the each of the individual programs.

28. The Company intends to finance the costs of its DSIC eligible work through its usual financing mechanisms, debt and equity. In each DSIC rate filing, the Company will identify its capital structure and cost of debt, in addition using the Return on Equity as determined in its base rate case proceeding or as defined in the most recent applicable Commission Quarterly Financial Report.

29. In order to ensure that its individual programs are cost-effective investments, PPL Electric will routinely review the effectiveness of its programs. Program and project impacts on SAIDI and System Average Interruption Frequency Index ("SAIFI"), in addition to potential reductions in outage response costs, are compared to the overall program and project costs. PPL Electric utilizes a project prioritization process that defines the cost-effectiveness of programs and projects to ensure effective optimization of reliability investments.

30. PPL Electric utilizes the information from its ongoing reviews of the effectiveness of its programs to determine the most cost-effective strategy for replacing its distribution infrastructure on a going forward basis. Reliability metric performance may result in the redirection of spending to help ensure PPL Electric's ability to meet its identified reliability targets in a cost-effective manner.

F. ACCELERATION OF INFRASTRUCTURE IMPROVEMENT

31. In its *Implementation Order*, the Commission noted that some utilities had already taken substantial steps toward increasing capital investment to address the issue of aging infrastructure. For those utilities, the Commission requested that the LTIIP "reflect how the DSIC will maintain or augment acceleration of infrastructure replacement and prudent capital investment." *Implementation Order*, p. 19.

32. As described in the LTIIP PPL Electric has already significantly increased its capital expenditures on distribution related infrastructure over historical spend. (*See* Attachment 1, p. 12, Figures 5 and 6) From 2009 to 2012, PPL Electric more than doubled the amount it was investing in capital infrastructure. The Company continued to accelerate its capital investment from 2013 to 2017, the five-year period of the Company's current LTIIP.

33. Consistent with the Commission's *Implementation Order*, PPL Electric has projected to continue its accelerated investment for eligible property for the period of 2018 through 2022. (*See* Attachment 1, pp. 15-16)

34. PPL Electric believes that repair, improvement, and replacement of aging distribution equipment and facilities will ensure that the Company can reduce the number of outages that are the result of equipment failure, which will directly improve the reliability of service provided by PPL Electric to its customers.

35. PPL Electric is aware of the direct impact the equipment included in the LTIIP has on its reliability metrics. (*See* Attachment 1, Appendix B) PPL Electric will use these metrics to monitor the success of its LTIIP programs. The programs included in the LTIIP are expected to prevent the growth in failures caused by aging equipment, and will eventually reduce the number of equipment failures experienced on PPL Electric's distribution system.

G. WORKFORCE MANAGEMENT AND TRAINING PLAN

36. The Company's workforce management and training program is described in the LTIIP. (*See* Attachment 1, pp. 13-15)

37. PPL Electric's workforce is comprised of both those employees who work directly for PPL Electric, and the workers who are hired by contractors of PPL Electric.

38. PPL Electric utilizes a wide variety of programs and tools to ensure that it has a qualified workforce.

39. As a measure to ensure the use of a qualified workforce, PPL Electric has adopted the definition of a Qualified Electrical Worker from the Occupational Safety and Health Administration ("OSHA") Regulation 29 CFR 1910.268 Electrical Power Generation, Transmission and Distribution, which is defined in the PPL Safety Rule Book and is provided to each employee. This OSHA standard is also incorporated into PPL Electric's training and qualification process for all electrical workers.

40. PPL Electric administers a rigorous, formal training and evaluation process for all of its directly employed qualified electrical workers. Training is required before an employee may perform work independently on exposed, energized electrical equipment greater than 50 volts, and these programs are unique to the job classification and work being performed by individual employees. The training is provided by experienced training professionals with developed curriculum. The extensive training may require up to five years to complete, with regular assessment and incremental qualifications throughout the duration of the training program. Retraining is conducted on a periodic basis as required by OSHA or more frequently when determined necessary.

41. In preparation for turnover associated with an aging workforce, PPL Electric developed a long range Strategic Workforce Plan ("SWP"). The SWP provides a fifteen-plus

year analysis of the projected employee turnover by job category and year, projections on worker availability, and strategies for both sourcing and recruiting, in order to ensure the long-term ability of PPL Electric to attract, hire, develop, and retain qualified workers.

42. For its contractors, PPL Electric's Contract Management department administers a standard process for soliciting contractors to perform work identified to be completed by independent contractors. Part of that process includes evaluating the qualification of contractors to perform work (both technical and financial capabilities to meet the contractual commitments, and level of qualification of employees), and may include reference checks if appropriate. Most independent contractors employ personnel through the building trades, which includes Union apprenticeship programs to help ensure that employees are qualified to perform assigned work. Employee qualification programs for non-Union independent contractors are stringently reviewed to assess the contractor's training program, such as on-the-job training and certification programs.

43. PPL Electric monitors contractor performance through several activities that may include direct job oversight through on-site supervision, monthly scorecards that evaluate such areas as job quality, safety performance, cost, and validating billing activities that meet contractual expectations.

H. OUTREACH AND COORDINATION ACTIVITIES

44. PPL Electric's outreach and coordination activities with other utilities, the Pennsylvania Department of Transportation, and local governments are described in the LTIIP. (*See* Attachment 1, p. 13) PPL Electric has established procedures for communicating with such entities regarding projects.

III. NOTICE AND EVIDENTIARY HEARINGS

45. Pursuant to the Commission's regulations, PPL Electric is serving this Petition and the attached LTIIP are being served on the statutory advocates and all parties of record to the Company's most recent base rate proceeding at Docket No. R-2015-2469275.

46. Neither Act 11 nor the Commission's regulations require hearings on proposed LTIIP.

47. The regulations provide that comments to proposed LTIIPs are to be filed within 30 days of the proposed LTIIP, and that comments that raise material factual issues will result in the LTIIP being referred to the Office of Administrative Law Judge. *See* 52 Pa. Code § 121.4(c). Accordingly, it is unknown at this time whether PPL Electric's proposed second LTIIP will be subject to evidentiary hearings.

IV. CONCLUSION

WHEREFORE, PPL Electric Utilities Corporation respectfully requests that the Pennsylvania Public Utility Commission approve the second Long-Term Infrastructure Improvement Plan for the period January 1, 2018 through December 31, 2022, as set forth in this Petition and the attachment hereto.

Respectfully submitted,

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Dated: August 31, 2017

Attorneys for PPL Electric Utilities Corporation

VERIFICATION

COMMONWEALTH OF PENNSYLVANIA

COUNTY OF LEHIGH

I, Stephen J. Gelatko, Director- Distribution Asset Planning, hereby state that the facts above set forth are true and correct to the best of my knowledge, information and belief, and that I expect to be able to prove the same at a hearing held in this matter. I understand that the statements herein made subject to the penalties of 18 Pa. C.S. § 4904 (relating to unsworn falsification to authorities).

Stephen J. Gelatko

STEPHEN J. GELATKO

Attachment 1

PPL Electric Utilities Corporation

Long-Term Infrastructure Improvement Plan

PPL Electric Utilities Corporation

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Introduction

PPL Electric Utilities Corporation ("PPL Electric" or "Company") is submitting this Long Term Infrastructure Improvement Plan ("LTIIP") pursuant to the requirements of Subchapter B, Distribution Systems, of the Public Utility Code, 66 Pa.C.S. §§ 1350-1360, the Public Utility Commission's ("PUC") Implementation Order for Establishment of a Distribution System Improvement Charge, entered on August 2, 2012 at Docket No. M-2012-2293611 and the Commission's regulations at 52 Pa. Code §§ 121.1 et seq. This LTIIP addresses a broad spectrum of Distribution Asset Management initiatives that the Company will use to continue its accelerated repair, improvement and replacement of aging infrastructure under this process, and is for the five-year period beginning January 1, 2018 and ending December 31, 2022..

PPL Electric strives to operate as efficiently as possible by performing the work required to maintain system integrity and reliability. Performance indicators such as System Average Interruption Frequency Index ("SAIFI"), Customer Average Interruption Duration Index ("CAIDI") and System Average Interruption Duration Index ("SAIDI") show that PPL Electric has been successful in its efforts. However, an increasing trend in equipment failures, combined with an aging infrastructure, indicate that PPL Electric has reached a point where extensive and accelerated investment in the distribution system is required. As equipment failures continue to rise, PPL Electric has been experiencing a significant increase in maintenance spending beyond normal inflationary pressures. The driver is a combination of both increased corrective and planned maintenance. PPL Electric has initiated and enhanced maintenance practices and programs to repair, improve, or replace certain distribution facilities in order to ensure adequate, efficient, safe and reliable service. PPL Electric began the implementation of the identified improvements in 2009 as a result of its "Asset Optimization Strategy" initiative, discussed later in this document, and has since continued to accelerate its capital investments through its current Commission-approved LTIIP.[1]

Addressing aging infrastructure will require continuation of an accelerated level of investment. Such investment includes not only replacing aging equipment, but also investment in advanced equipment and communication technologies that can facilitate further system reliability improvements. If accelerated, proactive re-investment does not occur, it is expected that system reliability will degrade, while the overall cost to maintain the distribution system will continue to rise. By investing in its distribution system on an accelerated basis, PPL Electric will ensure that its system continues to be safe, reliable, and able to meet the growing needs and expectations of its customers.

PPL Electric believes that managing finite resources to produce optimal results is essential for maintaining customer satisfaction. Criteria for program inclusion into the Long-Term Infrastructure Improvement Plan is not whether any single activity produces a positive reliability result, but rather, which portfolio of accelerated activities produces the best result for a given expenditure. PPL Electric's goal is focused on results (i.e., the reliability experienced by customers and associated rate impacts), not the rote execution of particular tasks.

Reliability Experience

The Distribution Asset Planning process employed by PPL Electric has been focused on maintaining reliability at the level that existed prior to passage of the Electricity Generation Customer Choice and Competition Act ("Customer Choice Act"). Since the 1994-1998 benchmark period, which defines PPL Electric's reliability

[1] In 2013 the Company obtained Commission approval of its current LTIIP for the period beginning January 1, 2013 through December 31, 2017, at Docket No. P-2012-2325034.

performance targets, PPL Electric's service reliability has experienced annual swings, positive and negative, resulting largely from varying weather conditions. Increased and accelerated levels of funding for distribution reliability programs will help to ensure more consistent performance below the PUC benchmark. Historical benchmark performance is illustrated in Figures 1 and 2.

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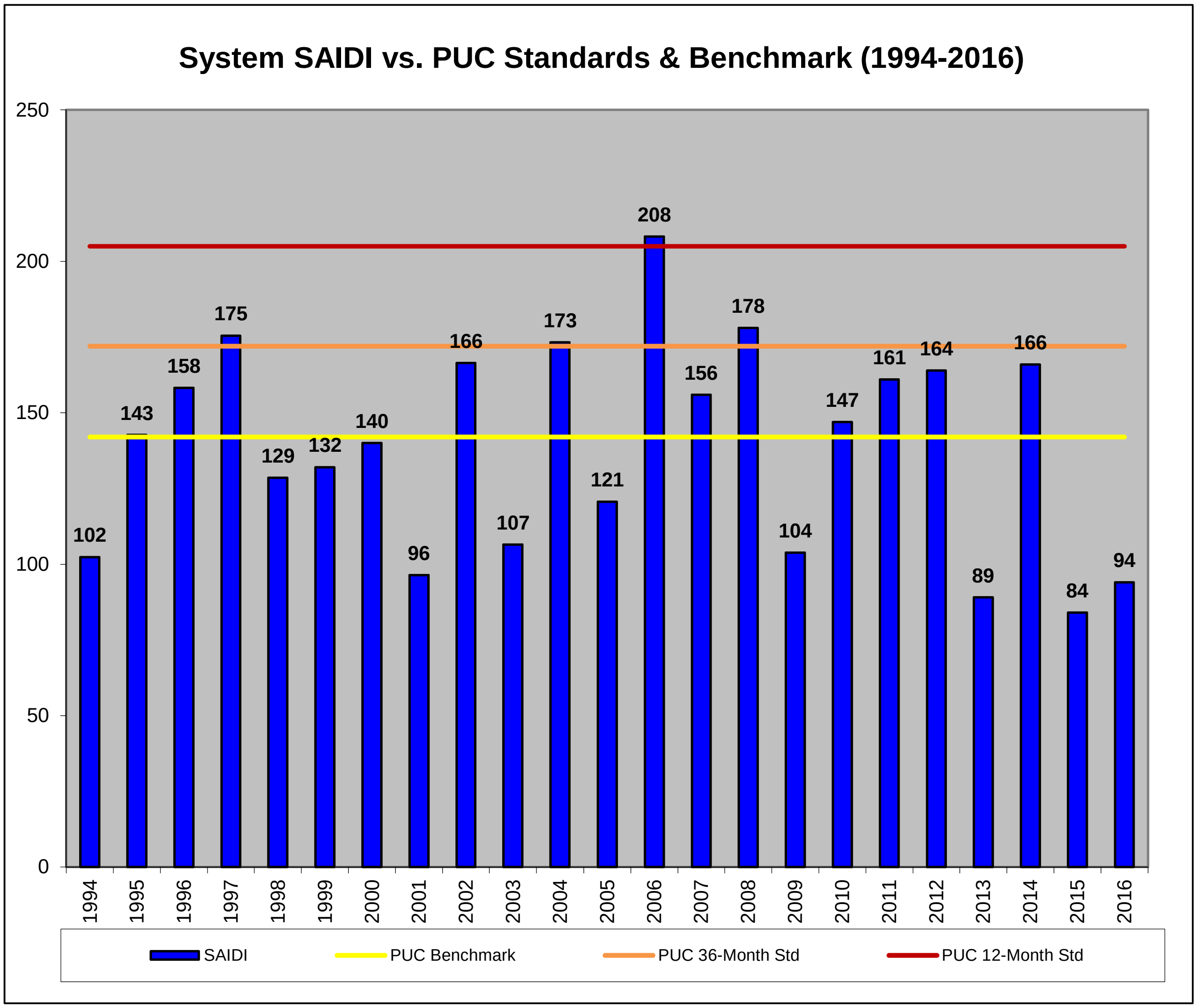

Figure 1: PPL Electric's SAIDI Performance

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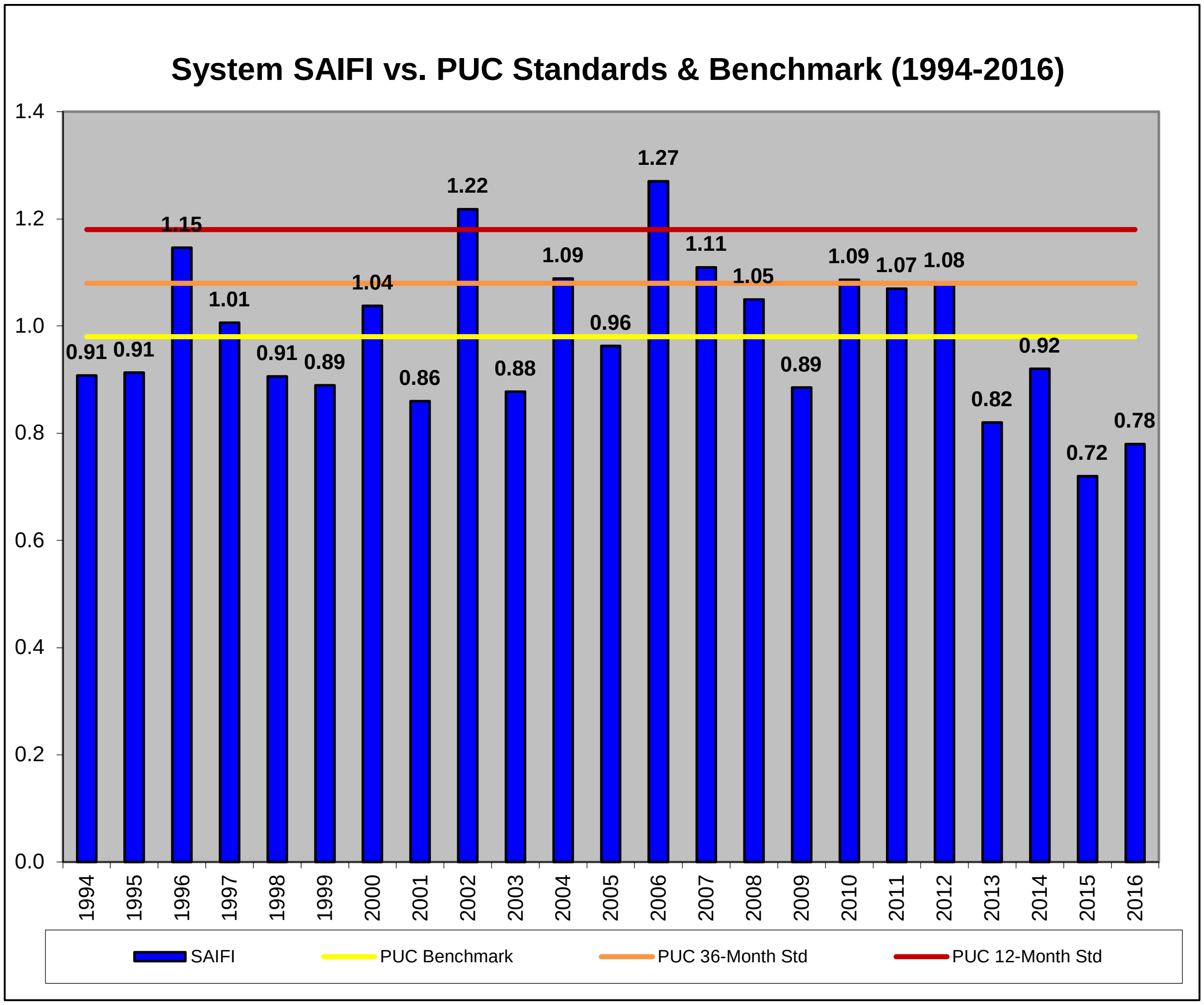

Figure 2: PPL Electric's SAIFI Performance

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A significant risk to PPL Electric's ability to meet reliability benchmarks is the large portion of distribution facilities, many of which were installed in the 1960's and 1970's, that are now beyond or nearing the end of their design lifetime. See Appendix A for average age of major units of property. The resultant effect on non-storm-related equipment failures is illustrated by the chart in Figure 3(a) below.

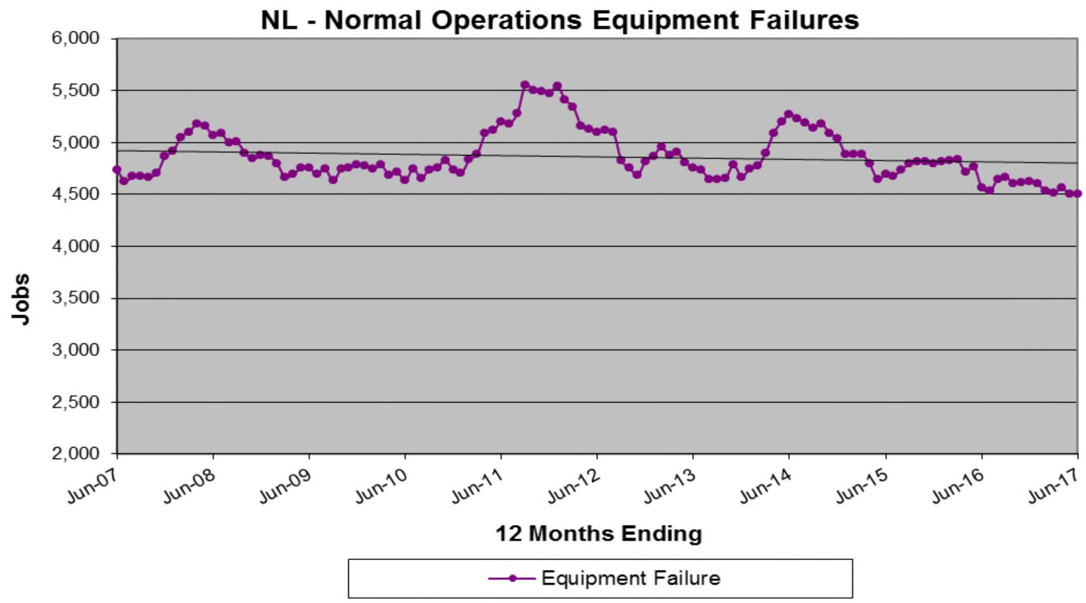

Figure 3a: Equipment Failure Service Interruption Cases

The number of no-light cases due to equipment failures is now trending downward due to investments over the past five to ten years, after having trended upward from 2001 through 2006 (see Figure 3B below). The need to remediate that equipment which is at or near end-of-life remains in order to maintain this favorable trajectory. Components contributing the most significantly to distribution equipment failures include poles/arms/attachments, overhead conductors, and substation equipment. See Appendix B for further details on asset contribution to reliability metrics.

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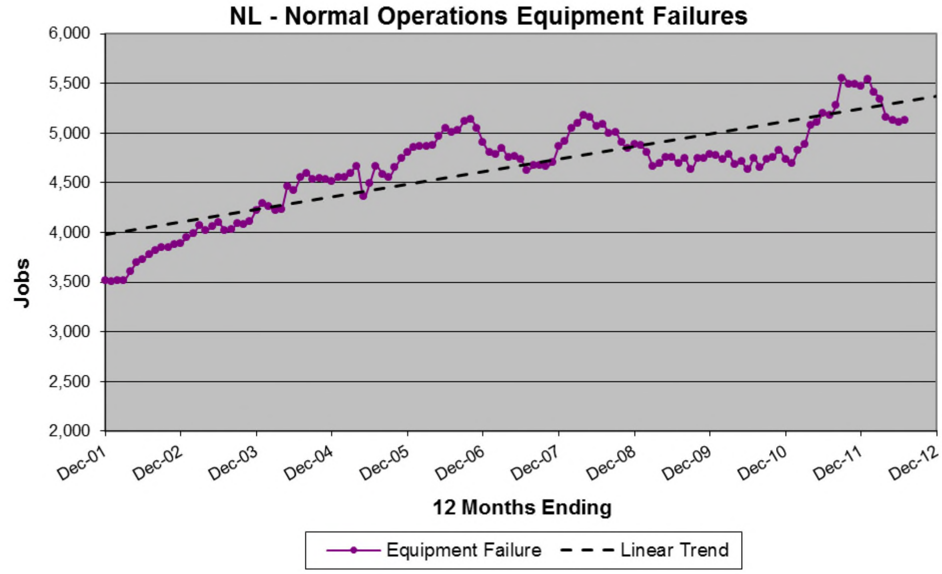

Figure 3b: Equipment Failure Service Interruption Cases 2001-2012

Response to Increasing Equipment Failure Rate

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

- Analyze and identify the drivers of historical trends of causes of service outages and other power service problems.
- Forecast future reliability metrics (SAIDI, SAIFI, and CAIDI) given existing mitigation programs' effect on the identified drivers.
- Identify new programs, policies, and activities to enhance or accelerate existing mitigation programs to avoid forecasted gaps between future reliability and benchmark targets.
- Identify, evaluate, and implement new technologies that enhance the Company's condition monitoring strategy.
- Evaluate and adjust existing programs, policies, and activities to produce the desired future results.
- Perform targeted data analytics against our aging infrastructure utilizing real-time, or near real-time, operational data to further improve reliability performance.
- Incorporate the resulting portfolio of existing and new programs, policies, and activities in PPL Electric's five-year business plan.

In June 2011, PPL Electric's Reliability Principles and Practices ("P&P") were revised to help reduce the overall impact to our customers from outages due to various causes, including but not limited to, equipment failures. The

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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 reasonable, acceptable and are in accordance with leading utility practices. More specifically, to reduce the number of customers experiencing permanent outages and outage duration over the long term, the following circuit design guidelines are used wherever practical, starting with those identified as Worst Performing Circuits ("WPCs"):

- Limit the line length to approximately 50 circuit miles;
- Limit customer count to less than 1,300 customers per circuit;
- Ensure the circuit has three-phase tie lines, and these tie lines will support the transfer of 50% of the customers for at least 95% of the hours in a year; and
- Use line automation to restore at least 50% of the customers by System Operator-controlled switching or automated switching.

Prioritization utilizing these design criteria is based on the greatest expected improvement in reliability for the entire system.

Several other mitigation initiatives have been undertaken to reduce the forecasted short-term equipment failure growth rate.

- **Enhanced Pole Inspection/Treatment Program:** Beginning in 2016, the Company's wood pole inspection and treatment program was enhanced from a partial excavation process to a full excavation process, whereby all poles that are inspected are fully excavated around the circumference of the pole to inspect and subsequently chemically treat to arrest decay and extend useful life at the same visit. The preservative treatment permits the next inspection to be at a uniform ten-year cycle. As an integral part of the ten-year pole inspection process, PPL observes, notes, and reports at-risk conditions of all pole attachments, specifically crossarms, braces, conductors, transformers, fuse cutouts, lightning arresters, reclosers, regulators, capacitors, switches, wildlife protection, vegetation encroachment, guys, anchors, ground wires, and ground rods.

- **Increased Utilization of Infrared Inspections:** 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"). Funding of infrared inspections and repairs was increased significantly during 2010 and has remained at a higher funding level. Infrared inspections occur on all 3-phase and 2-phase overhead lines adjacent to roadways every two years.

- **Expanded Operational Reviews ("EOR"):** EORs are performed on each feeder on a four-year cycle. The engineering review addresses both operational and reliability characteristics of each circuit. Voltage support, phase balancing, power factor maintenance and loading issues are addressed from an operational perspective. Service reliability analysis, exposure analysis, and field checks address reliability.

- **Distribution Automation Strategy:** In 2010, PPL Electric launched a "smart grid" pilot project that enables the Company to move power more efficiently, react instantaneously to changes on the delivery system, and automatically re-route power around problems that occur. After a very successful pilot in the Harrisburg region, substantial investment is planned to help ensure achievement of long term reliability goals. Distribution is currently realizing a ~30% reliability improvement in areas where Smart Grid has been fully deployed. Future plans include the installation of hundreds of automated electrical devices through 2021. The end-result will be a delivery system that operates more efficiently, recognizes problems immediately, and responds in seconds to restore the service for many customers who otherwise need to wait minutes or hours.

Although these programs have successfully slowed failure growth rates in the short-term, PPL Electric faces a long-term issue regarding aging infrastructure. The surge in electrical construction in the 1960's and 1970's has resulted in a large number of assets that have reached or are nearing the end of their useful lifetime. Consequently, in 2008-2009, PPL Electric conducted a major condition assessment and maintenance study of its distribution system. The result was the implementation of the Asset Optimization Strategy ("AOS"). The study found that programmatic and accelerated replacement of infrastructure would be the most cost-effective strategy to address aging infrastructure and ensure system reliability and integrity.

Asset Optimization Strategy

The purpose of the AOS study was to develop a strategy for accelerated capital replacement improvements that would combat the anticipated effects of aging infrastructure and bolster PPL Electric's ability to effectively maintain reliable electric service. With the Company entering a period where a significant number of assets are expected to reach the end of life, a plan was developed to intelligently replace assets prior to an unplanned failure that impacts customers. The plan includes replacements in kind, as well as upgrades to current standards.

Examples of AOS Projects include proactive replacement of substation equipment, Low Tension Network ("LTN") equipment, and vintage underground cable based on condition based health analysis. In 2017, Distribution Asset Management will leverage advanced analytic tools to develop and deploy new asset health dashboards that will improve our ability to predict failures of high valued asset across our system.

Accelerated Investment

Figure 4 below depicts PPL Electric's planned capital investment originally included in its 2008-2012 business plan for DSIC eligible property. This business plan was developed in 2007, prior to the AOS study.

	2008	2009	2010	2011	2012
Asset Optimization Strategy*	$ 1,305,907	$ 1,486,747	$ 761,235	$ 1,090,203	$ 1,284,506
Improve System Reliability	$ 10,613,221	$ 9,237,000	$ 8,742,719	$ 11,219,640	$ 11,792,252
Maintain System Reliability	$ 30,388,745	$ 30,148,238	$ 31,151,354	$ 31,939,787	$ 33,422,736
Unreimbursed Highway Relocations	$ 4,035,602	$ 3,528,317	$ 3,598,725	$ 3,677,628	$ 3,917,637
Total	**$ 46,343,476**	**$ 44,400,302**	**$ 44,254,033**	**$ 47,927,258**	**$ 50,417,131**

*Prior to the AOS Study, there was some work budgeted under other categories that were converted to the AOS category.

Figure 4: Original 2008-2012 Capital Investment Plan

Having concluded the AOS study, PPL Electric began engineering and making large material purchases for the identified proactive and accelerated replacements during 2009, followed by a ramp up period during 2010 and full implementation of the strategy in 2011. PPL Electric has refined processes and work planning efforts in support of the sustained investment levels. Acceleration of capital investment into the distribution infrastructure for the five-year period of 2008 through 2012is illustrated in Figure 5 below. PPL Electric has approximately doubled its investment in DSIC-eligible property from 2009-2012, as a result of the AOS study.

	2008	2009	2010	2011	2012
Asset Optimization Strategy	$115,046	$5,115,041	$19,661,586	$32,667,111	$18,700,002
Improve System Reliability	$7,177,339	$12,470,418	$33,186,012	$39,598,466	$25,882,744
Smart Grid Investment		$100,193	$9,299,164	$7,320,142	$2,118,695
Maintain System Reliabilty	$33,648,603	$34,407,064	$46,388,673	$47,206,474	$50,164,857
Unreimbursed Highway Relocations	$3,082,209	$3,265,414	$2,521,236	$4,858,351	$2,848,305
Total	**$44,023,197**	**$55,358,130**	**$111,056,671**	**$131,650,544**	**$99,714,603**

Figure 5: Accelerated Capital Investment

The timely recovery of the costs associated with such a large capital appetite is key to ensuring access to the capital markets for financing. Prior to the enactment of Act 11, PPL Electric faced the possibility of requiring more frequents rate cases, perhaps as often as annual filings. The availability of the DSIC mechanism ensures the timely cost recovery of investments in DSIC-eligible property which could result in less frequent and smaller rate increase requests in the future. As shown in Figure 6 below, from 2013 through 2017, as part of the Company's Commission-approved LTIIP, PPL Electric continued to accelerate its expenditures for needed capital improvements and repairs over its previous investment. This strategy will continue in their future business planning models.

	2013	2014	2015	2016	2017*
Asset Optimization Strategy	$22,841,590	$19,768,844	$26,654,632	$19,062,759	$30,115,857
Improve System Reliability	$47,449,928	$30,815,571	$29,252,533	$18,408,383	$29,224,656
Smart Grid Investment	$12,088,795	$17,227,377	$26,510,401	$30,691,602	$25,883,319
Maintain System Reliability	$51,631,883	$55,689,193	$57,243,664	$63,274,879	$53,802,908
Unreimbursed Highway Relocations	$3,979,635	$4,421,113	$2,776,572	$2,662,419	$3,415,634
Grand Total	**$137,991,830**	**$127,922,099**	**$142,437,802**	**$134,100,042**	**$142,442,374**

Figure 6: DSIC Capital Investment

*2017 represented forecasted spend in accordance with the 2016 AAOP

Implementation of Long-Term Infrastructure Improvement Plan

The instant Long Term Infrastructure Improvement Plan is a continuation of the AOS infrastructure replacements, in addition to various other prudent capital investments to ensure the safety and reliability of the distribution system. The investments are expected to mitigate the growth in equipment failure projections in the short-term and eventually reverse the trend in the long-term. Equipment failure trends and asset-specific contributions to system-level reliability metrics are analyzed on an ongoing basis to ensure funding is invested appropriately.

PPL Electric routinely reviews the effectiveness of programs to ensure cost-effective investment. Program/project impact on SAIDI and SAIFI, in addition to potential reductions in outage response costs, are compared to the overall program/project costs. PPL Electric utilizes a project prioritization process that defines the cost-effectiveness of programs/projects to ensure effective optimization of reliability investments. PPL Electric currently is improving the use of ongoing asset health indices to further refine asset replacement criteria.

Ongoing review of the effectiveness of investments to address equipment failure trends will likely result in adjustments to the strategy over time. Future Long Term Infrastructure Improvement Plans will reflect such adjustments. Additionally, work plans may fluctuate throughout a given year due to the need to reallocate resources in response to changing business needs. Some examples include shifting resources for storm response activities, project construction delays caused by a backlog of material deliveries, and the redirection of investment to cure costly equipment failures. In addition, during the project engineering phase, issues such as right-of-way requirements and environmental considerations can result in scope changes that also can delay actual construction. During construction of larger projects, additional scope needs can be identified, creating the need to defer other projects. Finally, reliability metric performance can result in redirection of spending to help ensure the ability to meet targets.

Projected expenditures for the replacement of failed equipment are based on a review of historical trends while considering current failure rates and proactive mitigating measures. For such programs, it is difficult to project the specific scope and location. Therefore, PPL Electric has provided only planned expenditures based on historical trending information.

Utility Outreach

PPL Electric continues to remain engaged, seeking out opportunities with other utilities and government officials on the planning and execution of future construction projects. A forum exists with the Utility Highway Liason Committee (UHLC), with whom PennDOT, the Turnpike Commission, other utilities, and the Energy Association of Pennsylvania meet quarterly to discuss policy issues, present and future projects, and relocation projects. The Company is a regular participant. Initiatives at these forums are focused primarily on improving state and utility interactions.

Utilization of a Qualified Work Force

PPL Electric Workforce

As a measure to ensure the use of a qualified workforce, PPL Electric has adopted the definition of a Qualified Electrical Worker from the OSHA Regulation 29 CFR 1910.268 Electrical Power Generation, Transmission and Distribution, which is defined in the PPL Safety Rule Book and is provided to each employee. It is also incorporated into the training and qualification process for all electrical workers.

PPL Electric administers a rigorous, formal training and evaluation process for all qualified electrical workers. Training is required before an employee may perform work independently on exposed, energized electrical equipment greater than 50 volts. Training requirements and programs are unique to the job classification and work being performed. Curriculum documents, outlining subject areas and training durations by job classification have been developed. Training may require up to 5 years to complete and incremental qualifications, following assessment, are identified throughout the duration of the training program. Retraining is conducted on a periodic basis as required by OSHA or more frequently when determined necessary.

PPL's formal training programs are administered by the Technical Development & Improvement ("TD&I") group. The training section of the TD&I group is comprised of approximately 37 full time employees, both training professionals and craft employees. Experienced training professionals lead the design and development of the training programs with input from subject matter expertise provided by craft employees from the field. Training program (curriculum) content is approved by a curriculum committee which is comprised of business line managers. The basic job requirement for an instructor includes 5-years of experience performing the work and attainment of Journeyman level (or equivalent) qualifications. Craft instructors are then trained and mentored. Training delivery is governed by PPL Electric policies and procedures to ensure quality and consistency.

Training is delivered in phases. A phase typically consists of a grouping of training modules into one training period of several days to several weeks. Training consists of both classroom theory and field work to gain hands-on practical learning experience. Trainees are evaluated throughout the program. Evaluation includes written examination and/or a performance examination. Employees must successfully complete each training module before progressing to the next phase of training.

In addition, trainees in key programs must complete an additional skills assessment prior to advancement to the next step. These assessments are coordinated by the TD&I group. The employees are evaluated (graded) by a panel comprised of knowledgeable field supervisors and experienced bargaining unit craft members. This independent evaluation serves as a quality control check on the TD&I training section.

Over the next 5 years, PPL Electric will be executing a resource strategy which includes formal training classes to hire and train new employees in preparation for upcoming attrition.

Contractor Workforce

PPL Electric's Sourcing department administers a standard process for soliciting contractors to perform work identified to be completed by independent contractors. The process includes issuance of a Request for Proposal ("RFP") to various contractors. That process includes a meeting to review the technical and administrative components of the work and normally a walk-down of the project area. Responses to the RFP are evaluated based on detailed financial and technical schedules that compare respondents' capabilities. Part of the RFP evaluation process includes evaluating the qualification of contractors to perform work (both technical and financial capabilities to meet the contractual commitments, and level of qualification of employees), and may include reference checks if appropriate. Any specific required qualifications of contractors would typically be outlined in the RFP and/or contract (for example: pole installation, permit and tag authorities, line construction by specific voltage, live line work, foundations, directional bore/trenching, underground networks).

Most independent contractors employ personnel through the building trades, which includes Union apprenticeship programs to help ensure that employees are qualified to perform assigned work. (This approach is comparable to PPL Electric's Union labor qualification training program.) Employee qualification programs for non-Union independent contractors are stringently reviewed to assess the contractor's training program, such as on-the-job training and certification programs.

Prior to award, contractors are screened for their safety performance and, if applicable, environmental record. Contractors that do not have an acceptable record receive no further consideration. In the event that a contractor working for PPL Electric incurs safety incidents and/or does not take appropriate safety measures, the contractor is terminated and prohibited from performing work for PPL Electric in the future.

PPL Electric has instituted a contractor orientation program that provides new contractors an opportunity to understand company expectations for performing work safely, mindful of public and private landowner considerations and administrative concerns (such as billing). PPL Electric also sponsors a monthly meeting, with all contractors required to attend, to review safety issues and other relevant topics.

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PPL Electric sponsors a training program that allows the contractors' employees to become qualified in PPL Electric's permit-and-tag system. Contractor employees who successfully complete the training program can be permit holders on PPL Electric's system.

PPL Electric monitors the contractors' performance through several activities that may include direct job oversight through on-site supervision, monthly scorecards that evaluate such areas as job quality, safety performance, cost, and validating billing activities that meet contractual expectations. If safety concerns are identified at a job site, any person has the ability and express duty to cease work until the concerns have been appropriately addressed, and a safety review team could be assembled to formally request a contractor to respond to safety concern. Safety violations could result in immediate contractor termination.

Before final acceptance of the contractor's work, a project Construction Supervisor completes a "Project Quality Evaluation Form" that verifies pass or fail for applicable areas of the job (which may include inspection of grounding, trench, foundations, final grade, structural components, poles/towers, conduits, electrical equipment, primary conductor, wiring, designations, and final completion of the Acceptance of Facilities form). Any failures are described along with description and dates of corrections to resolve the areas of concern before final acceptance of the contractor's quality of work.

Summary

As a result of the economic expansion and building boom of the 1960's and 1970's, nearly half of PPL Electric's distribution system was constructed 40 or more years ago. As this equipment deteriorates due to age, environmental exposure, and added load, it becomes increasingly critical to plan for the repair, upgrade, and/or replacement of these assets through the initiatives described above. In the absence of these initiatives, the efficiency, safety, and reliability of the electric distribution system is expected to be increasingly compromised. PPL Electric believes that the expenditures for these initiatives constitute a prudent and reasonable investment for managing its distribution assets and that each of the listed programs will successfully achieve one or more of the following benefits:

- Maintaining public and employee safety
- Reducing service outage durations and number of customers affected
- Reducing service outage restoration times
- Reducing service outage locating and repair times
- Controlling service outage repair costs
- Limiting failure-related damages and related costs, and
- Improving/maintaining power quality (voltage, flicker, etc.)

To achieve these results, PPL Electric anticipates the need for the following total capital expenditures over the 2018-2022 period. Note that planned expenditures for certain initiatives can fluctuate yearly due to the various factors identified previously. The Company intends to finance the costs of its DSIC eligible work through its usual financing mechanisms, debt and equity. In each DSIC rate filing, the Company will identify its capital structure and cost of debt, in addition using the Return on Equity as determined in its base rate case proceeding or as defined in the most recent applicable PUC Quarterly Financial Report.

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LTIIP	2018	2019	2020	2021	2022	5 YR Total
Copper Weld Copper	$0.76	$1.82	$2.50	$2.54	$2.04	$9.66
Cross-Yard 12 kV Underground Tie	$1.72	$1.65	$3.03	$2.99	$2.05	$11.44
C-Truss Distribution Poles	$4.25	$4.46	$4.43	$4.48	$5.05	$22.68
Customers Experiencing Multiple Interruptions	$2.78	$3.29	$4.36	$4.35	$3.81	$18.58
Distribution Animal Guarding	$0.70	$0.77	$0.76	$0.75	$0.77	$3.76
Distribution Automation Development	$12.07	$17.65	$21.11	$18.13	$6.02	$74.98
Distribution Failed Equipment	$16.90	$16.90	$17.70	$17.69	$17.90	$87.09
Distribution Pole Replacements	$17.45	$17.82	$18.13	$18.46	$19.09	$90.95
Distribution Reliability Preservation	$6.58	$8.09	$11.12	$11.10	$11.23	$48.12
Distribution Substation Circuit Breakers	$6.90	$6.04	$5.90	$5.78	$4.65	$29.27
Distribution Substation DC Equipment	$0.19	$0.26	$0.25	$0.25	$0.27	$1.22
Fiber Wrap Distribution Poles	$2.05	$2.15	$2.14	$2.15	$2.43	$10.91
Improve System Reliability Projects	$2.14	$28.36	$30.66	$65.50	$45.12	$171.78
Line Cutouts	$1.51	$1.51	$1.51	$1.51	$1.02	$7.07
Low Tension Network Primary Cable, Equipment and Structures	$2.77	$5.69	$5.65	$5.79	$3.09	$22.99
LTN AUTOMATION	$0.00	$3.43	$3.41	$4.67	$0.00	$11.51
Miscellaneous Substation Equipment	$1.36	$1.97	$2.23	$2.23	$2.06	$9.85
New Hydraulic Reclosers	$0.02	$0.23	$0.23	$0.23	$0.25	$0.96
Protection and Control	$1.90	$2.16	$4.98	$5.05	$5.18	$19.27
Reliability Preservation Emergent	$1.80	$1.77	$2.03	$1.74	$1.74	$9.08
Replace Deteriorated/Failed Low-Tension Network Equipment and Stru	$0.86	$0.86	$1.21	$1.21	$0.81	$4.95
Replace Deteriorirated/Failed Area Supply Substation Equipment	$2.53	$2.52	$3.02	$3.02	$2.48	$13.57
Replace Failed 12kV Underground Getaway Cable	$1.32	$1.52	$1.51	$1.51	$1.53	$7.39
Replace Failed Underground Cable	$14.19	$14.19	$14.70	$14.69	$14.86	$72.62
Substation 69/12 kV Transformer Replacement	$5.87	$5.04	$4.07	$4.08	$4.39	$23.45
Substation Animal Guarding	$0.51	$0.51	$0.51	$0.51	$0.26	$2.31
Underground Cable Replacement and Life Extension	$7.89	$7.98	$8.35	$8.33	$7.40	$39.95
Underground Getaway Cable Replacements and Life Extension	$5.05	$5.30	$7.05	$7.05	$6.10	$30.55
Unreimbursed Highway Relocations	$5.21	$4.60	$4.57	$4.56	$3.85	$22.78
Volt Var Optimization	$2.72	$2.97	$8.64	$4.79	$5.25	$24.36
Grand Total	$129.99	$171.52	$195.76	$225.15	$180.70	$903.13
	In Millions					

Almost all of the aforementioned initiatives take advantage of new technologies that did not exist when the associated assets were originally placed into service, and many of these technologies are very recent innovations. These technologies are expected not only to restore the assets to their original level of performance, but, in many cases, provide performance well beyond what previously was achievable in order to ensure and maintain adequate, efficient, safe, and reliable service.

Some of the initiatives, such as animal guarding, clearly have implied end-points, where no further opportunities for improvement remain. Others, such as Distribution Automation, eventually experience diminishing returns over time. Other initiatives, such as pole reinforcement and replacement, will be ongoing. Finally, some programs may become obsolete, while new programs may become desirable as a result of the evolution of new technologies. Because of these and other variables, the effectiveness of these programs is reviewed annually and programs are added, deleted, and/or modified, as necessary, to ensure that the expenditures are providing the desired benefits to customers at a reasonable cost.

Distribution Assets

The following pages detail 5-years projections for Long-Term Infrastructure Improvements initiatives that apply to distribution line assets. These assets include, but are not limited to, the following:

- Structures
  - Poles
  - Crossarms
  - Vaults
  - Manholes
- Overhead Conductors and Hardware
- Underground Cables and Hardware
- Switching Devices
  - Air Break Switches
  - Disconnect Switches
  - Switching Cabinets
- Protective Devices
  - Fuses
  - Reclosers
  - Network Protectors
  - Lightning Arresters
- Transformers
  - Overhead
  - Pad-Mounted
  - Submersible
  - Low Tension Network

PPL Electric Utilities Corporation

Distribution Pole Replacements

Program Description and Purpose

Replacement of distribution wood poles identified as non-restorable (cannot be reinforced) during the annual inspect and treat program or during a spot inspection in an effort to improve public and employee safety, as well as service reliability. This program contributes to storm hardening efforts and aims to improve public and employee safety, as well as service reliability, by reducing potential pole failures.

Identification/Justification Process

PPL Electric inspects approximately 90,000 poles per year. Historical data suggests an approximate 5% rejection rate from the population of yearly inspections; of those rejected, 70% are candidates for reinforcement while 25% are candidates for replacement. Replacing rejected poles avoids property damage and risk of accidental injury, and it mitigates the costs associated with extended service outages. Replacement rates are expected to fall as a result of PPL Electric's pole treatment program. The average age of an in-service wooden distribution pole is 38 years.

Scope

The scope of the program is a direct correlation to the number of wood pole inspections.

Planned Replacements in Units					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
2900-3200	2900-3200	2900-3200	2900-3200	2900-3200	14500-16000

Locations

Specific locations are a direct correlation to the wood pole inspection plan. Inspection locations are identified yearly primarily as a function of previous inspection dates, as well as ensuring cost-effectiveness of the program and minimizing inspection crew movements.

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$17.45	$17.82	$18.13	$18.46	$19.09	$90.95

PPL Electric Utilities Corporation

C-Truss Distribution Poles

Program Description and Purpose

Steel reinforcement (C-Trussing) of deteriorated distribution wood poles in order to restore the pole's original strength, ensure public safety, and maintain reliable electric service through the reduction of potential pole failures. This program contributes to storm hardening efforts by reducing potential pole failures.

Identification/Justification Process

PPL Electric inspects approximately 90,000 poles per year. Historical data suggests an approximate 10% rejection rate from the population of yearly inspections, of which historically 75% are candidates for steel reinforcement. When applicable, this method achieves a significant savings over pole replacement.

Scope

Planned Reinforcements in Units					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
5260-5815	5260-5815	5260-5815	5260-5815	5260-5815	26300-29075

Locations

Locations identified for C-trussing are a direct correlation to the number of wood pole inspections.

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$4.25	$4.46	$4.43	$4.48	$5.05	$22.68

PPL Electric Utilities Corporation

Fiber Wrap Distribution Poles

Program Description and Purpose

Fiber reinforcement of deteriorated distribution wood poles to improve the pole's strength, ensure public safety and maintain reliable electric service through the reduction of potential pole failures. Fiber wrapped poles are restored to 85% original strength. Fiber wrap is a reinforcement method by which a standing pole in Pennsylvania Department of Transportation (PennDOT) right of way is wrapped and cured in fiber reinforcement materials. This program contributes to storm hardening efforts and aims to improve public and employee safety, as well as service reliability, by reducing potential pole failures.

Identification/Justification Process

Fiber wrap candidates are selected from a pool of restorable poles in PennDOT's right-of-way on the basis of the condition of pole, the age of pole and the cost of replacement. Historically, reinforcement of poles within PennDOT right-of-way was not practiced and all poles that did not pass inspection were replaced. In an effort to increase cost-effectiveness, PPL Electric began fiber wrap reinforcement during 2012 and reduced the number of pole replacements from 30% of rejected poles to 25%. Shifting capital from replacement to fiber wrap allows capital to be invested in more effective areas.

Scope

Planned Fiber Wrap in Units					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
585-645	585-645	585-645	585-645	585-645	2925-3225

Locations

Locations identified for fiber wrap are a direct correlation to the wood pole inspection plan.

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$2.05	$2.15	$2.14	$2.15	$2.43	$10.91

PPL Electric Utilities Corporation

Line Cutouts

Program Description and Purpose

Replacement of porcelain cutouts on the 12kV system to avoice tracking along freeze/thaw cycle cracks, which can eventually lead to pole top fires.

Identification/Justification Process

Porcelain cutouts are identified via regularly scheduled line patrols (EOR, WPC, pole inspections). Locations are then prioritized via system exposure and historical locational propensity to pole top fire events.

Scope

Planned Cutouts in Units					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
400-500	400-500	400-500	400-500	400-500	2000-2500

Locations (Approximate total over 5 year plan)

Region	Units
Lehigh	375-460
Northeast	375-460
Central	375-460
Susquehanna	375-460
Harrisburg	375-460
Lancaster	375-460

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$1.51	$1.51	$1.51	$1.51	$1.02	$7.07

PPL Electric Utilities Corporation

Volt Var Optimization

Program Description and Purpose

Installation of capacitors on the 12 kV system to achieve a near unity power factor on the high side of the distribution substation transformers ensuring required overall power quality.

Identification/Justification Process

Capacitors are installed on the 12 kV system using VAR requirements that are identified annually by PPL Electric's distribution planning resources. PJM requires a minimum power factor of 0.97 as measured at the transmission/distribution interface point. Scope is determined by voltage and MVAR requirements to support any system shortages. Regional splits are analyzed annually based on need.

Scope

Planned Installations in Units					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
300-350	325-375	1000-1050	250-300	250-300	2125-2375

Locations (Approximate total over 5 year plan)

Region	Units
Lehigh	400-440
Northeast	220-260
Central	280-320
Susquehanna	250-290
Harrisburg	420-460
Lancaster	520-560

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$2.72	$2.97	$8.64	$4.79	$5.25	$24.36

PPL Electric Utilities Corporation

New Hydraulic Reclosers

Program Description and Purpose

Proactive installation of new hydraulic reclosers to improve reliability performance by increasing circuit sectionalizing ability. Reclosers minimize the number of customers affected by a sustained outage.

Identification/Justification Process

Locations are requested by regional reliability engineers and prioritized annually based on anticipated SAIDI savings. A gradual scope reduction is assumed in the outer years as a result of saturation of reclosers and other distribution automation equipment.

Scope

Planned Installations in Units					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
3-5	15-20	15-20	15-20	15-20	63-85

Locations (Approximate total over 5 year plan)

Region	Units
Lehigh	10-15
Northeast	10-15
Central	10-15
Susquehanna	10-15
Harrisburg	10-15
Lancaster	10-15

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$0.02	$0.23	$0.23	$0.23	$0.25	$0.96

PPL Electric Utilities Corporation

Distribution Animal Guarding

Program Description and Purpose

Proactive installation of animal guards on existing distribution overhead transformers and air break switches to improve circuit reliability. Animal guards help prevent animal-related contacts which cause service interruptions.

Identification/Justification Process

Air break switches have animal guarding installed as part of their inspection process. Transformers are identified both by opportunistic installation of guarding during other non-related work, and by on-the-spot or follow-up orders after responding to animal-caused outages.

Scope

Planned Animal Guards					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
300-400	300-400	300-400	300-400	300-400	1500-2000

Locations (Approximate total over 5 year plan)

Region	**Units**
Lehigh	250-350
Northeast	250-350
Central	250-350
Susquehanna	250-350
Harrisburg	250-350
Lancaster	250-350

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$0.70	$0.77	$0.76	$0.75	$0.77	$3.76

PPL Electric Utilities Corporation

Distribution Failed Equipment

Program Description and Purpose

Replacement or repair of failed or deteriorated capital units of distribution equipment, excluding underground cable, in order to maintain adequate service reliability.

Identification/Justification Process

Candidates are identified via inspections, both planned and ad-hoc, as well as actual outages and power service problems. Budget allocations are based on historical trends of hours charged to corrective work, in addition to projected trends of future equipment failures. Examples include, but are not limited to, failed reclosers, poles, capacitor banks, and air breaks.

Scope & Locations

Scope and locations are determined as equipment fails.

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$16.90	$16.90	$17.70	$17.69	$17.90	$87.09

PPL Electric Utilities Corporation

Replace Failed Underground Cable

Program Description and Purpose

Replacement of failed underground residential primary cables in order to maintain adequate service reliability.

Identification/Justification Process

Candidates are identified via actual failures. Budget recommendations are based on historical trends of hours charged to corrective work, in addition to projected trends of future equipment failures.

Scope & Locations

Scope and locations are determined as cable fails.

Planned Expenditures(in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$14.19	$14.19	$14.70	$14.69	$14.86	$72.62

PPL Electric Utilities Corporation

Replace Failed 12 kV Underground Getaway Cables

Program Description and Purpose

Replacement of failed 12 kV underground getaway cables in order to maintain adequate service reliability. Getaway failures can result in long duration outages. Getaway cables connect substations to outgoing feeders beyond the substation perimeter.

Identification/Justification Process

Candidates are identified via actual failures and cables with severely poor testing results. Budget recommendations are based on historical trends of hours charged to corrective work, in addition to projected trends of future equipment failures.

Scope & Locations

Scope and locations are determined as cable fails or fails testing.

Planned Expenditures(in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$1.32	$1.52	$1.51	$1.51	$1.53	$7.39

PPL Electric Utilities Corporation

Replace Deteriorated/Failed Low Tension Network Equipment and Structures

Program Description and Purpose

Replacement or repair of deteriorated and failed equipment related to low-tension networks, including submersible transformers, network protectors, manholes, and vault tops in order to maintain adequate service reliability. Low-tension networks are low voltage underground distribution facilities found in urban areas.

Identification/Justification Process

Candidates are identified via actual failures, inspections, testing, or work on the system. Budget recommendations are based on historical trends of hours charged to corrective work, in addition to projected trends of future equipment failures.

Scope & Locations

Scope and locations are determined as cable fails.

Planned Expenditures(in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$0.86	$0.86	$1.21	$1.21	$0.81	$4.95

PPL Electric Utilities Corporation

Underground Cable Replacement and Life Extension

Program Description and Purpose

Programmatic replacement and/or treatment of deteriorated underground cable to maintain reliable electric service. Specifically for underground residential developments ("URD"), PPL Electric's course of action is to treat the entire URD, where possible.

Identification/Justification Process

Candidates are selected based on history of cable failures. Once the initial failure is treated, remaining cable sections of the same vintage in the area are tested. Test results drive the decision to either replace the cable or treat it with a compound to restore cable insulation, known as cable curing. The profile of URD cable varies across URDs, thus making it difficult to predict whether cable curing or replacement will be the prevalent course of action in a given URD. On a system-wide basis, however, historical experience indicates that of the total number of cables in troubled URD locations, typically 35% can be cured, 25% require replacement, and 40% do not require immediate remediation.

Regional allocation of cable remediation is based on historical regional percent contribution to system-wide cable failures.

Scope

	Planned Scope In Cable Segments					
Treatment	**2018**	**2019**	**2020**	**2021**	**2022**	**Total Scope**
Replacement After Test	220-280	220-280	220-280	220-280	220-280	1100-1400
Cure	600-680	800-900	800-900	800-900	850-950	3850-4330
Proactive Replacement	150-175	150-175	150-175	150-175	150-175	750-875

Locations (Approximate total over 5 year plan)

Region	**Units**
Lehigh	1211-1339
Northeast	797-881
Central	524-580
Susquehanna	553-611
Harrisburg	1383-1529
Lancaster	1302-1440

PPL Electric Utilities Corporation

Planned Expenditures (in millions)

Planned Expenditures					
2018	2019	2020	2021	2022	Total
$7.89	$7.98	$8.35	$8.33	$7.40	$39.95

PPL Electric Utilities Corporation

Low Tension Network Primary Cable, Equipment and Structures

Program Description and Purpose

Programmatic replacement of deteriorated equipment related to low-tension networks, including: paper insulated lead cable (PILC), submersible transformers, network protectors, manholes, and vault tops. The purpose of this program is to ensure public safety and service reliability through the replacement of underground facilities that have reached the end of their expected life or show signs of premature age from prolonged exposure to corrosive environments.

Identification/Justification Process

Vintage PILC cable has a documented history of problems and was deemed prudent to replace entirely. Replacement and repair of manhole and vault tops is determined by regular inspection. Transformer and network protector replacements are determined through inspection and age, where assets exceeding 40 years in service are considered highest priority.

Scope

	Planned Replacements in Units (in Work Orders)					
	2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
Lead Cable	0-5	1-5	1-5	1-5	1-5	4-25
LTN Equipment	15-30	15-30	15-30	15-30	15-30	75-150

Locations (Approximate total over 5 year plan)

Region	LTN Equipment	Cable
Lehigh	25-65	0-7
Northeast	25-65	0-7
Central	25-65	0-7
Susquehanna	25-65	0-7
Harrisburg	25-65	0-7
Lancaster	25-65	0-7

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$2.77	$5.69	$5.65	$5.79	$3.09	$22.99

PPL Electric Utilities Corporation

LTN Automation

Program Description and Purpose

The purpose of the program is to install remote monitoring and control equipment in all Low Tension Network (LTN) vaults. This will allow for safer operation of LTNs, a reduction in maintenance costs, a reduction in failed equipment requiring replacement, and better data for asset planning and investment.

Identification/Justification Process

Rollout of this program began in the Leigh and Harrisburg regions. By the completion of this program, all LTN vaults will receive automation.

Scope

Planned Replacements in Units					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
0-1	1-2	1-2	2-3	0-1	4-9

Locations (Approximate total over 5 year plan)

Region	Units
Lehigh	0
Northeast	1
Central	1
Susquehanna	1
Harrisburg	0
Lancaster	1

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$0.00	$3.43	$3.41	$4.67	$0.00	$11.51

PPL Electric Utilities Corporation

Underground Getaway Cable Replacements and Life Extension

Program Description and Purpose

Programmatic replacement of aging 12 kV underground getaway cables, with an emphasis on conversion to overhead design, to prevent service outages and reduce outage durations for improved reliability.

Identification/Justification Process

Getaways are selected on a basis of failure history, cable test results, and age. Cables that are older than 40 years and serve a large number of customers, are given highest priority. The average age for UG cables identified for replacement is 38 years. PPL Electric also plans to incorporate treatment methods for getaways that are currently implemented for URD cables on the distribution system.

Scope

Planned Replacements in Units					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
30-35	30-35	40-50	40-50	35-45	175-215

Locations (Approximate total over 5 year plan)

Region	Units
Lehigh	39-44
Northeast	23-26
Central	28-31
Susquehanna	22-25
Harrisburg	46-52
Lancaster	33-37

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$5.05	$5.30	$7.05	$7.05	$6.10	$30.55

PPL Electric Utilities Corporation

Copper Weld Copper Replacement

Program Description and Purpose

Programmatic replacement of overhead #6 Copper, and #6, #6A and #7A Copper Weld overhead conductor to improve reliability of service by reducing potential for long-duration conductor failures. Such vintages of conductor are known to anneal and are often found in heavily wooded areas of the service territory where relocation, along with reconductoring, help to ensure future outages can be restored more quickly. PPL Electric currently is evaluating expanding this program to include other types of vintage cables/conductors.

Identification/Justification Process

Circuits are prioritized by an algorithm that weighs the amount of copper on the line and historic customer service interruptions.

Scope

Planned Projects					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
2-4	3-5	3-5	3-5	3-5	14-24

Locations (Approximate total over 5 year plan)

Region	**Projects**
Lehigh	2-3
Northeast	2-3
Central	2-4
Susquehanna	2-4
Harrisburg	2-4
Lancaster	2-4

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$0.76	$1.82	$2.50	$2.54	$2.04	$9.66

PPL Electric Utilities Corporation

Customers Experiencing Multiple Interruptions

Program Description and Purpose

Improve reliability for customers experiencing multiple interruptions (“CEMI”) and customers experiencing multiple momentary interruptions (“CEMMI”) via upgrades to their circuits. The purpose of the program is to prevent future outages from occurring and to increase communication with customers who experience five or more service outages within a one year period, or two or more momentary interruptions per month on average for a year.

Identification/Justification Process

Projects are identified by regional distribution planners and regional reliability supervisors once a circuit has customers who exceed a threshold of five or more service interruptions within a calendar year, or are downstream of devices that momentarily interrupt customers more than set thresholds for various time frames. Projects are vetted at cross-functional task force meetings (both for CEMI and CEMMI) for approval and ranked systematically based on historical CEMI performance, year-to-date CEMI performance, cost per customer benefit, and expected reliability improvements. CEMMI projects are ranked based on cost and number of customers affected, along with severity of issue. Examples include, but are not limited to, reconductoring lines, replacing and/or relocating protective equipment with new equipment, and building new tie lines to improve switching capabilities. It should be noted that sizes of projects vary significantly which can result in material swings in the number of planned projects.

Scope

Planned Projects						
Program	**2018**	**2019**	**2020**	**2021**	**2022**	**Total Scope**
CEMI	10-30	20-40	20-40	20-40	20-40	90-190
CEMMI	125-140	125-140	125-140	125-140	125-140	625-700

Locations

Locations are identified based upon emergent reliability needs.

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$2.78	$3.29	$4.36	$4.35	$3.81	$18.58

PPL Electric Utilities Corporation

Distribution Reliability Preservation

Program Description and Purpose

Upgrades to the distribution system as justified by regional reliability supervisors to improve reliability. Improvements are targeted towards WPCs, circuits with a history of customer complaints, or recommendations as a result of EORs. EORs are detailed reliability and operational analysis performed on 25% of a region's distribution circuits per year.

These projects are outside the scope of the Worst Performing Circuit program because they are smaller in nature and can be more quickly engineered and constructed.

Identification/Justification Process

Regional reliability supervisors identify and submit requests for small-scale circuit improvement projects. Projects under $50,000 are directly identified by the regions, approximately 60% of the budget is allotted towards these small improvements. Projects over $50,000 are ranked utilizing PPL Electric's investment prioritization tool to ensure funds are directed towards the most cost-effective projects. The number of projects and locations may vary depending on areas with reliability concerns. Examples include, but are not limited to, installation of fuses, fault indicators, reconductoring of vintage conductor, upgrading conductor to reduce impact of vegetation related service outages, and relocating sections of lines that may be inaccessible or prone to vegetation related service outages.

It should be noted projects vary significantly in size, which can result in material swings in the number of planned projects.

Scope

Planned Projects					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
15-35	20-40	35-55	35-55	35-55	140-240

Locations

Locations are identified based upon emergent reliability needs.

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$6.58	$8.09	$11.12	$11.10	$11.23	$48.12

PPL Electric Utilities Corporation

Reliability Preservation Emergent

Program Description and Purpose

Remediation of issues primarily associated with secondary voltage and emergent small-scale customer reliability needs in order to improve reliability.

Identification/Justification Process

Work is identified by line crews, as well as through customer calls, and is completed to avoid potential service outages, power quality concerns and safety issues. Examples include, but are not limited to, modifying capacitance to address voltage concerns, installing fusing to aid in sectionalizing, installing animal guards after multiple animal caused outages, and replacing transformers to resolve transformer overload. Budget recommendations are based on historical trends of hours charged.

Scope & Locations

Scope and locations are determined as emergent needs arise.

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$1.80	$1.77	$2.03	$1.74	$1.74	$9.08

PPL Electric Utilities Corporation

Distribution Automation Deployment

Program Description and Purpose

Upgrade existing air breaks, vacuum circuit reclosers ("VCRs"), and SCADA ("Supervisory Control and Data Acquisition") at distribution substations, and identify new locations to install automated air breaks and VCRs to improve circuit reliability. This will allow for automatic sectionalizing and restoration of customers during service outage conditions. This plan meets the recommendation the Commission issued on August 7, 2012 regarding outage mitigation techniques during storm events.

Recloser Replacements:

Prior to 2014, PPL Electric inspected and refurbished all reclosers (single and three-phase) on an eight-year cycle, pursuant to PUC Inspection and Maintenance Standard 52. Pa. Code § 57.198 (n)(7). In 2015, to improve reliability and move the company toward condition based maintenance, PPL Electric Utilities began replacing all three-phase reclosers with electronic vacuum devices on a ten year cycle. This plan was approved by the PUC in January 2014, and was filed as part of PPL Electric's 2016-2017 Inspection and Maintenance Plan filing.

Identification/Justification Process

Areas selected for deployment:

- Have concentrations of distribution feeders that have been identified as WPCs.
- Have the operational flexibility to allow transfers and restoration of customers when service outages occur.
- Have significantly contributed to system SAIDI and SAIFI.

Customer Benefits:

- 500,000 customers (36%) will be covered under the distribution automation deployment.
- Significant reductions in system SAIDI and SAIFI.
- Reduction of the number of customers experiencing long duration service interruptions. Distribution automation will sectionalize the service interruption to the smallest possible area in under five minutes.
- Major Event improvements:
    - Fewer resources needed for switching (trouble crews can focus on cutting loops and performing repairs).
    - Reduction in call volume due to automatic restoration of customers.

Approximately 16-28 distribution substations will be upgraded per year and approximately 223-532 distribution devices will be upgraded per year.

PPL Electric Utilities Corporation

Scope

	Planned Distribution Device Upgrades					
Voltage	**2018**	**2019**	**2020**	**2021**	**2022**	**Total Scope**
12 kV	300-350	300-350	300-350	300-350	150-200	1350-1600

Distribution devices include reclosers, air breaks, and communication infrastructure.

Locations (Approximate total over 5 year plan)

Region	Distribution Devices
Lehigh	225-275
Northeast	225-275
Central	225-275
Susquehanna	225-275
Harrisburg	225-275
Lancaster	225-275

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$12.07	$17.65	$21.11	$18.13	$6.02	$74.98

PPL Electric Utilities Corporation

System Reliability Improvement Projects ISR Projects

Program Description and Purpose

Large-scale improvements to distribution circuits with a history of poor reliability. This program addresses long-term projects, primarily aimed at WPCs. However, other proactive long-term projects with proven reliability benefit are included.

Identification/Justification Process

Each quarter, distribution planners and regional reliability supervisors meet to propose projects to improve WPCs. Projects are approved by distribution planning supervisors and vetted against other projects for scheduling based on historical reliability, potential benefit, and cost. Projects may span multiple years and are listed in the years they are planned to go in service. Scope is expected to increase in outer years as circuits and projects are identified. Examples include, but are not limited to, circuit reconfigurations with new tie lines, new lines and terminals, or the installation of substations for increased reliability.

Additionally, PPL Electric monitors large customer impact outages on a daily basis. A circuit that begins to show reliability deterioration and notable impact on reliability metrics requires a root cause analysis. Such analysis can result in the identification of a long-term project.

Note that the projects vary significantly in size, which can result in material swings in the number of planned projects.

Scope

Planned Projects					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
2-4	5-10	5-10	30-50	10-20	52-94

Locations (Approximate total over 5 year plan)

Region	Projects
Lehigh	8-20
Northeast	8-20
Central	8-20
Susquehanna	8-20
Harrisburg	8-20
Lancaster	8-20

PPL Electric Utilities Corporation

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$2.14	$28.36	$30.66	$65.50	$45.12	$171.78

PPL Electric Utilities Corporation

Unreimbursed Highway Relocations

Program Description and Purpose

Unreimbursed customer requested relocations of PPL Electric distribution facilities in support of highway and bridge projects throughout service territory.

Identification/Justification Process

The customers (project sponsors) include PennDOT, the PA Turnpike Commission, and various counties and municipalities. PPL Electric and the project sponsor execute a reimbursement agreement, and PPL Electric is reimbursed for its work based on the "pole count method", as defined in PennDOT's DM-5 manual. Historically, reimbursement for distribution projects is approximately 35%.

To accommodate highway relocations and other municipal projects, approximately 70-120 projects per year are placed in service. PPL Electric typically is notified of distribution relocation work 12 months or less before the start of requested utility relocation activities.

Scope & Locations

Scope and locations are determined as requests are received.

Planned Expenditures (in millions)

PPL Electric's expenditures to complete highway relocation projects are the net of total expenditures minus the project sponsor's reimbursements.

Planned Expenditures "Net Spend"					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$5.21	$4.60	$4.57	$4.56	$3.85	$22.78

PPL Electric Utilities Corporation

Substation Assets

The following pages detail 5-year projections for Long-Term Infrastructure Improvements initiatives that apply to distribution substation assets. These assets includes, but are not limited to, the following:

- Structures
    - Enclosures
    - Fences
- Overhead Conductors and Hardware
- Underground Cables and Hardware
- Switching Devices
    - Air Break Switches
    - Disconnect Switches
- Protective Devices
    - Circuit Breakers
    - Fuses
    - Reclosers
    - Lightning Arresters
- Transformers
    - Power
    - Station Service
    - Instrument

PPL Electric Utilities Corporation

Distribution Substation Circuit Breakers

Program Description and Purpose

Programmatic replacement of substation circuit breakers ("CBs") based on age and other factors to ensure reliable service. This program includes the replacement of 12 kV circuit breakers, as well as 69 kV circuit breakers that are classified as distribution facilities and equipment.

Identification/Justification Process

Candidates for replacement are identified based on age, operating issues, availability of spare/repair parts, and the availability of vendor technical support. Once identified, replacement of these facilities are coordinated and aligned with the replacement of other assets at the same substation within the five-year planning window.

The average age of the 12 kV circuit breakers that have been identified for replacement through 2017 is 48 years; the life expectancy is 50 years.

The specific type of 12 kV circuit breakers that have been targeted in this replacement program are the GE type FKD and FK oil CBs, Allis Chalmers type OZ and FZO oil CBs, Federal Pacific type AF and JCE oil CBs, McGraw Edison type VAC vacuum CBs, IT type VBK vacuum CBs, and GE type VIB vacuum CBs.

The average age of the 69 kV circuit breakers that have been identified for replacement through 2017 is 47 years; the life expectancy is 50 years.

The specific type of 69 kV circuit breakers that have been targeted for replacement in this program are the Allis Chalmers type FZO oil CBs and the GE type FK oil CBs.

Scope

	Planned Projects					
Voltage	**2018**	**2019**	**2020**	**2021**	**2022**	**Total Scope**
12 kV	30-35	26-31	26-31	26-31	26-31	134-159
69 kV	0-2	0-2	0-2	0-2	0-2	0-10

Locations (Approximate total over 5 year plan)

Region	Projects
Lehigh	25-30
Northeast	16-19
Central	18-22
Susquehanna	18-22
Harrisburg	29-35
Lancaster	26-31

PPL Electric Utilities Corporation

Planned Expenditures (in millions)

Planned Expenditures					
2018	2019	2020	2021	2022	Total
$6.90	$6.04	$5.90	$5.78	$4.65	$29.27

PPL Electric Utilities Corporation

Substation 69/12 kV Transformer Replacement

Program Description and Purpose

Programmatic replacement of distribution substation transformers to maintain reliable service.

Identification/Justification Process

Candidates for replacement are identified based on age and/or maintenance condition, both indicators of potential failure. Once identified, replacement of these facilities is coordinated and aligned with the replacement of other assets at the same substation within the five-year planning window. Replace approximately 5 per year, averaged over a five-year period.

The average age of assets identified for replacement is 52 years; 13 of these are beyond their expected life. These assets are of vintages between 1947 and 1973, manufactured by Westinghouse, U S Transformer, RTE-Asea, Moloney, Hevi-Duty, General Electric and Allis Chalmers.

Scope

Planned Projects					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
3-5	3-5	3-5	3-5	3-5	15-25

Locations (Approximate total over 5 year plan)

Region	Projects
Lehigh	1-2
Northeast	1-3
Central	4-7
Susquehanna	4-7
Harrisburg	1-3
Lancaster	1-3

Planned Expenditures (in millions)

Planned expenditures fluctuate due to timing of long lead material purchases.

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$5.87	$5.04	$4.07	$4.08	$4.39	$23.45

PPL Electric Utilities Corporation

Protection and Control

Program Description and Purpose

Programmatic replacement of protection and control equipment to maintain reliable distribution service to customers. Replacement of relays with modern microprocessor relays will enhance the ability for self-diagnostics, as well as continuous monitoring of the health of the device. Replacement of obsolete SCADA protocols and equipment will enable relays to perform properly.

Identification/Justification Process

Candidates for replacement are identified based on obsolescence, availability of vendor support, and age. Once identified, replacement of these facilities is coordinated and aligned with the replacement of other assets at the same substation within the five-year planning window. The specific type of relays that have been targeted for early replacement in this program are the Agastat 2400 Series, Westinghouse COI, General Electric IAC, General Electric CFF, General Electric NLR, ABB DPU 245/445, and Westinghouse COM.

Scope

Planned Projects					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
72-80	94-100	194-199	196-201	195-200	751-780

Locations (Approximate total over 5 year plan)

Region	Projects
Lehigh	170-177
Northeast	181-188
Central	137-143
Susquehanna	102-106
Harrisburg	72-75
Lancaster	155-162

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$1.90	$2.16	$4.98	$5.05	$5.18	$19.27

PPL Electric Utilities Corporation

Cross-Yard 12 kV Underground Ties

Program Description and Purpose

Programmatic replacement of underground substation cables to maintain reliable service.

Identification/Justification Process

Candidates for replacement are identified based on age and/or maintenance condition, both indicators of potential failure. Assets with an age significantly greater than 29 years are deemed good candidates for replacements. In addition, assets with unfavorable test results, which indicate the likelihood of failure, are prioritized for replacement. Currently, there is an average of 23 replaced per year over a five-year period. The average age of assets identified for replacement is 40 years. These assets were installed between 1960 and 1989; 124 of these assets are over 40 years old.

Scope

Planned Projects					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
20-25	20-25	40-45	40-45	25-30	145-170

Locations (Approximate total over 5 year plan)

Region	Projects
Lehigh	12-15
Northeast	41-48
Central	23-27
Susquehanna	12-14
Harrisburg	19-22
Lancaster	37-44

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$1.72	$1.65	$3.03	$2.99	$2.05	$11.44

PPL Electric Utilities Corporation

Replace Deteriorated/Failed Area Supply Substation Equipment

Program Description and Purpose

Replacement of failed or deteriorated equipment at area supply substations with in-kind equipment to maintain safe and reliable service.

Identification/Justification Process

Candidates are identified via actual failures, inspections, testing or work on the system. Budget recommendations are based on historical trends of hours charged to corrective work, in addition to projected trends of future equipment failures.

Scope & Locations

Scope and locations are determined as equipment fails.

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$2.53	$2.52	$3.02	$3.02	$2.48	$13.57

PPL Electric Utilities Corporation

Repair Failed 138/69/12 kV Transformers

Program Description and Purpose

Repair of failed distribution substation power transformers to "like new" condition to maintain safe and reliable service in a more cost-effective manner than the purchase of new units. Program only includes costs associated with the overhaul of the failed unit.

Identification/Justification Process

Budget projections include a failure rate of three transformers per year based upon a ten-year rolling average. Individual units are selected based upon the cost-effectiveness of rebuilding the unit when compared to scrapping.

Scope & Locations

Scope and locations are determined as equipment fails.

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
0	**0**	**0**	**0**	**0**	**0**

PPL Electric Utilities Corporation

Distribution Substation DC Equipment

Program Description and Purpose

Programmatic replacement of distribution substation DC equipment to maintain reliable service. This program includes the replacement of 24V, and 48V batteries, as well as battery chargers.

Identification/Justification Process

Candidates for replacement are identified based on age, operating issues, and availability of spare parts. Once identified, replacement of these facilities are coordinated and aligned with the replacement of other assets at the same substation within the five-year planning window. Currently, there is an average of 25 pieces of DC equipment scheduled to be replaced per year over the next five-year period. The average age of the DC equipment scheduled to be replaced through 2017 is 31 years; life expectancy of this type of equipment is 20 years. Of the devices being replaced, 80 devices will be beyond their expected life by the time of replacement.

Scope

Planned Projects					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
15-22	15-22	15-22	15-22	15-22	75-110

Locations (Approximate total over 5 year plan)

Region	Projects
Lehigh	19-23
Northeast	42-50
Central	13-16
Susquehanna	2-3
Harrisburg	18-22
Lancaster	9-11

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$0.19	$0.26	$0.25	$0.25	$0.27	$1.22

PPL Electric Utilities Corporation

Miscellaneous Substation Equipment

Program Description and Purpose

Programmatic replacement of older substation equipment, including air breaks, potential transformers (“PTs”), capacitance-coupled voltage transformers (“CCVTs”), circuit switchers, lightning arresters, voltage regulators, and DC panels in order to prevent future maintenance concerns and to maintain reliable service.

Identification/Justification Process

Candidates for replacement are identified based on age and/or maintenance condition, both indicators of potential failure. Once identified, replacement of these facilities is coordinated and aligned with the replacement of other assets at the same substation within the five-year planning window. Currently, there is an average of 44 pieces of equipment scheduled to be replaced per year over the next five-year period. The average age of assets identified for replacement is 47 years. These assets are of vintages between 1947 and 2000. Approximately 194 of these assets are projected to have exceeded their expected life by the time they are replaced.

Scope

Planned Projects					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
22-26	46-50	46-50	46-50	38-42	198-218

Locations (Approximate total over 5 year plan)

Region	Projects
Lehigh	39-44
Northeast	23-26
Central	44-49
Susquehanna	13-15
Harrisburg	2-3
Lancaster	73-81

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$1.36	$1.97	$2.23	$2.23	$2.06	$9.85

PPL Electric Utilities Corporation

Substation Animal Guarding

Program Description and Purpose

Improvements to existing distribution substation equipment via the proactive installation of animal guards. Guarded equipment includes transformer bushings, circuit breakers, fuse/disconnect switches, bus supporting insulators, surge arresters, station service transformers, PTs, and cable terminators.

Identification/Justification Process

Distribution substations are regionally prioritized based on historical animal-related service outages, number of customers served, substation load, and substation type. High priority substations are animal guarded first with the lower priority substations guarded in outer years.

Scope

Planned Installations in Units					
2018	**2019**	**2020**	**2021**	**2022**	**Total Scope**
1-3	**0-2**	**0-2**	**0-2**	**0-2**	**1-11**

Locations (Approximate total over 5 year plan)

Region	Units
Lehigh	0-2
Northeast	1-2
Central	1-2
Susquehanna	0-1
Harrisburg	0-2
Lancaster	1-4

Planned Expenditures (in millions)

Planned Expenditures					
2018	**2019**	**2020**	**2021**	**2022**	**Total**
$0.51	$0.51	$0.51	$0.51	$0.26	$2.31

Appendix A : Average Age of Major Units of Property

The below chart is a summary of key distribution assets, targeted for planned replacement and proactive installation.

Average Age of Major Units of Distribution Property		
Utility Account	**Description**	**Avg Asset Age***
362.0 - Station Equipment	DC System Equipment	15
362.0 - Station Equipment	Substation Animal Guards	8
362.0 - Station Equipment	Power Circuit Breakers	31
362.0 - Station Equipment	Power Transformers	38
362.0 - Station Equipment	Protection and Control Equipment	47
364.4 - Poles and Fixtures	Distribution Wood Poles	40
365.0 - Overhead Conductors, Device	Distribution Animal Guards	4
365.0 - Overhead Conductors, Device	OH Primary Conductor	46
365.0 - Overhead Conductors, Device	Air Break Switches	11
365.0 - Overhead Conductors, Device	Automatic Switches (Primarily OCRs/VCRs)	11
365.0 - Overhead Conductors, Device	Disconnect Switches	47
366.0 - Underground Conduit	UG Primary Conductor (includes Getaways and Cross Yard Ties)	34
366.0 - Underground Conduit	Equipment Foundation, Man Holes, Transformer Vaults	23
368.4 - Submersible or Padmt Type	UG Transformers (includes LTN Transformers & Network Protectors)	23
* Note that the average age of several classifications is skewed by recent increased installations. For example, automatic switches and animal		

PPL Electric Utilities Corporation

Appendix B : Asset Contribution To Reliability Metrics

The below table provides a summary of customers interrupted and Customer Minutes Interrupted ("CMI") by failed component. Note that both transmission and distribution substation outages are included in the Substation component asset type.

Outage Contribution By Component - Equipment Failure Cause - Non Major Events

		2012		2013		2014		2015		2016	
Component Asset Type	Component Desc	# Customers (Permanent)	CMI (Permanent)	# Customers (Permanent)	CMI (Permanent)	# Customers (Permanent)	CMI (Permanent)	# Customers (Permanent)	CMI (Permanent)	# Customers (Permanent)	CMI (Permanent)
Distribution	OH-Capacitor Bank	2,189	119,903	1,344	146,513	4,976	458,401	1,735	93,922	1,600	83,912
	OH-Lightning Arrester	7,287	1,346,042	2,184	337,493	5,941	912,371	6,498	684,672	5,139	612,653
	OH-Other Equipment(explain)	5,824	902,017	8,903	642,349	7,977	823,273	8,110	762,681	2,547	329,044
	OH-Pole/Arms Attachments	40,294	5,037,861	44,010	3,878,192	52,799	7,071,597	51,027	5,579,971	45,151	6,004,224
	OH-PRI Splices and Connectors	9,990	1,465,477	1,811	182,455	11,616	1,711,251	8,275	1,316,038	10,072	835,901
	OH-Primary/Neutral	155,182	20,735,933	110,920	11,403,222	135,265	18,154,581	56,987	6,954,675	86,286	10,705,378
	OH-SEC Splices and Connectors	1,136	78,534	1,442	65,573	2,779	275,914	1,214	87,138	1,304	95,760
	OH-Secondaries/Services	2,577	267,659	3,701	308,702	4,014	486,552	2,361	243,079	2,771	270,239
	OH-Switch/Automatic	17,114	1,662,503	13,755	1,541,246	22,601	1,977,567	21,615	2,144,995	23,817	2,407,415
	OH-Switch/Manual/AB/Disc/OS/LBD	10,452	1,489,230	13,835	1,072,340	10,504	1,054,227	15,794	1,260,374	9,751	1,024,191
	OH-Tap Fuse/Cutout	9,604	1,470,105	8,188	1,154,087	12,919	1,693,432	9,242	1,143,457	11,491	1,048,759
	OH-Transformer	13,078	1,756,699	12,787	1,718,849	11,332	1,725,239	10,490	1,553,114	8,980	1,303,702
	OH-Transformer Fuse/Cutout	16,072	2,086,304	20,127	2,222,051	23,293	2,766,684	19,823	2,345,677	17,583	1,965,905
	UG-Elbows	67	19,936	111	41,211	136	34,463	221	39,743	153	41,148
	UG-Lightning Arrester	12	3,831	32	5,945	69	12,333	85	19,657	48	10,038
	UG-Load Break Junctions	37	10,963	28	3,457	28	10,973	161	42,043	56	6,401
	UG-Low Tension Network	1	1,538			10	2,893			1	86
	UG-Other Equipment(explain)	284	70,130	267	22,549	131	22,973	836	296,418	46	6,902
	UG-Pads/Vaults/MHs & Splice Boxes	41	10,461	181	45,952	124	26,175	242	64,941	101	9,017
	UG-PRI Splices and Connectors	338	88,619	360	102,741	96	19,748	2,718	363,456	171	37,668
	UG-Primary Cable/Neutral	16,728	4,290,588	14,265	2,682,304	19,486	4,776,145	17,275	3,285,692	24,721	3,414,041
	UG-Riser Pole Equip & Devices	2,010	192,486	428	55,977	3,395	527,705	889	209,910	5,050	242,863
	UG-SEC Splices and Connectors	3	843	34	2,806	28	4,237	5	359	11	1,118
	UG-Secondaries/Services	226	64,598	302	86,227	428	138,911	372	84,825	129	25,745
	UG-Switchgear	169	10,245	909	100,790	1,566	164,350	1,271	246,905	1,015	151,369
	UG-Transformer/Transformer Fuse	1,926	472,567	1,621	371,035	1,636	444,280	1,950	513,487	1,638	368,796
Substation	SUB-Circuit Breaker	75,565	3,594,404	30,673	2,113,813	13,491	972,821	20,472	956,829	48,462	1,830,224
	SUB-Control/Relay	8,222	479,127	7,714	334,935	183	15,248			4,919	231,760
	SUB-Insulator	3,796	155,819							5,353	178,099
	SUB-Lightning Arrester			13,002	417,904	128	17,293	1	77	130	15,222
	SUB-Power Fuse	4,088	159,877	180	27,200	27	12,795	3,149	266,509	4,480	148,913
	SUB-Power Wiring					1,813	205,150				
	SUB-Structure							335	11,445		
	SUB-Switch/Automatic	2,676	119,863	7,972	123,951	20,849	2,121,410	1,363	55,084	3,218	102,216
	SUB-Switch/Manual/AB/Disc/LBD	14	838	1,361	71,515	2,594	331,214			1,964	42,677
	Sub-Transformer					2,459	180,278				
	SUB-Transformer	12,440	830,058	9,391	941,740	9,676	905,741	1,671	162,884	6,479	315,170
Total		**419,442**	**48,995,056**	**331,838**	**32,225,126**	**384,369**	**50,058,225**	**266,187**	**30,790,059**	**334,637**	**33,866,557**

PPL Electric Utilities Corporation

PPL Electric Utilities Corporation

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

For the Period of January 1, 2020 – December 31, 2021

Submitted by:

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Dated: October 1, 2018

PPL Electric Utilities Corporation

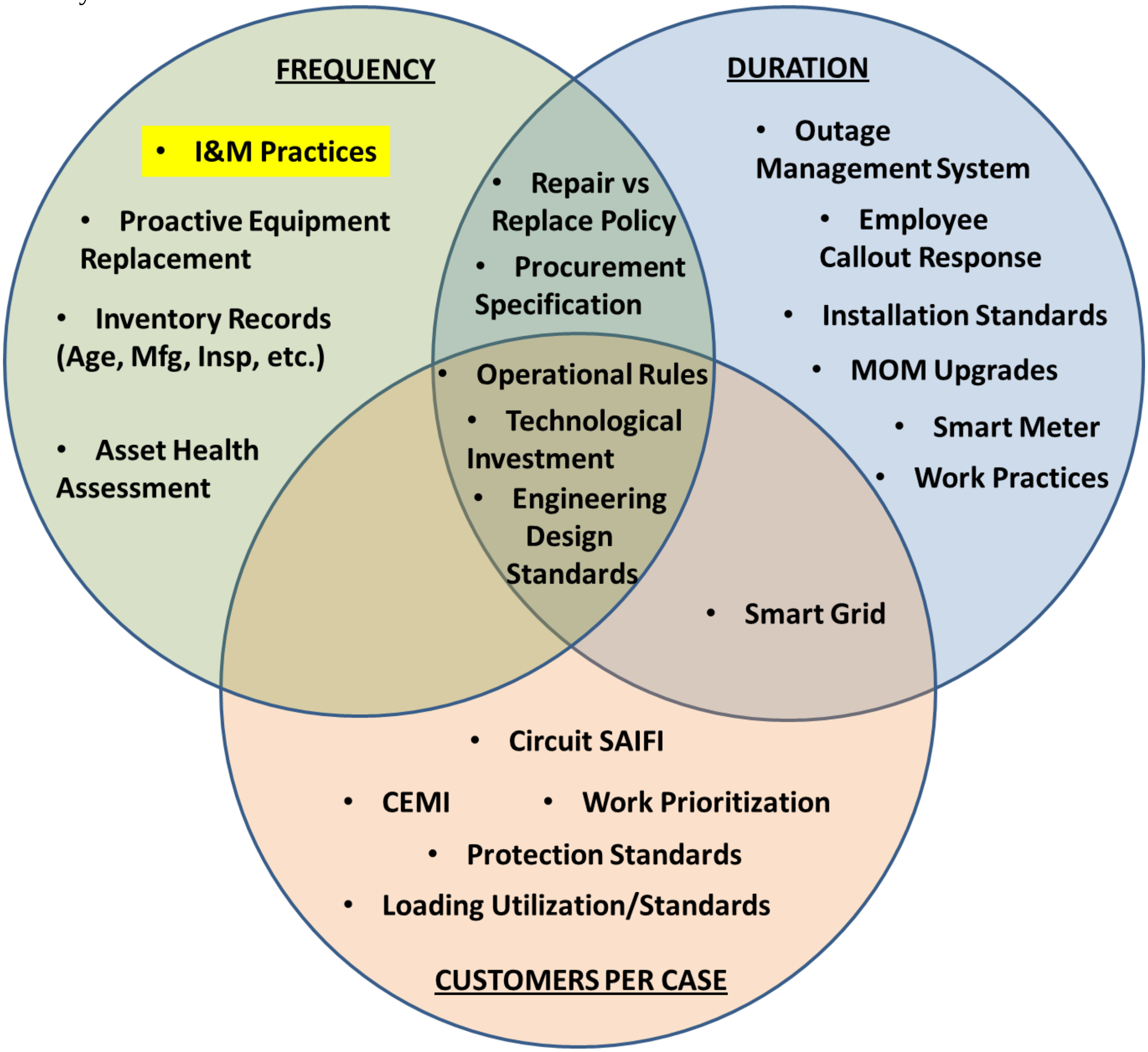
Table of Contents

Introduction

PPL Electric Utilities Corporation (“PPL Electric” or “Company”) is firmly committed to maintaining high levels of customer satisfaction. Customer surveys demonstrate that high levels of customer satisfaction depend upon providing reliable performance coupled with reasonable cost. PPL Electric has established a strong, long-term record of customer satisfaction and electric reliability. PPL Electric has earned 26 J. D. Power customer satisfaction awards – more than any other investor-owned utility in the country – since J. D. Power began studying customer satisfaction among electric utility customers. PPL Electric has ranked highest among large electric utilities in the eastern United States in J. D. Power annual study of residential customer satisfaction 15 times: in 1999 and from 2001-2007 and 2012-2018.

Ultimately, all of the costs of maintaining reliability are borne by the ratepayers. Therefore, managing finite resources to produce optimal results is essential in order to deliver excellence in customer satisfaction. The criteria for program inclusion is not whether any given activity produces a positive reliability result, but, rather, what portfolio of activities produces the best result for a given expenditure of resources given the specific reliability challenges faced by PPL Electric at this point in time, and for the foreseeable future. PPL Electric’s goal is focused on results (i.e., the reliability experienced by customers), not the rote execution of particular tasks.

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. The manageable factors 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 that typically overlap are those designed to minimize the number of customers affected should an outage occur. Realizing that not all outages are preventable, PPL Electric also directs rigorous efforts designed to reduce the duration of the outages that do occur. Examples of PPL Electric initiatives addressing each of the three reliability sectors, frequency (number of cases), customers affected per case, and duration are addressed below.

Frequency (number of cases)

- **Inspection and maintenance practices and programs:** 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 in 2010. The scope of these programs, procedures and activities covers all areas of the electrical infrastructure to include transmission, substations, distribution, and vegetation.

Transmission
Transmission inspection programs include aerial patrols and structure inspections, treatments and replacements. The patrols focus on comprehensive inspections, routine inspections, stop-go inspections, and identification of emergency work. The inspections encompass all equipment, including poles, arms, line switches, interrupters, arresters, grounding, guying, anchors and other key transmission components.

Substation
Substation maintenance programs include inspections, condition testing, and preventative maintenance of equipment, such as power transformers, circuit breakers, disconnects, power cables, and security 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 timely manner. In addition to time and condition-based maintenance, thermographic inspections help to ensure that substation equipment does not operate at elevated temperature levels, which could lead to premature failures.

Distribution
Distribution encompasses many maintenance aspects similar to transmission and substations, and also includes load surveys that assist in determining peak load requirements, and circuit analyses that help identify lines requiring maintenance work, voltage relief, or other capital improvements. Overhead line inspections identify the weak links in the system so that damaged or deteriorated equipment can be repaired or replaced. In addition, distribution maintenance includes inspections of poles, voltage regulators, line switches, capacitors, and other key distribution equipment. PPL Electric also tests underground cable for integrity to determine if the cable needs to be replaced, repaired or cured to prevent future failures.

Vegetation
The vegetation on PPL Electric's transmission and distribution rights-of-way is maintained using a combination of several management techniques. These include

reclearing, ground-to-sky trimming, hazard tree removal, tree pruning, and herbicide application. The work is prioritized based on the conditions observed and past performance.

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

- **Asset Optimization Strategy ("AOS"):** PPL Electric conducted a major condition assessment and maintenance study of its distribution system in 2009. This project was initiated to identify and address the challenges created by the Company's aging infrastructure. The objectives were to assess equipment health in seventeen distribution asset classes comprising approximately 30,000,000 units of equipment, and generate a strategy for capital replacements and maintenance improvements to address these challenges. PPL Electric conducts effectiveness reviews of the various programs comprising this strategy to ensure that aging infrastructure continues to be appropriately addressed.

- **Asset Health Assessment:** In 2015, asset health and criticality scores for substation and LTN ("Low Tension Network") vital equipment were captured and evaluated. As a result, AOS replacement programs for these asset classes were further refined based on the score ranking to achieve the most effective reliability impact per dollar invested. Additionally, Low Tension Network ("LTN") inspections and replacement programs are being adjusted to optimize cost and reliability based on the health and criticality scoring. PPL Electric continuously monitors the accuracy and effectiveness of these asset health and criticality scores, and in early 2018, as more data records were captured, began an initiative to develop predictive failure models of these vital assets with the intention of continuously improving the health and criticality scores. These continued health calculation efforts enable PPL Electric to more effectively mitigate risk and optimize reliability.

- **Long Term Infrastructure Improvement Plan:** In January 2018 the Commission approved PPL Electric's second 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 worst performing circuits ("WPCs").

- **Customers Experiencing Multiple Interruptions ("CEMI") Program:** The goal of the CEMI Program is to reduce the number of interruptions experienced by customers such that no customer has an excessive number of outages in any rolling 12 month period, and to communicate in an effective and timely manner with customers when multiple service interruptions do occur. CEMI performance is monitored closely by regional distribution planners and reliability supervisors to identify cost-effective solutions which are submitted to the CEMI Task Force for evaluation and consideration.

The CEMI program is structured around three key attributes:

- Anticipate – monitor, forecast, and attempt to prevent multiple service interruptions from occurring.
- Mitigate – when multiple service interruptions occur, determine root causes, develop solutions, and ultimately implement corrective actions to reduce the risk of future interruptions.
- Communicate – following multiple service interruptions, contact customers to inform them that PPL Electric is aware that a service interruption has occurred, provide the cause of the service interruption, and the Company's plans to prevent future service interruptions, among other pertinent details. In addition, when solutions are implemented, contact customers and advise them of the improvements.

- **Distribution and substation animal guarding:** Two programs were established in 2009 to limit service interruptions caused by animals. The first was to install animal guards on distribution overhead transformers and switches in locations with a high density of animal-related service outages, and the second was to install animal guard materials at all distribution substations by 2019. This has proven effective. Since the program's rollout, animal outages have decreased by 34%.

Customers affected per case

- **Expanded Operational Reviews ("EOR"):** EORs 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.

- **Reliability Principles and Practices ("P&P") Revisions:** The 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. Additional revisions to PPL Electric's P&P are underway to reduce the overall impact to our customers as the Company implements smart grid strategies.

- **Circuit SAIFI:** In 2013, PPL Electric launched a system wide initiative to install approximately 1,000 new fuses on single phase taps to limit the number of customers exposed to an outage on a given circuit. The Company continues to evaluate areas where fuse installation may reduce customer exposure to outages. As of 2018, over 2,600 locations have been fused, with more installations planned.

- **MAIFI**: In 2016, PPL Electric became one of the first electric utility companies in the nation to launch a concentrated effort to reduce momentary interruptions (defined as any power interruption less than five minutes) that customers experience. Through tracking momentary interruptions and concentrating on circuits that experience higher than average momentary interruptions per customer, PPL Electric is reducing the number of momentary power outages on the system.

Duration (minutes/case)

- **Restore App / Storm Event Management** ("STEM"): As of 2017, two mobile applications are available that significantly improve storm response efficiency and situational awareness. The Restore App is an application that enables non-PPL crews to receive information about outages directly to their smart devices or PCs. Previously this information was provided via phone calls or hand-delivered documents. The Restore App also enables field personnel to send photographs of damaged equipment to PPL Electric support staff. To support command center situational awareness and strategy development, an application known as Storm Event Management ("STEM") now makes outage information, resource allocation, and estimated restoration times available on smart devices and PCs.

- **Automated Callout:** As of 2013, an automated system has been employed to call employees into work for after-hours emergencies. This system performs callouts simultaneously, whereas the previous system performed callouts sequentially, which shortens response time under storm conditions when large numbers of employees must be called out to restore service to customers.

- **Outage Management System ("OMS") enhancements:** In 2015, PPL Electric completed an upgrade of its OMS system. Numerous improvements were made to the software, including a stronger model of the network grid, improved system response time, and improved outage scenario modeling.

- **Storm Central:** Storm Central is a user friendly tool that allows personnel to quickly find the information and tools, developed under PPL Electric's Emergency Response Plan, needed to support the restoration of service to our customers after an emergency event.

- **Distribution Automation:** In 2010, PPL Electric launched a "smart grid" pilot project that enables the Company to react rapidly to changes on the delivery system, and automatically re-route power around problems that occur. The project initially focused on the Harrisburg, Pa. area, but has since been rapidly expanded to cover all of our service territory. The project included the implementation of an advanced Distribution Management Systems ("DMS"), which is a breakthrough technology that enables our operators to see the status of our distribution network in real-time. In 2016, PPL Electric completed a system wide rollout of FISR (Fault Isolation and Service Restoration) technology. FISR identifies faulted sections and quickly develops an optimized restoration plan, then automatically executes that plan. Customers typically can be restored within five minutes from the start of the outage. This milestone is an industry first and looks to significantly reduce overall outage durations. Over 7,500 automated smart devices have been installed to date. Such installations allow for remote operation and monitoring of circuit sectionalizing equipment, and advanced fault location technology. The goals of these improvements are threefold:

    - Reduce the number of upstream customers affected by a service outage.

- Reduce the time necessary to restore customers by transferring circuit sections to alternate sources and limiting long-duration service outages to smaller circuit sections involving fewer customers.
- Facilitate fault location and reduce the time necessary for repair and restoration.

The end-result will be a delivery system that operates more efficiently, recognizes problems immediately, and responds in seconds to restore the service for many customers who otherwise need to wait for crews to physically respond to an outage.

- **Smart Meter Technology**: PPL Electric is a national leader in the use of advanced metering technology for the benefit of customers, having installed an advanced metering system for all customers between 2002 and 2004. The Company has used the technology to improve the efficiency of responding to service outages – especially during storm emergencies – and as a tool for reliability planning. PPL Electric began exchanging its power line carrier meters with radio frequency ("RF") based meters, in December 2016. The RF meters will allow for even more improvements in outage detection and restoration as well as proactive reliability planning and customer service. As of August 31, the Company has installed 950,659 RF meters with deployment to be completed by the end of 2019.

PPL Electric Reliability Results

The reliability planning and investment process employed by PPL Electric have been very effective, as evidenced by its reliability performance. This has been accomplished while preserving a reasonable cost of providing service.

PPL Electric Reliability Planning Process

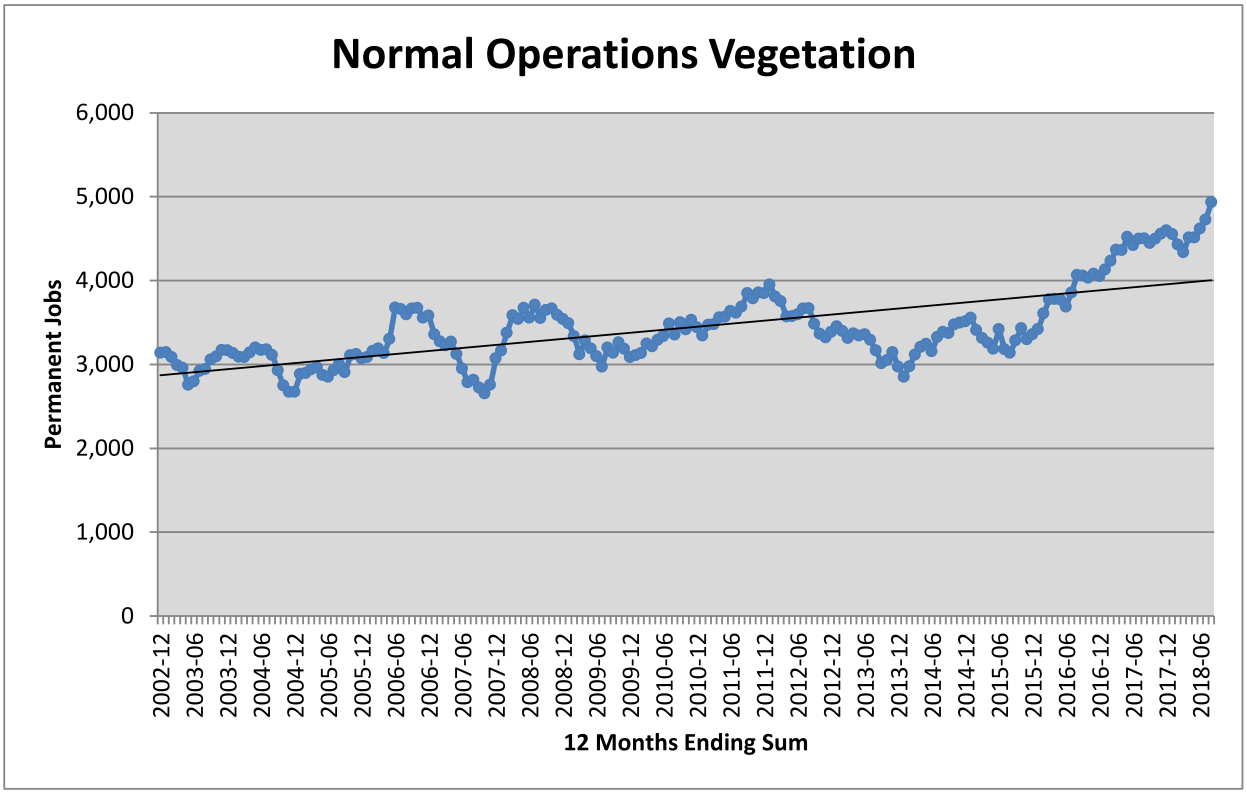
PPL Electric's process is forward-looking and proactive. It consists of the following:

- Analyze the historical trends of causes of service outages and other power service problems.
- Identify the drivers of those trends.
- Forecast future reliability metrics (SAIDI, SAIFI, CAIDI, and MAIFI) given existing mitigation programs' effect on the identified drivers.
- Identify new programs, policies and activities to add to or substitute for existing mitigation programs to avoid any forecasted gaps between future reliability and the desired levels.
- Identify, evaluate and implement new technologies that enhance its condition monitoring strategy
- Continually evaluate and adjust programs, policies and activities to produce the desired future results.
- The resulting portfolio of existing and new programs, policies and activities are incorporated in to PPL Electric's I&M plan.

PPL Electric Utilities Corporation

PPL Electric Reliability Analysis

Identification and understanding of trends creates the opportunity to plan programs to 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 12-month ending value to eliminate the effect of seasonal variation.



Vegetation Related Service Interruption Cases

PPL Electric is committed to continuing an aggressive tree trimming program to address the threat of tree related outages. It is worth noting that even when excluding major and PUC reportable storm events, 75% of vegetation related outages occur during adverse weather conditions. The saturated ground conditions prevalent in 2018 have resulted in higher than normal occurrences of healthy trees toppling into overhead conductor. Also of note is the ongoing infestation of the emerald ash borer in Pennsylvania, which is having a negative impact on vegetation related interruptions.

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.

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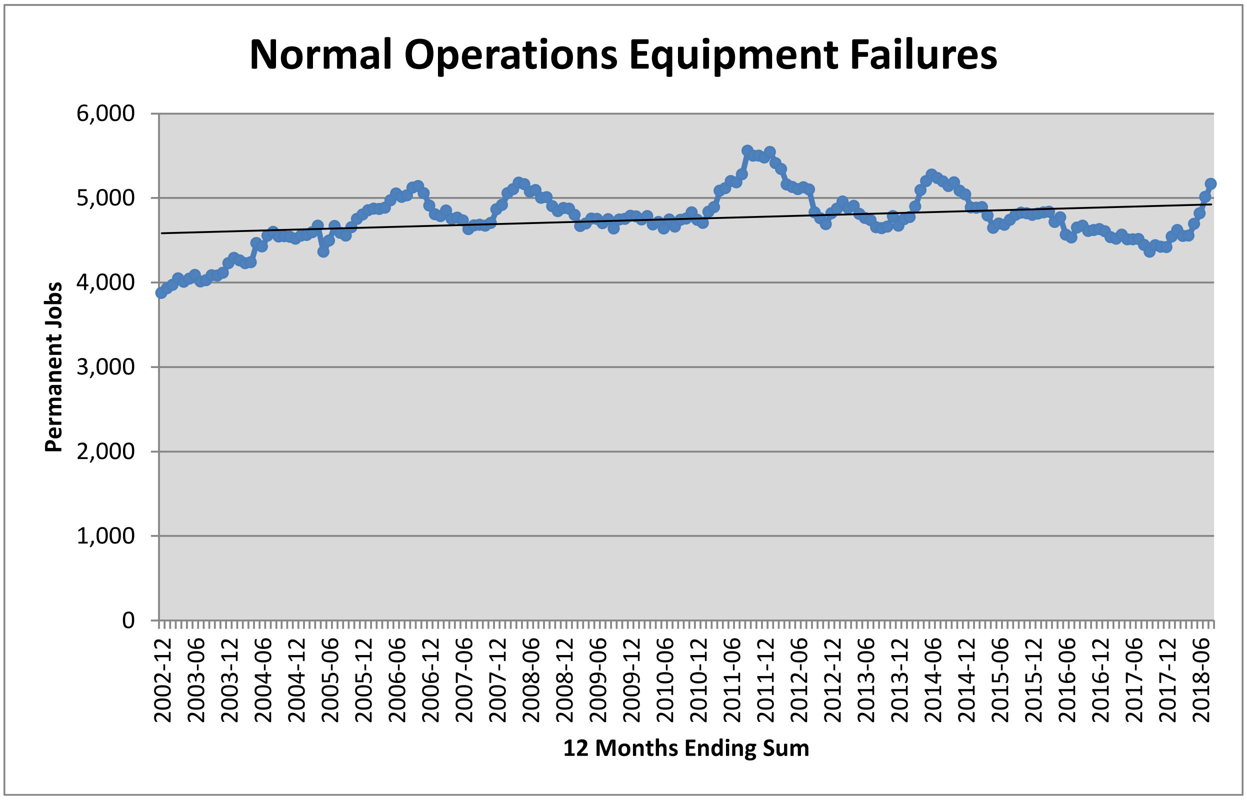

Equipment Failure Service Interruption Cases

The annual number of outages due to equipment failure rose steadily through mid-2011 and has generally stabilized or declined since then. The recent spike in equipment failures is partially a result of the addition of thousands of additional fuse locations: currently a fuse operation where no clear cause can be found is coded into outage data as an equipment failure. However, if the fault was caused by a transient contact that is no longer apparent, the fuse operated as intended and no equipment failed. This practice is being reviewed.

Other initiatives contributing to this stabilization are equipment replacements identified through Expanded Operational Reviews of 25% of circuits annually, aggressive worst performing circuit remediation, implementation of PPL Electric's Asset Optimization Strategy, enhanced pole inspection and treatment, distribution automation including a new Distribution Management System, and infrared inspections.

Although these programs have successfully slowed 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. Scheduled replacement of that infrastructure is necessary to avoid accelerating failure rates due to end of life fatigue.

PPL Electric Utilities Corporation

Reliability is the largest contributor to overall customer satisfaction. Satisfaction levels vary depending upon the amount of information provided to the customer regarding their outage. Providing customers with accurate information about their outage is increasingly important. Customers are more understanding of storm and weather-related service outage impacts than they are of other outage causes, such as utility equipment failures.

If it is more cost-effective to offset an increase in equipment failure cases with a program to reduce vegetation-related cases, the ratepayer is better served by this cost-effective choice. Similarly, if a program that reduces the average number of customers affected by each service outage is more cost-effective than a program to reduce the gross number of service outages, the more cost-effective program should be chosen. The management challenge is to maintain reliability within acceptable parameters in the most cost-effective manner, while keeping customer satisfaction levels high.

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 four previous I&M reports (2012-2013, 2014-2015, 2016-2017, and 2018-2019):

- 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 two previous I&M reports (2016-2017, 2018-2019):

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

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PPL Electric is again requesting acceptance of the following deviation from the intervals in the Commission standard as were included in the previous I&M report (2018-2019):

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

<u>52. Pa. Code § 57.198 (m) Recordkeeping(m)</u> *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 & Asset Management System (WAM) software application 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.

<u>52. Pa. Code § 57.198 (n)(1). Vegetation Management.</u> *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.*

<u>Program Description</u>

PPL Electric employs four-year and five-year inspection and trim cycles for its distribution circuits in its southern and northern territories respectively. The demarcation line for the northern and southern areas is the ridgeline of the Blue Mountains, which does not follow the borders of PPL Electric's regions. Based on conditions the cycle schedule may be modified, but not beyond established regulations. Additionally, a three-year inspection and trim cycle is currently applied to transmission lines in all of PPL Electric service territories.

PPL Electric rights-of-way will be maintained to the originally established clearances or the limits as defined in the right-of-way agreement, whichever is greater.

- 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 important. Tree contacts can result in short-circuits and subsequent service outages.

Taller species of trees that are permitted to grow under power lines eventually will contact the wires, 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

Multi-phase lines will be pruned to the full extent of the established tree line, not to exceed 25' from centerline and ground to sky pruning will be utilized.

Single-phase lines will be pruned to the full extent of the established tree line, not to exceed 15' from centerline and to a distance of 15' above the line. All dead or structurally weak limbs which 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), should be considered for proper lateral pruning using the centerline of the thoroughfare as a guideline. Fast growing tree species may need more aggressive pruning.

Another enhancement is hazard tree removal. "Hazard trees" are those trees outside the right of way that may be leaning, diseased, or otherwise pose a threat of falling on a distribution line. PPL Electric bears all costs of removing hazard trees and conducts the removal either based on right of way agreements or with property owner permission.

PPL Electric Utilities Corporation

Transmission

PPL Electric Utilities 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 taking into account the concerns of property owners and our obligations to electric customers. Low-growing grasses and other compatible species are permitted within the wire zone. In the remainder of the right-of-way, certain compatible trees and shrubs are allowed if they do not pose a reliability risk.

Inspection Plan

Distribution Vegetation Management			
	Area *(Line Miles)*	**Scheduled Trimming** *(Line Miles)*	
		2020	**2021**
PPL Electric Utilities Corporation *Total Line Miles (28,094)*	Lehigh (3,469)	788	795
	Northeast (5,190)	928	925
	Central (4,535)	900	903
	Susquehanna (5,769)	999	984
	Harrisburg (4,822)	1202	1004
	Lancaster (4,309)	964	972
	Totals	**5,781**	**5,583**

PPL Electric Utilities Corporation

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 ten years.

- Purpose

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

- Process

  Beginning in 2016, PPL Electric enhanced its pole inspection program from a partial excavation inspection program to a full excavation program. In a partial excavation program, each pole over the age of ten years that can be is excavated on two sides to a depth of 12 inches. In the current full excavation program, each pole over the age of ten years that is not set in concrete, asphalt or with a riser is fully excavated to a depth of 18 inches. The pole is inspected visually, sounded and bored above ground in addition to the full excavation. All measurable decay is entered into the contractor's engineering-based software program to determine the percentage of remaining strength, taking into consideration ANSI and NESC standards. If the percentage of remaining strength is below established parameters, a load calculation is performed to determine the pole's capacity to support the load in accordance with NESC standards. Poles younger than ten years are visually inspected only.

  Based upon 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), NESC rules and is consistent with industry practices.

PPL Electric Utilities Corporation

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. Load calculations are performed on every pole where new attachments are requested by third parties.

PPL Electric does not track service outages caused by pole equipment failure as a discrete category. Poles are contained within a category that includes poles arms, brackets, guys, push braces, pole top extensions and any other mounting hardware. In 2017, equipment failures requiring replacement in this category amounted to 374 (7.6% of total cases), of which only a small fraction are poles. Excluding pole fires, only 9 cases (0.3% of total cases) suggest broken PPL Electric-owned poles. (Nine poles represent 1/1000 of one percent of PPL Electric's 885,000 wood distribution pole inventory.) Most of the limited numbers 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 insignificant.

Beginning in 2010, the Company's wood pole maintenance program was enhanced from an inspection-only process to an inspection and treat program, whereby all poles passing the inspection are chemically treated to arrest decay at the same visit. The preservative treatment permits the next inspection to be at a uniform ten years, rather than the former one to nine-year cycle after original inspection applied to individual poles. Changing to a uniform ten-year cycle will enable more economic geographic-based inspections where all poles in a defined area are inspected, rather than the current method of inspecting scattered poles with individually specified intervals which maximizes the employee travel involved.

PPL Electric Utilities Corporation

Inspection Plan

Distribution Wood Pole Inspections			
	Area *(Poles)*	**Inspections Planned** *(Poles)*	
		2020	**2021**
PPL Electric Utilities Corporation *Total Poles (885,040)*	Lehigh (118,218)	12,022	12,022
	Northeast (175,862)	17,883	17,883
	Central (158,243)	16,092	16,092
	Susquehanna (160,991)	16,371	16,371
	Harrisburg (140,595)	14,297	14,297
	Lancaster (131,131)	13,335	13,335
	Totals	**90,000**	**90,000**

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

- PPL Electric obtains pole replacement data weekly. Critical poles, those that pose an immediate safety concern, are reinforced or replaced as soon as possible, and not later than 30 days after notification. Other non-restorable rejected poles generally are replaced within one year of identification. Pole strength and loading calculations are provided for each rejected pole to assist in reinforce versus replace decisions and schedule prioritization.

- Reinforcement by steel C-Truss, a galvanized steel truss which is banded around the pole in order to regain the pole's original strength or fiber wrap, several layers of high-strength fiberglass wrapped onto the pole and saturated with resin is completed within 90 days of identification. 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: Multi-phase overhead lines adjacent to roadways every two years.

  Visual inspection: Condition based – selected line segments. Inspections are scheduled under various conditions to include CEMI and WPC circuits, if warranted based on EORs, and if power quality issues are experienced. Additional patrols are conducted to ensure continued reliability include those in support of distribution construction projects as well as summer and winter readiness patrols.

  Pole inspection: Every ten years.

- Purpose

  The objective of an overhead line 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, ranked in order of priority 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 upon 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, bridges disconnects, 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 expanded operational reviews.) 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.

Pole Inspection: As an integral part of the ten-year pole inspection process, the wood poles are observed, with at-risk conditions of all pole attachments, specifically crossarms, braces, conductors, transformers, fuse cutouts, lightning arresters, reclosers, regulators, capacitors, switches, wildlife protection, vegetation encroachment, guys, anchors, ground wires and rods noted and reported.

- Justification for waiver

PPL Electric hereby proposes a continued deviation from the 1-2 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 applied to shorter visual cycles than this proposal would reduce the resources 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 employs a $2.00 per CMI saved cost threshold[1] as a principal criteria 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 producing better results, thus enabling the most effective portfolio

[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.

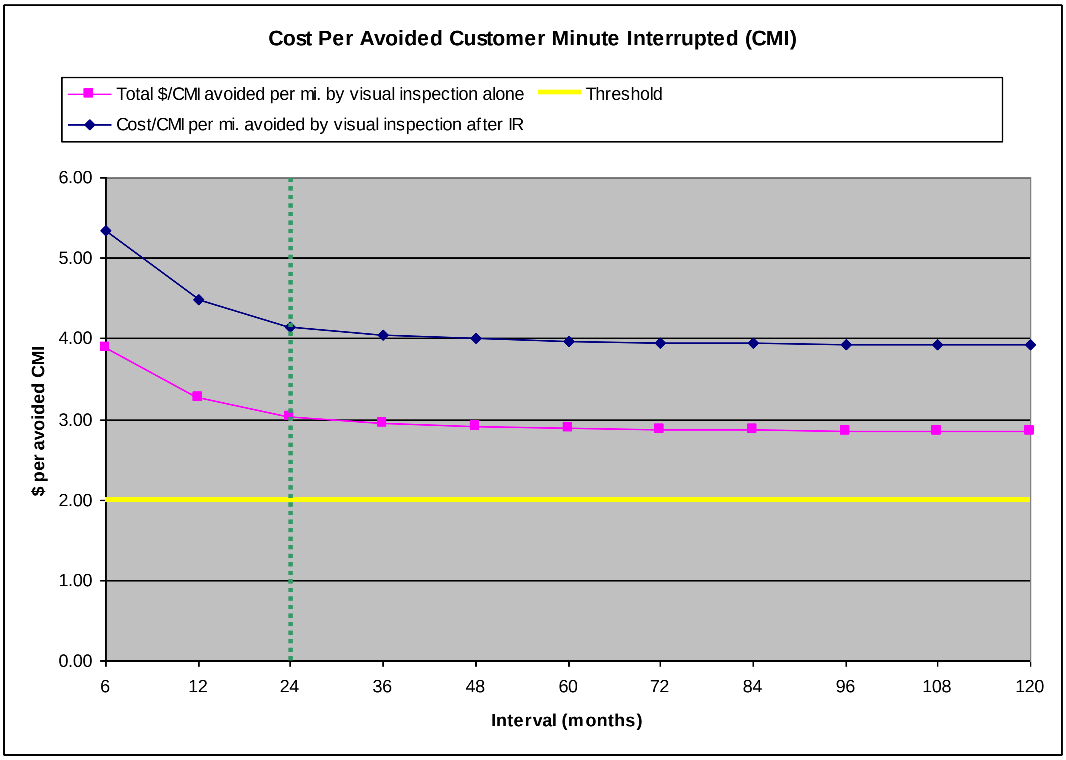
of programs. Because infrared costs per CMI saved are well below the threshold, PPL Electric instituted a two-year infrared cycle for accessible multi-phase lines.

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 will 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 thirteen 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.

PPL Electric Utilities Corporation



Overhead Line Inspection Cost per Avoided CMI

Although universal overhead visual inspections are not cost-effective, targeted visual inspections have more value. In a typical year, less than 15% of the circuits are responsible for 80% of equipment failure CMI. For the period 2002 to 2009, 30% of the circuits were responsible for 80% of equipment failure CMI.

Consequently, PPL Electric employs the condition-based visual inspection approach described above, combined with Expanded Operational Review field checks and overhead inspections in conjunction with pole inspections.

PPL Electric Utilities Corporation

Inspection Plan

PPL Electric will inspect multi-phase drivable lines every other year, per the total mileage listed in the chart below.

Distribution Overhead Multi-phase Line Infrared Inspections			
Total Line Miles/Drivable Line Miles[2]	**Line Miles by Region**	**Infrared Inspections Planned** *(Line Miles)*	
		2020	**2021**
PPL Electric Utilities Corporation *(Total System Line Miles: 8,626/8,195)*	Lehigh (1,337/1,270)	635	635
	Northeast (1,446/1,374)	687	687
	Central (1,618/1,537)	768	769
	Susquehanna (1,264/1,201)	601	600
	Harrisburg (1,411/1,340)	670	670
	Lancaster (1,550/1,473)	737	736
	Annual totals	**4,098**	**4,097**

[2] For planning purposes, an assumption that 95% of multi-phase line miles are drivable is employed.

PPL Electric Utilities Corporation

Distribution Overhead Visual Inspections			
	Line Miles by Region	**Estimated Visual Inspections** *(Line Miles)*	
		2020	**2021**
PPL Electric Utilities Corporation *Total System Line Miles (28,094)*	Lehigh (3,469)	390	390
	Northeast (5,190)	540	540
	Central (4,535)	480	480
	Susquehanna (5,769)	600	600
	Harrisburg (4,822)	510	510
	Lancaster (4,309)	480	480
	Annual totals	**3,000**	**3,000**

PPL Electric Utilities Corporation

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.

Distribution Overhead Infrared Inspections Corrective Maintenance		
	Variance from Normal Operating Temp.	**Days Allowed After Report Receipt for Service**
Secondaries	+20-60^o C	8 weeks
	> +60^o C	2 weeks
Disconnect Switches	+20-60^o C	8 weeks
	> +60^o C	2 weeks
All Other Facilities	+10-40^o C	8 weeks
	> +40^o C	2 weeks

- Visual

  The urgency for repairs is determined and an appropriate order of priority is assigned from four categories (Emergency, Priority, Unsatisfactory, and System Improvement) described 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.
Unsatisfactory; Defects with a lower probability of causing a service interruption if not corrected promptly. Scheduling Priority: 3	Corrective action must be taken within 3 months.
System Improvement; Conditions which could be altered to improve service reliability, with no immediate reduction of risk of service interruption. Scheduling Priority: 5	Corrective action may or may not be taken.

PPL Electric Utilities Corporation

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 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, replacement and curing program, which tests approximately 500-600 sections per year and cures approximately 600-800 sections per year.

  During 2012, PPL Electric performed a pilot of single phase pad-mounted transformer inspections of some of the older underground residential developments. The result was that, apart from some minor rusting, the conditions of the pad-mount transformers were in good working condition. These transformers were generally reliable so a formal inspection program would add little reliability benefit for excessive costs to the customer as outlined in the justification.

- 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, ranked in order of priority 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 2016, the estimated cost to inspect those transformers every two years was $1.3 million or $65 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 500,000 CMI on average to overall system reliability. An inspection and maintenance program for transformer condition would cost millions in expense for little improved 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

  PPL Electric has initiated an upgrade program to replace all three phase oil circuit reclosers ("OCRs") with vacuum circuit reclosers ("VCRs") based upon a review of the dominant failure modes and causes. The newer technology replaces oil with a vacuum as the interrupting media. This eliminates the OCR maintenance issues of carbonized oil, contact deterioration and the timing issues that sometimes occur with OCRs. In addition, the communication capabilities of the devices allows for PPL Electric to track data pertaining to the asset health which will allow PPL Electric to do condition based maintenance on these devices. PPL Electric received approval from the commission on January 3, 2014 to complete these replacements on a 10-year cycle starting in 2015.

Three-phase VCRs are subjected to infrared inspection on the same 2-year cycle as OCRs.

Three-phase OCR: 2-year infrared; 10-year replacement.

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

- Purpose

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

- Process

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

Three-phase OCRs are replaced with new communicating VCR units based upon installation date and type.

- Justification for waiver

PPL Electric hereby 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. With the planned installation of these communicating vacuum units, the devices have a longer life expectancy, and inspections can be planned.

As PPL Electric has been replacing older oil reclosing three phased units, reliability has improved from the decreasing number of failed units. In addition, PPL Electric experienced close to a 50% improvement in reliability within the initial smart grid pilot area.

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Replacement Plan

Actual scope is determined annually based upon the number of OCRs on the system, age, and model type of OCR. The projections below are tentative until replacement recommendations are provided.

Distribution Three Phase OCR Replacements			
	Area *(Number of Three Phase OCRs)*	**OCR Replacements Planned**	
		2020	**2021**
PPL Electric Utilities Corporation *Total Three Phase OCRs (473)*	Lehigh (94)	10	10
	Northeast (117)	12	12
	Central (101)	11	11
	Susquehanna (53)	6	6
	Harrisburg (51)	5	5
	Lancaster (57)	6	6
	Totals	**50**	**50**

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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**
Distribution- Supervisory control and data acquisition ("SCADA") Controlled	Quarterly	Annual
Distribution-Non SCADA	Quarterly	Annual

- Purpose

  Periodic substation inspections verify the integrity of station physical security, record and correct any security breaches, verify the proper fluid levels and gas pressures, and identify any leaks, verify the proper operation of essential station equipment and initiate any necessary corrective actions.

- Process

  Inspection of substation equipment and recording abnormal conditions of the equipment. Equipment inspected includes, but is not limited to:

  - Power transformers
  - Circuit breakers
  - Auxiliary equipment
  - Batteries and chargers
  - Control house
  - Yard and perimeter

- Justification for waiver

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

From 2016-2018, PPL Electric estimates that a yearly average of 826k CMI was avoided through repairs identified via the monthly substation inspection. The costs of inspection plus repair averaged $1.24 million per year, or $1.50 per CMI avoided, which is under the threshold employed by PPL Electric of $2.00 per CMI saved for identifying prudent reliability investments.

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PPL Electric plans to have SCADA at every substation, which provides real-time telemetry of potential issues. As of August 2018, PPL Electric has SCADA installed in 352 of the 353 total substations. 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 which allows the Company to be automatically alerted when substation abnormalities are detected, and automatically calculate remaining life on smart assets when operations occur.

Over the last four years, none of the repairs scheduled due to the monthly inspections have been critical repairs due to imminent failure risk. The repairs have been minor, and could have waited 90 additional days to be identified.

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.

Inspection Plan

Distribution Substation Visual Inspections			
	Area *(# of Substations)*	**Inspections Planned**	
		2020	**2021**
PPL Electric Utilities Corporation *Total Substations 361*	Lehigh (63)	252	252
	Northeast (58)	232	232
	Central (69)	276	276
	Susquehanna (50)	200	200
	Harrisburg (60)	240	240
	Lancaster (61)	244	244
	Totals	**1,444**	**1,444**

Appendix A: Transmission Programs and Procedures

Program	**Activity**
Helicopter Inspections – Stop-go	Aerial linemen perform annual routine transmission line patrols from a helicopter. They identify damaged or deteriorated equipment and any apparent vegetation issues. Engineers review the findings and develop plans for repair, replacement or remediation.
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.
Steel Structures – Inspection, Treatment, Replacement, Reinforcement/Repair	Steel transmission structures are examined and measured for the degree of decay and deterioration. Any issues identified by the inspection are then categorized with a priority rating and are scheduled for follow-up actions based on the criticality. Follow-up actions may include remediation or replacement of steel members or foundations to extend the life of the asset.
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. Repairs are either completed by line crews or aerial line crews to ensure efficient and effective repairs.
Line Switches – Maintenance and Inspection	Line personnel inspect, maintain and perform operational tests on 138kV and 69kV line air break switches on an as-needed basis to assure proper operation. Corrective action is taken as needed.
Line Switch Upgrades	Line personnel install lightning arresters on 138kV and 69kV line switches to increase system reliability. Existing parallel break air breaks and load sectionalizing air breaks are being upgraded to motor operated load break air breaks to improve switching capabilities, outage restoration times, and sectionalizing ability. Corrective action is taken as needed.

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Program	Activity
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.

Appendix B: Substation Programs and Procedures

Program	**Activity**
Load Survey	Automatic monitoring devices such as 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 identify and correct potential equipment problems before a failure or service interruption occurs.
Equipment Service	Electricians perform operational tests on power transformers, load tap changers (“LTC”), 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, high voltage fuses and high-speed automatic grounding switches. Depending on the type of equipment, “service” can include actions other than operational testing.
Inspection and Condition Assessment	Electricians inspect and perform condition assessments of 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. Corrective action is taken as needed.
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.

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Program	Activity
Condition Monitoring of Station Equipment	Electricians/Technicians perform dissolved gas-in-oil analysis, dielectric, and physical properties oil tests for oil in power transformers, and impedance and select 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	Electricians perform infrared 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 and Testing 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.
Capacitor – Inspection and Maintenance	Line personnel inspect and maintain associated electronic control equipment to assure proper operation. Line personnel repair or replace any defective equipment.
Voltage Regulator – Inspection and Maintenance	Line personnel inspect existing equipment for potential failure, and inspect and maintain controls and tap changers to assure proper operation. Line personnel repair or replace any defective equipment.
Overhead Line Switch – Inspection and Maintenance	Line personnel inspect switch installations to identify cracked or broken insulators / bushings, stuck or misaligned blades, insulation or gasket deterioration or other operational problems. Line personnel repair or replace any defective equipment.
Transformer Maintenance	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. Line personnel repair or replace any defective equipment.

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Program	Activity
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 SAIDI. Actual service interruption history is analyzed to identify causal or geographic patterns.
Underground Primary Cable – Testing, Maintenance, Replacement, Curing	Line personnel perform insulation and neutral tests on cable in residential developments with potential problems to identify deteriorated cable. Based on the results, the cable is placed back in service, repaired or replaced.
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.
Public Damaged 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.
Oil Circuit Reclosers	Line personnel replace in-service oil circuit reclosers on a time-based maintenance cycle. Removed units are tested, and may be refurbished and placed in inventory.
Line Protection Equipment	Line personnel replace in-service three phase oil circuit reclosers with communicating vacuum devices on a time-based maintenance cycle.
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.

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Appendix D: Vegetation Applications

Program	**Activity**
Tree Pruning	Tree pruning is scheduled based on field conditions observed and/or a system prioritization process. All 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 it is feasible to do so.
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 possible.
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 possible.

Attachment PPL-DIV 2-14-3

Confidential Attachment PPL-DIV 2-14-3 contains confidential Critical Energy/Electrical Infrastructure Information. PPL and PPL RI has requested protective treatment of this confidential attachment in its entirety.

Newport 50-02 - 2020 - PCA

Loading	Light Load	Summer Peak	Winter Peak
	4/26/20 4:30	7/3/20 19:45	1/26/20 7:45
MVA	1.00	2.75	3.15
MVAR	-0.23	0.27	0.090
MW	0.90	2.28	3.00
AMPA	40	114	153
AMPB	46	104	135
AMPC	37	91	108
% IMBAL	12.88%	11.83%	18.34%
AVG KV	12.78	12.90	12.84

Engineer	Brubaker	
Date Completed	2020	
Previous EOR Year	2016	☑ ENGR Reviewed?

General Comments

Task	Target	Status	Comments
Momentary Analysis	MAIFI Review	Complete	No entries. High AMI count. Remove hydraulic 16378S41130 and install Viper at 16178S41385. Remove fast trips
Past 5 Year WPC Review	WPC Review	Complete	
CEMI Review	CEMI Review	Complete	15 CEMI 8 customers, timber road and sugar run. Both are evaluated via WPC
Protection Analysis	WO Creation	Complete	WR 15158885
Outage Analysis	Outage(s) Review	Complete	see WOs below
Exposure Analysis	Exposure Review	Complete	
Voltage Profile	116V - 126V	Complete	one transformer is high - Per Steve Seifert, work is being completed under WO 58371248.
Load Balancing	<15%	Complete	phase swap A to C
Voltage Balancing	<3%	Complete	0.6%; good
Line Loading	<100%	Complete	CYME study
Vegetation Review	Vegetation Review	N/A	areas w/high tree outages reviewed via WPC

WO#	RIS/COMPLETED	Notes	Grid Locations	Description
58482761	9/29/2020		16178S41385	Remove hydraulic 16378S41130 and install Viper at 16178S41385. RELO-OCR-VIPER-16179S41369-55002-GILLHILL&LILBUFFALORD NPTQ3
58480370	5/20/2020		16186S41419	DCSI-OH-1P-FUSE-GILL HILL RD-NEWPORT Q3
58454061	4/13/2020		15948S42154	DSPP-OH-2P-TRIP SAVERS-50-02-30 MILFORD RD NEWPORT Q3
58432345	8/31/2020		15216S43236	DCSI-15216S43236-55002-INSTALL15KFUSE-WPC-Q1-STC
58541001	12/31/2021		13460S41056	DSPP-13460S41056-55002-TRIPSAVER-WPC

Newport 55-01 - 2020 - PCA

Loading	Light Load	Summer Peak	Winter Peak
	9/21/19 2:45	8/21/19 16:00	2/15/20 8:45
MVA	1.61	4.80	4.56
MVAR	-0.12	0.06	-0.534
MW	1.54	3.63	4.53
AMPA	75	184	190
AMPB	87	238	270
AMPC	63	147	157
% IMBAL	15.87%	25.63%	31.20%
AVG KV	12.84	12.92	12.95

Engineer	Brubaker	
Date Completed	2020	
Previous EOR Year	2016	☑ ENGR Reviewed?

General Comments

Task	Target	Status	Comments
Momentary Analysis	MAIFI Review	Complete	fast trips being removed at 17755S42265 and 19054S41746 due to poor momentary performance - WO 58396785
Past 5 Year WPC Review	WPC Review	Complete	this is close to being a chronic WPC. WO 58449219 to reconfigure worst section of 1PH. 3PH relocation job to put line along road
CEMI Review	CEMI Review	Complete	41 CEMI 9 customers. CEMI 8 customers being reconfigured to reduce exposure
Protection Analysis	WO Creation	Complete	WO 58528946 (8/27/21 RIS) Circuit verified to coordinate with all EFD fusing symbols
Outage Analysis	Outage(s) Review	Complete	additional fuses below
Exposure Analysis	Exposure Review	Complete	see fusing below
Voltage Profile	116V - 126V	Complete	capacitor work order created below for low voltage - high voltage is OK.
Load Balancing	<15%	Complete	B phase single phase taps are too large to transfer to other phases for balancing.
Voltage Balancing	<3%	Complete	good; 0.54%
Line Loading	<100%	Complete	CYME study complete - no loading concerns
Vegetation Review	Vegetation Review	N/A	forestry review through wpc process

WO#	RIS/COMPLETED	Notes	Grid Locations	Description
58491946	5/8/2020		16826S43896	DCSI-16826S43896-55001-INSTALL65KFUSE
58491947	5/13/2020		18113S42283	DCSI-18113S42283-55001-INSTALL80KFUSE
			cancelled - protection denied	DRPD-18310S42616-55001-TS-2OF2
			cancelled - protection denied	DRPD-18957S42622-55001-TS-1OF2
58529485	12/31/2021		17471S43445 toward 17462S43414	DCSI-OH-1P-FUSE-17471S43445-55001- 119 OWLHLW MILLERSTOWN Q2
58531571	12/31/2021		18608S43020	DCSI-OH-1P-FUSE-18608S43020-55001-307 RED HILL RD NEWPORT Q2
58531570	12/31/2021		17910S44492	DCSI-OH-FUSE-17910S44492-55001-405 PERRYVLY MILLERSTOWN-Q2
58531569	12/31/2021		20385S42553	DCSI-OH-1P-FUSE-20385S42553-55001-453 CENTER RD NEWPORT Q2
58548727	1/12/2021		18559S44922	FEQUIP-18559S44922-55001-1PH-CAP-CONNECT

Before the

PENNSYLVANIA PUBLIC UTILITY COMMISSION

PPL Electric Utilities Corporation

Energy Efficiency and Conservation Plan

Act 129 Phase IV

Docket No. M-2020-3020824

Revised May 24, 2021 in accordance with

PUC's Opinion and Order entered March 25, 2021

Table of Contents

Tables

Figures

Acronyms and Abbreviations

Acronym	Definition
ACR	Act 129 Compliance Rider
Act 129	Act 129 of 2008, P.L. 1592, 66 Pa. C.S. §§ 2806.1, 2806.2
BPM	Brushless permanent magnet
C&I	Commercial and industrial
CCFL	Cold-cathode fluorescent lamp
cfm	Cubic feet per minute
CHP	Combined heat and power
CIP	Continuous improvement process
Commission	Pennsylvania Public Utility Commission
CRAC	Computer room air conditioning
CRAH	Computer room air handling
CSP	Conservation service provider
DEER	California Database for Energy -Efficiency Resources
DLC	DesignLights Consortium
DOE	U.S. Department of Energy
EC	Electronically commutated
ECM	Electronically commutated motor
EDC	Electric distribution company
EE&C Plan	Act 129 Phase IV Energy Efficiency and Conservation Plan
EE&C Plan Template	EE&C Plan Template issued by the Commission on September 9, 2020, at Docket No. M-2020-3015228
EISA	Energy Independence and Security Act of 2007
EM&V	Evaluation, measurement, and verification
FCM	Forward capacity market
FHPC	Floating Head Pressure Control
FPIG	Federal Poverty Income Guidelines
GNE	Government/Nonprofit/Educational
GNI	Government, nonprofit, and institutional
HER	Home energy report
HID	High intensity discharge
HP	Horsepower
HVLS	High Volume Low Speed
IECC	International Energy Conservation Code
Implementation Order	Pennsylvania Public Utility Commission's Final Implementation Order entered on June 18, 2020, at Docket No. M-2020-3015228
IRR	Internal rate of return
kW	Kilowatt
kWh	Kilowatt-hour
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
LIURP	Low-Income Usage Reduction Program
M&V	Measurement and verification
MW	Megawatt
MWh	Megawatt-hour

Acronyms and Abbreviations

Acronym	Definition
MWh/year	MWh credited towards compliance target in the year a measure is installed
NTG	Net-to-gross
NYMEX	New York Mercantile Exchange
Pa PUC	Pennsylvania Public Utility Commission
Phase IV Plan	Act 129 Phase IV Energy Efficiency and Conservation Plan
PJM	PJM Interconnection LLC
PMS	Permanent magnet synchronous
PSC	Permanent split capacitor
psi	Pounds per square inch
psig	Pounds per square in gauge
QA/QC	Quality assurance and quality control
RFP	Request for proposals
SCOP	Seasonal coefficient of performance
SCR	Silicon controlled rectifier
SCT	Saturated condensing temperature
SEM	Strategic energy management
SP	Shaded-pole
SWE	Statewide Evaluator
T&D	Transmission and distribution
TRC	Total resource cost
TRM	Pennsylvania Technical Reference Manual
VFD	Variable-frequency drive
VSD	Variable speed drive
WRAP	Winter Relief Assistance Program

1 Overview of PPL Electric Utilities' Act 129 Phase IV Plan

1.1 Summary Description of the Plan

PPL Electric Utilities Corporation ("PPL Electric Utilities" or the "Company") hereby submits its Act 129 Phase IV Energy Efficiency and Conservation Plan ("EE&C Plan," "Plan," or "Phase IV Plan") in compliance with Act 129 of 2008, P.L. 1592, 66 Pa. C.S. §§ 2806.1, 2806.2 ("Act 129"). This Plan is being filed pursuant to the Pennsylvania Public Utility Commission's ("Pa PUC" or the "Commission") Final Implementation Order entered on June 18, 2020, at Docket No. M-2020-3015228,[1] the Commission's 2021 TRC Test Order at Docket No. M-2019-3006868,[2] and the Phase IV EE&C Plan Template served by Secretarial Letter on September 9, 2020, at Docket No. M-2020-3015228. The portfolio comprises the three continuing comprehensive programs and nine associated components listed in Table 1.

Table 1. PPL Electric Utilities' Phase IV Programs and Components

#	Programs and Components
1. Residential Program	
1.1	Appliance Recycling
1.2	Efficient Lighting – Specialty Bulbs
1.3	Energy Efficient Homes
1.4	Student Energy Efficient Education
2. Low-Income Program	
2.1	Low-Income Assessment
3. Non-Residential Program	
3.1	Small Commercial and Industrial Efficient Equipment Prescriptive Rebate
3.2	Large Commercial and Industrial Efficient Equipment Prescriptive Rebate
3.3	Small Commercial and Industrial Custom
3.4	Large Commercial and Industrial Custom

The portfolio offers PPL Electric Utilities' customers a cost-effective, equitable, flexible, and comprehensive set of programmatic choices, incentives, information, and educational opportunities. Together, these programs meet the goals set forth in the Implementation Order, including cost-effectively achieving all savings objectives within the required budget caps (Table 2). The three programs, along with their associated program components, are described in Section 3.

[1] *Energy Efficiency and Conservation Program*, Docket No. M-2020-3015228 (Order entered June 18, 2020) ("Implementation Order").

[2] *2021 Total Resource Cost (TRC) Test*, Docket No. M-2019-3006868 (Order entered Dec. 19, 2019) ("2021 TRC Test Order").

Table 2. Summary of Compliance Targets

	Compliance Target[1]	EE&C Plan[2]
Overall Energy Reductions (MWh/year)	1,250,157	1,602,794
Overall Peak Demand Reductions (MW)[3]	229	251
Low-Income Energy Reductions (MWh/year)[4]	72,509	68,342
Budget Cap (excluding SWE costs)	$307,506,880	$307,491,409
Cost-Effectiveness (per TRC)	1.0	1.15

[1] Per the Implementation Order, there are no government, nonprofit, and institutional ("GNI") compliance targets for Phase IV, page 5. PPL Electric Utilities will continue to serve the GNI sector through the Non-Residential Program.
[2] The overall energy reductions (MWh/year) exclude 200,000 MWh/year of carryover program savings from Phase III. Low-Income energy reductions (MWh/year) exclude 20,000 MWh/year of carryover program savings from Phase III.
[3] Peak Demand is at generation.
[4] Total includes Low-Income Small C&I and will not match Low Income Program/Sector total.

1.1.1 Portfolio Objectives

PPL Electric Utilities designed the Phase IV Plan to meet the requirements set forth by the Commission's Implementation Order:

- Offer programs for a five-year term, beginning on June 1, 2021, and concluding on May 31, 2026.
- Comply with the designated expenditure cap of 2% of 2006 annual revenues for each year of the five-year Plan, which equates to a total energy efficiency budget of approximately $307.5 million,[3] over the five-year Phase IV period, and an average program acquisition cost of approximately $0.246 per kWh saved.
- Achieve 3.3% reduction in overall energy consumption, which is equivalent to 1,250,157 MWh/year of gross verified savings. The EE&C Plan must be designed to achieve at least 15% of the total cumulative energy reduction target in each of the five program years, which equates to 187,524 MWh/year each year.
- Achieve required energy reduction set-aside target from the low-income customer sector (those who are at or below 150% of the Federal Poverty Income Guidelines ["FPIG"]), which is equal to a minimum of 5.8% (72,509 MWh per year of gross verified savings) of the total portfolio energy reductions. Compliance savings must come entirely from income-qualified programs and may not accrue from low-income customer participation in non-low-income-specific residential programs.
- Achieve compliance target of cumulative peak demand reduction of 229 MW gross verified savings exclusively through deployment of energy efficiency measures offering coincident peak reduction benefits. The EE&C Plan must be designed to achieve at least 15% of the total cumulative demand reduction target in each of the five program years, which equates to 34.35 MW per year.

[3] This dollar amount excludes approximately $5 million for PPL Electric Utilities' portion of the statewide evaluator ("SWE") costs that are not subject to the funding cap.

- Offer at least one comprehensive program for residential customers and one comprehensive program for non-residential customers.
- Provide a portfolio cost recovery tariff mechanism.
- Dedicate at least 50% of funds to incentives at the portfolio level.
- Ensure the portfolio is cost-effective based on the total resource cost ("TRC") test and compliance with TRC guidance.[4]
- Include high-level plans to measure, evaluate, and verify the performance of individual programs and the Plan as a whole.
- Allocate the cost of measures to the customer class that receives the benefit of those measures.

In addition, PPL Electric Utilities designed the EE&C Plan to accomplish several corporate objectives:

- Exceed compliance targets, by approximately 44% MWh[5] and 10% MW, to allow for evaluation and other uncertainties.
- Enhance program comprehensiveness by offering overarching programs to serve residential, low-income, small commercial and industrial ("C&I"), and large C&I customers. These programs comprise customizable measure offerings bundled into components that span end uses, consolidate administrative functions, and eliminate arbitrary program designations that may serve as a barrier to participation.
- Achieve broad stakeholder consensus to the extent practical.
- Provide significant energy efficiency education to encourage customers to take a more comprehensive, holistic approach to energy efficiency (such as upgrading multiple measures, like weatherization and HVAC and water heating systems, or conducting whole-house and whole-building upgrades).
- Provide programs that achieve high customer satisfaction.
- Provide a transition for customers from Phase III to Phase IV program:
    - Offer residential customers a comparable mix of measures and incentive levels as those provided during Phase III for at least the first three months of Phase IV.
    - Offer comparable incentives to customers with non-residential projects on the Phase III waitlist that are completed in early Phase IV.
- Allow Phase III non-residential projects on the waitlist that are completed in Phase IV within the first three months to be eligible for a rebate based on Phase III eligibility requirements.
- Provide low-income programs at no cost to participants, although Act 129 Compliance Rider ("ACR") charges will appear on their bills.
- Provide a number of energy efficiency measures to low-income households that are proportionate to those households' share of total energy usage in the service territory (17.19%).

[4] This TRC guidance is outline in the Commission's 2021 TRC Test Order.

[5] This includes 200,000 MWh/year of carryover savings from Phase III (28% without carryover savings).

- Deliver programs using a customer-sector approach that is flexible enough to control the pace of programs if customer preferences or market conditions change.
- Achieve a reasonable net-to-gross ("NTG") ratio for each program.
- Continue to support an effective trade ally network that stocks and promotes efficient equipment.
- Achieve an equitable distribution of programs, savings, and costs for all customer sectors.
- Nominate a portion of the portfolio's peak demand reduction into the PJM Interconnection LLC ("PJM") Forward Capacity Market ("FCM").

PPL Electric Utilities is well-positioned to deliver a portfolio of programs that will meet customers' needs, fulfill the Company's Plan objectives, and achieve the results required for Phase IV. The Company designed its programs to provide residential, low-income, and non-residential (small and large C&I) customers with a comprehensive range of options intended to drive participation. PPL Electric Utilities uses targeted marketing techniques that capitalize on ongoing market research and on customer and trade ally feedback to match outreach and messaging strategies with likely participants' primary participation drivers. The common features of all programs are education, customer care, technical support, quality assurance and quality control ("QA/QC"), and evaluation, measurement, and verification ("EM&V").

The entire portfolio is supported by financial incentives, an active trade ally network, tracking, and a delivery approach focused on providing customers the support they need to achieve their energy efficiency objectives and encourage their continued engagement with PPL Electric Utilities' programs. Implementation activities range from simple, common energy efficiency measures that can be installed with minimal oversight or administration to more complex measures that may be (but are not required to be) part of a facility-wide energy management strategy. The Plan identifies opportunities for customers in all sectors to participate in one or more program components.

1.1.2 Overall Strategy to Achieve Energy Efficiency and Conservation Goals

In Phase IV, PPL Electric Utilities' savings acquisition cost will increase from $0.20 to $0.246. In Phase III, to achieve compliance with a lower budget allocation, the Company implemented several operational and delivery strategies aimed at increasing cost efficiencies and ratepayer value. In Phase IV, PPL Electric Utilities will continue these efforts but also recognizes the need to increase the amount of savings per customer interaction to meet its Phase IV goals. Therefore, in the Phase IV portfolio, the Company will offer customers a more holistic path to achieving deep energy savings. To facilitate this approach, PPL Electric Utilities developed budgets, savings targets, and performance objectives based on comprehensive program offerings for its primary customer sectors: residential, low-income, and non-residential. To accomplish this, the Company relied on Phase IV market potential studies, its Phase III program delivery experience and evaluation results, and an analysis of the Phase IV compliance requirements including the overall residential, low-income, and non-residential savings targets.

PPL Electric Utilities then issued requests for proposals ("RFPs") for the design and delivery of residential, low-income, and non-residential (targeting both small C&I and large C&I customers) programs. The Company used the responses to the RFPs to confirm that its savings targets and budgets were achievable and to determine an appropriate mix of measures and delivery strategies to include in the EE&C Plan. In addition, PPL Electric Utilities engaged The Cadmus Group LLC ("Cadmus") to conduct a cost-effectiveness analysis of the EE&C Plan.[6]

This process enabled PPL Electric Utilities to identify overarching programs that target each key customer segment and encompass more granular paths for participation in the form of program components. These program components are based on measure bundles or delivery strategies so customers can participate at the level that best meets their needs without having to face administrative hurdles or participation barriers.

PPL Electric Utilities' sector-level programs include four Residential Program components, one Low-Income Program component, and four Non-Residential Program components (*i.e.*, two small C&I and two large C&I), together comprising the Phase IV EE&C portfolio. PPL Electric Utilities will continue to administer its programs, support its trade allies and strategic partners, and track and report its portfolio performance at the more granular component level. To customers, component-level administrative and delivery designations will be invisible, and the benefits of a holistic approach to efficiency will be clearly articulated. The portfolio is projected to be cost-effective and to comply with Act 129 targets, at or below the Company's budget cap.

To further support achievement of its Phase IV energy efficiency and conservation goals, PPL Electric Utilities has several additional portfolio strategies:

- ***Continue to deliver programs that optimize cost efficiency and deliver the greatest value to ratepayers.*** The Phase IV programs have a slightly higher acquisition cost than the Phase III programs,[7] primarily due to the loss of residential lighting opportunities, which were some of the least expensive savings. To address this, PPL Electric Utilities will continue to seek opportunities to reduce and control program administrative costs:
    - Offer comprehensive programs that focus on cost-effective measures with high savings and reasonable NTG ratios to all customer segments throughout the service territory.
    - Emphasize energy efficiency measures with coincident peak demand benefits to achieve demand reduction goals.

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[6] Cadmus is a 100% employee-owned consulting firm. For more than 30 years, Cadmus has been helping organizations forecast energy demand and trends, design programs and portfolios to capture the energy savings, and assess achievement of energy savings and demand reduction.

[7] The program acquisition cost is defined as PPL Electric Utilities' total cost to implement the program (including administration and incentives) divided by the annual kilowatt-hours saved.

  - Create simple incentive applications in multiple submission formats (such as hard copy mail-in, online, and tablet entry by trade allies).
  - Continue to focus on providing personalized and flexible customer service to help ensure customers receive timely feedback to questions, information and educational resources that are directly relatable and immediately applicable, and rapid rebate processing.

- ***Work directly with conservation service providers ("CSPs") that have institutional knowledge of PPL Electric Utilities' market and implementation environment***. These CSPs will implement comprehensive residential, low-income, and non-residential (small C&I and large C&I) programs and enable PPL Electric Utilities to accomplish several goals:
  - Provide a smooth a transition from Phase III to Phase IV programs to maximize customer satisfaction and allow seamless distribution of incentives (and savings) for projects that straddle both phases.[8]
  - Create economies of scale associated with cross-program functions (such as the customer call center, rebate processing, market analytics, marketing, website development, and program management).
  - Facilitate integrated customer engagement across all programs to improve the effectiveness of marketing, customer communications, and cross-promotion of efficiency opportunities, thereby increasing the extent of participation and project comprehensiveness and reducing outreach and recruitment costs.
  - Provide journey mapping to help identify pain points for PPL Electric Utilities' customers , so it can create an enhanced and effortless customer experience.
  - Journey mapping will enable PPL Electric Utilities to segment its customers based on distinct characteristics and create customized approaches to their needs.
  - Implement contracts that tie payments to CSP performance (in terms of costs and savings), ensuring that these providers are accountable for successful program delivery.
  - Continue to provide automated rebate applications and processing, QA/QC, performance tracking, reporting, and other functions where practical.

- ***Emphasize comprehensive solutions for all customers.*** PPL Electric Utilities' redesigned portfolio will accomplish three tasks:
  - Offer multiple savings opportunities (in terms of measures, end uses, delivery channels, and incentive mechanisms) in each program.

[8] The Company uses the in-service date of the project to determine whether to provide the funding under Phase III or Phase IV.

  - Provide customers with high-quality energy efficiency education through both digital and traditional print outreach and engagement channels as well as through direct communications with trade allies, CSPs, strategic partners, and PPL Electric Utilities' staff.
  - Promote the benefits of multiple-measure, comprehensive projects (whole-home and whole-building approaches).

- ***Ensure that program staff are effective, knowledgeable, and accountable to defined performance metrics.*** Engaged and knowledgeable staff are essential to successful programs. To this end, PPL Electric Utilities is committed to ensuring several qualities about its staff:
  - Have a full understanding of all aspects of their programs and the markets in which they operate.
  - Adhere to program-specific performance metrics to track, monitor, and analyze program success.
  - Benchmark program performance metrics against similar Pennsylvania and national programs.
  - Maintain effective relationships with trade allies through frequent communications and by striving to understand trade ally practices and business needs.
  - Possess a strong knowledge of customer preferences, behavioral triggers, motivations, and barriers.

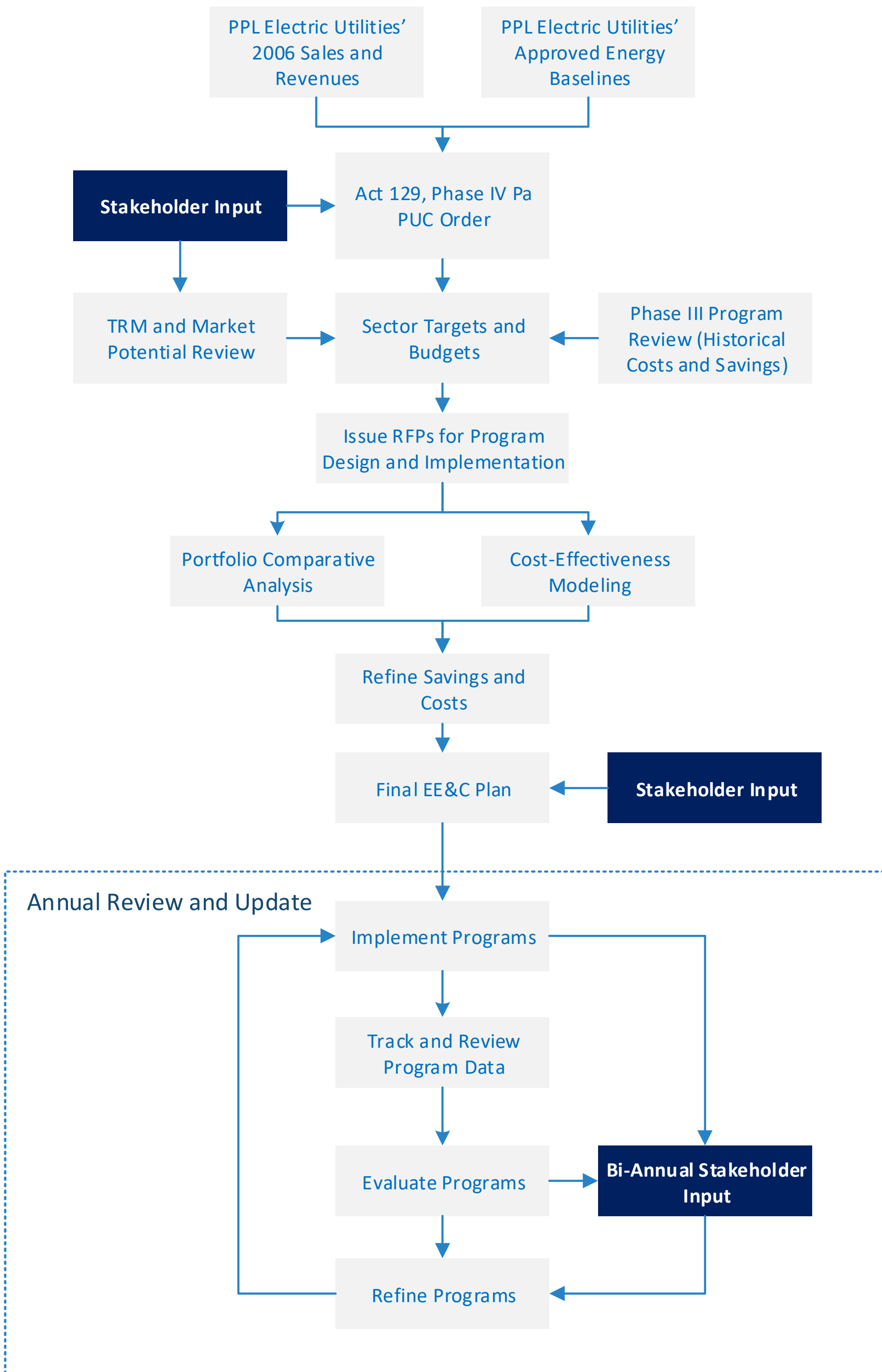
1.2 Plan Development Process and Key Assumptions

PPL Electric Utilities began developing the EE&C Plan shortly after the Pa PUC entered the Tentative Implementation Order on March 12, 2020, at Docket No. M-2020-3015228. After more than a decade of offering Act 129 programs, PPL Electric Utilities has cultivated an experienced professional staff of program managers who work closely with CSPs, trade allies, customers, and stakeholders to seek their input on programs and measures.

The Company designed the Plan to comply with Act 129's requirements and the Commission's Implementation Order and to draw on the Phase IV market potential studies (for energy efficiency and demand response), experience from Phase I through Phase III, stakeholder input, and the RFP responses from program implementers who informed the overarching strategy.

To achieve the Commission's energy savings targets within the required budget caps, PPL Electric Utilities looked to the implementation market for solutions. By issuing competitive RFPs requesting innovative strategies from potential implementation contractors, the Company was able to identify an optimal mix of measures and programs that can achieve significant energy savings at a comparatively low acquisition cost. Figure 1 summarizes PPL Electric Utilities' process for developing the Plan and ensuring continuous improvement.

Figure 1. Process for Developing the Plan



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1.2.1 Principles Guiding Development of the Plan

PPL Electric Utilities has a longstanding commitment to energy efficiency and helping customers use electricity wisely and save on their electricity bills. The Company relies on several principles to guide development of the measures, programs, and implementation strategies in its portfolio:

- ***Customer focus.*** During Phase I through Phase III, PPL Electric Utilities has consistently focused on the customer and improved its programs to meet changing customer and market preferences. The Company designed its portfolio to educate and empower customers to take actions that save energy and money by providing personalized customer service, accelerated rebate processing, and clear and easy-to-understand program information on its website and program applications. Phase IV will continue to build on the virtual strategies the Company began in Phase III for the sake of customer safety and convenience. Through the Plan, PPL Electric Utilities offers a diverse range of information, education, and incentives to help its customers engage in energy efficiency and make informed, sustainable choices that will have a lasting impact on their energy costs.
- ***Compliance with Act 129.*** Consistent with the requirements of Act 129 and the Implementation Order, PPL Electric Utilities developed a portfolio of cost-effective energy efficiency programs that consider stakeholders' input and will generate the energy savings and peak demand reductions needed to meet the goals required by Act 129 and the Commission. The Plan is designed to exceed PPL Electric Utilities' compliance targets by approximately 44% MWh[9] and 10% MW and within the budget cap.
- ***Flexibility to address changing market conditions.*** PPL Electric Utilities designed its Plan to achieve its EE&C targets within its designated budget cap even as market conditions and customer preferences change over time. The Company achieves this objective through specific actions:
    - Rely on a diverse set of proven, market-ready, and cost-effective energy efficiency (electric) technologies and conservation strategies.
    - Use an overarching program structure and CSPs that will help achieve economies of scale by consolidating program component-level administrative and delivery functions and by encouraging customer participation in multiple program components through effective cross-promotion and having a single view of the customer across all measures and components.
    - Provide multiple program options and controls that help PPL Electric Utilities manage the pace of programs (to achieve the savings and costs in the EE&C Plan) and reduce the frequency of formal EE&C Plan changes. These include modifying marketing tactics, adjusting incentive levels within specified ranges,

[9] This includes 200,000 MWh/year of carryover savings from Phase III (28% without carryover savings).

offering different measures at different times, and offering multiple delivery channels.

- ***Effective program design.*** To design these programs, the Company relied on proven, cost-effective technologies and delivery strategies and based its participation, savings, and cost projections on well-researched market potential data, historical performance, and analysis of regional and national trends in similar markets.
- ***Equitable programs.*** PPL Electric Utilities examined Phase III evaluation findings to identify the priorities, opportunities, and challenges faced by the variety of customer sectors, trade allies, and market partners that its programs serve. The Company designed the EE&C Plan to prioritize equity by capitalizing on identified opportunities and by mitigating challenges for disadvantaged customers. The Plan includes a range of measures and programs designed to meet the needs of all of PPL Electric Utilities' customers, with savings and costs distributed equitably across all customer sectors.
- ***Market acceptance.*** PPL Electric Utilities designed its Plan to stimulate market acceptance and installation of energy efficient technologies. The Company works closely with retailers, distributors, contractors, and other trade allies to encourage them to stock, specify, and promote energy efficient technologies. The EE&C Plan includes provisions for training and education; outreach to trade allies, distributors, and stakeholders; and an active awareness campaign to increase customer knowledge about and acceptance of the benefits of energy efficient equipment and to keep them informed about new advances in energy efficient products. PPL Electric Utilities will continue to encourage the wide availability of program-eligible energy efficiency measures and to support increasing demand for energy efficient products and equipment. The Company will monitor and adjust its programs' performance as required if programs are not successful or if NTG ratios are low.
- ***Commitment to low-income customers.*** The EE&C Plan continues PPL Electric Utilities' commitment to helping low-income customers reduce their electricity consumption. PPL Electric Utilities will continue its successful Low-Income Assessment component.

1.2.2 Developing the Portfolio

In its RFPs, the Company challenged bidders to propose a portfolio of program components that could achieve the required savings targets within the allocated budget. Specifically, each program must be designed to achieve verified gross energy savings and peak demand reduction that is approximately proportional to its customer mix and based on historical program performance over the five-year Plan period and to capture at least 15% of the total cumulative savings each year. Additionally, the Company required each program to meet its savings objective at a proportional total direct program cost (including incentives and non-incentives incurred by the CSP and excluding the allocation of common, portfolio-level costs) and overall cost (including common costs) within its overall budget cap. See Section 2 for program costs and savings detail in Table 10.

PPL Electric Utilities further directed its CSPs to adhere to its overall guiding principles and to comply with additional design features tailored to each customer sector, as described below.

- Residential Program
  - Achieve acceptable NTG ratios as determined by PPL Electric Utilities, its evaluator, or the SWE.
  - Wherever possible, be cost-effective as determined by the Pennsylvania 2021 TRC test method.
  - Offer diverse and comprehensive measure choices to all residential customers across PPL Electric Utilities' entire service territory.
  - Achieve high customer satisfaction (where at least 85% of customers rate themselves as *very satisfied* or *satisfied*).
- Low-Income Program
  - Offer a low-income component at no cost to households that are at or below 150% of the FPIG according to the U.S. Department of Health and Human Services in January of each program year.[10]
  - Provide a variety of energy efficiency measures and strive to maximize savings, within budget constraints, from direct install measures.
  - Achieve high customer satisfaction where at least 85% of customers rate themselves as *very satisfied* or *satisfied*).
  - Provide a broad selection of energy efficiency measures to qualifying low-income households.
  - Address renters and owners of single-family homes, multifamily buildings that are in the residential customer class and are occupied by low-income customers, and manufactured homes.
  - Offer information to Low-Income Assessment participants regarding PPL Electric Utilities' other universal service and energy conservation programs, such as the Company's Customer Assistance Program (*i.e.*, OnTrack).[11]
- Non-Residential Program
  - Achieve high customer satisfaction (where at least 85% of customers rate themselves as *very satisfied* or *satisfied*).
  - Offer a broad selection of energy efficiency measures across multiple end uses as well as to both the small C&I and large C&I customer segments across PPL Electric Utilities' service territory.

[10] The Low-Income Program is not required to be cost-effective (per the 2021 TRC Test Order) as long as the EE&C portfolio overall is cost-effective.

[11] Through its OnTrack Program, PPL Electric Utilities offers reduced monthly payments to assist low-income customers with account balances in arrears.

- Achieve acceptable NTG ratios as determined by PPL Electric Utilities, its evaluator, or the SWE.
- Be cost-effective as determined by the TRC test method.

PPL Electric Utilities worked with Cadmus to model program- and portfolio-level cost-effectiveness based on projected peak load reductions, energy savings, and costs (such as delivery, incentives, incremental measure, and participant costs). PPL Electric Utilities provided the lifecycle costs, savings, and avoided cost benefits, enabling Cadmus to compute the cost-effectiveness from a TRC perspective.[12] The key assumptions used to estimate energy savings and peak demand reduction, calculate costs, and determine cost-effectiveness are listed in Section 8.

Finally, PPL Electric Utilities iteratively adjusted the expected number of participants and customer incentive levels for each program component and for each measure to balance the portfolio, meet all savings targets, increase cost-effectiveness, and stay within the budget for each customer sector.

1.3 Summary Tables of Portfolio Savings Goals, Budgets, and Cost-Effectiveness

The tables in this section summarize the estimated savings, budget, and cost-effectiveness for PPL Electric Utilities' entire portfolio. The tables are numbered sequentially, with the formats matching those provided in the EE&C Plan Template issued by the Commission on September 9, 2020, at Docket No. M-2020-3015228. Each table caption includes a reference to the corresponding table number provided in the EE&C Plan Template:

- Table 3. Pa PUC Table 1 - Portfolio Summary of Lifetime Costs and Benefits of Energy Efficiency Measures
- Table 4. Pa PUC Table 2 - Summary of Portfolio Energy and Demand Savings (Meter-Level)
- Table 5. Pa PUC Table 3 - Summary of Portfolio Energy and Demand Savings (System-Level)
- Table 6. Pa PUC Table 4 - Summary of Portfolio Costs

Table 3. Pa PUC Table 1 - Portfolio Summary of Lifetime Costs and Benefits of Energy

Portfolio	Total Discounted Lifetime Costs ($000)[1]	Total Discounted Lifetime Benefits ($000)	Total Discounted Net[2] Lifetime Benefits ($000)	Cost-Benefit Ratio (TRC)
Residential (exclusive of Low-Income)[3]	$97,641	$98,235	$593	1.01
Low-Income	$43,976	$21,155	$(22,821)	0.48
Commercial/Industrial Small	$245,746	$367,754	$122,008	1.50
Commercial/Industrial Large	$396,663	$414,347	$17,684	1.04
Total	**$784,026**	**$901,490**	**$117,464**	**1.15**

[1] Discounted common costs are included in the appropriate sector totals. See Table 55 (Pa PUC Table 11) for the allocation of common costs.
[2] "Net" refers to the arithmetic difference between the previous two columns. It does not refer to net verified savings.
[3] The Implementation Order disallowed the inclusion of low-income participation in standard, non-low-income-specific residential programs in the calculation of savings towards the low-income carve-out.

[12] The calculation methods and assumptions used for estimating all program costs are provided in Appendix C.

Table 4. Pa PUC Table 2 - Summary of Portfolio Energy and Demand Savings

MWh Saved for Consumption Reductions (Meter-Level)	PY13		PY14		PY15		PY16		PY17		Total	
	1st-Year MWh	Lifetime MWh	1st-Year MWh	Lifetime MWh	1st-Year MWh	Lifetime MWh	1st-Year MWh	Lifetime MWh	1st-Year MWh	Lifetime MWh	1st-Year MWh	Lifetime MWh
Baseline[1]	38,214,368		38,214,368		38,214,368		38,214,368		38,214,368		38,214,368	
Residential Sector (*exclusive of Low-Income*) **– Cumulative Projected Portfolio Savings**	38,050	397,724	75,377	788,944	106,735	1,092,123	135,900	1,369,165	163,896	1,637,331	163,896	1,637,331
Low-Income Sector – Cumulative Projected Portfolio Savings	12,247	75,631	25,132	155,192	38,658	238,700	52,183	322,207	64,430	397,838	64,430	397,838
Commercial/Industrial Small Sector – Cumulative Projected Portfolio Savings	103,668	1,413,687	215,698	2,949,905	337,035	4,631,436	454,890	6,266,471	574,229	7,926,062	574,229	7,926,062
Commercial/Industrial Large Sector – Cumulative Net Weather Adjusted Savings	138,124	1,976,773	284,686	4,080,107	458,449	6,596,092	629,601	9,077,539	800,239	11,552,208	800,239	11,552,208
EE&C Plan Total – Cumulative Projected Savings	292,089	3,863,816	600,893	7,974,148	940,878	12,558,350	1,272,574	17,035,383	1,602,794	21,513,439	1,602,794	21,513,439
Estimated Phase III Carryover Savings											200,000	
Total Cumulative Projected Savings Phase IV + Estimated Phase III Carryover Savings	292,089		600,893		940,878		1,272,574		1,602,794		1,802,794	
EE&C Plan Total – Percentage of Target to be Met[2]	23%		48%		75%		102%		128%		144%	
Percent Reduction from Baseline	1%		2%		2%		3%		4%		5%	
Commission-Identified Goal[2]											1,250,157	
Percent Savings due to Portfolio Above or Below Commission-Identified Goal											44%	

[1] As defined in the Implementation Order.
[2] The Implementation Order directed that electric distribution companies ("EDCs") achieve at least 15% of the target amount in each program year.

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Table 5. Pa PUC Table 3 - Summary of Portfolio Energy and Demand Savings

MW Saved for Consumption Reductions (System-Level)	PY13		PY14		PY15		PY16		PY17		Total[3]	
	1st-Year MW	Lifetime MW	1st-Year MW	Lifetime MW	1st-Year MW	Lifetime MW	1st-Year MW	Lifetime MW	1st-Year MW	Lifetime MW	1st-Year MW	Lifetime MW
Baseline[1]												
Residential Sector (*exclusive of Low-Income*) **– Cumulative Projected Portfolio Savings**	8.30	8.30	16.48	16.48	23.59	23.59	30.36	30.36	36.96	36.96	36.96	36.96
Low-Income Sector – Cumulative Projected Portfolio Savings	1.86	1.86	3.83	3.83	5.89	5.89	7.95	7.95	9.82	9.82	9.82	9.82
Commercial/Industrial Small Sector – Cumulative Projected Portfolio Savings	17.16	17.16	35.44	35.44	55.06	55.06	74.10	74.10	93.37	93.37	93.37	93.37
Commercial/Industrial Large Sector – Cumulative Net Weather Adjusted Savings	19.59	19.59	40.26	40.26	64.15	64.15	87.64	87.64	111.05	111.05	111.05	111.05
EE&C Plan Total – Cumulative Projected Savings	46.92	46.92	96.00	96.00	148.69	148.69	200.05	200.05	251.20	251.20	251.20	251.20
EE&C Plan Total – Percentage of Target to be Met[2]	20%	20%	42%	42%	65%	65%	87%	87%	110%	110%	110%	110%
Percent Reduction from Baseline												
Commission-Identified Goal[1]											229	229
Percent Savings due to Portfolio Above or Below Commission-Identified Goal											10%	10%

[1] As defined in the Implementation Order.
[2] The Implementation Order directed that EDCs achieve at least 15% of the target amount in each program year.
[3] Demand savings in this table are at generation.

Table 6. Pa PUC Table 4 - Summary of Portfolio Costs[1]

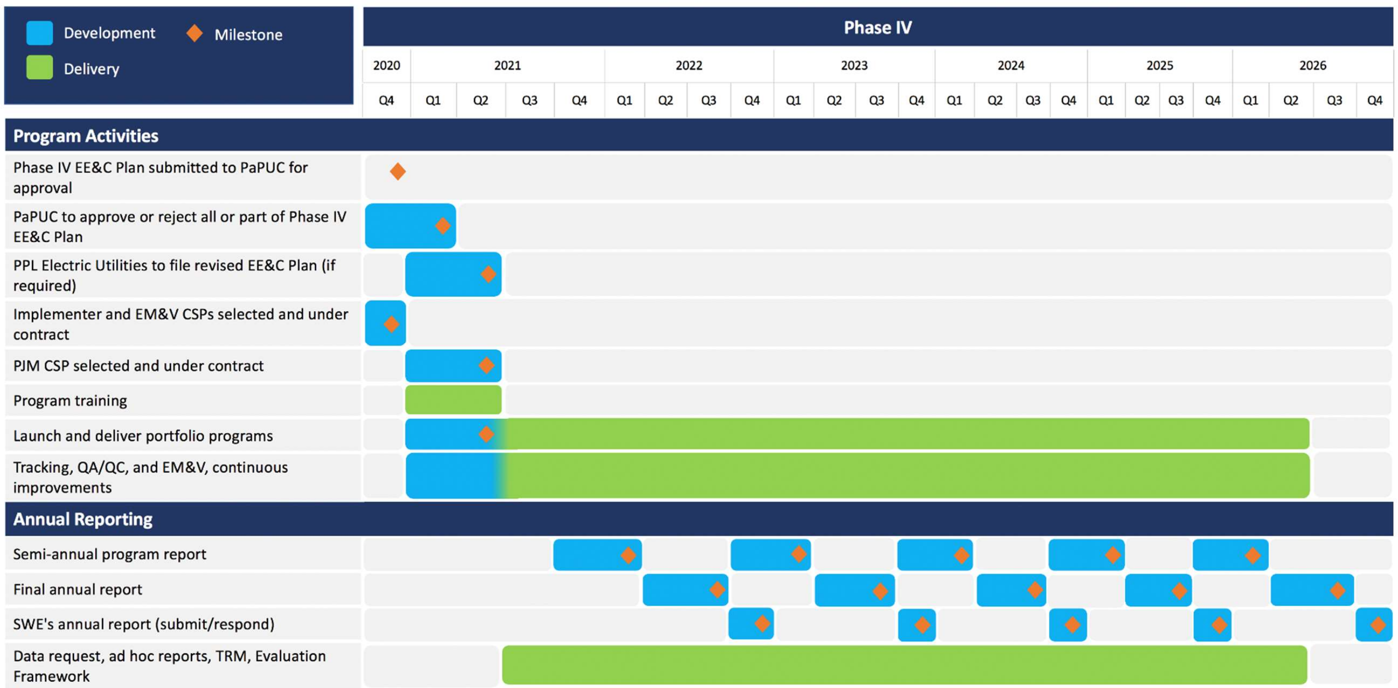
Sector	PY13		PY14		PY15		PY16		PY17	
	$000	%	$000	%	$000	%	$000	%	$000	%
Residential Portfolio Annual Budget	$13,479	22%	$13,639	21%	$12,701	20%	$12,453	20%	$12,475	20%
Low-Income Portfolio Annual Budget	$8,063	13%	$8,380	13%	$8,697	14%	$8,697	14%	$8,063	13%
Commercial/Industrial Small Portfolio Annual Budget	$14,966	24%	$15,662	25%	$15,638	25%	$15,225	24%	$15,348	25%
Commercial/Industrial Large Portfolio Annual Budget	$16,696	27%	$17,413	27%	$17,456	28%	$17,180	28%	$17,162	28%
Common Costs[2]	$8,620	14%	$8,620	14%	$8,620	14%	$8,620	14%	$8,620	14%
Total Portfolio Annual Budget	**$61,824**	**100%**	**$63,715**	**100%**	**$63,112**	**100%**	**$62,174**	**100%**	**$61,667**	**100%**

[1] Values in this table are nominal.
[2] Includes $5 million of SWE costs.

1.4 Summary of Program Implementation Schedule

Table 7 provides a visual summary of PPL Electric Utilities' implementation schedule in accordance with the Commission's EE&C Plan Template.

Table 7. PPL Electric Utilities Implementation Schedule



1.5 Strategy to Acquire 15% of Consumption Reduction and Peak Demand Reduction Target Each Program Year

Consistent with the Implementation Order, PPL Electric Utilities designed its programs to achieve at least 15% of the total consumption reduction target in each program year. The Company directed its CSPs to develop implementation strategies that also reflect this objective. The EE&C Plan includes many components and measures that will continue from Phase III. PPL Electric Utilities has significant experience with these measures and programs and believes it can control the programs' pace, as it has in previous phases. In addition, PPL Electric Utilities designed the EE&C Plan to focus on energy efficiency measures that provide coincident peak demand reduction opportunities.

PPL Electric Utilities will monitor actual performance, adjusting marketing, advertising, incentive levels, and eligible measures to manage participation as necessary to achieve at least 15% of its portfolio target annually.

1.6 Summary Description of the Programs or Measure Categories from which the Electric Distribution Company (EDC) Intends to Nominate Peak Demand Reduction into PJM's Forward Capacity Market (FCM), along with the Projected Megawatt Totals to be Bid by Year

Per the Implementation Order, PPL Electric Utilities will rely on energy efficiency measures with coincident peak demand reduction potential, such as lighting and cooling, in all its sector-level programs to achieve its annual and total peak demand reduction targets. Relying on this strategy will help the Company deliver consistent long-term peak demand reduction benefits at a lower cost than through targeted demand response programs.

PPL Electric Utilities will solicit bids from qualified CSPs to implement the nomination of a portion of its peak demand reduction as a capacity resource into PJM Interconnection LLC's ("PJM") Forward Capacity Market ("FCM"). At that time, PPL Electric Utilities will identify eligible peak demand reduction measures for nomination for each program. PPL Electric Utilities will own the forward capacity rights and the ability to bid this capacity into the PJM FCM for any energy efficiency project, measure installed, or product purchased, that includes an upstream/downstream/midstream discount, direct discount, rebate or incentive paid, or free measures installed or provided by PPL Electric Utilities, their representative CSP, partners, trade allies or distributors. By no later than January 1, 2022, PPL Electric Utilities will provide the other Joint Petitioners with details on the selected CSP's plan to nominate that capacity resource into the FCM, including how the CSP will ensure that the Company and its ratepayers are not exposed to the potential risk of penalties. At the Company's Act 129 EE&C stakeholder meetings throughout Phase IV, PPL Electric will provide updates on the nomination of this capacity resource.

1.7 Strategy to Manage EE&C Portfolio and Engage Customers and Trade Allies

For its implementation strategy, PPL Electric Utilities will rely on a broad range of CSPs, employees, trade allies, community agencies, stakeholders, and other entities engaged in energy efficiency to promote, deliver, and support the effective deployment of programs.

PPL Electric Utilities will use two program-level CSPs—one CSP will implement the residential and non-residential (small C&I and large C&I) programs and one CSP will deliver the low-income program—to deliver its portfolio. These CSPs will have the primary responsibility to design and deliver the EE&C programs, including marketing, customer care, application and rebate processing, and development and maintenance of effective trade ally networks, while jointly developing marketing plans with PPL Electric Utilities. In addition, PPL Electric Utilities will provide some overarching marketing and customer care for EE&C programs. PPL Electric Utilities will also enhance its marketing efforts and customer experience by developing an energy analyzer.

PPL Electric Utilities based its implementation strategy on an assessment of features needed to engage customers in EE&C programs and encourage them to take energy efficient actions. The engagement approach involves active, ongoing outreach to customers and trade allies. The Company follows several key strategies:

- Conduct annual EM&V to obtain several objectives:
    - Identify marketing channels and tactics most likely to elicit responses from customers and trade allies.
    - Understand drivers, motivations, and challenges to implementing energy efficiency upgrades among specific customer segments and related to common customer characteristics.
    - Develop messaging strategies matched to key customer and trade ally drivers.
    - Assess customer response to programs and evaluate whether programs are meeting customer needs.
- Offer a range of voluntary customer programs that provide tangible benefits.
- Emphasize customer service among PPL Electric Utilities staff, CSPs, and trade allies.
- Evaluate customer satisfaction and response.
- Modify programs as necessary to improve programs and customer satisfaction.
- Coordinate with trade allies, community-based organizations, and other local market participants through outreach, training, and co-marketing so that these partners are aware of PPL Electric Utilities' programs, can effectively articulate program features and benefits to potential customers, and can support customers in their decision to take energy efficiency actions.

In addition to CSPs' and PPL Electric Utilities' marketing, the success of Phase IV programs will depend on trade allies and other market partners to engage customers, promote programs, evaluate projects, and stock and install energy efficient equipment. The Company's objective is to strike a reasonable balance of costs, ratepayer value, customer choice, quality service, and energy and capacity savings. If necessary to achieve savings objectives, the Company will offer incentives to trade allies that promote, stock, and install efficient measures included in the EE&C Plan.

1.8 Data Management, Quality Assurance, and Evaluation Processes

The following sections describe the Company's approach to implementing data management, QA/QC, and evaluation processes.

1.8.1 Data Management

Each CSP's tracking system and PPL Electric Utilities' tracking database allow for program activities to be tracked daily. These systems generate reports and queries to allow for ongoing monitoring, management, analysis, and reporting of activities.

1.8.2 Quality Assurance and Quality Control

During planning and design, PPL Electric Utilities will continue to follow QA procedures to promote consistency and avoid errors. QC activities and inspection points during the implementation and evaluation phases help guide the correction of errors and identification of areas for improvement. Together, QA and QC will improve program performance.

PPL Electric Utilities will employ QA/QC procedures for Act 129 at various levels of program implementation, including CSP recruitment and training, data tracking, program operations, and inspections:

- Anticipate, detect, and prevent problems or errors rather than reacting to them.
- Strive to perform work correctly the first time.
- Establish screening and qualification protocols to confirm that qualified individuals perform all work functions.
- Train staff, CSPs, and trade allies to maintain current knowledge and skills needed for their positions.
- Document data collection and QA/QC protocols and conduct a full review to confirm that the proper data are collected consistently, resources are allocated appropriately, and program performance can be measured accurately.
- Conduct adequate planning, coordination, supervision, and technical direction.
- Define and develop a clear understanding of job requirements and procedures.
- Conduct post-installation inspections of an appropriately sized random sample of participants to confirm that the program-reported measures were installed, followed best practices and procedures, and function as expected.

A detailed description of PPL Electric Utilities' QA/QC protocols and standards is provided in Section 6.

1.8.3 Evaluation Processes

PPL Electric Utilities' EM&V CSP will conduct ongoing and annual evaluations of each program in compliance with all Pa PUC requirements and the Evaluation Framework. As part of this process, the EM&V CSP will develop an Evaluation Plan that describes the EM&V scope of work, objectives, methods, and activities for evaluating program impacts, processes, cost-effectiveness, net savings analysis, and QA/QC protocols.

The EM&V CSP will develop this Evaluation Plan in accordance with Evaluation Framework requirements and submit it to the SWE for review and approval. PPL Electric Utilities and the EM&V CSP will review (at least annually) and may update the Evaluation Plan if changes are made to programs, participation levels, savings levels, or Act 129 evaluation requirements.

The EM&V CSP will conduct evaluations annually, focusing the impact evaluation on developing accurate estimates of the programs' actual savings based on protocols developed by the SWE and the Commission, as summarized in the Evaluation Framework and the Pennsylvania Technical Reference Manual ("TRM"), as well as in the Pa PUC's Implementation Order. The impact evaluation also will include an assessment to confirm that all data required for the impact evaluation are collected (evaluability assessment). For the process evaluation, the CSP will focus on qualitative assessments of the programs' design, operation, and implementation.

The CSP will also conduct annual evaluations to determine the cost-effectiveness of the programs and portfolio using the TRC test method specified by the Commission in its 2021 TRC Test Order.

Finally, the CSP will conduct net savings evaluations as indicated by the Evaluation Framework and outlined in the Evaluation Plan to determine the net verified savings of each program. Net savings include the effects of free ridership and spillover. The EM&V CSP may also propose to conduct market effects studies to understand changes in the market and to further inform net savings. Guidance for net savings analyses are provided in the Evaluation Framework, with periodic updates from the SWE and the NTG Working Group.

Over the life of the Phase IV EE&C Plan, PPL Electric Utilities expects to revisit and revise a number of assumptions to reflect updated market conditions. The Company will submit required revisions to the Commission for review and approval in accordance with the Commission's requirements for revising EE&C Plans.

1.9 Cost Recovery Mechanism

Act 129 directs each EDC to establish a reconcilable cost recovery tariff mechanism in accordance with 66 Pa. C.S. § 1307 and to include this mechanism in its EE&C Plan (66 Pa. C.S. § 2806.1(b)(1)(i)(H), (k)(1)).

2 Energy Efficiency Portfolio/Program Summary Tables and Charts

The following tables provide a quantitative overview of the Phase IV Plan. Note that tables in this section are numbered sequentially, but the applicable table formats are based on those provided in the Commission's EE&C Plan Template (as noted below). The table captions include references to the corresponding table numbers provided in the EE&C Plan Template.

Tables in this section are the following:

- Table 8. Pa PUC Table 5 – Residential, C&I Small, and C&I Large Portfolio Summaries
- Table 9. Pa PUC Table 6 – Budget and Parity Analysis
- Table 10. Summary of Costs and Savings by Program and Customer Sector

Table 8. Pa PUC Table 5 - Residential, C&I Small, and C&I Large Portfolio Summaries

Program Name	Component Name	Program Market	Program Two-Sentence Summary	Program Years Operated	Lifetime MWh Savings	Lifetime MW Savings	Percentage of Portfolio Resource Savings (MWh% and MW%)	
Residential Portfolio Program (*exclusive of Low-Income)*	Appliance Recycling	All customers (primarily residential)	Free pick up and recycling of inefficient refrigerators, freezers, room air conditioners and possibly dehumidifiers. Incentive paid for each eligible appliance.	PY13 - PY17	251,392	12	1%	5%
	Efficient Lighting – Specialty Bulbs	All customers (primarily residential)	Upstream retail promotion and incentives applied to eligible light emitting diode ("LED") specialty bulbs. Other distribution channels include online, mail, directly to customers, welcome kits, etc.	PY13 - PY17	305,678	3	1%	1%
	Energy Efficient Homes	Existing and new residential single family and multifamily homes	Offers rebates on a wide range of energy efficient measures for retrofit and new construction applications.	PY13 - PY17	754,102	16	4%	7%
	Student Energy Efficient Education	Residential customers: students and teachers	Energy efficiency education targeting primary and secondary grades, including classroom presentations, curriculum, and energy efficiency kits.	PY13 - PY17	326,158	3	2%	1%
	Home Energy Efficiency Report[1]	Residential single and multifamily	Education, online home energy surveys and Home Energy Reports comparing energy use to other customers in PPL Electric Utilities' service territory, and offering energy efficiency and demand response tips.	PY15 - PY17	-	-	0%	0%
	Totals for Residential Sector				1,637,331	34	8%	14%
Low-Income Sector Program	Low-Income Assessment	Income-qualified single family, multifamily and manufactured homes	Offers a range of free direct install energy efficiency measures to customers whose incomes are at or below 150% of FPIG.	PY13 - PY17	397,838	9	2%	4%

Program Name	Component Name	Program Market	Program Two-Sentence Summary	Program Years Operated	Lifetime MWh Savings	Lifetime MW Savings	Percentage of Portfolio Resource Savings (MWh% and MW%)	
	Low-Income Assessment	Small C&I	Offers a range of free direct install energy efficiency measures in the tenant units of low-income residents living in master-metered multifamily buildings in the Small C&I rate class.	PY13 – PY17	58,681	0.5	0%	0%
	Totals for Low-Income Sector[2]				456,519	10	2%	4%
Commercial/Industrial Small Portfolio Program	SCI- Custom and Efficient Equipment	Small C&I	Provides rebates/incentives for a list of qualified energy efficiency measures and custom measures not included in PPL Electric Utilities' other programs. Includes combined heat and power ("CHP"), process upgrades, retro-commissioning, and other measures.	Custom PY13 - PY17	2,382,043	23	11%	10%
				Efficient Equipment PY13 - PY17	5,485,338	63	25%	27%
	Totals for C&I Small Sector[3]				7,867,381	85	37%	36%
Commercial/Industrial Large Portfolio Program	LCI-Custom and Efficient Equipment	Large C&I	Provides rebates/incentives for a list of qualified energy efficiency measures and custom measures not included in PPL Electric Utilities' other programs. Includes CHP, , process upgrades, retro-commissioning, and other measures.	Custom PY13 - PY17	8,152,152	68	38%	29%
				Efficient Equipment PY13 - PY17	3,400,056	38	16%	16%
	Totals for C&I Large Sector				11,552,208	107	54%	45%
Totals for Plan					21,513,439	235	100%	100%

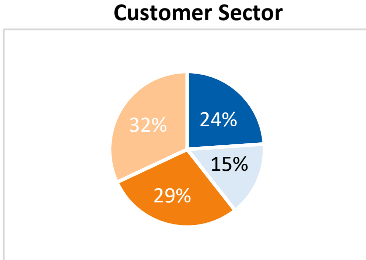
[1] Although PPL Electric Utilities does not currently project participation for HERs in the Phase IV Plan, the Company may decide to offer HERs within the Phase IV period, within the approved budget, and therefore includes the HERS component in this table.
[2] Includes savings from master-metered multifamily buildings with low-income occupants. These savings count toward the low-income compliance target but the program costs and savings are accounted for under the customer sector corresponding to the rate class of the building's meter in assessing program cost-effectiveness. The total will not match Table 10.
[3] Excludes savings from master-metered multifamily buildings with low-income occupants. These savings count toward the low-income compliance target but the program costs and savings are accounted for under the customer sector corresponding to the rate class of the building's meter in assessing program cost-effectiveness. The total will not match Table 10.

Table 9. Pa PUC Table 6 - Budget and Parity Analysis

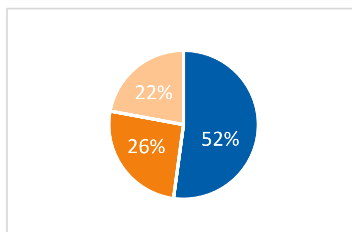
Customer Sector	Phase IV EE&C Budget (inclusive of allocated common cost)	% of Total EDC EE&C Budget	% of EDC Total Annual Revenue	% of EDC Total MWh Sales
Residential Sector (*exclusive of Low-Income*)	$74,769,386	24%	52%	39%
Low Income Sector[1]	$48,386,210	15%		
Residential Subtotal	$123,155,596	39%	52%	39%
Commercial/Industrial Small Sector	$89,392,278	29%	26%	39%
Commercial/Industrial Large Sector	$99,943,535	32%	22%	22%
Non-Residential Subtotal	$189,335,813	61%	48%	61%
EDC TOTAL	**$312,491,409**	**100%**	**100%**	**100%**

[1] Customers in the Low-Income sector are all customers in the residential customer class. Therefore, the Low-Income sector's figures are included in the Residential part of this table.

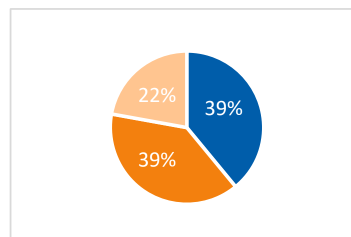
% Budget by Customer Sector



% Revenue by Customer Sector



% MWh Sales by Customer Sector



Residential Residential Low Income C&I Small C&I Large

Table 10. Summary of Costs and Savings by Program and Customer Sector[1]

Component	Residential			Low-Income			Small C&I			Large C&I			Total Cost ($1000)	Total MWh/yr. Reduc-tion[2,3,10]	$/kWh[4]	Total MW Reduc-tion[2,5]	$/kW[4,8]	TRC Ratio[9]
	Costs ($1000)	Savings MWh/yr[2]	Savings MW/yr[2]	Costs ($1000)	Savings MWh/yr[2]	Savings MW/yr[2]	Costs ($1000)	Savings MWh/yr[2]	Savings MW/yr[2]	Costs ($1000)	Savings MWh/yr[2]	Savings MW/yr[2]						
Total Residential Program	$64,747	163,896	37										$64,747	163,896	$0.40	37	$1,752	1.11
Total Low-Income Program				$41,900	64,430	10	$2,000	3,912	1				$43,900	68,342	$0.64	10	$4,245	0.56
Total Non-Residential Program							$74,838	570,317	93	$85,906	800,239	111	$160,745	1,370,556	$0.12	204	$788	1.27
Total - Direct Program Costs	**$64,747**			**$41,900**			**$76,838**			**$85,906**			**$269,391**					**1.21**
Percent of Total Direct Costs[6]	24.03%			15.55%			28.52%			31.89%			100%					
Common Costs Allocation[7]	$10,023			$6,486			$12,554			$14,037			$43,100					
TOTAL ESTIMATED EE&C PLAN COST[7]	**$74,769**			**$48,386**			**$89,392**			**$99,944**			**$312,491**					**1.15**
Estimated SWE Cost													**$5,000**					
Total Cost excluding SWE Costs													**$307,491**					
Total Estimated Phase IV MWh/Yr Reduction[3]		163,896			64,430			574,229			800,239			1,602,794				
Total Estimated Phase IV MW Reduction[5]			37			10			93			111				251		
Phase IV Cost Cap													$307,506					
Energy Reduction Compliance Target (MWh/year)[3]					72,509									1,250,157				
Peak Demand Reduction Compliance Target (MW)[5]																229		
$/kWh (direct & common) for energy efficiency programs	$0.46			$0.75			$0.16			$0.12					$0.19			
Carryover from Phase III					20,000									200,000				
Total Plan and Carryover MWh/yr					84,430									1,802,794				

[1] Peak demand savings are gross verified MW at the generator level (grossed up to reflect transmission and distribution ("T&D") line losses).
[2] Savings are for measures installed and operable from June 1, 2021, through May 31, 2026.
[3] MWh/year are on a verified gross basis.
[4] Program acquisition cost for energy efficiency programs equals program costs divided by first year's savings.
[5] MW are on a verified gross basis.
[6] Direct percentages are slightly different for common costs as none of the Key Account Management costs are allocated to residential or low income sectors.
[7] Includes $5 million SWE costs that are not subject to the cost cap.
[8] $/kW are rounded values.
[9] Costs and savings from master metered multifamily are associated with the Non-Residential Program. Program TRC ratio excludes common costs.
[10] Master metered multifamily savings to be applied to the low income sector compliance target

3 Program and Component Descriptions

3.1 Process Used for Selection of Programs and Components

To enhance customer engagement in energy efficiency, PPL Electric Utilities revised the structure of its program offerings for Phase IV. Rather than offering a portfolio of individual programs consisting of bundled measure offerings, PPL Electric Utilities' Phase IV Plan will focus on providing each target customer sector with comprehensive solutions. PPL Electric Utilities will contract with implementation CSPs that will be tasked with providing balanced, integrated offerings to customers in the sector(s) over which they are responsible.

Customers are typically unaware of the existence of program designations; they simply want to find information easily, have a smooth participation process, and receive their incentive quickly. Under the new design, customers in the key sector will have the opportunity to implement as many, or as few, of individual energy efficiency and peak demand improvements as they like. PPL Electric Utilities designed its Phase IV programs to facilitate a seamless customer experience and provide the flexibility to enable customers who want deeper, more comprehensive efficiency upgrades to implement the project that best fits their needs and budget.

Because implementation CSPs will be tasked with (and will receive incentives for) delivering comprehensive solutions across an entire customer sector, they will be empowered to educate customers on the benefits of holistic energy efficiency strategies and to cross-promote appropriate solutions that result in more complete retrofits and higher energy and peak demand savings per participant. This comprehensive, solutions-based portfolio approach is consistent with best practices and industry trends.

The revised portfolio structure offers PPL Electric Utilities an opportunity to capture operational efficiencies, facilitate more extensive promotion and participation, encourage deeper energy efficiency and peak demand enhancements per customer, and have greater flexibility and control to manage program delivery and achieve objectives. Each program comprises components through which PPL Electric Utilities can deliver targeted offerings to its customers based on the predominant operational and delivery characteristics of that component.

These program components are very similar to the successful offerings in Phases I through III. Under its revised program design strategy, PPL Electric Utilities will continue to administer, evaluate, and report on program performance at a component level. PPL Electric Utilities developed separate budgets, savings targets, and performance objectives for each program—residential, low-Income, and non-residential—and for the associated program components. Delineation of components will be largely invisible from a customer perspective, especially in the residential sector. Access to individual measures or whole home solutions will be broadly customizable and solely at the customer's discretion. This strategy allows PPL Electric Utilities and its CSPs and trade allies to capitalize on the existing portfolio's momentum and enhance the customer experience by broadening customers' choices.

The remainder of this section provides details on individual programs, program components, and the analysis PPL Electric Utilities conducted to construct its Phase IV portfolio.

3.1.1 Portfolio Objectives and Metrics that Define Success

Portfolio Objectives

PPL Electric Utilities designed the Phase IV EE&C Plan to meet the requirements set forth by the Implementation Order and to achieve additional objectives associated with customer satisfaction and operational efficiency. These objectives are described in detail in Section 1 of this Plan.

Metrics that Define Success

The primary objectives of this Plan are to meet the requirements of Act 129 and encourage more efficient use of electric power by PPL Electric Utilities' customers. PPL Electric Utilities will monitor its progress in meeting these objectives by tracking specific performance indicators and, when deficiencies are found, identifying corrective action. The Company will employ a range of EM&V, QA/QC, and data tracking activities to assess and monitor program and component performance and customer and trade ally satisfaction throughout Phase IV. Table 11 identifies the performance indicators and metrics PPL Electric Utilities will use to measure program and component success.

Table 11. Key Indicators and Metrics for Monitoring Portfolio Success

Key Indicator	Metrics
Market Response	• Number of participants • Number of measures installed per participant • Participation benchmarked against industry norms • Feedback from trade allies
Impacts	• kWh/year savings • kW/year saving • Average project size
Customer and Trade Ally Satisfaction	• Responses to participant surveys administered as part of QA and/or EM&V • Feedback from trade allies
Operating Efficiency	• Application processing time • Incentive processing time • Expenditures in each category • Acquisition cost ($/kWh saved)[1] • Levelized cost ($/kWh saved)[1]
Cost-Effectiveness	• TRC benefit/cost ratio

[1] Acquisition cost is ratio of total EDC expenditures to annual kWh. Levelized cost is the full TRC cost (including participant cost) over lifetime kWh.

3.1.2 How Program Components Were Constructed

PPL Electric Utilities relied on its Phase III program designs as a template for assigning eligible energy efficiency and peak demand measures to specific program components for analyzing cost-effectiveness and impacts. The Company then examined new measures identified through the Phase IV market potential studies, its Phase III experience, and other market research to assess the ability of these measures to supplement or enhance existing customer offerings. PPL Electric Utilities assigned each promising measure to one or more components and then estimated participation and costs based on previous experience and an analysis of Phase IV requirements, including compliance targets and associated budgets.

After defining sector-level budgets and targets, PPL Electric Utilities issued RFPs for the design and implementation (i.e., delivery) of the residential, non-residential, and low-income programs. These RFPs were intended to confirm that PPL Electric Utilities' savings targets and budgets were achievable and realistic for each sector and to confirm the types of programs, components, and measures to include in the EE&C Plan.

Each measure underwent an extensive technical and economic screening analysis (see Section 8) to determine component, program, and portfolio-level cost-effectiveness. This analysis was the basis for iteratively adjusting individual elements to balance the portfolio and provide a reasonable mix of programs to meet all the Act 129 requirements. These requirements include the low-income set-aside targets, the overall cost cap, equity and comprehensiveness across customer segments, and cost-effectiveness at the portfolio level. The result is a mix of proven energy efficiency and peak demand strategies that will enable PPL Electric Utilities to reach its program goals within the parameters set forth in Act 129 and the Implementation Order.

For the launch and delivery of programs in Phase IV, PPL Electric Utilities will capitalize on existing activities and relationships with market partners, rely on the implementation CSPs' delivery experience, and account for the seasonality of some program components to achieve its Act 129 goals.

PPL Electric Utilities' Phase IV programs are intended to provide comprehensive energy and peak demand savings across end uses, as shown in Figure 2.

Figure 2. End Uses Addressed, by Program

End-Use	Residential	Low Income	Non-Residential
Agricultural			●
Appliances	●	●	
Appliance Recycling	●	●	●
Audits	●	●	
CHP			●
Compressed Air			●
Cooling	●		
Cooling Chillers			●
Food Service			●
Heat Pump	●	●	●
Heating	●		
HVAC			●
Industrial			●
Kits	●	●	
Lighting	●	●	●
Lighting Controls			●
Miscellaneous	●	●	●
Motors, Pumps & Fans			●
New Homes	●		
Office Equipment			●
Plug Loads	●	●	
Pool Pumps	●		
Refrigeration (Commercial)			●
Thermostats	●	●	
Ventilation			●
Water Heat	●	●	●
Weatherization	●	●	

3.1.3 Measures Included in the Portfolio of Program Components

Measures to be offered in the Phase IV program components are described in Sections 3.2 through 3.4 (see the Eligible Measures and Incentive Strategy section in each program component description).

3.1.4 Comprehensive Measures to Be Offered

The Implementation Order directs EDCs to "include at least one comprehensive program for residential customers and at least one comprehensive program for non-residential customers."[13] To satisfy this requirement for residential customers, PPL Electric Utilities will offer two programs: (1) the Residential

[13] Implementation Order at 23.

Program targeting its non-low-income customers; and (2) the Low-Income Program targeting its low-income customers. Both programs will provide a comprehensive mix of cost-effective energy efficiency measures for all building types (single-family, multifamily, and manufactured homes and existing and new construction). Both programs will offer in-home energy audits that assess end uses, including weatherization, water heating, lighting (available through the Efficient Lighting component), HVAC, and appliances. Residential customers will receive energy efficiency and peak demand education and be encouraged to implement multiple measures and to take a comprehensive approach to energy efficiency.

To meet the requirement for non-residential customers, PPL Electric Utilities will offer the Non-Residential Program that will target business customers of all sizes and in every segment, as well as government and educational institutions and master metered low-income multifamily buildings, with a comprehensive range of prescriptive measures (including HVAC, lighting, and water heating) as well as opportunities to implement a custom efficiency project for measures not included in PPL Electric Utilities' Energy Efficient Equipment (prescriptive) component and not included in the TRM. Custom component measures cover a comprehensive set of non-residential needs, including new or replacement energy efficient and peak demand-saving equipment, retro-commissioning, repairs, equipment optimization, building management or industrial process controls, new construction projects, CHP, and operational and process improvements that result in cost-effective energy efficiency savings.

3.2 Residential Program (2021-2026)

The following sections describe the components in PPL Electric Utilities' Residential Program:

- Appliance Recycling
- Efficient Lighting – Specialty Bulbs
- Energy Efficient Homes
- Student Energy Efficient Education

The next sections describe each component and their objectives; target market; implementation strategy; issues, risks, and risk management strategy; anticipated costs to participating customers; ramp-up strategy; marketing strategy; eligible measures and incentive strategy; deadline for rebate applications; start date with key schedule milestones; EM&V; administrative requirements; and estimated savings and participation. Please note that participation levels, savings, costs, and incentive ranges are estimates as directed by the Pa PUC EE&C Plan Template.

Table 12 lists estimated savings and costs by program year. The Residential Program budget is 20.7% of the total portfolio budget.[14]

Table 12. Pa PUC Table 9 - Residential Costs and Benefits by Program Year and Total ($1000)

Cost Element		PY13	PY14	PY15	PY16	PY17	Phase IV Total [1]
Total Budget ($000)		$13,479	$13,639	$12,701	$12,453	$12,475	$64,747
Incentives ($000)	Rebates	$3,939	$4,001	$4,035	$4,063	$4,101	$20,138
	Upstream/Midstream Buydown	$2,981	$2,911	$1,932	$1,687	$1,685	$11,195
	Kits	$1,003	$1,002	$967	$971	$926	$4,870
	Direct Install Materials & Labor	$678	$631	$649	$584	$548	$3,090
	Incentive Total	**$8,601**	**$8,545**	**$7,582**	**$7,305**	**$7,259**	**$39,293**
Non-Incentives ($000)	CSP Program Design	$46	-	-	-	-	$46
	CSP Administrative	$644	$675	$708	$736	$761	$3,524
	CSP Delivery Fees	$3,478	$3,706	$3,696	$3,689	$3,719	$18,288
	CSP Marketing	$490	$493	$495	$503	$515	$2,496
	EDC Administrative	$220	$220	$220	$220	$220	$1,100
	EDC Other	-	-	-	-	-	-
	Non-Incentive Total	**$4,878**	**$5,094**	**$5,119**	**$5,148**	**$5,216**	**$25,453**
Percent Incentives		64%	63%	60%	59%	58%	61%

[1] Total values may not equal the sum of all program year values due to rounding.

[14] This percentage represents the program budget without common costs over the total portfolio budget, which includes common costs.

The Residential Program is projected to be cost-effective, with a TRC test ratio of 1.01. Table 13 shows net present value benefits and costs, net benefits, and the overall benefit/cost ratio.

Table 13. Residential Program Cost-Effectiveness Results, TRC Test ($1,000)

NPV Benefits	$98,235
NPV Costs	$97,641
Net Benefits	$593
Benefit/Cost Ratio	1.01

As noted in Section 1.6, PPL Electric Utilities will rely on energy efficiency measures with coincident peak demand reduction potential to achieve its annual and total demand reduction goals. PPL Electric Utilities will target end uses to nominate roughly 1 to 20% of eligible PJM peak demand savings from the Residential Program over the five-year Plan. PPL Electric Utilities is not aware at this time which measures will be nominated; however, they will likely include cooling and lighting. PPL Electric Utilities will competitively select a qualified third-party vendor to provide technical support in nominating a portion of its peak demand reductions as a capacity resource in PJM's FCM.

Appliance Recycling

Description

PPL Electric Utilities offers free pick-up and recycling of refrigerators, freezers, dehumidifiers, room air conditioners, and possibly consumer electronics (without savings or incentive). The Company offers customers a rebate for each recycled appliance, which must be plugged in and functioning when picked up. Room air conditioners, consumer electronics (if offered), and dehumidifiers are eligible for pick up with a refrigerator or freezer. PPL Electric Utilities may decide to allow dehumidifiers and room air conditioners as stand-alone measures. If feasible, the Company will offer small appliance pick-up events to which customers may bring room air conditioners and/or dehumidifiers for disposal and receive PPL Electric Utilities' incentives. The component will have the flexibility to offer in-person home pick-up or contactless curbside pick-up.

PPL Electric Utilities offers scheduling, pick-up, and decommissioning of refrigerators and freezers units and transports the units to a Pennsylvania-based processing center for disposal in an environmentally responsible manner. The disposal process involves removing hazardous materials, such as chlorinated fluorocarbons, from the refrigerant and foam insulation, preparing refrigerant for reclamation, and recycling other materials including metal and plastic.

Objectives

The objectives of Appliance Recycling are:

- Encourage customers to dispose of their existing, inefficient refrigerators, freezers, air-conditioning units, and dehumidifiers in an environmentally responsible manner.
- Reduce the use of secondary, inefficient refrigerators, freezers, and air-conditioning units.

- Enhance relationships with box stores and independent retailers to encourage participation in the "buy new and recycle" component.
- Decommission appliances on the site to prevent resale in a secondary market.
- Promote other PPL Electric Utilities energy efficiency programs.
- Achieve a total energy reduction of approximately 48,311 MWh/year and 13.2 MW[15] gross verified savings.
- Achieve high customer and trade ally satisfaction.

Target Market

Appliance Recycling targets residential customers but is available to customers in all sectors with working, residential-grade refrigerators, freezers, dehumidifiers, and room air-conditioning units. PPL Electric Utilities also encourages landlords and multifamily property managers/owners in its service territory to recycle refrigerators and freezers in their tenant units.

Implementation Strategy

The Residential CSP will manage and deliver Appliance Recycling to customers, which involves scheduling, picking up appliances, decommissioning, recycling, training retailer staff to promote the component, and tracking data. The Residential CSP will also support program-level functions by operating a customer call center, marketing and advertising, processing incentives, and tracking component activities. PPL Electric Utilities' energy efficiency staff will provide overall strategic direction and management. The EM&V CSP will provide evaluation services.

Issues, Risks, and Risk Management Strategy

Table 14 presents market risks associated with Appliance Recycling and strategies PPL Electric Utilities will use to manage each risk.

Table 14. Appliance Recycling Issues, Risks, and Risk Management Strategies

Component Issue	Risk	Risk Management Strategies
Convenient time required for customer to be available for pick-up.	Customer may have the interest to recycle but not have time available.	Residential CSP works with customers to provide as convenient a pick-up as possible. On a case-by-case basis, special pick-up times may be arranged to meet customer needs.
Lack of component awareness among customers.	Customer participation might be low.	Residential CSP manages a robust marketing strategy, including distributing materials at community events and to retailers, running a media campaign, and designing PPL Electric Utilities bill inserts.
Customer may not see benefit of recycling qualified appliance(s).	Customer disposes of units through channels other than this component.	Residential CSP works with retailers where new units are sold to display information about the benefits of recycling. PPL Electric Utilities offers free pick-up

[15] Peak Demand is at generation.

Component Issue	Risk	Risk Management Strategies
		services plus an incentive to encourage customers to recycle appliances.

Anticipated Costs to Participating Customers

There are no direct costs incurred by customers in this component.

Ramp-up Strategy

Appliance Recycling is an existing, mature offering being carried forward from Phase III. The Residential CSP will develop marketing materials to facilitate the transition to Phase IV.

Marketing Strategy

PPL Electric Utilities' staff will work with the Residential CSP to develop and execute a marketing plan that captures sector-level economies of scale and employs targeted outreach where practical. The marketing strategy may include the following:

- Promote component through "Connect," bill inserts, the Customer Engagement Hub, and email blasts.
- Provide online access to the component via the Company's EE&C website.
- Distribute materials at community events.
- Advertise through multiple channels.
- Educate retailer staff and customers through in-store events.
- Distribute point-of-purchase materials to local retailers.
- Train local retailer staff to cross-promote component when customers purchase a new refrigerator.
- Conduct targeted outreach to PPL Electric Utilities' customers who submit a new refrigerator rebate application.

Eligible Measures and Incentive Strategy

Qualified customers receive free pick-up and disposal and an incentive for recycling working refrigerators, freezers, dehumidifiers, room air conditioners, and possibly consumer electronics (without savings or incentives). Room air conditioners, consumer electronics, and dehumidifiers may be picked up along with a qualified refrigerator or freezer. PPL Electric Utilities may decide to allow dehumidifiers and room air conditioners as stand-alone measures.

Table 15 lists PPL Electric Utilities' measures, minimum eligibility qualifications, and ranges of incentive levels.

Table 15. Pa PUC Table 7-Appliance Recycling Eligible Measures and Incentives

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit)
Dehumidifier Recycling	Per Product	No	Retirement and recycling without direct EDC replacement of an operable but older and inefficient room dehumidifier unit that would not have otherwise been recycled.	$10	4	$10 to $25
Recycle Fridge	Per Product	No	Working unit, > 10 cubic feet and ≤ 30 cubic feet	$35	6	$35 to $75
Recycle Freezer	Per Product	No	Working unit, > 10 cubic feet and ≤ 30 cubic feet	$35	5	$35 to $75
RAC Recycling	Per Product	No	Retirement and recycling without direct EDC replacement of an operable but older and inefficient room AC (RAC) unit that would not have otherwise been recycled.	$10	3	$10 to $25

Not all measures may be available at all times. PPL Electric Utilities may suspend a measure depending on popularity, pace of the component (savings and costs), free ridership, evaluation requirements, complexity of information required from customers, administrative requirements for the measure, or other reasons. PPL Electric Utilities will review the component continually and may adjust available measures or eligibility qualifications to achieve savings and cost budgets. The Company may offer tiered incentives that encourage the recycling of older equipment, installation of multiple measures, or a more comprehensive whole-home or facility approach.

Deadline for Rebate Applications

There is no rebate application for this component.

Start Date with Key Schedule Milestones

Appliance Recycling is currently offered in Phase III, and PPL Electric Utilities will manage the transition to Phase IV. Table 16 lists estimated key schedule milestones for Appliance Recycling. PPL Electric Utilities will lead implementation or provide management oversight of all tasks.

Table 16. Appliance Recycling Schedule and Milestones

Schedule	Milestones
11/30/2020	Phase IV EE&C Plan submitted to Pa PUC
06/01/2021	Launch Phase IV component
Annually starting 01/15/2022	EDCs submit semiannual program report
Annually starting 09/30/2022	EDCs submit final annual program report
05/31/2026	Program ends

Evaluation, Measurement, and Verification

EM&V requirements will be detailed in PPL Electric Utilities' Evaluation Plan, which will be submitted to the SWE for review. PPL Electric Utilities and its EM&V CSP will conduct annual evaluations of each program component in compliance with all Pa PUC requirements and the Evaluation Framework. As part of this process, the EM&V CSP will review a sample of CSP records to verify quantity, efficiency level, and qualifying equipment. The EM&V CSP will follow all applicable methods in the TRM and the Evaluation Framework to calculate energy savings and peak demand reduction. For the Appliance Recycling component, PPL Electric Utilities anticipates conducting annual impact evaluations and conducting one process evaluation during Phase IV (activities vary by year).

Administrative Requirements

The Residential CSP will provide overall administrative and operational management of Appliance Recycling. PPL Electric Utilities will provide oversight and operational support to establish effective deployment.

Estimated Savings and Participation

Table 17 shows the order of magnitude participation estimates for Appliance Recycling. Actual quantities will vary, and PPL Electric Utilities will manage the component to stay within budget.

Table 17. Pa PUC Table 8-Appliance Recycling Participation [1]

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Dehumidifier Recycling	Energy Savings (MWh/year)	2,334	2,334	2,334	2,139	1,945	11,086
	Demand Reduction (MW)	0.522	0.522	0.522	0.479	0.435	2.481
	Projected Participation	3,120	3,120	3,120	2,860	2,600	14,820
Recycle Fridge	Energy Savings (MWh/year)	6,006	5,460	5,678	4,941	4,668	26,754
	Demand Reduction (MW)	0.672	0.611	0.635	0.553	0.522	2.994
	Projected Participation	14,300	13,000	13,520	11,765	11,115	63,700
Recycle Freezer	Energy Savings (MWh/year)	1,539	1,539	1,539	1,539	1,399	7,556
	Demand Reduction (MW)	0.172	0.172	0.172	0.172	0.157	0.845
	Projected Participation	2,860	2,860	2,860	2,860	2,600	14,040
RAC Recycling	Energy Savings (MWh/year)	606	594	583	571	560	2,915
	Demand Reduction (MW)	1.218	1.194	1.171	1.148	1.125	5.857
	Projected Participation	4,597	4,506	4,417	4,332	4,246	22,097

[1] To show numerical values in the Pa PUC Table 8 tables, deviation from the standard use of decimals throughout Section 3 may have been applied.

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]

[2] Total values may not equal the sum of all program year values due to rounding

Efficient Lighting - Specialty Bulbs

Description

PPL Electric Utilities encourages residential customers to purchase and install specialty LED bulbs.[16] Participating customers can purchase a variety of discounted LED bulbs at local retail stores and the Company's Online Marketplace. The Residential CSP will manage operations and provide support to participating retailers and manufacturers that promote and sell eligible bulbs.

Objectives

The objectives of Efficient Lighting are:

- Provide a mechanism for customers to easily obtain discounted specialty LED bulbs in local retail stores and/or the Online Marketplace.
- Achieve widespread visibility through independent and regional retailers that carry eligible specialty LED bulbs.
- Develop and execute strategies aimed at continuing the transformation of the market for specialty LED bulbs.
- Educate customers on new lighting technologies.
- Engage retailers by educating and training retail sales associates about specialty LED bulbs.
- Achieve a total energy reduction of approximately 20,379 MWh/year and 3.7 MW[17] gross verified savings.
- Achieve high customer and trade ally satisfaction.

Target Market

Efficient Lighting targets residential customers but is available to all PPL Electric Utilities customers.

Implementation Strategy

The Residential CSP will administer the component by managing retailer/manufacturer recruitment, delivering incentives to participating energy efficient light bulb manufacturers, providing marketing and educational support, and overseeing marketing and product placement in retail stores. The Residential CSP will also support program-level functions by operating a customer call center, following PPL Electric Utilities' marketing and branding guidelines, and tracking activities. PPL Electric Utilities' energy

[16] Based on actual results from Phase III, PPL Electric Utilities estimated a portion of costs and savings associated with the Efficient Lighting Component for the small C&I sector from cross-sector sales. The actual costs and savings for the small C&I sector will be determined by the EM&V CSP during the annual evaluation.

[17] Peak Demand is at generation.

efficiency staff will provide overall strategic direction and management. The EM&V CSP will provide evaluation services.

Issues, Risks, and Risk Management Strategy

Table 18 presents market risks associated with Efficient Lighting and the strategies PPL Electric Utilities will use to manage each risk.

Table 18. Efficient Lighting Issues, Risks, and Risk Management Strategies

Component Issue	Risk	Risk Management Strategies
Cost of energy efficient bulbs may be higher than the customer is willing to pay.	• Low sales translating to low savings. • Customers may not be willing to purchase new, more efficient light bulbs if their current light bulbs are functioning. • Economic conditions may limit customers' ability to purchase energy efficient bulbs.	• PPL Electric Utilities offers incentives to offset the cost of efficient bulbs at retail locations. PPL Electric Utilities will likely use other distribution channels such as offering free bulbs at customer giveaway events, and through the Online Marketplace. • PPL Electric Utilities educates customers on the long-term energy cost-saving benefits of higher efficiency lighting.
Lack of customer awareness about energy usage associated with different types of bulbs.	Customers do not see a need to use more efficient bulbs.	Residential CSP manages a robust marketing and education strategy, including point-of-sale promotions and discounts.
Reduction in savings due to Energy Independence and Securities Act of 2007 standards.	Specialty bulb market saturation.	PPL Electric Utilities determines the proper product mix of bulbs to reduce reliance on savings for specific bulbs
Energy efficient bulb performance.	Customer may not purchase energy efficient bulbs if they perceive bulbs do not perform well.	Residential CSP conducts ongoing communication with retailers, including training, outreach, and education.
Changing technology may affect lifecycle cost.	Customer decision-making process may change as new technology becomes available in the market.	PPL Electric Utilities adds new measures as efficiency improves.

Anticipated Costs to Participating Customers

Although the incentives will cover a portion of the efficient products' incremental costs, participating customers will be responsible for the remaining costs of purchased LED bulbs. Customer-incurred costs will vary by bulb type.

Ramp-up Strategy

This is a relaunch of the Efficient Lighting offering from Phase III, but focusing specifically on specialty bulbs. The Residential CSP will develop marketing material to facilitate the transition to Phase IV.

Marketing Strategy

PPL Electric Utilities will work with the Residential CSP to develop and execute a marketing plan that captures sector-level economies of scale and employs targeted outreach where practical. The marketing strategy may include the following:

- Promote the component through "Connect," bill inserts, the Customer Engagement Hub, and email blasts.
- Provide online access to the program via the Company's EE&C website.
- Advertise through multiple channels.
- Educate retailer staff and customers through in-store events.
- Distribute point-of-purchase materials to local retailers.
- Collaborate with ENERGY STAR® and lighting manufacturers.
- Cross-promote the lighting component with other energy efficiency educational materials.

Eligible Measures and Incentive Strategy

Table 19 identifies PPL Electric Utilities' list of measures, minimum eligibility qualifications, and range of incentive levels. In general, the incentives provided at the retail level are designed to cover up to 50% of the retail cost of LEDs.

Table 19. Pa PUC Table 7- Efficient Lighting Eligible Measures and Incentives

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit)
TCP 11.68 Downlight Solid State Retrofit	Per Pack	No	Downlight fixture, ≥ 400 lumens	$22	15	$5 to $8
Decorative and Min-Base AVG	Per Pack	No	Decorative, mini-base, or globe, 250- 2,600 lumens	$11	15	$5 to $8
Globe AVG	Per Pack	No	Decorative, mini-base, or globe, 250- 2,600 lumens	$20	15	$5 to $8
Reflectors AVG	Per Pack	No	Reflectors or outdoor, 250-2,600 lumens	$22	15	$5 to $8
Outdoor AVG	Per Pack	No	Reflectors or outdoor, 250-2,600 lumens	$22	15	$5 to $8
MaxLite 11 Parabolic Aluminized Reflector	Per Bulb	No	Reflectors or outdoor, 250-2,600 lumens	N/A	N/A	$5 to $8
MaxLite 5 Globe	Per Bulb	No	Decorative, mini-base, or globe, 250- 2,600 lumens	N/A	N/A	$5 to $8
MaxLite 6.5 Multifaceted Reflector	Per Bulb	No	Reflectors or outdoor, 250-2,600 lumens	N/A	N/A	$5 to $8
Philips 4.5 Specialty	Per Bulb	No	Decorative, mini-base, or globe, 250- 2,600 lumens	N/A	N/A	$5 to $8
Philips 7.2 Bulged Reflector	Per Bulb	No	Reflectors or outdoor, 250-2,600 lumens	N/A	N/A	$5 to $8
Philips 9 Bulged Reflector	Per Bulb	No	Reflectors or outdoor, 250-2,600 lumens	N/A	N/A	$5 to $8
TCP 10.5 Parabolic Aluminized Reflector	Per Bulb	No	Reflectors or outdoor, 250-2,600 lumens	N/A	N/A	$5 to $8

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit)
TCP 4 Globe	Per Bulb	No	Decorative, mini-base, or globe, 250- 2,600 lumens	N/A	N/A	$5 to $8
TCP 5 Globe	Per Bulb	No	Decorative, mini-base, or globe, 250- 2,600 lumens	N/A	N/A	$5 to $8
TCP 5 Specialty	Per Bulb	No	Decorative, mini-base, or globe, 250- 2,600 lumens	N/A	N/A	$5 to $8
TCP 7.5 Reflector	Per Bulb	No	Reflectors or outdoor, 250-2,600 lumens	N/A	N/A	$5 to $8
TCP 9.5 Bulged Reflector	Per Bulb	No	Reflectors or outdoor, 250-2,600 lumens	N/A	N/A	$5 to $8

All measures may not be available at all times. PPL Electric Utilities may suspend a measure depending on popularity, pace of the component (savings and costs), free ridership, evaluation requirements, administrative requirements for the measure, or other reasons. PPL Electric Utilities will review the component continually and may adjust available measures or eligibility qualifications to achieve savings and cost budgets.

Deadline for Rebate Applications

PPL Electric Utilities offers Efficient Lighting incentives at the point of sale; therefore, there is no rebate application.

Start Date with Key Schedule Milestones

Efficient Lighting was offered in Phase III, and PPL Electric Utilities will facilitate its relaunch as a component in Phase IV, but focus on specialty lighting. Table 20 lists the estimated key schedule milestones

Table 20. Efficient Lighting Schedule and Milestones

Schedule	Milestones
11/30/2020	Phase IV EE&C Plan submitted to Pa PUC
06/01/2021	Launch Phase IV component
Annually starting 01/15/2022	EDCs submit semiannual program report
Annually starting 09/30/2022	EDCs submit final annual program report
05/31/2026	Program ends

Evaluation, Measurement, and Verification

The EM&V requirements will be detailed in PPL Electric Utilities' Evaluation Plan, which will be submitted to the SWE for review. PPL Electric Utilities and its EM&V CSP will conduct annual evaluations of each component in compliance with all Pa PUC requirements and the Evaluation Framework. As part of this process, the EM&V CSP will verify savings attributable to this component. The EM&V CSP will verify bulb quantities and savings for lighting distributed through other channels (such as giveaways) where the specific participant is known. The EM&V CSP will follow all applicable methods in the TRM and the Evaluation Framework to calculate energy savings and peak demand reduction. For Efficient Lighting, PPL Electric Utilities anticipates conducting annual impact and process evaluations (activities vary by year).

Administrative Requirements

The Residential CSP will provide overall administrative and operational management of Efficient Lighting. PPL Electric Utilities will provide oversight and operational support to establish effective deployment.

Estimated Participation

Table 21 shows the order of magnitude participation estimates for Efficient Lighting. Actual quantities will vary, and PPL Electric Utilities will manage the component to stay within budget.

Table 21. Pa PUC Table 8-Efficient Lighting Projected Participation [1]

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
TCP 11.68 Downlight Solid State Retrofit	Energy Savings (MWh/year)	1,175	914	200	95	70	2,454
	Demand Reduction (MW)	0.113	0.088	0.019	0.009	0.007	0.236
	Projected Participation	135,040	105,000	23,000	10,900	8,000	281,940
Decorative and Min-Base AVG	Energy Savings (MWh/year)	1,330	1,136	242	97	56	2,861
	Demand Reduction (MW)	0.128	0.109	0.023	0.009	0.005	0.275
	Projected Participation	275,000	235,000	50,000	20,000	11,588	591,588
Globe AVG	Energy Savings (MWh/year)	609	533	127	81	33	1,383
	Demand Reduction (MW)	0.585	0.512	0.122	0.078	0.031	1.329
	Projected Participation	120,000	105,000	25,000	16,000	6,400	272,400
Reflectors AVG	Energy Savings (MWh/year)	4,712	4,749	1,542	308	156	11,468
	Demand Reduction (MW)	0.452	0.456	0.148	0.030	0.015	1.101
	Projected Participation	382,000	385,000	125,000	25,000	12,637	929,637
Outdoor AVG	Energy Savings (MWh/year)	864	873	301	116	58	2,212
	Demand Reduction (MW)	0.164	0.165	0.057	0.022	0.011	0.419
	Projected Participation	89,037	90,000	31,000	11,963	6,000	228,000

[1] To show numerical values in the Pa PUC Table 8 tables, deviation from the standard use of decimals throughout Section 3 may have been applied.
[2] Total values may not equal the sum of all program year values due to rounding.

Energy Efficient Homes

Description

PPL Electric Utilities provides comprehensive energy efficiency options for new and existing homes. The Company offers a range of energy efficient measures, rebates, education, and services that help its customers increase their homes' efficiency. The component contains these delivery channels:

- The **new homes channel** encourages construction of energy efficient new homes through a rebate to builders or homeowners who exceed the energy efficiency performance required by current building codes in newly constructed homes. This offer is for both single-family and multifamily buildings.
- In the **comprehensive in-home audit and weatherization channel**, customers learn about the benefits of energy efficiency measures, such as appliance recycling, lighting, HVAC, and water heating. Depending on audit recommendations, customers may receive direct-install or giveaway measures and may qualify for insulation and air sealing rebates. Energy efficiency kits may also be offered to PPL Electric Utilities' customers interested in learning more about energy efficiency and the programs offered by the Company.
- In the **midstream and/or downstream energy efficiency equipment** channel PPL Electric Utilities provides rebates for high-performance heat pumps, heat pump water heaters, pool pumps, and central air conditioners, as well as other energy efficient appliances.

PPL Electric Utilities is also considering offering an enhanced bonus incentive to customers who install a comprehensive package of measures.

Objectives

The objectives of Energy Efficient Homes are:

- Encourage customers to view energy efficiency in a holistic manner.
- Provide customers with education, audits, and energy-saving solutions.
- Promote construction of energy efficient new homes.
- Educate construction industry professionals and other trade allies about the benefits of energy efficient homes.
- Achieve a total energy reduction of approximately 57,777 MWh/year and 16.93 MW[18] gross verified savings.
- Achieve high customer and trade ally satisfaction.

[18] Peak Demand is at generation.

Target Market

Energy Efficient Homes is targeted to residential homebuilders and customers residing in single-family and individually metered multifamily homes.

Implementation Strategy

The Residential CSP will deliver Energy Efficient Homes to customers and homebuilders through marketing, participant recruitment, and trade ally recruitment and support. Because the component consists of three separate channels, trade ally support will vary. These are the responsibilities of the Residential CSP and PPL Electric Utilities:

- ***New homes.*** The Residential CSP will identify, recruit, and train potential builders; assist new home builders with paperwork; answer specific questions; test new home performance; and issue incentives to builders and homeowners.
- ***Audit and weatherization.*** The Residential CSP will conduct in-home audits; identify, recruit, and train HVAC contractors; form and maintain a trade ally network; and answer questions.
- ***Energy efficient equipment.*** The Residential CSP will work with retailers, distributors, trade allies, and manufacturers to promote energy efficient equipment such as HVAC equipment and pool pumps through a midstream approach that builds on its current and new relationships with distributors in PPL Electric Utilities' service territory and may decide to offer an HVAC Tune-Up Optimization measure within this component. PPL Electric Utilities will continue to broaden its market reach by offering rebates for qualified products at the point of sale.
- ***Online Marketplace***. PPL Electric Utilities will offer customers the opportunity to purchase energy efficient lighting and equipment through a virtual storefront.

The Residential CSP will also support program-level functions by operating a customer call center, managing marketing and advertising, processing incentives to customers, and tracking activities.
PPL Electric Utilities will provide overall strategic direction and management. The EM&V CSP will provide evaluation services.

Issues, Risks, and Risk Management Strategy

Table 22 presents market risks associated with Energy Efficient Homes and the strategies PPL Electric Utilities will use to manage each risk.

Table 22. Energy Efficient Homes Issues, Risks, and Risk Management Strategies

Component Issue	Risk	Risk Management Strategies
Efficiency is not a common priority for builders and customers.	Builders do not take advantage of rebates, resulting in lower savings.	Residential CSP educates builders on the value and benefits associated with energy efficiency.
Builders may not abide by the efficient building practices required to qualify for the rebate	Builders may choose cheaper, less efficient equipment and building practices.	Residential CSP educates builders on the performance standards and building practices required to qualify for program rebates.
The economic environment may limit the ability of builders and customers to purchase energy efficient equipment and appliances for these reasons: • High-efficiency equipment is viewed as too expensive. • There is little incentive to upgrade equipment that is still operational or to weatherize a home.	Builders or customers may choose to install cheaper, less efficient equipment.	• Residential CSP conducts robust program marketing and provides general energy efficiency information to customers. • PPL Electric Utilities offers rebates that help reduce incremental costs. • Residential CSP educates customers on the long-term energy cost-saving benefits of higher-efficiency equipment and home weatherization.

Anticipated Costs to Participating Customers

Costs incurred by Energy Efficient Homes participants will vary by delivery channel and type of qualifying equipment installed through the component.

Ramp-up Strategy

Energy Efficient Homes is an existing, mature offering carried forward from Phase III. The Residential CSP will develop marketing material to facilitate the transition to Phase IV. The CSP also plans to make rebates for HVAC equipment and pool pumps available through a midstream channel. PPL Electric Utilities may continue to offer downstream rebates on these measures.

Marketing Strategy

PPL Electric Utilities will work with the Residential CSP to develop and execute a marketing plan that captures sector-level economies of scale and employs targeted outreach where practical. The marketing strategy may include the following:

- Promote component through “Connect,” bill inserts, the Customer Engagement Hub, and email blasts.
- Provide online access to the component via the Company’s EE&C website.
- Advertise through multiple marketing channels.
- Identify builders through collaboration with state and regional builders’ associations and provide them with component details.
- Educate retailer staff and customers through in-store events.
- Distribute point-of-purchase materials to local retailers.

- Recruit and train retailers and distributors on qualifying technology, rebates, and cross-promotion.

The Residential CSP will also conduct outreach to previously participating and new trade allies (retailers, manufacturers, distributors, homebuilders, and contractors) and provide them with rebate information, educate them on Phase IV changes, and offer ongoing support. After the Residential Program CSP's contract is approved by the Commission, PPL Electric Utilities will develop and implement a detailed marketing plan to foster increased Residential Program participation. This marketing plan will support all components of the Residential Program after the Phase IV EE&C Plan is approved, including the Energy Efficient Homes Component, and will be designed to achieve the 122,803 MWh/year of projected savings targeted in the Energy Efficient Homes Component. Copies of this marketing plan will be provided to the other Joint Petitioners by no later than January 1, 2022.

Eligible Measures and Incentive Strategy

Table 23 lists PPL Electric Utilities' expected measures, minimum eligibility qualifications, and incentive level ranges.

Table 23. Pa PUC Table 7-Energy Efficient Homes Eligible Measures and Incentives

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit)
Connected Thermostat-Electric Heat AVG (downstream)	Per Product	No	ENERGY STAR Certified Product List	$140	11	Up to $200
Connected Thermostat-CAC AVG (downstream)	Per Product	No	ENERGY STAR Certified Product List	$140	11	Up to $200
New Homes-Connected Thermostat-Electric Heat (downstream)	Per Product	No	ENERGY STAR Certified Product List	$140	11	Up to $200
New Homes-Connected Thermostat-CAC (downstream)	Per Product	No	ENERGY STAR Certified Product List	$140	11	Up to $200
Fuel Switching – Central Heating (downstream) Maximum of 75 units for residential customers	Per Project	No	Must replace electric equipment with ENERGY STAR certified natural gas, propane, or fuel oil equipment	$8,600	15	Up to $300
Fuel Switching – DHW (downstream) Maximum of 75 units for residential customers	Per Project	No	Must replace electric water heater with ENERGY STAR certified natural gas or propane equipment	$1,416	11	Up to $300
HPWH-AVG	Per Project	No	ENERGY STAR	$671	10	Up to $500
Air Sealing -AVG (weatherization – downstream)	Per Project	No	Must be performed in accordance with BPI standards with pre- and post-blower door testing. Must have a 10% minimum improvement. Home must have a main source electric heating or central air conditioning.	$1,596	15	Up to $200

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit)
ENERGY STAR Dehumidifiers (downstream)	Per Product	No	ENERGY STAR	$11	12	Up to $25
Ductless Mini-Split Heat Pump (16 SEER/9.0 HSPF) – replacing baseboard/room AC	Per Project	No	ENERGY STAR	$3,847	15	Up to $500
ENERGY STAR Air Source Heat Pump 16 SEER/9.0 HSPF/12.5 EER or Higher	Per Project	No	ENERGY STAR	$987	15	Up to $400
ENERGY STAR Air Source Heat Pump 17.5 SEER/9.7 HSPF/EER 13.5 or Higher	Per Project	No	ENERGY STAR	$1,222	15	Up to $500
ENERGY STAR Refrigerator (downstream)	Per Product	No	ENERGY STAR, at least 15% more efficient than baseline	$68	14	Up to $75
Ceiling Insulation AVG-Electric Heat (weatherization – downstream)	Per Project	No	The existing R-value cannot exceed R-30. Final R-value must be ≥ R-49, home has electric main source heat. Rebate cannot exceed the cost of the measure.	$2,401	15	75% of cost, up to $500
Ceiling Insulation AVG-Non-Electric Heat (weatherization – downstream)	Per Project	No	The existing R-value cannot exceed R-30. Final R-value must be ≥ R-49, home has central air conditioning. Rebate cannot exceed the cost of the measure.	$2,401	15	75% of cost, up to $300
Basement Wall Insulation AVG (weatherization – downstream)	Per Project	No	Home has electric main source heat or central air conditioning. Basement or crawl space insulation should have either a minimum R-10 continuous insulated sheathing on the interior or exterior of the home, or R-13 cavity insulation at the interior of the crawl space wall in International Energy Conservation Code ("IECC") Climate Zone 4, and R-15 continuous or R-19 cavity insulation in zones 5 or 6.	$1,870	15	75% of cost, up to $500
ENERGY STAR Central Air Conditioner (13 SEER/12EER to 16 SEER/12.5EER)	Per Project	No	ENERGY STAR	$1,037	15	Up to $400
ENERGY STAR Central Air Conditioner (14 SEER/12EER to 17.5 SEER/13.5EER)	Per Project	No	ENERGY STAR	$719	15	Up to $500
Variable speed pool pump	Per Project	No	Replace constant speed	$396	10	Up to $350

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit)
New Homes-15% or higher better than code-Electric Heat	Per Project	No	Individually metered, must have own heating, < 6 stories, dwellings must occupy 80% or more of occupiable space, 15% or higher better than code	$1,930	15	Up to $4,500
New Homes-15% or higher better than code-Gas Heat	Per Project	No	Individually metered, must have own heating, < 6 stories, dwellings must occupy 80% or more of occupiable space, 15% or higher better than code	$1,930	15	Up to $4,500
In-Home Audit Incentive (Elec Heat + AC)	Per Project	No	Home has electric main source heat and central air conditioning	$0	0	Up to $350
In-Home Audit Incentive (Elec Heat or Central AC)	Per Project	No	Home has electric main source heat or central air conditioning	$0	0	Up to $200
Comprehensive Retrofit Bonus- Tier 1[2]	Per Project	No	Tier 1	$0	0	Up to $250
Comprehensive Retrofit Bonus- Tier 2[2]	Per Project	No	Tier 2	$0	0	Up to $350
Electric Hot Water Kit (Single Family – In-Home Audits)	Per Kit	No	Electric hot water only	$38	7	$38
Gas Hot Water Kit (Single Family – In-Home Audits)	Per Kit	No	Gas hot water only	$29	6	$29
Electric Hot Water Kit (Single Family)	Per Kit	No	Electric hot water only	$38	7	$38
Gas Hot Water Kit (Single Family)	Per Kit	No	Gas hot water only	$29	6	$29
Smart Thermostat (Online Marketplace)	Per Product	No	ENERGY STAR	$140	11	Up to $75
Weatherstrip (Online Marketplace)	Per Project	No	Must be installed on doors, windows, or attic hatches/doors	$2	15	Up $5
Advanced Power Strip (Online Marketplace)	Per Product	No	Tier 1	$32	5	Up to $15
Occupancy Sensor Switch (Online Marketplace)	Per Product	No	Installation of occupancy sensors and/or connected ("smart") lighting	$26	10	Up to $15
ENERGY STAR Dehumidifier (Online Marketplace)	Per Product	No	ENERGY STAR	$11	12	Up to $25
Electric Hot Water Kit (Single Family – Virtual Assessments)	Per Kit	No	Electric hot water only	$38	7	$38
Gas Hot Water Kit (Single Family – Virtual Assessments)	Per Kit	No	Gas hot water only	$29	6	$29
ENERGY STAR Air Purifier (downstream rebates and online marketplace)	Per Product	No	ENERGY STAR	$74	9	N/A
Water Heater Pipe Insulation (online marketplace)	Per Foot	No	≥ R-3	$4	15	N/A

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit)
Holiday Lights (online marketplace)	Per Product	No	Replace incandescent holiday lights	$6	10	N/A
ENERGY STAR Clothes Washers (downstream rebates)	Per Product	No	ENERGY STAR	$187	11	N/A
ENERGY STAR Ceiling Fans (downstream rebates)	Per Product	No	ENERGY STAR	$15	15	N/A
GSHP DeSuperheaters (midstream)	Per Project	No	Installation on new or existing Ground Source Heat Pump to replace any type of electric water heater	$1,811	15	N/A
Solar Water Heaters (midstream)	Per Project	No	Existing electric water heater	$6,655	15	N/A
Water Heater Tank Wrap (online marketplace)	Per Project	No	Installation of R-8 wrap insulation to existing electric water heater with R-24 or less	$72	7	N/A
Compact Refrigerators (downstream rebates)	Per Product	No	ENERGY STAR	$36	14	N/A
Duct Sealing 50% unvented crawlspace, 30% attic (average)	Per Project	No	Home with electric ducted heating system. Requires duct leakage test by BPI certified trade allies.	$479	15	N/A
Duct Sealing & Insulation 50% unvented crawlspace, 30% attic (average)	Per Project	No	Home with electric ducted heating system. Requires duct leakage test by BPI certified trade allies.	$1,702	15	N/A
Custom Measures	Per kW	No	Minimum TRC requirement may be implemented as a requirement for projects if necessary to help ensure the program or portfolio TRC is greater than 1.0. Incentive $500/kW, incentive capped at $1,000.	N/A	N/A	N/A
Home Energy Report	Per Project	No	Must be PPL Electric Utilities residential customer	N/A	Varies based on TRM	N/A

All measures may not be available at all times. PPL Electric Utilities may suspend a measure depending on popularity, pace of the component (savings and costs), free ridership, evaluation requirements, complexity of information required by customer, administrative requirements for the measure, or other reasons. PPL Electric Utilities will review the component continually and may add or adjust available measures, eligibility qualifications, or incentives to achieve savings and cost budgets. It may offer tiered incentives that encourage installation of multiple measures or a more comprehensive whole home or facility approach. PPL Electric Utilities plans to work with other EDCs and stakeholders to offer a consistent mechanism for new home construction delivery.

PPL Electric Utilities will offer comprehensive in-home diagnostic audits throughout Phase IV. The cost of a comprehensive audit may vary depending on the auditor chosen by the customer. Customers will receive a rebate, the amount of which may vary depending on the type of heating and cooling equipment installed in the home.

To the extent that a project is eligible under the new construction offering, the Company will work with interested stakeholders to help ensure that the Act 129 funds allocated for multifamily affordable housing projects are not substituted for funds otherwise provided through state or federal assistance programs.

Deadline for Rebate Applications

The rebate application will list the deadline for its submission. The deadline will not exceed 180 days from the date the measure was installed or purchased. For some measures, PPL Electric Utilities may allow customers to request project preapproval to lock in the stipulated incentive level and guarantee project funding.

Start Date with Key Schedule Milestones

Table 24 lists the estimated key schedule milestones for Energy Efficient Homes. PPL Electric Utilities will lead implementation or provide management oversight of all tasks.

Table 24. Energy Efficient Homes Schedule and Milestones

Schedule	Milestones
11/30/2020	Phase IV EE&C Plan submitted to Pa PUC
06/01/2021	Launch Phase IV component
Annually starting 01/15/2022	EDCs submit semiannual program report
Annually starting 09/30/2022	EDCs submit final annual program report
05/31/2026	Program ends

Evaluation, Measurement, and Verification

The EM&V requirements will be detailed in PPL Electric Utilities' Evaluation Plan, which will be submitted to the SWE for review. PPL Electric Utilities and its EM&V CSP will conduct annual evaluations of each component in compliance with all Pa PUC requirements and the Evaluation Framework. The EM&V CSP will follow all applicable methods in the TRM and the Evaluation Framework to calculate energy savings and peak demand reduction. For Energy Efficient Homes, PPL Electric Utilities anticipates conducting annual impact and process evaluations (activities vary by year).

Through Energy Efficient Homes, PPL Electric Utilities offers incentives for new home construction, in-home energy audits, and a variety of weatherization and equipment. Each of these requires an evaluation approach specifically tailored to the product.

As part of the savings verification and evaluation, the EM&V CSP will review a sample of participant rebates and Residential CSP records to verify the quantity, efficiency level, and rebate qualifications by measure type. Because the Company offers a variety of equipment and services, the EM&V CSP will stratify the verification sample accordingly, designating a sample size appropriate for each stratum and technology. Overall, the sample size will meet the level of rigor specified in the Evaluation Framework, which will probably be 85% confidence with 15% precision (85/15) at the component level, the same as in Phase III. In its annual reports, PPL Electric Utilities will provide the Energy Efficient Homes Component's actual incentive costs, electric savings, and demand reductions broken down by the following three categories: (a) new homes; (b) audit and weatherization; and (c) energy efficient equipment.

Administrative Requirements

The Residential CSP will provide overall administrative and operational management of Energy Efficient Homes. PPL Electric Utilities will provide oversight and operational support to establish effective deployment.

Estimated Participation

Table 25 shows the order of magnitude participation estimates for Energy Efficient Homes. Actual quantities will vary, and PPL Electric Utilities will manage the component to stay within budget.

Table 25. Pa PUC Table 8-Energy Efficient Homes Projected Participation [1]

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Connected Thermostat-Electric Heat AVG (downstream)	Energy Savings (MWh/year)	439	447	457	465	475	2,283
	Demand Reduction (MW)	0.019	0.019	0.020	0.020	0.021	0.099
	Projected Participation	720	735	750	764	780	3,749
Connected Thermostat- CAC AVG (downstream)	Energy Savings (MWh/year)	60	61	62	63	65	311
	Demand Reduction (MW)	0.009	0.009	0.009	0.010	0.010	0.047
	Projected Participation	343	350	358	364	372	1,786
New Homes-Connected Thermostat-Electric Heat (downstream)	Energy Savings (MWh/year)	198	202	206	210	214	1,029
	Demand Reduction (MW)	0.007	0.007	0.007	0.007	0.008	0.039
	Projected Participation	455	464	473	482	493	2,367
New Homes-Connected Thermostat-CAC (downstream)	Energy Savings (MWh/year)	47	48	49	50	51	243
	Demand Reduction (MW)	0.008	0.008	0.008	0.008	0.008	0.039
	Projected Participation	455	464	473	482	493	2,367
Fuel Switching – Central Heating (downstream) Maximum of 75 units for residential customers	Energy Savings (MWh/year)	96	96	96	96	96	481
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	15	15	15	15	15	75
Fuel Switching – DHW (downstream) Maximum of 75 units for residential customers	Energy Savings (MWh/year)	41	41	41	41	41	207
	Demand Reduction (MW)	0.003	0.003	0.003	0.003	0.003	0.017
	Projected Participation	15	15	15	15	15	75
HPWH-AVG	Energy Savings (MWh/year)	722	722	748	762	803	3,758
	Demand Reduction (MW)	0.060	0.060	0.062	0.063	0.067	0.313
	Projected Participation	516	516	535	545	574	2,686
Air Sealing -AVG (weatherization – downstream)	Energy Savings (MWh/year)	32	31	29	27	27	146
	Demand Reduction (MW)	0.0004	0.0004	0.0003	0.0003	0.0003	0.0017
	Projected Participation	30	29	27	25	25	136

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
ENERGY STAR Dehumidifiers (downstream)	Energy Savings (MWh/year)	640	654	669	676	695	3,334
	Demand Reduction (MW)	0.161	0.164	0.168	0.170	0.174	0.836
	Projected Participation	3,318	3,390	3,467	3,503	3,600	17,278
Ductless Mini-Split Heat Pump (16 SEER/9.0 HSPF) – replacing baseboard/room AC	Energy Savings (MWh/year)	1,677	1,711	1,745	1,779	1,815	8,728
	Demand Reduction (MW)	0.125	0.127	0.130	0.132	0.135	0.649
	Projected Participation	514	525	535	546	557	2,676
ENERGY STAR Air Source Heat Pump 16 SEER/9.0 HSPF/12.5 EER or Higher	Energy Savings (MWh/year)	763	778	792	-	-	2,332
	Demand Reduction (MW)	0.214	0.218	0.222	-	-	0.654
	Projected Participation	1,288	1,313	1,338	-	-	3,939
ENERGY STAR Air Source Heat Pump 17.5 SEER/9.7 HSPF/EER 13.5 or Higher	Energy Savings (MWh/year)	-	-	-	809	824	1,634
	Demand Reduction (MW)	-	-	-	0.167	0.170	0.337
	Projected Participation	-	-	-	1,367	1,392	2,759
ENERGY STAR Refrigerator (downstream)	Energy Savings (MWh/year)	80	82	84	85	87	418
	Demand Reduction (MW)	0.017	0.017	0.017	0.018	0.018	0.086
	Projected Participation	1,711	1,745	1,780	1,816	1,852	8,904
Ceiling Insulation AVG-Electric Heat (weatherization – downstream)	Energy Savings (MWh/year)	183	187	190	194	198	953
	Demand Reduction (MW)	0.004	0.005	0.005	0.005	0.005	0.023
	Projected Participation	232	237	241	246	251	1,207
Ceiling Insulation AVG-Non-Electric Heat (weatherization – downstream)	Energy Savings (MWh/year)	45	46	47	48	49	236
	Demand Reduction (MW)	0.002	0.003	0.003	0.003	0.003	0.013
	Projected Participation	131	134	136	139	142	682
Basement Wall Insulation AVG (weatherization – downstream)	Energy Savings (MWh/year)	34	34	34	34	34	169
	Demand Reduction (MW)	0.0017	0.0017	0.0017	0.0017	0.0017	0.0086
	Projected Participation	20	20	20	20	20	100
ENERGY STAR Central Air Conditioner (13 SEER/12EER to 16 SEER/12.5EER)	Energy Savings (MWh/year)	271	291	340	-	-	901
	Demand Reduction (MW)	0.161	0.173	0.202	-	-	0.536
	Projected Participation	932	1,000	1,169	-	-	3,101
ENERGY STAR Central Air Conditioner (14 SEER/12EER to 17.5 SEER/13.5EER)	Energy Savings (MWh/year)	-	-	-	245	259	504
	Demand Reduction (MW)	-	-	-	0.149	0.158	0.307
	Projected Participation	-	-	-	850	900	1,750
Variable speed pool pump	Energy Savings (MWh/year)	687	701	473	826	882	3,569
	Demand Reduction (MW)	0.226	0.230	0.156	0.271	0.290	1.173
	Projected Participation	472	481	325	567	606	2,451
New Homes-15% or higher better than code-Electric Heat	Energy Savings (MWh/year)	2,887	2,946	3,004	3,063	3,125	15,025
	Demand Reduction (MW)	1.126	1.149	1.172	1.195	1.219	5.862
	Projected Participation	1,088	1,110	1,132	1,154	1,178	5,663
New Homes-15% or higher better than code-Gas Heat	Energy Savings (MWh/year)	781	796	812	828	844	4,061
	Demand Reduction (MW)	0.690	0.704	0.719	0.732	0.747	3.592
	Projected Participation	667	680	694	707	722	3,470
In-Home Audit Incentive (Elec Heat + AC)	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	50	51	52	53	54	260
In-Home Audit Incentive (Elec Heat or Central AC)	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	26	26	27	27	28	134
	Energy Savings (MWh/year)	-	-	-	-	-	-

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Comprehensive Retrofit Bonus- Tier 1[3]	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	75	70	80	80	86	391
Comprehensive Retrofit Bonus- Tier 2[3]	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	25	36	30	20	20	131
Electric Hot Water Kit (Single Family – In-Home Audits)	Energy Savings (MWh/year)	8	8	8	8	8	39
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.004
	Projected Participation	50	51	52	53	54	260
Gas Hot Water Kit (Single Family – In-Home Audits)	Energy Savings (MWh/year)	2	3	3	3	3	13
	Demand Reduction (MW)	0.0002	0.0002	0.0002	0.0003	0.0003	0.0012
	Projected Participation	26	27	27	28	28	136
Electric Hot Water Kit (Single Family)	Energy Savings (MWh/year)	569	578	586	595	604	2,931
	Demand Reduction (MW)	0.061	0.062	0.063	0.064	0.065	0.316
	Projected Participation	3,753	3,808	3,864	3,922	3,980	19,327
Gas Hot Water Kit (Single Family)	Energy Savings (MWh/year)	229	233	237	240	244	1,183
	Demand Reduction (MW)	0.022	0.022	0.023	0.023	0.023	0.113
	Projected Participation	2,489	2,529	2,569	2,611	2,653	12,851
Smart Thermostat (Online Marketplace)	Energy Savings (MWh/year)	224	229	233	238	243	1,166
	Demand Reduction (MW)	0.034	0.035	0.035	0.036	0.037	0.177
	Projected Participation	1,290	1,316	1,342	1,369	1,396	6,712
Weatherstrip (Online Marketplace)	Energy Savings (MWh/year)	20	22	23	24	24	112
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0004
	Projected Participation	580	620	660	680	680	3,220
Advanced Power Strip (Online Marketplace)	Energy Savings (MWh/year)	15	15	15	16	16	77
	Demand Reduction (MW)	0.002	0.002	0.002	0.002	0.002	0.008
	Projected Participation	182	186	189	193	197	947
Occupancy Sensor Switch (Online Marketplace)	Energy Savings (MWh/year)	0	0	1	1	1	3
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	17	17	18	18	18	88
ENERGY STAR Dehumidifier (Online Marketplace)	Energy Savings (MWh/year)	154	154	154	154	154	772
	Demand Reduction (MW)	0.039	0.039	0.039	0.039	0.039	0.194
	Projected Participation	800	800	800	800	800	4,000
Electric Hot Water Kit (Single Family – Virtual Assessments)	Energy Savings (MWh/year)	84	85	87	89	90	435
	Demand Reduction (MW)	0.009	0.009	0.009	0.010	0.010	0.047
	Projected Participation	551	562	573	584	596	2,866
Gas Hot Water Kit (Single Family – Virtual Assessments)	Energy Savings (MWh/year)	10	10	11	11	11	53
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.005
	Projected Participation	110	112	115	117	119	573
ENERGY STAR Air Purifier (downstream rebates and online marketplace)	Energy Savings (MWh/year)	-	90	90	90	90	362
	Demand Reduction (MW)	-	0.010	0.010	0.010	0.010	0.041
	Projected Participation	-	163	163	163	163	650
Water Heater Pipe Insulation (online marketplace)	Energy Savings (MWh/year)	-	4.8	4.8	4.8	4.8	19.1
	Demand Reduction (MW)	-	0.0001	0.0001	0.0001	0.0001	0.0006
	Projected Participation	-	125	125	125	125	500
Holiday Lights (online marketplace)	Energy Savings (MWh/year)	-	2	2	2	2	10
	Demand Reduction (MW)	-	-	-	-	-	-

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
	Projected Participation	-	125	125	125	125	500
ENERGY STAR Clothes Washers (downstream rebates)	Energy Savings (MWh/year)	-	12	12	12	12	48
	Demand Reduction (MW)	-	0.001	0.001	0.001	0.001	0.005
	Projected Participation	-	125	125	125	125	500
ENERGY STAR Ceiling Fans (downstream rebates)	Energy Savings (MWh/year)	-	4	4	4	4	15
	Demand Reduction (MW)	-	0.0003	0.0003	0.0003	0.0003	0.0011
	Projected Participation	-	125	125	125	125	500
GSHP DeSuperheaters (midstream)	Energy Savings (MWh/year)	-	1	1	1	1	4
	Demand Reduction (MW)	-	0.0001	0.0001	0.0001	0.0001	0.0003
	Projected Participation	-	3	3	3	3	10
Solar Water Heaters (midstream)	Energy Savings (MWh/year)	-	12	12	12	12	47
	Demand Reduction (MW)	-	0.001	0.001	0.001	0.001	0.006
	Projected Participation	-	6	6	6	6	25
Water Heater Tank Wrap (online marketplace)	Energy Savings (MWh/year)	-	17	17	17	17	68
	Demand Reduction (MW)	-	0.002	0.002	0.002	0.002	0.008
	Projected Participation	-	125	125	125	125	500
Compact Refrigerators (downstream rebates)	Energy Savings (MWh/year)	-	0.4	0.4	0.4	0.4	1.7
	Demand Reduction (MW)	-	0.0001	0.0001	0.0001	0.0001	0.0003
	Projected Participation	-	13	13	13	13	50
Duct Sealing 50% unvented crawlspace, 30% attic (average)	Energy Savings (MWh/year)	-	9	9	9	9	38
	Demand Reduction (MW)	-	0.001	0.001	0.001	0.001	0.003
	Projected Participation	-	19	19	19	19	75
Duct Sealing & Insulation 50% unvented crawlspace, 30% attic (average)	Energy Savings (MWh/year)	-	15	15	15	15	59
	Demand Reduction (MW)	-	0.002	0.002	0.002	0.002	0.010
	Projected Participation	-	19	19	19	19	75

[1] To show numerical values in the Pa PUC Table 8 tables, deviation from the standard use of decimals throughout Section 3 may have been applied.
[2] Total values may not equal the sum of all program year values due to rounding.
[3] The Company will begin offering the Comprehensive Retrofit Bonus Incentives within the Energy Efficient Homes Component by no later than January 1, 2022.

Student Energy Efficient Education

Description

PPL Electric Utilities offers energy efficiency kits and education to students and teachers. The component consists of these three channels:

- **Primary Grade Energy Efficiency Education**, in which the Company offers an interactive classroom presentation to students in grades 2-3.
- **Intermediate Grade Energy Efficiency Education**, in which the Company offers an interactive classroom presentation to students in grades 5-7.
- **Secondary Grade Energy Efficiency Education**, in which the Company offers an interactive classroom presentation to students in grades 9-12.

The presentation educates students about energy and conservation topics using hands-on activities. Content is correlated to Pennsylvania Education Academic Standards for the appropriate grade levels and endorsed by the Pennsylvania Department of Education. Students who participate in the presentation receive a take-home energy efficiency kit.

The CSP will offer a poster contest and innovation challenge, which will support the component by giving students an additional opportunity to reflect on what they learned and how they acted on tips provide during the presentations.

PPL Electric Utilities will provide participating teachers with energy efficiency measures, such as smart power strips, to use as instructional aides to educate students about energy efficiency.

Objectives

The objectives of Student Energy Efficient Education are:

- Expand and promote energy efficiency literacy through education outreach components.
- Provide energy efficiency education to students offered through school assemblies and classroom curriculum.
- Confirm energy efficiency education correlates to Pennsylvania Education Academic Standards.
- Provide students and teachers with a take-home kit of energy efficiency measures that can be installed at home.
- Provide teachers with energy efficiency information, lesson plans, activities, training, materials, and support for classroom use.
- Achieve a total energy reduction of approximately 37,429 MWh/year and 3.1 MW[19] gross verified savings.
- Achieve high customer and teacher satisfaction.

Target Market

PPL Electric Utilities targets Student Energy Efficient Education to residential customers throughout its service territory by using schools as an outreach mechanism.

Implementation Strategy

The Residential CSP will deliver the component to schools and have sole responsibility for marketing to and recruiting potential schools and teachers, creating curriculum correlated to Pennsylvania Education Academic Standards, securing endorsement by the Pennsylvania Department of Education, conducting the energy efficiency presentations, and assembling and shipping the take-home energy efficiency kits. The Residential CSP will also provide support by operating a customer call center, following PPL Electric Utilities’ marketing and branding guidelines, and tracking activities.

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[19] Peak Demand is at generation.

PPL Electric Utilities' energy efficiency staff will provide overall strategic direction and management. The EM&V CSP will provide evaluation services.

Issues, Risks, and Risk Management Strategy

Table 26 presents market risks associated with Student Energy Efficient Education and the strategies PPL Electric Utilities will use to manage each risk.

Table 26. Student EE Education Issues, Risks, and Risk Management Strategies

Component Issue	Risk	Risk Management Strategies
Teachers may not have time in their schedules to incorporate the presentations.	Lesson plans are often created far in advance and teachers may not see value in the presentation and, therefore, may not participate.	Residential CSP ensures that the curriculum is correlated to the Pennsylvania Education Academic Standards and fits into teachers' existing lesson plans.
Customers do not install the energy efficiency measures or complete the survey included in their take-home kits	Although the education component would be completed, measurable energy savings would not be achieved.	• Residential CSP provides instructions on how to install the devices in the kits. • Residential CSP manages a customer call center for participants who have questions about the kits or how to install the measures.
Virtual presentations.	Not as much direct interactions with students, so it may be more difficult to capture their attention.	• Residential CSP may provide follow-up calls with teachers and email follow-ups with students after the presentation.

Anticipated Costs to Participating Customers

There are no direct costs incurred by customers in this component.

Ramp-up Strategy

Student Energy Efficient Education is an existing, mature offering being carried forward from Phase III. The Residential CSP will develop marketing material to facilitate the transition to Phase IV.

Marketing Strategy

To recruit teachers and schools to participate in Student Energy Efficient Education, the Residential CSP will work with PPL Electric Utilities to secure a list of qualified schools in the PPL Electric Utilities' service territory. The Residential CSP will issue promotional materials directly to potential participants via email and direct mail.

Eligible Measures and Incentive Strategy

Participants in each component receive a take-home energy efficiency kit that contains a variety of low-cost measures, such as LEDs and water-saving measures. PPL Electric Utilities will review the component continually and may adjust available measures or eligibility qualifications to achieve savings and cost budgets.

Table 27. Pa PUC Table 7-Student EE Education Eligible Measures and Incentives

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit)
Bright Kids (Primary School) Kit	Per Kit	No	Meets current TRM requirements	$20	5	$20
Take Action (Middle School) Kit	Per Kit	No	Meets current TRM requirements	$31	9	$31
Innovation (High School) TI Strip Kit	Per Kit	No	Meets current TRM requirements	$30	9	$30

Deadline for Rebate Applications

PPL Electric Utilities offers Student Energy Efficient Education services at no cost to customers; therefore, there is no rebate application.

Start Date with Key Schedule Milestones

Student Energy Efficient Education is currently offered in Phase III, and PPL Electric Utilities will facilitate the transition to Phase IV. Table 28 lists the estimated key schedule milestones for Student Energy Efficient Education. PPL Electric Utilities will lead implementation or provide management oversight of all tasks.

Table 28. Student Energy Efficient Education Schedule and Milestones

Schedule	Milestones
11/30/2020	Phase IV EE&C Plan submitted to Pa PUC
06/01/2021	Launch Phase IV component
Annually starting 01/15/2022	EDCs submit semiannual program report
Annually starting 09/30/2022	EDCs submit final annual program report
05/31/2026	Program ends

Evaluation, Measurement, and Verification

The EM&V requirements will be detailed in PPL Electric Utilities' Evaluation Plan, which will be submitted to the SWE for review. PPL Electric Utilities and its EM&V CSP will conduct annual evaluations of each component in compliance with all Pa PUC requirements and the Evaluation Framework. As part of this process, the EM&V CSP will review a sample of CSP records and student surveys and will follow all applicable methods in the TRM and the Evaluation Framework to calculate energy savings and peak demand reduction. For the Student Energy Efficient Education component, PPL Electric Utilities anticipates conducting annual impact and process evaluations (activities vary by year).

Through Student Energy Efficient Education, PPL Electric Utilities offers classroom training for students and delivers energy conservation kits free of charge to participants. Typically, the energy efficiency kits include a paper/online survey for students to complete. As part of the evaluation, the EM&V CSP will analyze data collected from all returned student surveys.

Administrative Requirements

The Residential CSP will provide overall administrative and operational management of Student Energy Efficient Education. PPL Electric Utilities will provide oversight and operational support to establish effective deployment.

Estimated Participation

Table 29 shows order of magnitude participation estimates for Student Energy Efficient Education. Actual quantities will vary, and PPL Electric Utilities will manage the component to stay within budget.

Table 29. Pa PUC Table 8-Student Energy Efficient Education Projected Participation[1]

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Bright Kids (Primary School) Kit	Energy Savings (MWh/year)	557	562	535	524	497	2,676
	Demand Reduction (MW)	0.048	0.048	0.046	0.045	0.043	0.230
	Projected Participation	5,594	5,652	5,377	5,271	5,000	26,894
Take Action (Middle School) Kit	Energy Savings (MWh/year)	5,302	5,238	5,135	4,992	4,665	25,331
	Demand Reduction (MW)	0.402	0.397	0.389	0.379	0.354	1.921
	Projected Participation	15,230	15,045	14,750	14,340	13,400	72,765
Innovation (High School) TI Strip Kit	Energy Savings (MWh/year)	2,016	2,016	1,738	1,912	1,738	9,422
	Demand Reduction (MW)	0.156	0.156	0.135	0.148	0.135	0.730
	Projected Participation	5,800	5,800	5,000	5,500	5,000	27,100

[1] To show numerical values in the Pa PUC Table 8 tables, deviation from the standard use of decimals throughout Section 3 may have been applied.
[2]Total values may not equal the sum of all program year values due to rounding.

Residential Pilot Programs

Description

During Program Year 13 (i.e., June 1, 2021, to May 31, 2022), PPL Electric Utilities will work with its Residential CSP or other contractors to develop proposals for a Deep Energy Retrofits pilot program and a Net Zero Building pilot program. As part of the pilot programs, PPL Electric Utilities will examine program designs and incentive structures that are offered in other jurisdictions for similar programs and pilots. The Company's proposals will include a description of the pilots' goals, how the performance of the pilots will be measured, data to be tracked, projected cost, performance and participation, and schedule. Each of the pilot programs will have a budget of no less than $500,000 and no more than $1 million. PPL Electric Utilities will present the proposals to stakeholders in Program Year 13. The Company will submit, within a reasonable time, a description of the pilot program(s) to the Commission and stakeholders prior to implementation in accordance with Section 9.1.4 of the Phase IV EE&C Plan. If either or both of the pilots require a change to the Phase IV EE&C Plan, the Company will review the change with stakeholders and submit the change to the Commission in a petition to modify the Phase IV

EE&C Plan. Assuming that no Phase IV EE&C Plan change is required to implement these pilot programs, PPL Electric Utilities will begin implementing these pilot programs no later than Program Year 14 to allow sufficient time to analyze the pilot programs' results and incorporate learnings within Phase IV. PPL Electric Utilities' EM&V CSP will assess the pilot programs' performance and will recommend changes to PPL Electric Utilities' full-scale energy efficiency offerings based on the EM&V CSP's assessment of the pilot programs' performance.

3.3 *Low-Income Program (2021-2026)*

This section summarizes PPL Electric Utilities' Low-Income Program component (*i.e.*, Low-Income Assessment) and the component's objectives, target market, implementation strategy, issues, risks and risk management strategy, anticipated costs to participating customers, ramp-up strategy, marketing strategy, eligible measures and incentive strategy, deadline for rebate applications, start date with key schedule milestones, EM&V, administrative requirements, estimated savings and participation, and plans for achieving compliance with the Implementation Order.

Table 30 lists estimated savings and costs by program year. The Low-Income Program budget is 13.4% of the total portfolio budget.[20]

Table 30. Pa PUC Table 9 - Low-Income Costs and Benefits by Program Year ($1000) [1]

Cost Element		PY13	PY14	PY15	PY16	PY17	Phase IV Total [2]
Total Budget ($000)		$8,063	$8,380	$8,697	$8,697	$8,063	$41,900
Incentives ($000)	Rebates	-	-	-	-	-	-
	Upstream/Midstream Buydown	-	-	-	-	-	-
	Kits	$151	$159	$167	$167	$151	$796
	Direct Install Materials & Labor	$4,281	$4,453	$4,625	$4,625	$4,281	$22,265
	Incentive Total	**$4,432**	**$4,613**	**$4,792**	**$4,792**	**$4,432**	**$23,062**
Non-Incentives ($000)	CSP Program Design	-	-	-	-	-	-
	CSP Administrative	$806	$806	$806	$806	$806	$4,031
	CSP Delivery Fees	$2,462	$2,592	$2,721	$2,721	$2,462	$12,958
	CSP Marketing	-	-	-	-	-	-
	EDC Administrative	$220	$220	$220	$220	$220	$1,100
	EDC Other	$143	$150	$157	$157	$142	$750
	Non-Incentive Total	**$3,631**	**$3,768**	**$3,905**	**$3,905**	**$3,631**	**$18,839**
Percent Incentives		55%	55%	55%	55%	55%	55%

[1] Excludes benefits and costs from master-metered multifamily buildings with low-income occupants. These savings count toward the low-income compliance target but the program costs and savings are accounted for under the customer sector corresponding to the rate class of the building's meter in assessing program cost-effectiveness.
[2] Total values may not equal the sum of all program year values due to rounding.

The Low-Income Program is projected not to be cost-effective, with a TRC test ratio of 0.48. Table 31 shows net present value benefits and costs, net benefits, and the overall benefit/cost ratio.

[20] This percentage represents the program budget without common costs over the total portfolio budget, which includes common costs.

Table 31. Low-Income Program Cost-Effectiveness Results, TRC Test ($1,000) [1]

NPV Benefits	$21,155
NPV Costs	$43,976
Net Benefits	($22,821)
Benefit/Cost Ratio	0.48

[1] Excludes benefits and costs from master-metered multifamily buildings with low-income occupants. These savings count toward the low-income compliance target but the program costs and savings are accounted for under the customer sector corresponding to the rate class of the building's meter in assessing program cost-effectiveness.

As noted in Section 1.6, PPL Electric Utilities will rely on energy efficiency measures with coincident peak demand reduction potential to achieve its annual and total peak demand reduction goals. PPL Electric Utilities will target end uses to nominate roughly 1 to 20% of eligible PJM peak demand savings from the low-income program over the five-year Plan. PPL Electric Utilities is not aware at this time which measures will be nominated; however, they will likely include cooling and lighting. PPL Electric Utilities will competitively select a qualified third-party vendor to provide technical support in nominating a portion of its peak demand reductions as a capacity resource in PJM's FCM.

Low-Income Assessment

Description

Through Low-Income Assessment, PPL Electric Utilities will offer a broad selection of no-cost energy-saving improvements and education to qualifying low-income customers residing in single-family homes, individually metered multifamily units, and manufactured homes.[21] Direct installation of energy efficiency measures for lighting, water aeration, and weatherization will be offered through PPL Electric Utilities' in-home and remote assessment delivery channels. Additionally, PPL Electric Utilities will offer comprehensive measures, such as ductless mini-split heat pumps, heat pump maintenance, heat pump water heaters, building shell measures, and smart thermostats through the in-home assessment delivery channel.

Low-income residents in individually metered multifamily units will be eligible for all measures provided in the Low-Income Assessment, but specific measures may require landlord approval. Common space in multifamily building will be treated separately through PPL Electric Utilities' Non-Residential Program. Multifamily buildings' eligibility requirements are not affected by the number of living units in the

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[21] Under Low-Income Assessment, individually metered and master-metered low-income multifamily residences are eligible for the same measures as individually metered single family low-income residences. Individually metered manufactured homes are also eligible for the same measures as any other type of individually metered home receiving services from Low-Income Assessment as long as they meet income guidelines.

buildings. PPL Electric Utilities also will provide the same measures available under the Low-Income Program inside the tenant units of low-income residents in master-metered multifamily buildings at no direct cost to the building owners or those tenants, subject to: (1) the measures' eligibility qualifications; (2) landlord approval; (3) available program funds; (4) the overall Low-Income Program acquisition cost; and (5) a limit on cumulative spending of $2.0 million in direct costs during Phase IV. All delivery channels are subject to available funding and must fall within the overall acquisition cost of the program.

Objectives

The objectives of the Low-Income Assessment component are:

- Provide low-income customers with no-cost energy-saving improvements and education to help them reduce their energy and peak demand usage.
- Achieve high customer, preferred partner, and trade ally satisfaction.
- Promote other PPL Electric Utilities energy efficiency program components.
- Provide low-income customers several options for receiving services safely and in consideration of their preferences.
- Achieve a total energy reduction of approximately 64,430 MWh/year and 9.8 MW/year[22] of gross verified savings.
- Increase the safety of low-income customers' homes by installing no-cost measures such as smoke and carbon monoxide detectors, which will be coordinated with the Low-Income Usage Reduction Program ("LIURP") Assessment.

Target Market

Through Low-Income Assessment, PPL Electric Utilities targets low-income customers (renters and owners) living in single-family homes, individually metered multifamily buildings (residential customer class), master-metered multifamily buildings (small C&I customer class) and manufactured homes. To qualify as low-income, household income must be at or below 150% of the Federal Poverty Income Guidelines (FPIG). Enrollees in PPL Electric Utilities' OnTrack Program are eligible.[23] Tenants must obtain landlord approval for certain measures to participate in the component. The number of units in a multifamily building does not affect the eligibility of its residents to receive energy-saving improvements and education.

Implementation Strategy

The Low-Income CSP will deliver the Low-Income Assessment component and will be responsible for outreach, customer recruitment, assessments, education, and equipment installation. The Low-Income CSP will also support sector-level functions, including operating a customer call center, marketing, and

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[22] Peak Demand is at generation.

[23] Through its OnTrack Program, PPL Electric Utilities offers reduced monthly payments to assist low-income customers with account balances in arrears.

tracking activities. PPL Electric Utilities' energy efficiency staff will provide overall strategic direction and management. The EM&V CSP will provide evaluation services.

Issues, Risks, and Risk Management Strategy

Table 32 presents market risks associated with Low-Income Assessment and the strategies PPL Electric Utilities will use to manage each risk.

Table 32. Low-Income Assessment Issues, Risks, and Risk Management Strategies

Component Issue	Risk	Risk Management Strategies
Homeowner and landlord lack of component awareness.	Low participation	• Low-Income CSP markets directly to income-eligible customers and through other partners and trade allies. • Low-Income CSP conducts neighborhood sweeps where few customers have participated in assessments. • Low-Income CSP markets at town hall gatherings and other venues
Difficulty getting landlord approval for participation by low-income tenants.	Low participation among renters	• Low-Income CSP markets directly to landlords. • Low-Income CSP seeks joint ventures with equipment suppliers, trade allies, and other organizations to provide additional incentives/discounts (such as financial incentives to eliminate code violations) to remove landlord barriers.
Possible saturation of eligible assessment participants.	Low participation and savings	• PPL Electric Utilities strongly encourages that all OnTrack Program enrollees also participate in Low-Income Assessment. • Low-Income CSP installs additional measures for customers who previously participated. • Low-Income CSP reaches out to landlords who previously declined participation.

Anticipated Costs to Participating Customers

There are no direct costs incurred by customers in this component.

Ramp-up Strategy

The Low-Income Assessment is an existing, mature component being carried forward from Phase III. The Low-Income CSP will develop marketing materials and an implementation strategy to facilitate the transition to Phase IV.

Marketing Strategy

PPL Electric Utilities will work with the Low-Income CSP to develop and execute a marketing plan that captures sector-level economies of scale and employs targeted outreach where practical. In addition to the current outreach encouraging OnTrack customers to participate in Low-Income Assessment, the Company will work with the Low-Income CSP to create and target marketing and outreach to eligible low-income customers who are not enrolled in OnTrack. The Company will describe its Low-Income Assessment marketing efforts at its Act 129 EE&C stakeholder meetings and ask stakeholders for feedback and recommendations.

The marketing strategy may include the following:

- Promote the component in PPL Electric Utilities' publications.
- Provide online access to the component through the Company's EE&C website.
- Introduce a welcome kit to recruit customers for the Low-Income Assessment component.
- Implement direct outreach, such as neighborhood sweeps, community and town hall events, and door-to-door canvassing, to create awareness about the Low-Income Assessment component; such outreach will involve identifying low-income neighborhoods, multifamily buildings, and manufactured home parks that may benefit from services and canvassing with door hangers.
- Conduct targeted telemarketing and direct mailing to customers participating in the OnTrack Program and Low-Income Home Energy Assistance Program ("LIHEAP") and to other income-eligible customers.
- Develop partnerships with housing and redevelopment authorities, community action groups, and other social service agencies. PPL Electric Utilities will develop a list of available assistance programs for each county in its service territory that it can provide to households served through its Act 129 programs and will work with its CBOs and other members of its Universal Service Advisory Committee to help create and maintain these lists for use by PPL Electric Utilities' Low-Income Program CSP.
- Recruit multifamily building owners and tenants to implement energy efficiency measures.

Eligible Measures and Incentive Strategy

Table 33 identifies PPL Electric Utilities' list of measures, minimum eligibility qualifications, and range of incentive levels.

Table 33. Pa PUC Table 7-Low-Income Assessment Eligible Measures and Incentives

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Full Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit)
Welcome Kit REA	Per Kit	Yes	Must be current OnTrack customer	$9	15	$9
Welcome Kit On-site	Per Kit	Yes	Must be current OnTrack customer	$9	15	$9
Water Kit SF REA	Per Kit	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	N/A	N/A	N/A
Water Kit MF REA	Per Kit	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	N/A	N/A	N/A
Water Kit SF On-site	Per Kit	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	N/A	N/A	N/A
Water Kit MF On-site	Per Kit	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	N/A	N/A	N/A
Kitchen Aerator SF REA	Per Product	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	$3	10	$3
Kitchen Aerator MF REA	Per Product	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	$3	10	$3
Bath Aerator SF REA	Per Product	Yes	Electric hot water only, maximum flow rate is 0.5 gallons per minute	$2	10	$2

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Full Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit)
Bath Aerator MF REA	Per Product	Yes	Electric hot water only, maximum flow rate is 0.5 gallons per minute	$2	10	$2
Low Flow Showerhead SF REA	Per Product	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	$9	9	$9
Low Flow Showerhead MF REA	Per Product	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	$9	9	$9
Low Flow Showerhead Hand Held SF REA	Per Product	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	$15	9	$15
Low Flow Showerhead Hand Held MF REA	Per Product	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	$15	9	$15
LED Night Light REA	Per Product	Yes	Meets current TRM requirements, Replaces incandescent night light	$2	8	$2
LED Specialty (Globe/Candelabra) REA	Per Bulb	Yes	Meets current TRM requirements, ENERGY STAR	$8	15	$8
LED GSL A-Line (9 Watt or other) REA	Per Bulb	Yes	Meets current TRM requirements, ENERGY STAR	$7	15	$7
LED Reflector (Par/BR/R/downlight) REA	Per Bulb	Yes	Meets current TRM requirements, ENERGY STAR	$10	15	$10
Smart Strips - Tier 1 REA	Per Product	Yes	Meets current TRM requirement	$25	5	$25
Remote assessment & Energy Education REA	Per Project	Yes	Must be PPL Electric Utilities customer regardless of heating fuel	$60	1	$60
Carbon Monoxide Detector REA	Per Product	Yes	Must be recommended by auditor	$20	1	$20
Smoke Alarm REA	Per Product	Yes	Must be recommended by auditor	$7	1	$7
Kitchen Aerator SF On-site	Per Product	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	$3	10	$3
Kitchen Aerator MF On-site	Per Product	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	$3	10	$3
Bath Aerator SF On-site	Per Product	Yes	Electric hot water only, maximum flow rate is 0.5 gallons per minute	$2	10	$2
Bath Aerator MF On-site	Per Product	Yes	Electric hot water only, maximum flow rate is 0.5 gallons per minute	$2	10	$2
Water Heater Pipe Insulation On-site	Per Foot	Yes	Electric hot water only	$2	13	$2
Low Flow Showerhead SF On-site	Per Product	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	$9	9	$9
Low Flow Showerhead MF On-site	Per Product	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	$9	9	$9
Low Flow Showerhead Hand Held SF On-site	Per Product	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	$15	9	$15
Low Flow Showerhead Hand Held MF On-site	Per Product	Yes	Electric hot water only, maximum flow rate is 1.5 gallons per minute	$15	9	$15
Thermostatic Shower Restriction Valve SF On-site	Per Product	Yes	Electric hot water only, Meets current TRM requirements	N/A	N/A	N/A
Thermostatic Shower Restriction Valve MF On-site	Per Product	Yes	Electric hot water only, Meets current TRM requirements	N/A	N/A	N/A

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Full Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit)
Water Heater Temperature Setback On-site	Per Product	Yes	Electric hot water only, Meets current TRM requirements	$10	2	$10
Heat Pump Water Heater Replacement On-site	Per Project	Yes	Electric hot water only, ENERGY STAR	$2,768	10	$2,768
Furnace Whistle On-site	Per Product	Yes	Meets current TRM requirements	N/A	N/A	N/A
LED Night Light On-site	Per Product	Yes	Meets current TRM requirements, Replaces incandescent night light	$2	8	$2
LED Specialty (Globe/Candelabra) On-site	Per Bulb	Yes	Meets current TRM requirements, ENERGY STAR	$8	15	$8
LED A-Line (9 Watt or other) On-site	Per Bulb	Yes	Meets current TRM requirements, ENERGY STAR	$7	15	$7
LED Reflector (Par/BR/R/downlight) On-site	Per Bulb	Yes	Meets current TRM requirements, ENERGY STAR	$10	15	$10
Removal/Disposal of Extra Refrigeration Unit On-site	Per Product	Yes	Existing, working refrigerator or freezer 10-30 cubic feet in size, unit is primary or secondary unit	N/A	N/A	N/A
Recycle and Replace Freezer On-site	Per Product	Yes	Existing, working refrigerator or freezer 10-30 cubic feet in size, unit is primary or secondary unit	$696	5	$696
Smart Strips - Tier 1 On-site	Per Product	Yes	Meets current TRM requirement	$25	5	$25
Carbon Monoxide Detector On-site	Per Product	Yes	Must be recommended by auditor	$20	1	$20
Smoke Alarm On-site	Per Product	Yes	Must be recommended by auditor	$7	1	$7
Smart Thermostat Heat Pump On-site	Per Product	Yes	ENERGY STAR	$320	11	$320
Smart Thermostat Electric Furnace On-site	Per Product	Yes	ENERGY STAR	N/A	N/A	N/A
Heat Pump Maintenance On-site	Per Product	Yes	Repair or replacement, Meets current TRM requirements	$250	3	$250
On-site Assessment & Energy Education On-site	Per Product	Yes	Must be PPL Electric Utilities customer regardless of heating fuel	$135	1	$135
Ductless Mini-split Heat Pumps On-site	Per Product	Yes	Repair or replacement, Meets current TRM requirements. ENERGY STAR	Up to $8,000	15	Up to $8,000
Ceiling/Attic or Wall Insulation - Baseboard Heat	Per Home	Yes	Meets current TRM requirements. Not applicable for individually metered multifamily units	Up to $2,500	15	Up to $2,500
Ceiling/Attic or Wall Insulation - Heat Pump	Per Home	Yes	Meets current TRM requirements. Not applicable for individually metered multifamily units	Up to $2,500	15	Up to $2,500
Residential Air Sealing - Baseboard Heat	Per Home	Yes	Meets current TRM requirements	Up to $800	15	Up to $800
Residential Air Sealing - Heat Pump	Per Home	Yes	Meets current TRM requirements	Up to $800	15	Up to $800

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Full Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit)
Water Heater Pipe Insulation REA	Per Foot	Yes	Electric hot water only	N/A	N/A	N/A
Thermostatic Shower Restriction Valve SF REA	Per Product	Yes	Electric hot water only, Meets current TRM requirements	N/A	N/A	N/A
Thermostatic Shower Restriction Valve MF REA	Per Product	Yes	Electric hot water only, Meets current TRM requirements	N/A	N/A	N/A
Furnace Whistle REA	Per Product	Yes	Meets current TRM requirements	N/A	N/A	N/A
Recycle and Replace Refrigerator REA	Per Product	Yes	Existing, working refrigerator or freezer 10-30 cubic feet in size, unit is primary or secondary unit	N/A	N/A	N/A
Removal/Disposal of Extra Refrigeration Unit REA	Per Product	Yes	Existing, working refrigerator or freezer 10-30 cubic feet in size, unit is primary or secondary unit	N/A	N/A	N/A
Recycle and Replace Freezer REA	Per Product	Yes	Existing, working refrigerator or freezer 10-30 cubic feet in size, unit is primary or secondary unit	N/A	N/A	N/A
Smart Strips - Tier 2 REA	Per Product	Yes	Meets current TRM requirement	N/A	N/A	N/A
ES Dehumidifier REA	Per Product	Yes	ENERGY STAR	N/A	N/A	N/A
Battery Replaced in Existing Smoke Alarm REA	Per Product	Yes	As recommended by auditor	N/A	N/A	N/A
Recycle and Replace Refrigerator On-site	Per Product	Yes	Existing, working refrigerator or freezer 10-30 cubic feet in size, unit is primary or secondary unit	$923	6	$923
Smart Strips - Tier 2 On-site	Per Product	Yes	Meets current TRM requirement	N/A	N/A	N/A
Energy Star Dehumidifier On-site	Per Product	Yes	ENERGY STAR	N/A	N/A	N/A
Battery Replaced in Existing Smoke Alarm On-site	Per Product	Yes	As recommended by auditor	N/A	N/A	N/A
Energy Star Air Purifiers	Per Product	Yes	Meets current TRM requirements.	N/A	N/A	N/A
Room AC (RAC) Retirement	Per Product	Yes	Meets current TRM requirements.	N/A	N/A	N/A
Energy Star Room AC (RAC) Replacement	Per Product	Yes	Meets current TRM requirements.	N/A	N/A	N/A
Variable Speed Pool Pump	Per Product	Yes	Meets current TRM requirements.	N/A	N/A	N/A
SCI MMMF Direct Install - Master Meter[2]	Per Project	No	Participants must be low-income residents in a master-metered multifamily building. Must meet current TRM requirements.	$315	15	$315

[1] All eligible measures are listed in this table regardless of participation projections. N/A indicates measure may be offered in future program years but not at the launch of Phase IV.

[2] Represents eligible measures for master-metered multifamily buildings with low-income occupants. These measures count toward the

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Full Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit)

low-income compliance target but the program costs and savings are accounted for under the customer sector corresponding to the rate class of the building's meter in assessing program cost-effectiveness.

PPL Electric Utilities and the Low-Income CSP will work with stakeholders, community based organizations ("CBOs"), preferred partners, and trade allies to create partnerships that can take advantage of additional incentives or cost savings for low-income customers. The Low-Income CSP will make reasonable efforts to meet with the natural gas distribution companies ("NGDCs") that operate within PPL Electric Utilities' service territory to identify and evaluate opportunities for coordination of low-income EE&C programs that are funded by residential customers. At its annual EE&C stakeholder meetings, PPL Electric Utilities will present information about these coordination efforts and will allow stakeholders to provide feedback and recommendations.

All measures may not be available at all times. PPL Electric Utilities will review the component continually and may adjust available measures or eligibility qualifications to achieve savings and cost budgets. Additionally, up to $2.0 million of the Low-Income Assessment's budget will be dedicated to: (1) space heating; (2) building shell measures; (3) water heater maintenance, repair, or replacement; and (4) appliance replacement/recycling.

PPL Electric Utilities will coordinate Low-Income Assessment with its LIURP Assessment consistent with the Company's coordination in Phase III to maximize the effectiveness of measures and services provided to participants. If measures are jointly funded by PPL Electric Utilities' LIURP and Low-Income Program, PPL Electric Utilities will allocate the actual costs and savings for jointly funded measures based upon the percentage of total costs paid by each funding source. In addition, to further coordinate delivery of services to low-income households and help minimize the number of LIURP and Low-Income Program contractors who visit a customer's service location, the Low-Income CSP will consider, when selecting potential subcontractors, the efficiencies that can be gained by subcontracting work under the Low-Income Assessment component to CBOs who provide services under the Company's LIURP. The Low-Income CSP will also provide all of those CBOs with any invites to bid or requests for proposals to serve as subcontractors.

If a low-income home is eligible for full cost treatment,[24] the Company will install eligible measures through both LIURP Assessment and Low-Income Assessment budgets, provided that the following conditions are all met:

- The customer receives landlord approval, as appropriate.

[24] Full cost treatment may include weatherization and other measures outside scope of traditional assessments.

- The customer has installed electric heat in at least 50% of the home.
- The customer's home did not previously receive full cost services through the Low-Income Winter Relief Assistance Program (WRAP) in Phase III.
- The customer's home has no health or safety concerns that prevent the installation of full cost measures.
- The cost of the full cost measures can be accommodated in the LIURP Assessment or Low-Income Assessment budget.

Some measures provided in a home will be covered by Low-Income Assessment and others by LIURP Assessment. PPL Electric Utilities intends to increase the coordination and provide additional efficiencies between the Low-Income Assessment and LIURP Assessment, including:

- Single source for coordinated marketing campaigns.
- Reduced customer acquisition cost.
- Integrated intake and customer eligibility screening.
- Additional LIURP pre-screening opportunities for enhanced delivery of the program.
- Streamlined administrative and management processes.
- Consistent QA/QC procedures.

Potential LIURP Assessment measures will be identified during the Low-Income Assessment. If eligibility is determined, a Personal Energy Guide will refer the customer to a Preferred Partner for the installation of the LIURP measures.[25]

The Low-Income Assessment will provide baseload measures for LIURP Assessment customers whose income is less than 150% of the FPIG, allowing more of the LIURP budget to focus on comprehensive measures. Baseload measures for customers whose income is between 150% and 200%- of the FPIG will be funded through the LIURP budget.

Deadline for Rebate Applications

PPL Electric Utilities offers Low-Income Assessment services at no cost to customers; therefore, there is no rebate application.

Start Date with Key Schedule Milestones

Table 34 lists the estimated key schedule milestones for Low-Income Assessment. PPL Electric Utilities staff will lead implementation or provide management oversight of all tasks.

[25] See page 127 for Preferred Partner definition.

Table 34. Low-Income Assessment Schedule and Milestones

Schedule	Milestones
11/30/2020	Phase IV EE&C Plan submitted to Pa PUC
06/01/2021	Launch Phase IV component
Annually starting 01/15/2022	EDCs submit semiannual program report
Annually starting 09/30/2022	EDCs submit final annual program report
05/31/2026	Program ends

Evaluation, Measurement, and Verification

The EM&V requirements will be detailed in PPL Electric Utilities' Evaluation Plan, which will be submitted to the SWE for review. The EM&V CSP will follow all applicable methods in the TRM to calculate energy savings and peak demand reduction. PPL Electric Utilities anticipates conducting annual impact evaluations and conducting process evaluations at least once during Phase IV.

The EM&V CSP will review a sample of participant records to verify the quantity, efficiency level, and qualification based on measure type and job type. If a home receives measures from Low-Income Assessment and LIURP Assessment, the Evaluation Plan will describe how their savings will be allocated.

Administrative Requirements

The Low-Income CSP will provide overall administrative and operational management of Low-Income Assessment. PPL Electric Utilities will provide oversight and operational support to establish effective deployment.

Estimated Participation

Table 35 shows the order of magnitude participation estimates for Low-Income Assessment. Actual quantities will vary, and PPL Electric Utilities will manage the component to stay within budget.

Table 35. Pa PUC Table 8-Low-Income Assessment Projected Participation [1]

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Welcome Kit REA	Energy Savings (MWh/year)	251	265	278	278	251	1,323
	Demand Reduction (MW)	0.142	0.149	0.157	0.157	0.142	0.746
	Projected Participation	11,765	12,385	13,004	13,004	11,765	61,923
Welcome Kit On-site	Energy Savings (MWh/year)	108	113	119	119	108	567
	Demand Reduction (MW)	0.061	0.064	0.067	0.067	0.061	0.320
	Projected Participation	5,042	5,308	5,573	5,573	5,042	26,539
Water Kit SF REA	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	-	-	-	-	-	-
Water Kit MF REA	Energy Savings (MWh/year)	-	-	-	-	-	-

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	-	-	-	-	-	-
Water Kit SF On-site	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	-	-	-	-	-	-
Water Kit MF On-site	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	-	-	-	-	-	-
Kitchen Aerator SF REA	Energy Savings (MWh/year)	1,128	1,187	1,246	1,246	1,128	5,935
	Demand Reduction (MW)	0.156	0.164	0.173	0.173	0.156	0.822
	Projected Participation	4,681	4,927	5,174	5,174	4,681	24,637
Kitchen Aerator MF REA	Energy Savings (MWh/year)	44	47	49	49	44	234
	Demand Reduction (MW)	0.006	0.006	0.007	0.007	0.006	0.032
	Projected Participation	246	259	272	272	246	1,297
Bath Aerator SF REA	Energy Savings (MWh/year)	536	564	592	592	536	2,818
	Demand Reduction (MW)	0.074	0.078	0.082	0.082	0.074	0.390
	Projected Participation	7,021	7,391	7,761	7,761	7,021	36,955
Bath Aerator MF REA	Energy Savings (MWh/year)	35	37	39	39	35	185
	Demand Reduction (MW)	0.005	0.005	0.005	0.005	0.005	0.026
	Projected Participation	370	389	408	408	370	1,945
Low Flow Showerhead SF REA	Energy Savings (MWh/year)	301	316	332	332	301	1,582
	Demand Reduction (MW)	0.025	0.026	0.028	0.028	0.025	0.131
	Projected Participation	1,040	1,095	1,150	1,150	1,040	5,475
Low Flow Showerhead MF REA	Energy Savings (MWh/year)	16	16	17	17	16	82
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.007
	Projected Participation	55	58	61	61	55	288
Low Flow Showerhead Hand Held SF REA	Energy Savings (MWh/year)	1,052	1,107	1,163	1,163	1,052	5,536
	Demand Reduction (MW)	0.087	0.092	0.096	0.096	0.087	0.458
	Projected Participation	3,641	3,832	4,024	4,024	3,641	19,162
Low Flow Showerhead Hand Held MF REA	Energy Savings (MWh/year)	55	58	61	61	55	288
	Demand Reduction (MW)	0.005	0.005	0.005	0.005	0.005	0.024
	Projected Participation	192	202	212	212	192	1,009
LED Night Light REA	Energy Savings (MWh/year)	156	158	162	162	156	796

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	6,584	6,664	6,836	6,835	6,584	33,503
LED Specialty (Globe/Candelabra) REA	Energy Savings (MWh/year)	853	898	942	942	853	4,488
	Demand Reduction (MW)	0.120	0.127	0.133	0.133	0.120	0.634
	Projected Participation	31,937	33,618	35,298	35,298	31,937	168,088
LED GSL A-Line (9 Watt or other) REA	Energy Savings (MWh/year)	3,411	3,590	3,770	3,770	3,411	17,952
	Demand Reduction (MW)	0.599	0.631	0.662	0.662	0.599	3.155
	Projected Participation	127,747	134,470	141,194	141,194	127,747	672,350
LED Reflector (Par/BR/R/downlight) REA	Energy Savings (MWh/year)	187	197	206	206	187	983
	Demand Reduction (MW)	0.027	0.028	0.030	0.030	0.027	0.141
	Projected Participation	4,562	4,803	5,043	5,043	4,562	24,013
Smart Strips - Tier 1 REA	Energy Savings (MWh/year)	1,787	1,881	1,975	1,975	1,787	9,403
	Demand Reduction (MW)	0.185	0.194	0.204	0.204	0.185	0.972
	Projected Participation	20,074	21,131	22,188	22,188	20,074	105,655
Remote assessment & Energy Education REA	Energy Savings (MWh/year)	487	513	539	539	487	2,565
	Demand Reduction (MW)	0.004	0.004	0.005	0.005	0.004	0.022
	Projected Participation	9,125	9,605	10,085	10,085	9,125	48,025
Carbon Monoxide Detector REA	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	650	726	753	753	650	3,532
Smoke Alarm REA	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	6,475	6,814	7,154	7,154	6,474	34,071
Kitchen Aerator SF On-site	Energy Savings (MWh/year)	199	209	220	220	199	1,047
	Demand Reduction (MW)	0.028	0.029	0.030	0.030	0.028	0.145
	Projected Participation	826	870	913	913	826	4,348
Kitchen Aerator MF On-site	Energy Savings (MWh/year)	8	8	9	9	8	41
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.006
	Projected Participation	43	46	48	48	43	229
Bath Aerator SF On-site	Energy Savings (MWh/year)	95	99	104	104	95	497
	Demand Reduction (MW)	0.013	0.014	0.014	0.014	0.013	0.069
	Projected Participation	1,239	1,304	1,370	1,370	1,239	6,522
Bath Aerator MF On-site	Energy Savings (MWh/year)	6	7	7	7	6	33

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.005
	Projected Participation	65	69	72	72	65	343
Water Heater Pipe Insulation On-site	Energy Savings (MWh/year)	13	13	14	14	13	66
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.005
	Projected Participation	1,610	1,695	1,780	1,780	1,612	8,477
Low Flow Showerhead SF On-site	Energy Savings (MWh/year)	53	56	59	59	53	279
	Demand Reduction (MW)	0.004	0.005	0.005	0.005	0.004	0.023
	Projected Participation	183	193	203	203	183	965
Low Flow Showerhead MF On-site	Energy Savings (MWh/year)	3	3	3	3	3	15
	Demand Reduction (MW)	0.0002	0.0002	0.0003	0.0003	0.0002	0.0012
	Projected Participation	10	10	11	11	10	52
Low Flow Showerhead Hand Held SF On-site	Energy Savings (MWh/year)	186	195	205	205	186	977
	Demand Reduction (MW)	0.015	0.016	0.017	0.017	0.015	0.081
	Projected Participation	642	676	710	710	642	3,382
Low Flow Showerhead Hand Held MF On-site	Energy Savings (MWh/year)	10	10	11	11	10	51
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.004
	Projected Participation	34	36	37	37	34	178
Thermostatic Shower Restriction Valve SF On-site	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	-	-	-	-	-	-
Thermostatic Shower Restriction Valve MF On-site	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	-	-	-	-	-	-
Water Heater Temperature Setback On-site	Energy Savings (MWh/year)	34	35	37	37	34	177
	Demand Reduction (MW)	0.003	0.003	0.003	0.003	0.003	0.015
	Projected Participation	338	356	374	374	338	1,780
Heat Pump Water Heater Replacement On-site	Energy Savings (MWh/year)	146	153	161	161	146	767
	Demand Reduction (MW)	0.008	0.009	0.009	0.009	0.008	0.043
	Projected Participation	80	84	88	88	80	420
Furnace Whistle On-site	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	-	-	-	-	-	-
LED Night Light On-site	Energy Savings (MWh/year)	29	30	32	32	29	151

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	1,208	1,271	1,335	1,335	1,208	6,356
LED Specialty (Globe/Candelabra) On-site	Energy Savings (MWh/year)	74	78	82	82	74	391
	Demand Reduction (MW)	0.010	0.011	0.012	0.012	0.010	0.055
	Projected Participation	2,780	2,927	3,073	3,073	2,780	14,633
LED A-Line (9 Watt or other) On-site	Energy Savings (MWh/year)	559	588	618	618	559	2,942
	Demand Reduction (MW)	0.098	0.103	0.109	0.109	0.098	0.517
	Projected Participation	20,933	22,035	23,137	23,137	20,933	110,175
LED Reflector (Par/BR/R/downlight) On-site	Energy Savings (MWh/year)	33	35	36	36	33	173
	Demand Reduction (MW)	0.005	0.005	0.005	0.005	0.005	0.025
	Projected Participation	805	848	890	890	805	4,238
Removal/Disposal of Extra Refrigeration Unit On-site	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	-	-	-	-	-	-
Recycle and Replace Refrigerator On-site	Energy Savings (MWh/year)	4	4	4	4	4	20
	Demand Reduction (MW)	0.0003	0.0003	0.0003	0.0003	0.0003	0.002
	Projected Participation	8	8	9	9	8	42
Recycle and Replace Freezer On-site	Energy Savings (MWh/year)	4	4	4	4	4	20
	Demand Reduction (MW)	0.0003	0.0003	0.0003	0.0003	0.0003	0.002
	Projected Participation	8	8	9	9	8	42
Smart Strips - Tier 1 On-site	Energy Savings (MWh/year)	215	226	238	238	215	1,131
	Demand Reduction (MW)	0.022	0.023	0.025	0.025	0.022	0.117
	Projected Participation	2,415	2,543	2,670	2,670	2,415	12,713
Carbon Monoxide Detector On-site	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	175	190	212	212	175	964
Smoke Alarm On-site	Energy Savings (MWh/year)	-	-	-	-	-	-
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	950	1,000	1,050	1,050	950	5,000
Smart Thermostat Heat Pump On-site	Energy Savings (MWh/year)	11	12	12	12	11	59
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.006
	Projected Participation	19	20	21	21	19	102
	Energy Savings (MWh/year)	-	-	-	-	-	-

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Smart Thermostat Electric Furnace On-site	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	-	-	-	-	-	-
Heat Pump Maintenance On-site	Energy Savings (MWh/year)	4	4	5	5	4	22
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.004
	Projected Participation	19	20	21	21	19	102
On-site Assessment & Energy Education On-site	Energy Savings (MWh/year)	86	91	95	95	86	453
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.004
	Projected Participation	1,610	1,695	1,780	1,780	1,610	8,475
Ductless Mini-split Heat Pumps On-site	Energy Savings (MWh/year)	21	22	23	23	21	110
	Demand Reduction (MW)	0.002	0.002	0.002	0.002	0.002	0.011
	Projected Participation	10	10	11	11	10	50
Ceiling/Attic or Wall Insulation - Baseboard Heat	Energy Savings (MWh/year)	8	9	9	9	8	44
	Demand Reduction (MW)	0.0001	0.0002	0.0002	0.0002	0.0001	0.0008
	Projected Participation	8	8	9	9	8	41
Ceiling/Attic or Wall Insulation - Heat Pump	Energy Savings (MWh/year)	2	2	2	2	2	11
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0004
	Projected Participation	5	5	5	5	5	24
Residential Air Sealing - Baseboard Heat	Energy Savings (MWh/year)	30	31	33	33	30	157
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.006
	Projected Participation	23	24	26	26	23	122
Residential Air Sealing - Heat Pump	Energy Savings (MWh/year)	11	12	12	12	11	59
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0006
	Projected Participation	14	15	15	15	14	73
SCI MMMF Direct Install - Master Meter[3]	Energy Savings (MWh/year)	744	783	821	821	743	3,912
	Demand Reduction (MW)	0.092	0.097	0.102	0.102	0.092	0.483
	Projected Participation	845	889	933	933	844	4,444

[1] To show numerical values in the Pa PUC Table 8 tables, deviation from the standard use of decimals throughout Section 3 may have been applied.
[2] Total values may not equal the sum of all program year values due to rounding.
[3] Includes savings from master-metered multifamily buildings with low-income occupants. These savings count toward the low-income compliance target but the program costs and savings are accounted for under the customer sector corresponding to the rate class of the building's meter in assessing program cost-effectiveness.

Plans for Achieving Compliance with the Implementation Order

PPL Electric Utilities designed its EE&C Plan to achieve its low-income targets with Phase IV transactions (projects that are implemented during Phase IV) through an income-qualified component only, the Low-Income Assessment.

Health and Safety Pilot Program

PPL Electric Utilities' Low-Income CSP will implement a low-income health and safety pilot program to remediate health and safety hazards that prevent low-income customers from receiving comprehensive energy efficiency measures. The pilot program will be funded at no less than $400,000 and no more than $750,000 over the five-year Phase IV and will prioritize high usage customers. Through this pilot, PPL Electric will assess the extent to which addressing health and safety barriers will allow it to increase energy and bill savings and decrease other universal service program costs. PPL Electric Utilities also will track which EE&C measures were allowed to be installed through the installation of the various health and safety measures in the participating customers' homes.

3.4 Non-Residential Program (2021-2026)

PPL Electric Utilities' Non-Residential Program will be offered to all large C&I and small C&I customers, including government and educational institutions and master metered low-income multifamily buildings. The following sections describe the two components in PPL Electric Utilities' Non-Residential Program:

- Efficient Equipment (Prescriptive)
- Custom

The component sections below provide the component description; objectives; target market; implementation strategy; issues, risks, and risk management strategy; anticipated costs to participating customers; ramp-up strategy; marketing strategy; eligible measures and incentive strategy; deadline for rebate applications; start date with key schedule milestones; EM&V; administrative requirements; and estimated savings and participation. Please note that participation levels, savings, costs, and incentive ranges are estimates as directed by the Pa PUC EE&C Plan Template.

Table 36 and Table 37 list estimated savings and costs by program year and in total for the Non-Residential Program (large C&I and small C&I, respectively). The Non-Residential Large C&I budget is 27.5% of the total portfolio budget, and the Non-Residential Small C&I budget is 24.6% of the total portfolio budget.[26]

Table 36. Pa PUC Table 9 - Large C&I Costs and Benefits by Program Year ($1000)

Cost Element		PY13	PY14	PY15	PY16	PY17	Phase IV Total [1]
Total Budget ($000)		$16,696	$17,413	$17,456	$17,180	$17,162	$85,906
Incentives ($000)	Rebates	$10,733	$11,191	$11,189	$10,993	$10,955	$55,060
	Upstream/Midstream Buydown	$537	$552	$533	$507	$501	$2,630
	Kits	-	-	-	-	-	-

[26] This percentage represents the program budget without common costs over the total portfolio budget, which includes common costs.

Cost Element		PY13	PY14	PY15	PY16	PY17	Phase IV Total [1]
	Direct Install Materials & Labor	-	-	-	-	-	-
	Incentive Total	**$11,270**	**$11,742**	**$11,722**	**$11,500**	**$11,456**	**$57,690**
Non-Incentives ($000)	CSP Program Design	$101	-	-	-	-	$101
	CSP Administrative	$769	$849	$885	$906	$934	$4,343
	CSP Delivery Fees	$4,032	$4,254	$4,262	$4,176	$4,159	$20,884
	CSP Marketing	$414	$457	$477	$488	$503	$2,339
	EDC Administrative	$110	$110	$110	$110	$110	$550
	EDC Other	-	-	-	-	-	-
	Non-Incentive Total	**$5,426**	**$5,671**	**$5,734**	**$5,680**	**$5,706**	**$28,216**
Percent Incentives		68%	67%	67%	67%	67%	67%

[1] Total values may not equal the sum of all program year values due to rounding.

Table 37. Pa PUC Table 9 - Small C&I Costs and Benefits by Program Year ($1000) [1]

Cost Element		PY13	PY14	PY15	PY16	PY17	Phase IV Total [2]
Total Budget ($000)		$14,966	$15,662	$15,638	$15,225	$15,348	$76,838
Incentives ($000)	Rebates	$8,331	$8,781	$8,768	$8,523	$8,622	$43,025
	Upstream/Midstream Buydown	$1,461	$1,483	$1,445	$1,393	$1,370	$7,152
	Kits	-	-	-	-	-	-
	Direct Install Materials & Labor	$416	$458	$470	$467	$433	$2,245
	Incentive Total	**$10,208**	**$10,722**	**$10,683**	**$10,384**	**$10,425**	**$52,422**
Non-Incentives ($000)	CSP Program Design	$129	-	-	-	-	$129
	CSP Administrative	$822	$875	$887	$888	$906	$4,378
	CSP Delivery Fees	$3,319	$3,548	$3,546	$3,430	$3,482	$17,325
	CSP Marketing	$378	$407	$413	$413	$423	$2,034
	EDC Administrative	$110	$110	$110	$110	$110	$550
	EDC Other	-	-	-	-	-	-
	Non-Incentive Total	**$4,758**	**$4,940**	**$4,955**	**$4,841**	**$4,922**	**$24,416**
Percent Incentives		68%	68%	68%	68%	68%	68%

[1] Includes benefits and costs from master-metered multifamily buildings with low-income occupants. These savings count toward the low-income compliance target but the program costs and savings are accounted for under the customer sector corresponding to the rate class of the building's meter in assessing program cost-effectiveness.
[2] Total values may not equal the sum of all program year values due to rounding.

Table 38 and Table 39 show net present value benefits and costs, net benefits, and the overall benefit/cost ratio for the large C&I and small C&I sectors, respectively.

Table 38. Large C&I Cost-Effectiveness Results, TRC Test ($1,000)

NPV Benefits	$414,347
NPV Costs	$396,663
Net Benefits	$17,684
Benefit/Cost Ratio	1.04

Table 39. Small C&I Cost-Effectiveness Results, TRC Test ($1,000) [1]

NPV Benefits	$367,754
NPV Costs	$245,746
Net Benefits	$122,008
Benefit/Cost Ratio	1.50

[1] Includes benefits and costs from master-metered multifamily buildings with low-income occupants. These savings count toward the low-income compliance target but the program costs and savings are accounted for under the customer sector corresponding to the rate class of the building's meter in assessing program cost-effectiveness.

As noted in Section 1.6, PPL Electric Utilities will rely on energy efficiency measures with coincident peak demand reduction potential to achieve its annual and total peak demand reduction goals. PPL Electric Utilities will target end uses to nominate roughly 1% to 20% of eligible PJM peak demand savings from the Non-Residential Program over the five-year Plan. PPL Electric Utilities is not aware at this time which measures will be nominated; however, they will likely include cooling and lighting. PPL Electric Utilities will competitively select a qualified third-party vendor to provide technical support in nominating a portion of its peak demand reductions as a capacity resource in PJM's FCM.

Efficient Equipment Component

The Efficient Equipment component is the same for both large C&I and small C&I customers unless noted otherwise.

Description

Through the Efficient Equipment component, PPL Electric Utilities promotes the purchase and installation of a wide range of high-efficiency measures, including lighting, HVAC, refrigeration, motors/drives, commercial kitchen equipment, agricultural equipment, equipment controls, and new construction projects. The Company provides customers financial incentives based on the measure installed and savings achieved, which offset the higher purchase costs of energy efficient and peak demand-saving equipment.

The component has four delivery channels:

- **Downstream rebates.** In Phase IV, PPL Electric Utilities will continue to offer rebate submissions, similar to the downstream channel successfully used in Phase III. Customers, contractors, or trade allies will submit applications for review and validation by the Non-Residential CSP. The

CSP will review and validate all submitted applications and eligible projects will be processed and incentives paid upon project completion and final savings calculations.

- **Direct discount.** PPL Electric Utilities will implement the direct discount delivery channel to engage small C&I customers. This approach is supported by a network of qualified contractors and higher incentives that motivate them to complete projects that would otherwise not receive their attention. The Non-Residential CSP helps the contractor orchestrate the project from beginning to end on behalf of the customer. Small C&I customers benefit by having an expert identify the applicable measures, manage the project, and apply for and secure incentives to offset the upfront cost of the project. The amount of the incentive appears on the project invoice, and the customer is responsible for the remaining project cost. Once the project is complete and the application is updated, the Non-Residential CSP commences measurement and verification. The CSP then reimburses the contractor with a check for the incentive.
- **Direct install.** In Phase IV, PPL Electric Utilities will build on the successful direct install offering from Phase III. The Non-Residential CSP will target hard-to-reach small C&I customers and provide a no-cost assessment to identify retrofit measures and operational improvements to lower energy consumption and costs and to install energy efficiency measures. After the assessment, the Non-Residential CSP will send customers an assessment report with additional recommendations to support their overall energy efficiency and peak demand needs and goals and recommendations for qualified trade allies with whom they can work.
- **Midstream**. PPL Electric Utilities will continue using a midstream delivery channel to help customers choose and procure certain high-efficiency products more quickly and easily than through typical downstream methods. In the midstream approach, trade allies and customers may purchase high-efficiency products listed by ENERGY STAR or DesignLights Consortium ("DLC") directly from participating and qualified midstream distributors and receive an immediate rebate at the point of purchase. This approach has proven to raise customer and trade ally satisfaction; reduce administrative expenses; increase the volume of installed, high-efficiency lighting and socket upgrades, particularly for customers implementing routine projects; and lower the number of contractors and customers who use high-efficiency lighting products but fail to submit program applications.

The Non-Residential CSP will manage and coordinate the Efficient Equipment component, maintain a call and rebate processing center, recruit and educate trade allies, and conduct marketing to achieve the desired participation and encourage customers to take a whole-building approach or implement multiple measures.

Objectives

The objectives of the Efficient Equipment component are:

- Provide energy and peak demand-savings opportunities and incentives to qualified customers.
- Increase the market penetration of high-efficiency technologies and building systems for customers by offering incentives for high-efficiency and ENERGY STAR-rated appliances, lighting equipment, and HVAC systems.

- Increase customer awareness of the features and benefits of energy efficient equipment.
- Support emerging technologies and nontypical efficiency solutions in cost-effective applications.
- Engage trade allies to stock, promote, and provide high-efficiency technology options to customers.
- Promote other PPL Electric Utilities energy efficiency program components.
- Collect energy, peak demand, and operating data from customers, as required to confirm customer and measure eligibility and to determine energy and peak demand savings and cost-effectiveness.
- Achieve a total energy reduction of approximately 665,361 MWh/year and 108 MW[27] gross verified savings for large C&I and small C&I customers, or business types.

Implementation Strategy

The Non-Residential CSP will deliver the Efficient Equipment component promoting the various energy efficiency options available to the non-residential customer segment with a range of marketing and outreach tactics. The Efficient Equipment component relies on projects being initiated by customers, trade allies, distributors, and the Non-Residential CSP. The Non-Residential CSP will build on trade ally and distributor relationships to co-market energy efficient equipment and the value of participation.

Key steps include the following:

- Educate customers on energy efficiency opportunities and direct them to the appropriate path through marketing activities, the website, or direct contact with equipment distributors or equipment installation contractors/trade allies.
- Have customers complete applications or work with customers, equipment/appliance retailers, midstream distributors, and installation contractors to complete program applications.
- Ensure customers/contractors submit the required documentation for processing.
- Review pending and completed project documentation to verify applicant is a PPL Electric Utilities customer and the completed project and installed equipment meet program eligibility criteria.
- When possible, work with customers to confirm project preapproval before ordering energy efficiency equipment.
- Recruit and develop an effective trade ally network.
- Process applications and issue rebates for qualified projects/equipment.
- Verify completed equipment/appliance installation for a sample of participants to confirm program integrity as part of M&V.

[27] Peak Demand is at generation.

Issues, Risks, and Risk Management Strategy

Table 40 presents market risks associated with the Efficient Equipment component and the strategies that PPL Electric Utilities will use to manage each risk.

Table 40. Efficient Equipment Issues, Risks, and Risk Management Strategies

Component Issue	Risk	Risk Management Strategies
Customer or building owner does not prioritize energy efficiency.	• Decision-makers choose to install cheaper, less efficient equipment with shorter payback/internal rate of return ("IRR"), resulting in lower savings. • Owners are not informed about how their facility uses energy. • Existing debt may limit funds to purchase new efficient equipment. • Customers place a priority on fluctuating commodity prices.	• PPL Electric Utilities offers incentives to reduce payback and IRR for business owners. • Non-Residential CSP offers planning assistance to enhance energy savings. • Non-Residential CSP educates customers about the long-term benefits of energy efficiency, available incentives, and other components.
Customers typically replace equipment only upon failure.	• Customers see no need to replace functioning equipment. • Customers are not informed about the most efficient equipment available when the need to replace it is immediate. Some efficient equipment may have a longer delivery time that would affect customer operations.	• Non-Residential CSP educates trade allies and customers about available energy efficient choices before equipment fails and encourages businesses to plan for equipment replacement. • PPL Electric Utilities provides incentives for trade allies to stock, promote, and install efficient measures.
Customers are unaware of the benefits of installing and properly maintaining energy efficient equipment.	• Customers do not properly maintain equipment, and savings benefits erode over time.	• Non-Residential CSP promotes the importance and value of equipment maintenance and training.

Anticipated Costs to Participating Customers

Costs incurred by customers participating in Efficient Equipment will vary by the specific type of efficient equipment installed.

Ramp-Up Strategy

Efficient Equipment component is an existing, mature offering being carried forward from Phase III. The Non-Residential CSP will develop marketing material to facilitate the transition to Phase IV. The Non-Residential CSP has developed a transitional strategy to bridge incentives for customers whose participation in the program spans Phase III and Phase IV.

PPL Electric Utilities expects to implement the following transition plan between Phase III and Phase IV:

- Projects on the Phase III waitlist will receive comparable incentives if completed and installed early in Phase IV. Comparable is defined as the Phase III rebate, up to $0.05/annual kWh saved and subject to Phase III per project or per customer incentive caps. Projects must be completed by August 31, 2021, for most measures. PPL Electric Utilities will consider exceptions to that deadline on a case-by-case basis, depending on the project details.

- Projects approved (funds reserved) in Phase III that are installed (placed in service) in Phase IV may be eligible for the approved Phase III rebate and will be accounted for as Phase IV projects.

Marketing Strategy

PPL Electric Utilities will work with the Non-Residential CSP to develop and execute a marketing plan that captures sector-level economies of scale and employs targeted outreach where practical. The marketing strategy may include the following:

- Take advantage of trade ally and manufacturer relationships to co-market energy efficient equipment and products.
- Host webinars.
- Participate in trade shows and other outreach events.
- Communicate and provide access to program component information on the Company's EE&C website.
- Promote the component in newsletters.
- Advertise using newspaper, radio, direct mail, bill inserts, cross-program component advertisements, commercial ads, and other mass media.
- Coordinate advertising opportunities with trade allies.
- Develop, publish, and distribute brochures and case studies.
- Conduct one-on-one marketing to small C&I customers through trade allies, business accounts specialists, and Non-Residential CSP outreach.
- Target marketing to facility managers, building or process engineers, building owners and managers associations, HVAC contractors, energy services firms, architects and engineers, real estate developers, economic development organizations, customer advocacy groups, trade associations, and other trade allies to encourage installation of new energy efficient technologies and adoption of best-operating practices.
- Provide specific outreach to individual tenants as well as building owners and property managers in leased commercial buildings to encourage participation in the program.
- Target specific sectors identified as having a high unrealized energy efficiency potential.
- Publish marketing materials including charts, brochures, and case studies.
- Provide newsletters and coordinate with key market partners, including trade associations and agencies.
- Use limited time offers, special promotions, and no-cost measures to promote energy efficiency.
- Offer trade ally incentives and rewards.
- Cross-promote through other PPL Electric Utilities energy efficiency program components.
- Provide information and training on specific technologies directed towards niche markets.

- Incorporate customers in area- or territory-focused promotions.
- Work with distributors to promote and encourage purchases of efficient equipment to capture savings opportunities missed by other outreach methods.

Eligible Measures and Incentive Strategy

PPL Electric Utilities will offer rebates and incentives to qualified customers (or trade allies, depending on the delivery channel) who submit completed applications and documentation of the efficiency measures installed. Customers will have the option to assign rebate payments to a third party.

PPL Electric Utilities offers performance incentives based on the avoided or reduced energy (kWh/year) or peak demand (kW) savings resulting from the project. Incentives may be capped at 50% to 100% of the total project costs (excluding internal labor) or $500,000 and are subject to an annual cap for each project and each participating customer. The per-customer-site cap is defined as one building with one or more meters. A parent company cap of $1 million per year will apply to a campus setting or multiple buildings (on the same property or in different locations) with a common owner. For all measures offered through the Efficient Equipment component, PPL Electric Utilities will provide incentives in the range of $0.02 to $0.22 per annual kWh saved and/or $30 to $1,200 per kW peak demand.

PPL Electric Utilities may distribute lighting measures to customers through the traditional rebate, direct discount (i.e., incentive paid to a trade ally), direct install, or midstream channel. Table 41 and Table 42 lists PPL Electric Utilities’ measures and minimum eligibility qualifications for large C&I and small C&I, respectively.

Table 41. Pa PUC Table 7-Large C&I Efficient Equipment Rebates Eligible Measures and Incentives

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Lighting Improvements	Per Project	No	Products must meet the minimum requirements of ENERGY STAR or the DLC and complete PA TRM Lighting Form.	$46,521	13	Up to $0.22/kWh and/or up to $1,200/kW first year savings
LED Exit Signs	Per Product	No	Replacement of existing incandescent or fluorescent exit signs with a new LED exit sign.	$55	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
HVAC Systems	Per Product	No	This measure excludes water source, ground source, and groundwater source heat pump measures that are covered in the Water Source and Geothermal Heat Pumps measure. All HVAC applications other than comfort cooling and heating, such as process cooling, are ineligible for this measure.	$194	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Electric Chillers	Per Product	No	Installation of high efficiency electric chillers that exceed the minimum performance allowed by the current PA Energy Code.	$4,021	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Water Source and Geothermal Heat Pumps	Per Product	No	High-efficiency groundwater source, water source, or ground source heat pump system that exceeds the energy efficiency requirements of the IECC 2015, Table 403.2.3(1).	$52,603	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Ductless mini-split heat pumps < 5.4 tons	Per Product	No	<5.4 tons, ENERGY STAR with inverter technology.	$2,313	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Room A/C	Per Product	No	ENERGY STAR	-$65	9	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Guest Room Occupancy Sensor controls	Per Ton	No	Guest rooms that are equipped with energy management thermostats replacing manual heating/cooling temperature set-point and fan On/Off/Auto thermostat controls.	$180	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Economizer controls	Per Control	No	Adding an economizer and dual enthalpy (differential) control on existing HVAC unit with no economizer or with a non-functional/disabled economizer.	$1,421	10	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
VFD Improvements	Per Control	No	A motor with a variable-frequency drive ("VFD") control replacing a motor without an existing VFD control.	$2,607	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ECM Circulating fan	Per Product	No	Circulating fan motors of 1 horsepower ("HP") or less with a baseline shaded-pole ("SP") or permanent-split capacitor ("PSC") evaporator fan motor in an air handling unit.	$417	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
VSD on Kitchen Exhaust Fan	Per Fan	No	The energy efficient condition is a kitchen ventilation system equipped with a variable speed drive ("VSD") and demand ventilation controls and sensors. The baseline equipment is kitchen ventilation that has a constant speed ventilation motor.	$2,296	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Refrigeration/Freezer Cases	Per Product	No	ENERGY STAR, Eligible refrigerators and freezers are self-contained with vertical-closed transparent or solid doors.	$853	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High efficiency evaporator fan motors for walk in or reach in cases	Per Product	No	Replacement of existing SP evaporator fan motors or PSC motors in walk-in or reach-in refrigerated display cases with an electronically commutated motor ("ECM") or a permanent magnet synchronous ("PMS") motor.	$343	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Evaporator Fan controllers	Per Control	No	Installation of evaporator fan controls in medium-temperature walk-in or reach-in coolers and low temperature walk-in or reach-in freezers.	$563	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Anti-sweat heater controls	Per Control	No	Adding controls to glass door cooler or refrigerator with uncontrolled heaters utilizing either ON/OFF or micro pulse controls.	$1,051	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Variable speed refrigeration compressor	Per Horsepower	No	VSD control system replacing a slide valve control system in existing commercial refrigeration systems.	$85	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Strip curtains for walk-in freezers and coolers	Per Door	No	Install or retrofit strip curtains in commercial walk-in cooler and freezer doors. Strip curtains must be at least 0.06 inches thick.	$359	4	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Night covers for display cases	Per Foot	No	Install on existing open-type refrigerated display cases, where covers are deployed during the facility's unoccupied hours.	$42	5	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Auto door closers	Per Product	No	Retrofit doors not equipped with auto-closers and assume the doors have strip curtain for walk-in coolers and freezers. Auto-closer must be able to firmly close door when it is within one inch of full closure. Walk-in door perimeter must be ≥ 16 feet.	$498	8	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Door gaskets for walk-in and reach-in coolers and freezers	Per Door	No	Replace worn-out gaskets with new better-fitting gaskets.	$98	4	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Low or No anti-sweat heat for reach-in freezers and coolers	Per Door	No	Install a no-heat/low-heat clear glass door on an upright display case. Limited to door heights of 57 inches or more. Doors must have either heat reflective treated glass, be gas filled, or both.	$1,213	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Refrigerated Display cases with doors replacing open cases	Per Foot	No	A new, vertical case with no sweat doors that meets federal standard requirements.	$449	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Adding doors to existing refrigerated display cases	Per Foot	No	Retrofit existing vertical open display cases with zero heat doors.	$521	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Ice machines	Per Product	No	ENERGY STAR	$378	8	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Beverage machine controls	Per Product	No	Added to non-ENERGY STAR machines.	$180	5	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Office equipment	Per Product	No	ENERGY STAR	$10	6	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Cycling refrigerated thermal mass dryer	Per Horsepower	No	Baseline: non-cycling (e.g., continuous) air dryer with a capacity of 600 cubic feet per minute ("cfm") or below. The replacement of desiccant, deliquescent, heat-of-compression, membrane, or other types of dryers does not qualify under this measure.	$24	10	Up to $0.22/kWh and/or up to $1,200/kW first year savings
No-loss condensate drains	Per Product	No	Retrofit existing timed drained system with new no-loss condensate drains.	$194	5	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Variable speed drive air compressor	Per Horsepower	No	Install or retrofit a single VSD unit less than 40 HP with variable speed control.	$191	13	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High efficiency ventilation fans with and w/o thermostats	Per Product	No	Agricultural Application: Installation of high efficiency ventilation fans where standard efficiency ventilation fans are replaced and/or the installation of a thermostat controlling either new efficient fans or existing fans.	$175	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
VSD Controller on dairy vacuum pumps	Per Product	No	Agricultural Application: Installation of a VSD and controls on dairy vacuum pumps, or the purchase of dairy vacuum pumps with variable speed capability.	$5,120	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Lighting Improvements for Midstream	Per Fixture	No	Products must meet the minimum requirements of ENERGY STAR or the DLC and complete PA TRM Lighting Form.	$77	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Lighting Improvements for Midstream	Per Lamp	No	Products must meet the minimum requirements of ENERGY STAR or the DLC and complete PA TRM Lighting Form.	$6	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
HVAC Systems Midstream	Per Product	No	This measure excludes water source, ground source, and groundwater source heat pump measures that are covered in the Water Source and Geothermal Heat Pumps measure. All HVAC applications other than comfort cooling and heating, such as process cooling, are ineligible for this measure.	$194	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Ductless mini-split heat pumps < 5.4 tons Midstream	Per Product	No	<5.4 tons, ENERGY STAR with inverter technology.	$2,313	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Ice machines Midstream	Per Product	No	ENERGY STAR	$378	8	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial fryer Midstream	Per Product	No	ENERGY STAR	$1,038	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial hot food holding cabinet Midstream	Per Product	No	ENERGY STAR	$895	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
High efficiency ventilation fans with and w/o thermostats Midstream	Per Product	No	Agricultural Application: Installation of high efficiency ventilation fans where standard efficiency ventilation fans are replaced and/or the installation of a thermostat controlling either new efficient fans or existing fans.	$175	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
VSD Controller on dairy vacuum pumps Midstream	Per Product	No	Agricultural Application: Installation of a VSD and controls on dairy vacuum pumps, or the purchase of dairy vacuum pumps with variable speed capability.	$5,120	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Lighting Controls	Per kW Controlled	No	Lighting controls turn lights on and off automatically, which are activated by time, light, motion, or sound.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
LED Channel Signage	Per Foot	No	Replacement of neon and/or incandescent channel letter signs with efficient LED channel letter signs. Replacement signs cannot use more than 20% of the actual input power of the sign that is replaced.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
LED Refrigeration Display Case Lighting	Per Door	No	Installation of LED case lighting with or without motion sensors on existing refrigerators, coolers, and freezers - specifically on vertical displays.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Fuel Switching	Per Product	No	Must replace electric equipment with ENERGY STAR certified natural gas, propane, or fuel oil equipment.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Computer room A/C	Per Product	No	Newly installed computer room air conditioner systems that exceed the baseline efficiencies (in seasonal coefficient of performance ("SCOP")) outlined in Table 3-56 of the current PA TRM.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Computer room A/C EC fans	Per Product	No	Installation of electronically commutated ("EC") plug fans in computer room air conditioning ("CRAC") and computer room air handling ("CRAH") units.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Computer room VFD on fans	Per Horsepower	No	Installation of a VSD to control AC fan motors in CRAC and CRAH units.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Circulation Fan: High Volume Low Speed	Per Product	No	Installation of High Volume Low Speed ("HVLS") fans (diameters ranging from 8 to 24 feet) replacing conventional circulating fans. Commercial and industrial applications only.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Premium Efficiency Motors	Per Horsepower	No	Replacement of old motors with new energy efficient motors of the same rated HP.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ECM Circulator Pump	Per Pump	No	An ECM or brushless permanent magnet (BPM) circulator pump replacing single-speed induction motor circulator pumps in space heating and hot water applications.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High Efficiency Pumps	Per Horsepower	No	Compliant pumps will achieve a PEI of 1.0 or less. All pumps manufactured after January 27, 2020 must comply with the U.S. Department of Energy's ("DOE") energy conservation standard as described in 10 CFR 431 Subpart Y.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Heat Pump Water Heaters	Per Product	No	Installation of a heat pump water heater instead of a code minimum electric water heater.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Low Flow Pre-rinse Sprayers	Per Product	No	Efficient low flow pre-rinse sprayers that use less than 1.6 gallons of water per minute. Only applicable to premises with electric water heating.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Fuel Switching: electric water heaters to gas/propane	Per Product	No	Must replace electric water heater with ENERGY STAR certified natural gas or propane equipment.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Floating head pressure control ("FHPC")	Per Control	No	Adding FHPCs to a refrigeration system. FHPCs must have a minimum Saturated Condensing Temperature ("SCT") programmed for the floating head pressure control of ≤ 70 ºF. The use of FHPC would require balanced-port expansion valves, allowing satisfactory refrigerant flow over a range of head pressures. The compressor must be 1 HP or larger.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Evaporator coil defrost controls	Per Evaporator Unit	No	Adding defrost controls to existing walk-in coolers or freezers without defrost controls.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Suction pipe insulation for walk-in coolers and freezers	Per Foot	No	Insulate bare refrigeration suction pipes for walk-in coolers and freezers according to the current PA TRM requirements.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Air cooled refrigeration condenser	Per Ton	No	Installing an efficient, close-approach air-cooled refrigeration condenser that meets the current PA TRM requirements.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Refrigerated case light occupancy sensors	Per Watt Controlled	No	Installation of motion-based lighting controls that allow the LED case lighting to be dimmed or turned off completely during unoccupied conditions.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Refrigeration economizers	Per Compressor Horsepower	No	Economizers installed on a walk-in refrigeration system.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Clothes washer	Per Product	No	ENERGY STAR, installed in commercial laundromats or multifamily complex laundry rooms.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR bathroom ventilation fan	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Snack machine controls	Per Product	No	Added to non-ENERGY STAR, non-refrigerated machines.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Electric steam cooker	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Combination oven	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial convection oven	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial fryer	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial hot food holding cabinet	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial Dishwasher	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial Griddle	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Wall and Ceiling Insulation	Per SQFT	No	Applies to buildings that are heated and/or cooled using electricity. Existing construction buildings are required to meet or exceed the code requirement. New construction buildings must exceed the code requirement.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Office Equipment - Network power management enabling	Per Workstation	No	Applicable to any software that manages workstations in a networked environment that meets the current PA TRM requirements.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Advanced power strips	Per Workstation	No	Installation of an Advanced Power Strip Tier 1 or Tier 2.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Servers	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Server virtualization	Per Product	No	Servers must be consolidated to increase utilization of the remaining servers, and the virtualized servers must be either a) removed or b) physically disconnected from power.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Air-entraining air nozzle	Per Product	No	Replace non-air entraining air nozzle (open copper tube of 1/8-inch or 1/4-inch orifice diameter) with an energy efficient air-entraining air nozzle that uses less than 15 cfm at 100 pounds per square inch ("psi") for industrial applications.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Air tanks for Load/No load compressors	Per Horsepower	No	Minimum storage ratio of 4 gallons per cfm.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Compressed air controller	Per Horsepower	No	The baseline condition is having no existing pressure/flow controller and an existing compressed air system with a total compressor motor capacity ≥ 40 hp. This measure requires a minimum storage of 3gal/cfm.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Compressed air low pressure drop filters	Per Horsepower	No	The baseline condition is a standard coalescing filter with a pressure drop of 3 psi when new and 5 psi or more at element change. The efficient condition is a low pressure drop filter with pressure drop not exceeding 1 psi when new and 3 psi at element change.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Compressed air mist eliminators	Per Horsepower	No	The compressed air system must be greater than 50 HP to qualify, and the mist eliminator must have less than a 1 pound per square inch gauge ("psig") pressure drop and replace a coalescing filter.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High efficiency transformer	Per Product	No	Transformers more efficient than the federal standard.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Engine block heat timer	Per Product	No	Agricultural Application: Installation of a timer on an engine block heater.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High frequency battery chargers	Per Product	No	Baseline equipment is a silicon controlled rectifier ("SCR") or ferroresonant battery charger system with minimum 8-hour shift operation five days per week. Energy-efficient equipment is a high frequency battery charger system with a minimum power conversion efficiency of 90% and 8-hour shift operation five days per week.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Automatic Milker takeoffs	Per Cow	No	Agricultural Application: Automatic milker take-offs that determine milking end time, and the vacuum pump system serving the impacted milking units must be equipped with a variable speed drive.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Dairy scroll compressors	Per Product	No	Agricultural Application: Installation of a scroll compressor to replace an existing reciprocating compressor or to be installed in a new construction application.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Heat reclaimers	Per Product	No	Agricultural Application: Installation of heat recovery equipment on dairy parlor milk refrigeration systems to heat hot water. This measure only applies to dairy parlors with electric water heating equipment.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High Volume Low Speed fans	Per Product	No	Agricultural Application: Installation of HVLS fans to replace conventional circulating fans. HVLS fans are a minimum of 16 feet long in diameter.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Livestock waterer	Per Product	No	Agricultural Application: Thermostatically controlled with 2 inches or more of factory-installed insulation.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Low pressure irrigation system	Per Acre	No	Agricultural Application: Replace systems operating on 50% or less than existing system pressure.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
New Construction Lighting	Per SQFT	No	Eligible lighting equipment and fixture/lamp types include fluorescent fixtures (lamps and ballasts), compact fluorescent lamps, high intensity discharge ("HID") lamps, interior and exterior LED lamps and fixtures, cold-cathode fluorescent lamps ("CCFLs"), induction lamps, and lighting controls.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Electric steam cooker Midstream	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Combination oven Midstream	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial convection oven Midstream	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial Dishwasher Midstream	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial Griddle Midstream	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Automatic Milker takeoffs Midstream	Per Cow	No	Agricultural Application: Automatic milker take-offs that determine milking end time, and the vacuum pump system serving the impacted milking units must be equipped with a variable speed drive.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Dairy scroll compressors Midstream	Per Product	No	Agricultural Application: Installation of a scroll compressor to replace an existing reciprocating compressor or to be installed in a new construction application.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Heat reclaimers Midstream	Per Product	No	Agricultural Application: Installation of heat recovery equipment on dairy parlor milk refrigeration systems to heat hot water. This measure only applies to dairy parlors with electric water heating equipment.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
High Volume Low Speed fans Midstream	Per Product	No	Agricultural Application: Installation of HVLS fans to replace conventional circulating fans. HVLS fans are a minimum of 16 feet long in diameter.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Livestock waterer Midstream	Per Product	No	Agricultural Application: Thermostatically controlled with 2-inches or more of factory-installed insulation.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Table 42. Pa PUC Table 7-Small C&I Efficient Equipment Rebates Eligible Measures and Incentives

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Lighting Improvements	Per Project	No	Products must meet the minimum requirements of ENERGY STAR or the DLC and complete PA TRM Lighting Form.	$46,521	13	Up to $0.22/kWh and/or up to $1,200/kW first year savings
LED Exit Signs	Per Product	No	Replacement of existing incandescent or fluorescent exit signs with a new LED exit sign.	$55	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
HVAC Systems	Per Product	No	This measure excludes water source, ground source, and groundwater source heat pump measures that are covered in the Water Source and Geothermal Heat Pumps measure. All HVAC applications other than comfort cooling and heating, such as process cooling, are ineligible for this measure.	$194	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Electric Chillers	Per Product	No	Installation of high efficiency electric chillers that exceed the minimum performance allowed by the current PA Energy Code.	$4,021	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Water Source and Geothermal Heat Pumps	Per Product	No	High-efficiency groundwater source, water source, or ground source heat pump system that exceeds the energy efficiency requirements of the IECC 2015, Table 403.2.3(1).	$52,603	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Ductless mini-split heat pumps < 5.4 tons	Per Product	No	<5.4 tons, ENERGY STAR with inverter technology.	$2,313	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Room A/C	Per Product	No	ENERGY STAR	-$65	9	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Guest Room Occupancy Sensor controls	Per Ton	No	Guest rooms that are equipped with energy management thermostats replacing manual heating/cooling temperature set-point and fan On/Off/Auto thermostat controls.	$180	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Economizer controls	Per Control	No	Adding an economizer and dual enthalpy (differential) control to an HVAC unit with no economizer installers or with a non-functional/disabled economizer.	$1,421	10	Up to $0.22/kWh and/or up to $1,200/kW first year savings
VFD Improvements	Per Control	No	A motor with a VFD control replacing a motor without a VFD control.	$2,607	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ECM Circulating fan	Per Product	No	Circulating fan motors of 1 HP or less with a baseline SP or PSC evaporator fan motor in an air handling unit.	$417	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
VSD on Kitchen Exhaust Fan	Per Fan	No	The energy efficient condition is a kitchen ventilation system equipped with a VSD and demand ventilation controls and sensors. The baseline equipment is kitchen ventilation that has a constant speed ventilation motor.	$2,296	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Refrigeration/Freezer Cases	Per Product	No	ENERGY STAR. Eligible refrigerators and freezers are self-contained with vertical-closed transparent or solid doors.	$853	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High efficiency evaporator fan motors for walk in or reach in cases	Per Product	No	Replacement of existing SP evaporator fan motors or PSC motors in walk-in or reach-in refrigerated display cases with ECM or PMS motor.	$343	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Evaporator Fan controllers	Per Control	No	Installation of evaporator fan controls in medium-temperature walk-in or reach-in coolers and low temperature walk-in or reach-in freezers.	$563	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Anti-sweat heater controls	Per Control	No	Adding controls to glass door cooler or refrigerator with uncontrolled heaters utilizing either ON/OFF or micro pulse controls.	$1,051	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Variable speed refrigeration compressor	Per Horsepower	No	VSD control system replacing a slide valve control system in existing commercial refrigeration systems.	$85	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Strip curtains for walk-in freezers and coolers	Per Door	No	Install or retrofit strip curtains in commercial walk-in cooler and freezer doors. Strip curtains must be at least 0.06 inches thick.	$359	4	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Night covers for display cases	Per Foot	No	Install on existing open-type refrigerated display cases, where covers are deployed during the facility's unoccupied hours.	$42	5	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Auto door closers	Per Product	No	Retrofit doors not equipped with auto-closers and assume the doors have strip curtain for walk-in coolers and freezers. The auto-closer must be able to firmly close the door when it is within one inch of full closure. Walk-in door perimeter must be ≥ 16 feet.	$498	8	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Door gaskets for walk-in and reach-in coolers and freezers	Per Door	No	Replace worn-out gaskets with new better-fitting gaskets.	$98	4	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Low or No anti-sweat heat for reach-in freezers and coolers	Per Door	No	Install a no-heat/low-heat clear glass door on an upright display case. Limited to door heights of 57 inches or more. Doors must have either heat reflective treated glass, be gas filled, or both.	$1,213	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Refrigerated Display cases with doors replacing open cases	Per Foot	No	A new, vertical case with no sweat doors that meets federal standard requirements.	$449	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Adding doors to existing refrigerated display cases	Per Foot	No	Retrofit existing vertical open display cases with zero heat doors.	$521	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Ice machines	Per Product	No	ENERGY STAR	$378	8	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Beverage machine controls	Per Product	No	Added to non-ENERGY STAR machines.	$180	5	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Office equipment	Per Product	No	ENERGY STAR	$10	6	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Cycling refrigerated thermal mass dryer	Per Horsepower	No	Baseline: non-cycling (e.g., continuous) air dryer with a capacity of 600 cfm or below. The replacement of desiccant, deliquescent, heat-of-compression, membrane, or other types of dryers does not qualify under this measure.	$24	10	Up to $0.22/kWh and/or up to $1,200/kW first year savings
No-loss condensate drains	Per Product	No	Retrofit existing timed drained system with new no-loss condensate drains.	$194	5	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Variable speed drive air compressor	Per Horsepower	No	Install or retrofit a single VSD unit less than 40 HP with variable speed control.	$191	13	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High efficiency ventilation fans with and w/o thermostats	Per Product	No	Agricultural Application: Installation of high efficiency ventilation fans where standard efficiency ventilation fans are replaced and/or the installation of a thermostat controlling either new efficient fans or existing fans.	$175	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
VSD Controller on dairy vacuum pumps	Per Product	No	Agricultural Application: Installation of a VSD and controls on dairy vacuum pumps, or the purchase of dairy vacuum pumps with variable speed capability.	$5,120	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Lighting Improvements for Midstream	Per Fixture	No	Products must meet the minimum requirements of ENERGY STAR or the DLC and complete PA TRM Lighting Form.	$77	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Lighting Improvements for Midstream	Per Bulb	No	Products must meet the minimum requirements of ENERGY STAR or the DLC and complete PA TRM Lighting Form.	$6	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
HVAC Systems Midstream	Per Product	No	This measure excludes water source, ground source, and groundwater source heat pump measures that are covered in the Water Source and Geothermal Heat Pumps measure. All HVAC applications other than comfort cooling and heating, such as process cooling, are ineligible for this measure.	$194	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Ductless mini-split heat pumps < 5.4 tons Midstream	Per Product	No	<5.4 tons, ENERGY STAR with inverter technology.	$2,313	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Ice machines Midstream	Per Product	No	ENERGY STAR	$378	8	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial fryer Midstream	Per Product	No	ENERGY STAR	$1,038	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial hot food holding cabinet Midstream	Per Product	No	ENERGY STAR	$895	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
High efficiency ventilation fans with and w/o thermostats Midstream	Per Product	No	Agricultural Application: Installation of high efficiency ventilation fans where standard efficiency ventilation fans are replaced and/or the installation of a thermostat controlling either new efficient fans or existing fans.	$175	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
VSD Controller on dairy vacuum pumps Midstream	Per Product	No	Agricultural Application: Installation of a VSD and controls on dairy vacuum pumps, or the purchase of dairy vacuum pumps with variable speed capability.	$5,120	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Adding doors to existing refrigerated display cases Direct Discount	Per Foot	No	Retrofit existing vertical open display cases with zero heat doors.	$521	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Air tanks for Load/No load compressors Direct Discount	Per Horsepower	No	Minimum storage ratio of 4 gallons per cfm.	$80	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Air-entraining air nozzle Direct Discount	Per Product	No	Replace non-air entraining air nozzle (open copper tube of 1/8-inch or 1/4-inch orifice diameter) with an energy efficient air-entraining air nozzle that uses less than 15 cfm at 100 psi for industrial applications.	$89	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Anti-sweat heater controls Direct Discount	Per Control	No	Adding controls to glass door cooler or refrigerator with uncontrolled heaters utilizing either ON/OFF or micro pulse controls.	$1,051	12	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Auto door closers Direct Discount	Per Product	No	Retrofit doors not equipped with auto-closers, and assume the doors have strip curtain for walk-in coolers and freezers. The auto-closer must be able to firmly close the door when it is within one inch of full closure. The walk-in door perimeter must be ≥ 16 feet.	$498	8	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Beverage machine controls Direct Discount	Per Product	No	Added to non-ENERGY STAR machines.	$180	5	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Compressed air controller Direct Discount	Per Horsepower	No	The baseline condition is having no existing pressure/flow controller and an existing compressed air system with a total compressor motor capacity ≥ 40 hp. This measure requires a minimum storage of 3gal/cfm.	$27	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Compressed air low pressure drop filters Direct Discount	Per Horsepower	No	The baseline condition is a standard coalescing filter with a pressure drop of 3 psi when new and 5 psi or more at element change. The efficient condition is a	$10	10	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
			low pressure drop filter with pressure drop not exceeding 1 psi when new and 3 psi at element change.			
Compressed air mist eliminators Direct Discount	Per Horsepower	No	The compressed air system must be greater than 50 HP to qualify, and the mist eliminator must have less than a 1 psig pressure drop and replace a coalescing filter.	$22	5	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Cycling refrigerated thermal mass dryer Direct Discount	Per Horsepower	No	Baseline: non-cycling (e.g., continuous) air dryer with a capacity of 600 cfm or below. The replacement of desiccant, deliquescent, heat-of-compression, membrane, or other types of dryers does not qualify under this measure.	$24	10	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Economizer controls Direct Discount	Per Control	No	Adding an economizer and dual enthalpy (differential) control to an HVAC unit with no economizer installers or with a non-functional/disabled economizer.	$1,421	10	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Evaporator Fan controllers Direct Discount	Per Control	No	Installation of evaporator fan controls in medium-temperature walk-in or reach-in coolers and low temperature walk-in or reach-in freezers.	$563	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High efficiency evaporator fan motors for walk in or reach in cases Direct Discount	Per Product	No	Replacement of existing SP evaporator fan motors or PSC motors in walk-in or reach-in refrigerated display cases with an ECM or a PMS motor.	$343	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
LED Refrigeration Display Case Lighting Direct Discount	Per Door	No	Installation of LED case lighting with or without motion sensors on existing refrigerators, coolers, and freezers - specifically on vertical displays.	$51	8	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Lighting Controls Direct Discount	Per kW Controlled	No	Lighting controls turn lights on and off automatically, which are activated by time, light, motion, or sound.	$387	8	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Lighting Improvements Direct Discount	Per Project	No	Products must meet the minimum requirements of ENERGY STAR or the DLC and complete PA TRM Lighting Form.	$46,521	13	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Low Flow Pre-rinse Sprayers Direct Discount	Per Product	No	Efficient low flow pre-rinse sprayers that use less than 1.6 gallons of water per minute. Only applicable to premises with electric water heating.	$124	8	Up to $0.22/kWh and/or up to $1,200/kW first year savings
No-loss condensate drains Direct Discount	Per Product	No	Retrofit existing timed drained system with new no-loss condensate drains.	$194	5	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Refrigerated case light occupancy sensors Direct Discount	Per Watt Controlled	No	Installation of motion-based lighting controls that allow the LED case lighting to be dimmed or turned off completely during unoccupied conditions.	$1	8	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Strip curtains for walk-in freezers and coolers Direct Discount	Per Door	No	Install or retrofit strip curtains in commercial walk-in cooler and freezer doors. Strip curtains must be at least 0.06 inches thick.	$359	4	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Variable speed drive air compressor Direct Discount	Per Horsepower	No	Install or retrofit a single VSD unit less than 40 HP with variable speed control.	$191	13	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Variable speed refrigeration compressor Direct Discount	Per Horsepower	No	VSD control system replacing a slide valve control system in existing commercial refrigeration systems.	$85	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Lighting Improvements Direct Install	Per Project	No	Products must meet the minimum requirements of ENERGY STAR or the DLC and complete PA TRM Lighting Form.	$186	13	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Low Flow Pre-rinse Sprayers Direct Install	Per Product	No	Efficient low flow pre-rinse sprayers that use less than 1.6 gallons of water per minute. Only applicable to premises with electric water heating.	$72	8	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Lighting Controls	Per kW Controlled	No	Lighting controls turn lights on and off automatically, which are activated by time, light, motion, or sound.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
LED Channel Signage	Per Foot	No	Replacement of neon and/or incandescent channel letter signs with efficient LED channel letter signs. Replacement signs cannot use more than 20% of the actual input power of the sign that is replaced.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
LED Refrigeration Display Case Lighting	Per Door	No	Installation of LED case lighting with or without motion sensors on existing refrigerators, coolers, and freezers - specifically on vertical displays.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Fuel Switching	Per Product	No	Must replace electric equipment with ENERGY STAR certified natural gas, propane, or fuel oil equipment.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Computer room A/C	Per Product	No	Newly installed computer room air conditioner systems that exceed the baseline efficiencies (in SCOP) outlined in Table 3-56 of the current PA TRM.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Computer room A/C EC fans	Per Product	No	Installation of EC plug fans in CRAC and CRAH units.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Computer room VFD on fans	Per Horsepower	No	Installation of a VSD to control AC fan motors in CRAC and CRAH units.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Circulation Fan: High Volume Low Speed	Per Product	No	Installation of HVLS fans (diameters ranging from 8 to 24 feet) replacing conventional circulating fans. Commercial and industrial applications only.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Premium Efficiency Motors	Per Horsepower	No	Replacement of old motors with new energy efficient motors of the same rated HP.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ECM Circulator Pump	Per Pump	No	An ECM or BPM circulator pump replacing single-speed induction motor circulator pumps in space heating and hot water applications.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High Efficiency Pumps	Per Horsepower	No	Compliant pumps will achieve a PEI of 1.0 or less. All pumps manufactured after January 27, 2020 must comply with the DOE's energy conservation standard as described in 10 CFR 431 Subpart Y.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Heat Pump Water Heaters	Per Product	No	Installation of a heat pump water heater instead of a code minimum electric water heater.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Low Flow Pre-rinse Sprayers	Per Product	No	Efficient low flow pre-rinse sprayers that use less than 1.6 gallons of water per minute. Only applicable to premises with electric water heating.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Fuel Switching: electric water heaters to gas/propane	Per Product	No	Must replace electric water heater with ENERGY STAR certified natural gas or propane equipment.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Floating head pressure controls	Per Control	No	Adding FHPCs to a refrigeration system. FHPCs must have a minimum SCT programmed for the floating head pressure control of ≤ 70 ºF. The use of FHPC would require balanced-port expansion valves, allowing satisfactory refrigerant flow over a range of head pressures. The compressor must be 1 HP or larger.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Evaporator coil defrost controls	Per Evaporator Unit	No	Adding defrost controls to existing walk-in coolers or freezers without defrost controls.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Suction pipe insulation for walk-in coolers and freezers	Per Foot	No	Insulate bare refrigeration suction pipes for walk-in coolers and freezers according to the current PA TRM requirements.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Air cooled refrigeration condenser	Per Ton	No	Installing an efficient, close-approach air-cooled refrigeration condenser that meets the current PA TRM requirements.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Refrigerated case light occupancy sensors	Per Watt Controlled	No	Installation of motion-based lighting controls that allow the LED case lighting to be dimmed or turned off completely during unoccupied conditions.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Refrigeration economizers	Per Compressor Horsepower	No	Economizers installed on a walk-in refrigeration system.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Clothes washer	Per Product	No	ENERGY STAR, installed in commercial laundromats or multifamily complex laundry rooms.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR bathroom ventilation fan	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Snack machine controls	Per Product	No	Added to non-ENERGY STAR, non-refrigerated machines.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Electric steam cooker	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Combination oven	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial convection oven	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial fryer	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial hot food holding cabinet	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial Dishwasher	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
ENERGY STAR Commercial Griddle	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Wall and Ceiling Insulation	Per SQFT	No	Applies to buildings that are heated and/or cooled using electricity. Existing construction buildings are required to meet or exceed the code requirement. New construction buildings must exceed the code requirement.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Office Equipment - Network power management enabling	Per Workstation	No	Applicable to any software that manages workstations in a networked environment that meets the current PA TRM requirements.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Advanced power strips	Per Workstation	No	Installation of an Advanced Power Strip.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Servers	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Server virtualization	Per Product	No	Servers must be consolidated to increase utilization of the remaining servers, and the virtualized servers must be either a) removed or b) physically disconnected from power.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Air-entraining air nozzle	Per Product	No	Replace non-air entraining air nozzle (open copper tube of 1/8-inch or 1/4-inch orifice diameter) with an energy efficient air-entraining air nozzle that uses less than 15 cfm at 100 psi for industrial applications.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Air tanks for Load/No load compressors	Per Horsepower	No	Minimum storage ratio of 4 gallons per cfm.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Compressed air controller	Per Horsepower	No	The baseline condition is having no existing pressure/flow controller and an existing compressed air system with a total compressor motor capacity ≥ 40 hp. This measure requires a minimum storage of 3gal/cfm.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Compressed air low pressure drop filters	Per Horsepower	No	The baseline condition is a standard coalescing filter with a pressure drop of 3 psi when new and 5 psi or more at element change. The efficient condition is a low pressure drop filter with pressure drop not	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
			exceeding 1 psi when new and 3 psi at element change.			
Compressed air mist eliminators	Per Horsepower	No	The compressed air system must be greater than 50 HP to qualify, and the mist eliminator must have less than a 1 psig pressure drop and replace a coalescing filter.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High efficiency transformer	Per Product	No	Transformers more efficient than the federal standard.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Engine block heat timer	Per Product	No	Agricultural Application: Installation of a timer on an engine block heater.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High frequency battery chargers	Per Product	No	The baseline equipment is a SCR or ferroresonant battery charger system with minimum 8-hour shift operation five days per week. The energy efficient equipment is a high frequency battery charger system with a minimum power conversion efficiency of 90% and 8-hour shift operation five days per week.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Automatic Milker takeoffs	Per Cow	No	Agricultural Application: Automatic milker take-offs that determine milking end time, and the vacuum pump system serving the impacted milking units must be equipped with a variable speed drive.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Dairy scroll compressors	Per Product	No	Agricultural Application: Installation of a scroll compressor to replace an existing reciprocating compressor or to be installed in a new construction application.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Heat reclaimers	Per Product	No	Agricultural Application: Installation of heat recovery equipment on dairy parlor milk refrigeration systems to heat hot water. This measure only applies to dairy parlors with electric water heating equipment.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High Volume Low Speed fans	Per Product	No	Agricultural Application: Installation of HVLS fans to replace conventional circulating fans. HVLS fans are a minimum of 16 feet long in diameter.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Livestock waterer	Per Product	No	Agricultural Application: Thermostatically controlled with 2-inches or more of factory-installed insulation.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Low pressure irrigation system	Per Acre	No	Agricultural Application: Replace systems operating on 50% or less than existing system pressure.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
New Construction Lighting	Per SQFT	No	Eligible lighting equipment and fixture/lamp types include fluorescent fixtures (lamps and ballasts), compact fluorescent lamps, HID lamps, interior and exterior LED lamps and fixtures, CCFLs, induction lamps, and lighting controls.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Electric steam cooker Midstream	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Combination oven Midstream	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial convection oven Midstream	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial Dishwasher Midstream	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
ENERGY STAR Commercial Griddle Midstream	Per Product	No	ENERGY STAR	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Automatic Milker takeoffs Midstream	Per Cow	No	Agricultural Application: Automatic milker take-offs that determine milking end time, and the vacuum pump system serving the impacted milking units must be equipped with a variable speed drive.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Dairy scroll compressors Midstream	Per Product	No	Agricultural Application: Installation of a scroll compressor to replace an existing reciprocating compressor or to be installed in a new construction application.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Heat reclaimers Midstream	Per Product	No	Agricultural Application: Installation of heat recovery equipment on dairy parlor milk refrigeration systems to heat hot water. This measure only applies to dairy parlors with electric water heating equipment.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
High Volume Low Speed fans Midstream	Per Product	No	Agricultural Application: Installation of HVLS fans to replace conventional circulating fans. HVLS fans are a minimum of 16 feet long in diameter.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Livestock waterer Midstream	Per Product	No	Agricultural Application: Thermostatically controlled with 2-inches or more of factory-installed insulation.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Door gaskets for walk-in and reach-in coolers and freezers Direct Discount	Per Door	No	Replace worn-out gaskets with new better-fitting gaskets.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Evaporator coil defrost controls Direct Discount	Per Evaporator Unit	No	Adding defrost controls to existing walk-in coolers or freezers without defrost controls.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
LED Exit Signs Direct Discount	Per Product	No	Early replacement of existing incandescent or fluorescent exit signs with a new LED exit sign.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Night covers for display cases Direct Discount	Per Foot	No	Install on existing open-type refrigerated display cases, where covers are deployed during the facility's unoccupied hours.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Snack machine controls Direct Discount	Per Product	No	Added to non-ENERGY STAR, non-refrigerated machines.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Suction pipe insulation for walk-in coolers and freezers Direct Discount	Per Foot	No	Insulate bare refrigeration suction pipes for walk-in coolers and freezers according to the current PA TRM requirements.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

All measures may not be available at all times. PPL Electric Utilities may suspend a measure depending on popularity, pace of the component savings and costs, free ridership, evaluation requirements, complexity of the information required from customers, administrative requirements for the measure, or other reasons. PPL Electric Utilities will review the component continually and may adjust available measures or eligibility qualifications to achieve savings and cost budgets.

PPL Electric Utilities may offer tiered incentives that encourage the installation of multiple measures or a more comprehensive whole facility approach. Measures, eligibility requirements, and incentives may change to reflect progress, changes in the TRM, market conditions, or other factors. PPL Electric Utilities shall strive to keep the rebates and per-site caps as consistent as possible while recognizing the need to adjust incentives and caps to control the pace of components within their savings and cost budgets.

PPL Electric Utilities may also implement a minimum TRC requirement for qualifying measures if it is necessary to help ensure the Non-Residential Program or portfolio TRC is greater than 1.0. PPL Electric Utilities will notify customers, trade allies, and stakeholders at least 60 days before the effective date of this TRC requirement or a subsequent change in the TRC requirement. Any TRC requirement would be in effect for new applications submitted after the effective date.

Deadline for Rebate Applications

The rebate application website and portal will state the deadline for final submission. The deadline will not exceed 180 days from the date the measure was installed. For some measures, PPL Electric Utilities will allow customers to request project preapproval to lock in the stipulated incentive level and guarantee the funding. PPL Electric Utilities will require preapproval for some non-custom measures or specific customer sectors to allow sufficient time to identify budget commitments and reduce the likelihood of exceeding budgets for the component or customer sectors. PPL Electric Utilities reserves the right to waive the preapproval requirement with 60 days' notice to customers, trade allies and stakeholders.

Start Date with Key Schedule Milestones

Table 43 lists the estimated key schedule milestones for the Efficient Equipment component. PPL Electric Utilities will lead implementation or provide management oversight of all tasks.

Table 43. Efficient Equipment Component Schedule and Milestones

Schedule	Milestones
11/30/2020	Phase IV EE&C Plan submitted to Pa PUC
06/01/2021	Launch Phase IV component
Annually starting 01/15/2022	EDCs submit semiannual program report
Annually starting 09/30/2022	EDCs submit final annual program report
05/31/2026	Program ends

Evaluation, Measurement, and Verification

The EM&V requirements will be detailed in PPL Electric Utilities' Evaluation Plan, which will be submitted to the SWE for review. PPL Electric Utilities and its EM&V CSP will conduct annual evaluations of each component in compliance with all Pa PUC requirements and the Evaluation Framework. As part of this process, the EM&V CSP will review a sample of participant rebate applications and Non-Residential CSP records to verify quantity, efficiency level, and qualifying equipment. The EM&V CSP will follow all applicable methods in the TRM and the Evaluation Framework to calculate energy savings and peak demand reduction.

For the Non-Residential Efficient Equipment component, PPL Electric Utilities anticipates conducting annual impact and process evaluations (activities vary by year).

The EM&V CSP will develop an evaluation plan and sampling protocol that fits the Efficient Equipment component and all associated delivery channels. The EM&V CSP will review a sample of participant and Non-Residential CSP records to verify quantity, efficiency level, and qualifying equipment. On-site assessment may be included as a verification activity.

Administrative Requirements

The Non-Residential CSP will administer and provide operational management of the Efficient Equipment component. PPL Electric Utilities will provide oversight and operational support to establish effective deployment.

Estimated Participation

Table 44 and Table 45 show the order of magnitude participation estimates for Large and Small C&I Efficient Equipment. Actual quantities will vary, and PPL Electric Utilities will manage the component to stay within budget.

Table 44. Pa PUC Table 8-Large C&I Efficient Equipment Projected Participation [1]

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Lighting Improvements	Energy Savings (MWh/year)	46,451	46,451	44,128	41,806	41,341	220,177
	Demand Reduction (MW)	6.720	6.720	6.384	6.048	5.981	31.854
	Projected Participation	445	445	423	401	396	2,111
LED Exit Signs	Energy Savings (MWh/year)	10	10	10	9	9	50
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.006
	Projected Participation	42	42	40	38	38	201
HVAC Systems	Energy Savings (MWh/year)	421	421	421	421	421	2,107
	Demand Reduction (MW)	0.084	0.084	0.084	0.084	0.084	0.422
	Projected Participation	83	83	83	83	83	415

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Electric Chillers	Energy Savings (MWh/year)	11	11	11	11	11	53
	Demand Reduction (MW)	0.008	0.008	0.008	0.008	0.008	0.040
	Projected Participation	0.5	0.5	0.5	0.5	0.5	2.4
Water Source and Geothermal Heat Pumps	Energy Savings (MWh/year)	0.5	0.5	0.5	0.5	0.5	2.5
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0004
	Projected Participation	0.4	0.4	0.4	0.4	0.4	1.9
Ductless mini-split heat pumps < 5.4 tons	Energy Savings (MWh/year)	49	49	49	49	49	244
	Demand Reduction (MW)	0.005	0.005	0.005	0.005	0.005	0.023
	Projected Participation	11	11	11	11	11	56
ENERGY STAR Room A/C	Energy Savings (MWh/year)	1	1	1	1	1	4
	Demand Reduction (MW)	0.002	0.002	0.002	0.002	0.002	0.008
	Projected Participation	21	21	21	21	21	105
Guest Room Occupancy Sensor controls	Energy Savings (MWh/year)	82	82	82	82	82	412
	Demand Reduction (MW)	0.015	0.015	0.015	0.015	0.015	0.073
	Projected Participation	210	210	210	210	210	1,048
Economizer controls	Energy Savings (MWh/year)	26	26	26	26	26	130
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	2	2	2	2	2	12
VFD Improvements	Energy Savings (MWh/year)	365	365	365	365	365	1,825
	Demand Reduction (MW)	0.033	0.033	0.033	0.033	0.033	0.167
	Projected Participation	25	25	25	25	25	124
ECM Circulating fan	Energy Savings (MWh/year)	3	3	3	3	3	17
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.006
	Projected Participation	8	8	8	8	8	42
VSD on Kitchen Exhaust Fan	Energy Savings (MWh/year)	2	2	2	2	2	11
	Demand Reduction (MW)	0.0003	0.0003	0.0003	0.0003	0.0003	0.0014
	Projected Participation	1	1	1	1	1	4

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
ENERGY STAR Refrigeration/Freezer Cases	Energy Savings (MWh/year)	3	3	4	4	4	18
	Demand Reduction (MW)	0.0003	0.0004	0.0004	0.0005	0.0005	0.0022
	Projected Participation	6	7	8	9	9	40
High efficiency evaporator fan motors for walk in or reach in cases	Energy Savings (MWh/year)	99	118	128	138	148	632
	Demand Reduction (MW)	0.012	0.015	0.016	0.017	0.018	0.077
	Projected Participation	215	258	279	301	322	1,376
Evaporator Fan controllers	Energy Savings (MWh/year)	2	2	2	2	2	11
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.003
	Projected Participation	3	3	3	3	3	13
Anti-sweat heater controls	Energy Savings (MWh/year)	14	17	18	19	21	88
	Demand Reduction (MW)	0.002	0.002	0.002	0.002	0.002	0.010
	Projected Participation	5	7	7	8	8	35
Variable speed refrigeration compressor	Energy Savings (MWh/year)	0.01	0.01	0.01	0.01	0.01	0.06
	Demand Reduction (MW)	0.000001	0.000002	0.000002	0.000002	0.000002	0.000008
	Projected Participation	0.0	0.1	0.1	0.1	0.1	0.3
Strip curtains for walk-in freezers and coolers	Energy Savings (MWh/year)	1	1	1	2	2	7
	Demand Reduction (MW)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0010
	Projected Participation	0.1	0.2	0.2	0.2	0.2	0.9
Night covers for display cases	Energy Savings (MWh/year)	0.002	0.002	0.002	0.002	0.003	0.011
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	0.0	0.1	0.1	0.1	0.1	0.3
Auto door closers	Energy Savings (MWh/year)	0.3	0.3	0.3	0.4	0.4	1.7
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0002	0.0006
	Projected Participation	0.2	0.3	0.3	0.3	0.4	1.6
Door gaskets for walk-in and reach-in coolers and freezers	Energy Savings (MWh/year)	0.2	0.2	0.2	0.2	0.2	1.0
	Demand Reduction (MW)	0.00002	0.00003	0.00003	0.00003	0.00003	0.00014
	Projected Participation	1	1	1	1	1	5

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Low or No anti-sweat heat for reach-in freezers and coolers	Energy Savings (MWh/year)	0.0	0.1	0.1	0.1	0.1	0.3
	Demand Reduction (MW)	0.00001	0.00001	0.00001	0.00001	0.00001	0.00003
	Projected Participation	0.1	0.1	0.1	0.1	0.1	0.6
Refrigerated Display cases with doors replacing open cases	Energy Savings (MWh/year)	0.3	0.3	0.3	0.4	0.4	1.6
	Demand Reduction (MW)	0.00003	0.00004	0.00004	0.00004	0.00005	0.00020
	Projected Participation	1	1	1	1	1	5
Adding doors to existing refrigerated display cases	Energy Savings (MWh/year)	0	1	1	1	1	3
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003
	Projected Participation	1	1	2	2	2	7
ENERGY STAR Ice machines	Energy Savings (MWh/year)	2	2	2	3	3	12
	Demand Reduction (MW)	0.000	0.000	0.001	0.001	0.001	0.003
	Projected Participation	1	2	2	2	2	8
Beverage machine controls	Energy Savings (MWh/year)	0.1	0.1	0.1	0.1	0.1	0.4
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	0.0	0.1	0.1	0.1	0.1	0.3
ENERGY STAR Office equipment	Energy Savings (MWh/year)	0.5	0.5	0.5	0.5	0.5	2.4
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003
	Projected Participation	6	6	6	6	6	30
Cycling refrigerated thermal mass dryer	Energy Savings (MWh/year)	0.03	0.03	0.03	0.03	0.03	0.16
	Demand Reduction (MW)	0.00001	0.00001	0.00001	0.00001	0.00001	0.00003
	Projected Participation	1	1	1	1	1	3
No-loss condensate drains	Energy Savings (MWh/year)	3	3	3	3	3	14
	Demand Reduction (MW)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0024
	Projected Participation	1	1	1	1	1	7
Variable speed drive air compressor	Energy Savings (MWh/year)	0.3	0.3	0.3	0.3	0.3	1.5
	Demand Reduction (MW)	0.00005	0.00005	0.00005	0.00005	0.00005	0.00024
	Projected Participation	0.4	0.4	0.4	0.4	0.4	2.2

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
High efficiency ventilation fans with and w/o thermostats	Energy Savings (MWh/year)	0.3	0.3	0.3	0.3	0.3	1.6
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003
	Projected Participation	1	1	1	1	1	4
VSD Controller on dairy vacuum pumps	Energy Savings (MWh/year)	2	2	2	2	2	11
	Demand Reduction (MW)	0.0003	0.0003	0.0003	0.0003	0.0003	0.0017
	Projected Participation	0.3	0.3	0.3	0.3	0.3	1.5
Lighting Improvements for Midstream	Energy Savings (MWh/year)	5,709	5,713	5,427	5,142	5,085	27,077
	Demand Reduction (MW)	1.064	1.065	1.012	0.959	0.948	5.047
	Projected Participation	6,521	6,525	6,199	5,874	5,808	30,927
Lighting Improvements for Midstream	Energy Savings (MWh/year)	309	309	294	278	275	1,465
	Demand Reduction (MW)	0.063	0.063	0.060	0.056	0.056	0.297
	Projected Participation	6,521	6,525	6,199	5,874	5,808	30,927
HVAC Systems Midstream	Energy Savings (MWh/year)	136	271	339	339	339	1,423
	Demand Reduction (MW)	0.024	0.047	0.059	0.059	0.059	0.247
	Projected Participation	21	42	52	52	52	220
Ductless mini-split heat pumps < 5.4 tons Midstream	Energy Savings (MWh/year)	28	57	71	71	71	297
	Demand Reduction (MW)	0.002	0.005	0.006	0.006	0.006	0.024
	Projected Participation	5	10	13	13	13	54
ENERGY STAR Ice machines Midstream	Energy Savings (MWh/year)	1	1	1	1	1	4
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0007
	Projected Participation	0.4	0.4	0.4	0.4	0.4	2.2
ENERGY STAR Commercial fryer Midstream	Energy Savings (MWh/year)	1	1	1	1	1	6
	Demand Reduction (MW)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0009
	Projected Participation	0.4	0.4	0.4	0.4	0.4	2.2
ENERGY STAR Commercial hot food holding cabinet Midstream	Energy Savings (MWh/year)	1	1	1	1	1	4
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0006
	Projected Participation	0.4	0.4	0.4	0.4	0.4	2.2

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
High efficiency ventilation fans with and w/o thermostats Midstream	Energy Savings (MWh/year)	0.2	0.4	0.5	0.5	0.5	1.9
	Demand Reduction (MW)	0.0000	0.0001	0.0001	0.0001	0.0001	0.0003
	Projected Participation	0	1	1	1	1	4
VSD Controller on dairy vacuum pumps Midstream	Energy Savings (MWh/year)	1	1	2	2	2	7
	Demand Reduction (MW)	0.0001	0.0002	0.0002	0.0002	0.0002	0.0009
	Projected Participation	0.1	0.1	0.2	0.2	0.2	0.7

[1] To show numerical values in the Pa PUC Table 8 tables, deviation from the standard use of decimals throughout Section 3 may have been applied.
[2] Total values may not equal the sum of all program year values due to rounding.

Table 45. Pa PUC Table 8-Small C&I Efficient Equipment Projected Participation [1]

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Lighting Improvements	Energy Savings (MWh/year)	46,451	46,451	44,128	41,806	41,341	220,177
	Demand Reduction (MW)	6.720	6.720	6.384	6.048	5.981	31.854
	Projected Participation	445	445	423	401	396	2,111
LED Exit Signs	Energy Savings (MWh/year)	10	10	10	9	9	50
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.006
	Projected Participation	42	42	40	38	38	201
HVAC Systems	Energy Savings (MWh/year)	421	421	421	421	421	2,107
	Demand Reduction (MW)	0.084	0.084	0.084	0.084	0.084	0.422
	Projected Participation	83	83	83	83	83	415
Electric Chillers	Energy Savings (MWh/year)	11	11	11	11	11	53
	Demand Reduction (MW)	0.008	0.008	0.008	0.008	0.008	0.040
	Projected Participation	0.5	0.5	0.5	0.5	0.5	2.4
Water Source and Geothermal Heat Pumps	Energy Savings (MWh/year)	0.5	0.5	0.5	0.5	0.5	2.5
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0004
	Projected Participation	0.4	0.4	0.4	0.4	0.4	1.9
Ductless mini-split heat pumps < 5.4 tons	Energy Savings (MWh/year)	49	49	49	49	49	244
	Demand Reduction (MW)	0.005	0.005	0.005	0.005	0.005	0.023
	Projected Participation	11	11	11	11	11	56
ENERGY STAR Room A/C	Energy Savings (MWh/year)	1	1	1	1	1	4
	Demand Reduction (MW)	0.002	0.002	0.002	0.002	0.002	0.008

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
	Projected Participation	21	21	21	21	21	105
Guest Room Occupancy Sensor controls	Energy Savings (MWh/year)	82	82	82	82	82	412
	Demand Reduction (MW)	0.015	0.015	0.015	0.015	0.015	0.073
	Projected Participation	210	210	210	210	210	1,048
Economizer controls	Energy Savings (MWh/year)	26	26	26	26	26	130
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	2	2	2	2	2	12
VFD Improvements	Energy Savings (MWh/year)	365	365	365	365	365	1,825
	Demand Reduction (MW)	0.033	0.033	0.033	0.033	0.033	0.167
	Projected Participation	25	25	25	25	25	124
ECM Circulating fan	Energy Savings (MWh/year)	3	3	3	3	3	17
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.006
	Projected Participation	8	8	8	8	8	42
VSD on Kitchen Exhaust Fan	Energy Savings (MWh/year)	2	2	2	2	2	11
	Demand Reduction (MW)	0.0003	0.0003	0.0003	0.0003	0.0003	0.0014
	Projected Participation	1	1	1	1	1	4
ENERGY STAR Refrigeration/Freezer Cases	Energy Savings (MWh/year)	3	3	4	4	4	18
	Demand Reduction (MW)	0.0003	0.0004	0.0004	0.0005	0.0005	0.0022
	Projected Participation	6	7	8	9	9	40
High efficiency evaporator fan motors for walk in or reach in cases	Energy Savings (MWh/year)	99	118	128	138	148	632
	Demand Reduction (MW)	0.012	0.015	0.016	0.017	0.018	0.077
	Projected Participation	215	258	279	301	322	1,376
Evaporator Fan controllers	Energy Savings (MWh/year)	2	2	2	2	2	11
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.003
	Projected Participation	3	3	3	3	3	13
Anti-sweat heater controls	Energy Savings (MWh/year)	14	17	18	19	21	88
	Demand Reduction (MW)	0.002	0.002	0.002	0.002	0.002	0.010
	Projected Participation	5	7	7	8	8	35
Variable speed refrigeration compressor	Energy Savings (MWh/year)	0.01	0.01	0.01	0.01	0.01	0.06
	Demand Reduction (MW)	0.000001	0.000002	0.000002	0.000002	0.000002	0.000008
	Projected Participation	0.0	0.1	0.1	0.1	0.1	0.3
Strip curtains for walk-in freezers and coolers	Energy Savings (MWh/year)	1	1	1	2	2	7

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
	Demand Reduction (MW)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0010
	Projected Participation	0.1	0.2	0.2	0.2	0.2	0.9
Night covers for display cases	Energy Savings (MWh/year)	0.002	0.002	0.002	0.002	0.003	0.011
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	0.0	0.1	0.1	0.1	0.1	0.3
Auto door closers	Energy Savings (MWh/year)	0.3	0.3	0.3	0.4	0.4	1.7
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0002	0.0006
	Projected Participation	0.2	0.3	0.3	0.3	0.4	1.6
Door gaskets for walk-in and reach-in coolers and freezers	Energy Savings (MWh/year)	0.2	0.2	0.2	0.2	0.2	1.0
	Demand Reduction (MW)	0.00002	0.00003	0.00003	0.00003	0.00003	0.00014
	Projected Participation	1	1	1	1	1	5
Low or No anti-sweat heat for reach-in freezers and coolers	Energy Savings (MWh/year)	0.0	0.1	0.1	0.1	0.1	0.3
	Demand Reduction (MW)	0.00001	0.00001	0.00001	0.00001	0.00001	0.00003
	Projected Participation	0.1	0.1	0.1	0.1	0.1	0.6
Refrigerated Display cases with doors replacing open cases	Energy Savings (MWh/year)	0.3	0.3	0.3	0.4	0.4	1.6
	Demand Reduction (MW)	0.00003	0.00004	0.00004	0.00004	0.00005	0.00020
	Projected Participation	1	1	1	1	1	5
Adding doors to existing refrigerated display cases	Energy Savings (MWh/year)	0	1	1	1	1	3
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003
	Projected Participation	1	1	2	2	2	7
ENERGY STAR Ice machines	Energy Savings (MWh/year)	2	2	2	3	3	12
	Demand Reduction (MW)	0.000	0.000	0.001	0.001	0.001	0.003
	Projected Participation	1	2	2	2	2	8
Beverage machine controls	Energy Savings (MWh/year)	0.1	0.1	0.1	0.1	0.1	0.4
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	0.0	0.1	0.1	0.1	0.1	0.3
ENERGY STAR Office equipment	Energy Savings (MWh/year)	0.5	0.5	0.5	0.5	0.5	2.4
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003
	Projected Participation	6	6	6	6	6	30

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Cycling refrigerated thermal mass dryer	Energy Savings (MWh/year)	0.03	0.03	0.03	0.03	0.03	0.16
	Demand Reduction (MW)	0.00001	0.00001	0.00001	0.00001	0.00001	0.00003
	Projected Participation	1	1	1	1	1	3
No-loss condensate drains	Energy Savings (MWh/year)	3	3	3	3	3	14
	Demand Reduction (MW)	0.0005	0.0005	0.0005	0.0005	0.0005	0.0024
	Projected Participation	1	1	1	1	1	7
Variable speed drive air compressor	Energy Savings (MWh/year)	0.3	0.3	0.3	0.3	0.3	1.5
	Demand Reduction (MW)	0.00005	0.00005	0.00005	0.00005	0.00005	0.00024
	Projected Participation	0.4	0.4	0.4	0.4	0.4	2.2
High efficiency ventilation fans with and w/o thermostats	Energy Savings (MWh/year)	0.3	0.3	0.3	0.3	0.3	1.6
	Demand Reduction (MW)	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003
	Projected Participation	1	1	1	1	1	4
VSD Controller on dairy vacuum pumps	Energy Savings (MWh/year)	2	2	2	2	2	11
	Demand Reduction (MW)	0.0003	0.0003	0.0003	0.0003	0.0003	0.0017
	Projected Participation	0.3	0.3	0.3	0.3	0.3	1.5
Lighting Improvements for Midstream	Energy Savings (MWh/year)	15,644	15,573	15,004	14,436	14,182	74,838
	Demand Reduction (MW)	2.916	2.903	2.797	2.691	2.644	13.950
	Projected Participation	17,869	17,787	17,138	16,488	16,198	85,480
Lighting Improvements for Midstream	Energy Savings (MWh/year)	847	843	812	781	767	4,050
	Demand Reduction (MW)	0.172	0.171	0.165	0.158	0.156	0.821
	Projected Participation	17,869	17,787	17,138	16,488	16,198	85,480
HVAC Systems Midstream	Energy Savings (MWh/year)	271	542	678	678	678	2,846
	Demand Reduction (MW)	0.047	0.094	0.118	0.118	0.118	0.495
	Projected Participation	42	84	105	105	105	441
Ductless mini-split heat pumps < 5.4 tons Midstream	Energy Savings (MWh/year)	57	113	142	142	142	595
	Demand Reduction (MW)	0.005	0.009	0.011	0.011	0.011	0.048
	Projected Participation	10	20	26	26	26	107
ENERGY STAR Ice machines Midstream	Energy Savings (MWh/year)	2	2	2	2	2	8
	Demand Reduction (MW)	0.0003	0.0003	0.0003	0.0003	0.0003	0.0015
	Projected Participation	1	1	1	1	1	4

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
ENERGY STAR Commercial fryer Midstream	Energy Savings (MWh/year)	2	2	2	2	2	11
	Demand Reduction (MW)	0.0004	0.0004	0.0004	0.0004	0.0004	0.0019
	Projected Participation	1	1	1	1	1	4
ENERGY STAR Commercial hot food holding cabinet Midstream	Energy Savings (MWh/year)	2	2	2	2	2	8
	Demand Reduction (MW)	0.0002	0.0002	0.0002	0.0002	0.0002	0.0012
	Projected Participation	1	1	1	1	1	4
High efficiency ventilation fans with and w/o thermostats Midstream	Energy Savings (MWh/year)	0	1	1	1	1	4
	Demand Reduction (MW)	0.0001	0.0001	0.0002	0.0002	0.0002	0.0007
	Projected Participation	1	2	2	2	2	8
VSD Controller on dairy vacuum pumps Midstream	Energy Savings (MWh/year)	1	3	3	3	3	14
	Demand Reduction (MW)	0.0002	0.0003	0.0004	0.0004	0.0004	0.0018
	Projected Participation	0.1	0.3	0.3	0.3	0.3	1.4
Adding doors to existing refrigerated display cases Direct Discount	Energy Savings (MWh/year)	1	1	2	2	2	7
	Demand Reduction (MW)	0.0001	0.0002	0.0002	0.0002	0.0002	0.0008
	Projected Participation	1	3	4	4	4	16
Air tanks for Load/No load compressors Direct Discount	Energy Savings (MWh/year)	0.1	0.2	0.2	0.2	0.2	0.7
	Demand Reduction (MW)	0.00001	0.00002	0.00002	0.00002	0.00002	0.00011
	Projected Participation	0.2	0.4	0.4	0.4	0.4	1.9
Air-entraining air nozzle Direct Discount	Energy Savings (MWh/year)	4	4	4	5	4	22
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.001	0.003
	Projected Participation	2	2	2	3	2	11
Anti-sweat heater controls Direct Discount	Energy Savings (MWh/year)	88	183	204	225	226	928
	Demand Reduction (MW)	0.010	0.020	0.022	0.025	0.025	0.102
	Projected Participation	28	58	65	72	72	295
Auto door closers Direct Discount	Energy Savings (MWh/year)	15	26	27	27	26	120
	Demand Reduction (MW)	0.005	0.009	0.009	0.009	0.009	0.042
	Projected Participation	11	19	19	20	19	88
Beverage machine controls Direct Discount	Energy Savings (MWh/year)	13	18	18	16	16	82
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	9	13	13	12	12	58

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Compressed air controller Direct Discount	Energy Savings (MWh/year)	0.2	0.2	0.2	0.3	0.3	1.2
	Demand Reduction (MW)	0.00002	0.00004	0.00004	0.00004	0.00004	0.00018
	Projected Participation	1	1	1	1	1	6
Compressed air low pressure drop filters Direct Discount	Energy Savings (MWh/year)	0.02	0.02	0.02	0.02	0.02	0.08
	Demand Reduction (MW)	0.000002	0.000002	0.000002	0.000002	0.000002	0.000012
	Projected Participation	0.4	0.4	0.4	0.4	0.4	2.1
Compressed air mist eliminators Direct Discount	Energy Savings (MWh/year)	0.02	0.02	0.02	0.02	0.02	0.08
	Demand Reduction (MW)	0.000002	0.000002	0.000002	0.000002	0.000002	0.000012
	Projected Participation	0.2	0.2	0.2	0.2	0.2	1.1
Cycling refrigerated thermal mass dryer Direct Discount	Energy Savings (MWh/year)	0.01	0.01	0.01	0.01	0.01	0.06
	Demand Reduction (MW)	0.000002	0.000002	0.000002	0.000002	0.000002	0.000009
	Projected Participation	0.2	0.2	0.2	0.2	0.2	1.1
Economizer controls Direct Discount	Energy Savings (MWh/year)	6	12	12	12	6	46
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	0	1	1	1	0	3
Evaporator Fan controllers Direct Discount	Energy Savings (MWh/year)	1	1	1	1	1	4
	Demand Reduction (MW)	0.0002	0.0002	0.0002	0.0003	0.0003	0.0011
	Projected Participation	1	1	1	1	1	4
High efficiency evaporator fan motors for walk in or reach in cases Direct Discount	Energy Savings (MWh/year)	4	8	9	10	10	41
	Demand Reduction (MW)	0.000	0.001	0.001	0.001	0.001	0.005
	Projected Participation	7	14	16	18	18	73
LED Refrigeration Display Case Lighting Direct Discount	Energy Savings (MWh/year)	32	56	54	53	49	245
	Demand Reduction (MW)	0.005	0.009	0.008	0.008	0.007	0.037
	Projected Participation	70	122	118	115	107	533
Lighting Controls Direct Discount	Energy Savings (MWh/year)	37	64	63	61	57	282
	Demand Reduction (MW)	0.007	0.012	0.012	0.012	0.011	0.054
	Projected Participation	42	73	71	69	64	320
Lighting Improvements Direct Discount	Energy Savings (MWh/year)	18,104	18,670	18,104	17,538	16,972	89,388
	Demand Reduction (MW)	2.592	2.673	2.592	2.511	2.430	12.800
	Projected Participation	168	174	168	163	158	831

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Low Flow Pre-rinse Sprayers Direct Discount	Energy Savings (MWh/year)	11	13	13	13	13	62
	Demand Reduction (MW)	0.002	0.002	0.002	0.002	0.002	0.010
	Projected Participation	11	13	13	13	13	61
No-loss condensate drains Direct Discount	Energy Savings (MWh/year)	1	1	1	1	1	5
	Demand Reduction (MW)	0.0001	0.0002	0.0002	0.0002	0.0002	0.0007
	Projected Participation	0.2	0.4	0.4	0.4	0.4	1.9
Refrigerated case light occupancy sensors Direct Discount	Energy Savings (MWh/year)	0.02	0.03	0.03	0.03	0.03	0.13
	Demand Reduction (MW)	-	-	-	-	-	-
	Projected Participation	6	10	9	9	9	43
Strip curtains for walk-in freezers and coolers Direct Discount	Energy Savings (MWh/year)	4	6	8	10	12	40
	Demand Reduction (MW)	0.001	0.001	0.001	0.001	0.002	0.005
	Projected Participation	0	1	1	1	1	4
Variable speed drive air compressor Direct Discount	Energy Savings (MWh/year)	2	4	4	4	4	17
	Demand Reduction (MW)	0.000	0.001	0.001	0.001	0.001	0.003
	Projected Participation	3	4	4	5	4	20
Variable speed refrigeration compressor Direct Discount	Energy Savings (MWh/year)	1	1	1	1	2	6
	Demand Reduction (MW)	0.0001	0.0002	0.0002	0.0002	0.0002	0.0008
	Projected Participation	3	5	6	6	7	27
Lighting Improvements Direct Install	Energy Savings (MWh/year)	1,623	1,894	1,860	1,826	1,758	8,962
	Demand Reduction (MW)	0.233	0.272	0.267	0.262	0.252	1.286
	Projected Participation	758	884	868	852	821	4,182
Low Flow Pre-rinse Sprayers Direct Install	Energy Savings (MWh/year)	105	157	167	172	167	768
	Demand Reduction (MW)	0.018	0.028	0.029	0.030	0.029	0.135
	Projected Participation	126	189	202	208	202	928

[1] To show numerical values in the Pa PUC Table 8 tables, deviation from the standard use of decimals throughout Section 3 may have been applied.
[2] Total values may not equal the sum of all program year values due to rounding.

Custom Component

The Custom component is the same for both large C&I and small C&I customers unless noted otherwise.

Description

Through the Custom component, PPL Electric Utilities will offer incentives to support completion of complex and comprehensive projects that involve measures not covered by the Efficient Equipment component. These measures include, but are not limited to, operational process improvements, retro-commissioning, equipment optimization, CHP, solar, advanced lighting controls, compressed air, and other custom measures.

As with Efficient Equipment, PPL Electric Utilities' Custom component will be offered through a downstream approach. The Non-Residential CSP will work with customers and trade allies to identify and qualify custom projects. Customers or trade allies will submit applications for review. Eligible projects will be processed, and incentives will be paid upon project completion and final savings review.

In Phase IV, an HVAC Optimization delivery channel will be added to serve customers with packaged HVAC systems. The Non-Residential CSP will work with a network of trade allies to implement this channel to produce additional, cost-effective energy and peak demand savings. A Strategic Energy Management ("SEM") offering may also be implemented at some time during Phase IV. Though the SEM would be a measure in the Custom component, incentive levels may differ from the standard custom incentive amount.

Objectives

The objectives of the Custom component are:

- Provide energy and peak demand-savings opportunities and incentives to qualified customers.
- Encourage customers to take a comprehensive, whole-facility approach to energy efficiency by installing high-efficiency custom measures or processes.
- Encourage qualifying equipment repairs, optimization, and operational or process changes that reduce electricity consumption.
- Increase customer awareness of the features and benefits of energy efficient equipment.
- Support emerging technologies and nontypical efficiency solutions in cost-effective applications.
- Encourage advanced energy efficiency strategies required for certification by national market transformation programs such as Leadership in Energy and Environmental Design ("LEED"), Architecture 2030, or ENERGY STAR Buildings.
- Engage trade allies to stock, promote, and provide high-efficiency technology options to customers.
- Promote other PPL Electric Utilities energy efficiency components.

- Collect energy, peak demand, and operating data from customers, as required to confirm customer and measure eligibility and to determine energy and peak demand savings and cost-effectiveness.
- Achieve a total energy reduction of approximately 705,195 MWh/year and 96 MW[28] gross verified savings that will target large C&I and small C&I customers, or business types.

Implementation Strategy

The Non-Residential CSP will deliver the Custom component, promoting the various energy efficiency options available to the non-residential customer segment with a range of marketing and outreach tactics. The Custom component relies on projects being initiated by customers, trade allies, distributors, and the Non-Residential CSP. The Non-Residential CSP will build on trade ally and distributor relationships to co-market energy efficient equipment and the value of participation.

For custom measures, the Non-Residential CSP will work directly with trade allies and customers to help identify, develop, and implement custom projects. The Non-Residential CSP will develop project scopes, analyze costs, determine potential energy and peak demand savings of proposed projects, conduct field verification of completed projects, and help determine the reported energy and peak demand savings from installed projects. The EM&V CSP will conduct independent evaluations to determine verified savings. The Non-Residential CSP will develop, update, and process rebate applications and payments. PPL Electric Utilities will manage the Non-Residential CSP.

Key steps include the following:

- Educate customers on energy efficiency opportunities and direct them to the appropriate path through marketing activities, the website, or direct contact with equipment distributors or equipment installation contractors/trade allies.
- Have customers complete applications or work with customers, equipment/appliance retailers, midstream distributors, and installation contractors to complete program applications.
- Ensure customers/contractors submit the required documentation for processing.
- Review pending and completed project documentation to verify applicant is a PPL Electric Utilities customer and the completed project and installed equipment meet eligibility criteria.
- When possible, work with customers to confirm project preapproval before ordering energy efficiency equipment.
- Recruit and develop an effective trade ally network.
- Process applications and issue rebates for qualified projects/equipment.
- Verify completed equipment/appliance installation for a sample of participants to confirm component integrity as part of M&V.

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[28]Peak Demand is at generation.

Issues, Risks, and Risk Management Strategy

Table 46 presents market risks associated with the Custom component and strategies PPL Electric Utilities will use to manage each risk.

Table 46. Custom Component Issues, Risks, and Risk Management Strategies

Component Issue	Risk	Risk Management Strategies
Customer or building owner does not prioritize energy efficiency.	• Decision-makers choose to install cheaper, less efficient equipment with shorter payback/IRR, resulting in lower savings. • Owners are not informed about how their facility uses energy. • Existing debt may limit funds to purchase new efficient equipment. • Customers place a priority on fluctuating commodity prices.	• PPL Electric Utilities offers incentives and programs to reduce payback and IRR for business owners. • Non-Residential CSP offers planning assistance to enhance energy savings. • Non-Residential CSP educates customers about the long-term benefits of energy efficiency, available incentives, and other components.
Customers typically replace equipment only upon failure.	• Customers see no need to replace functioning equipment. • Customers are not informed about the most efficient equipment available when the need to replace it is immediate. Some efficient equipment may have a longer delivery time that would affect customer operations.	• Non-Residential CSP educates trade allies and customers about available energy efficient choices before equipment fails and encourages businesses to plan for equipment replacement. • PPL Electric Utilities provides incentives for trade allies to stock, promote, and install efficient measures.
Customers are unaware of the benefits of installing and properly maintaining energy efficient equipment.	• Customers do not properly maintain equipment, and savings benefits erode over time.	• Non-Residential CSP promotes the importance and value of equipment maintenance and training.

Anticipated Costs to Participating Customers

Costs incurred by customers participating in the Custom component will vary based on the specific type of efficient equipment installed.

Ramp-Up Strategy

The Custom component is an existing, mature offering being carried forward from Phase III. The Non-Residential CSP will develop marketing material to facilitate the transition to Phase IV. The Non-Residential CSP has developed a transitional strategy to bridge incentives for customers whose participation spans Phase III and Phase IV.

PPL Electric Utilities expects to implement the following transition plan between Phase III and Phase IV:

- Projects on the Phase III waitlist will receive comparable incentives if completed and installed early in Phase IV. Comparable is defined as the Phase III rebate, up to $0.05 (Efficient Equipment), $0.06 (Custom)/annual kWh saved and subject to Phase III per project or per customer incentive caps. Projects must be completed by August 31, 2021, for most measures. PPL Electric Utilities will consider exceptions to that deadline on a case-by-case basis, depending on the project details.

- Projects approved (funds reserved) in Phase III that are installed (placed in service) in early Phase IV may be eligible for the approved Phase III rebate and will be accounted for as Phase IV projects.

Marketing Strategy

PPL Electric Utilities will work with the Non-Residential CSP to develop and execute a marketing plan that captures sector-level economies of scale and employs targeted outreach where practical. The marketing strategy may include the following:

- Take advantage of trade ally and manufacturer relationships to co-market energy efficient equipment and products.
- Host webinars.
- Participate in trade shows and other outreach events.
- Communicate and provide access to program component information on the Company's EE&C website.
- Promote the components in newsletters.
- Advertise using newspaper, radio, direct mail, bill inserts, cross component advertisements, commercial ads, and other mass media.
- Coordinate advertising opportunities with trade allies.
- Conduct one-on-one marketing to small C&I customers through trade allies, business accounts specialists, and Non-Residential CSP outreach.
- Target marketing to facility managers, building or process engineers, building owners and managers associations, HVAC contractors, energy services firms, architects and engineers, real estate developers, economic development organizations, customer advocacy groups, trade associations, and other trade allies to encourage installation of new energy efficient technologies and adoption of best-operating practices.
- Provide specific outreach to individual tenants as well as building owners and property managers in leased commercial buildings to encourage participation.
- Target specific sectors identified as having a high unrealized energy efficiency potential.
- Publish marketing materials including charts, brochures, and case studies.
- Provide newsletters and coordinate with key market partners, including trade associations and agencies.
- Use limited time offers, special promotions, and no-cost measures to promote energy efficiency.
- Offer trade ally incentives and rewards.
- Cross-promote through other PPL Electric Utilities energy efficiency components.
- Provide information and training on specific technologies directed towards niche markets.
- Incorporate customers in area- or territory-focused promotions.

- Work with distributors to promote and encourage purchases of efficient equipment to capture savings opportunities missed by other outreach methods.

Eligible Measures and Incentive Strategy

PPL Electric Utilities will offer rebates and incentives to qualified customers (or trade allies, depending on the delivery channel) who submit completed applications and documentation of the efficiency measures installed. Customers will have the option to assign rebate payments to a third party.

PPL Electric Utilities offers performance incentives based on the avoided or reduced kWh/year or kW peak demand reductions resulting from the project. Incentives may be capped at 50% to 100% of the total project costs (excluding internal labor) or $500,000 and are subject to an annual cap for each project and each participating customer. The per-customer-site cap is defined as one building with one or more meters. A parent company cap of $1 million per year will apply to a campus setting or multiple buildings (on the same property or in different locations) with a common owner. For all measures offered through the Custom component, PPL Electric Utilities will provide incentives in the range of $0.02 to $0.22 per annual kWh saved and/or $30 to $1,200 per kW peak demand.

Table 47 and Table 48 lists PPL Electric Utilities' measures and minimum eligibility qualifications for large C&I and small C&I, respectively.

Table 47. Pa PUC Table 7-Large C&I Custom Eligible Measures and Incentives

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Custom Combined Heat and Power	Per Project	No	Preapproval is required for all CHP projects.	$2,174,821	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Custom HVAC Optimization	Per Product	No	Applies to documented tune-ups for package or split systems up to 20 tons. All HVAC applications other than comfort cooling and heating, such as process cooling, are ineligible for this measure. Preapproval is required for all custom projects.	$263	3	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Compressed Air Retrofit	Per Project	No	Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$57,969	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Custom Horticultural Lighting	Per Project	No	Agricultural Application: Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$71,602	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Custom VFD Improvements	Per Project	No	Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$140,710	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Custom Refrigeration	Per Project	No	Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$43,554	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Custom Process Improvement	Per Project	No	Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$215,583	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Custom HVAC	Per Project	No	Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$711,897	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Custom Solar	Per Project	No	Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$1,169,564	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
LCI-Behavioral operational improvements	Per Project	No	Must be PPL Electric Utilities customer	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Table 48. Pa PUC Table 7-Small C&I Custom Eligible Measures and Incentives

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Custom Combined Heat and Power	Per Project	No	Preapproval is required for all CHP projects.	$2,174,821	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Custom HVAC Optimization	Per Product	No	Applies to documented tune-ups for package or split systems up to 20 tons. All HVAC applications other than comfort cooling and heating, such as process cooling, are ineligible for this measure. Preapproval is required for all custom projects.	$263	3	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Compressed Air Retrofit	Per Project	No	Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$57,997	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Custom Horticultural Lighting	Per Project	No	Agricultural Application: Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$71,602	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Custom VFD Improvements	Per Project	No	Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$148,642	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Custom Refrigeration	Per Project	No	Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$43,554	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Custom Process Improvement	Per Project	No	Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$215,689	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Custom HVAC	Per Project	No	Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$423,863	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings

Measure[1]	Unit	Low-Income Measure (Yes/No)	Eligibility Requirements	Incremental Cost ($/unit)	Estimated Useful Life	Incentive Amount or Incentive Range ($/unit) [2,3]
Custom Solar	Per Project	No	Per project cap will range from $250,000 to $500,000 per customer site per year or $1 million per parent company per year for customers with multiple sites. Incentive cannot exceed 50% - 100% of the total project cost (excluding internal labor). Preapproval is required for all custom projects.	$1,169,564	15	Up to $0.22/kWh and/or up to $1,200/kW first year savings
Custom HVAC Optimization Direct Discount	Per Product	No	Applies to documented tune-ups for package or split systems up to 20 tons. All HVAC applications other than comfort cooling and heating, such as process cooling, are ineligible for this measure. Preapproval is required for all custom projects.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings
SCI-Behavioral operational improvements	Per Project	No	Must be PPL Electric Utilities customer.	N/A	N/A	Up to $0.22/kWh and/or up to $1,200/kW first year savings

For Custom measures, projects must meet a minimum TRC of 0.7 for CHP and a minimum TRC of 0.85 for other types of projects (non-CHP). PPL Electric Utilities may implement a new minimum TRC requirement for projects if it is necessary to help ensure the Non-Residential Program or portfolio TRC is greater than 1.0. PPL Electric Utilities will notify customers, trade allies, and stakeholders at least 60 days before the effective date of a change in the TRC requirement. Any TRC requirement would be in effect for new applications submitted after the effective date.

All measures may not be available at all times. PPL Electric Utilities may suspend a measure depending on popularity, pace of the component savings and costs, free ridership, evaluation requirements, complexity of the information required from customers, administrative requirements for the measure, or other reasons. PPL Electric Utilities will review the component continually and may adjust available measures or eligibility qualifications to achieve savings and cost budgets.

PPL Electric Utilities may offer tiered incentives that encourage the installation of multiple measures or a more comprehensive whole facility approach. Measures, eligibility requirements, and incentives may change to reflect progress, changes in the TRM, market conditions, or other factors. PPL Electric Utilities shall strive to keep the rebates and per-site caps as consistent as possible while recognizing the need to adjust incentives and caps to control the pace of components within their savings and cost budgets.

Deadline for Rebate Applications

The rebate application website and portal will state the deadline for its submission. The deadline will not exceed 180 days from the date the measure was installed.. For Custom measures, PPL Electric Utilities will require preapproval to allow it (or the Non-Residential CSP) sufficient time to qualify the project, minimize free ridership, screen for cost-effectiveness, determine the site-specific M&V plan, and conduct any required pre-metering.

Start Date with Key Schedule Milestones

Table 49 lists the estimated key schedule milestones for the Custom component. PPL Electric Utilities will lead implementation or provide management oversight of all tasks.

Table 49. Custom Component Schedule and Milestones

Schedule	Milestones
11/30/2020	Phase IV EE&C Plan submitted to Pa PUC
6/01/2021	Launch Phase IV component
Annually starting 01/15/2022	EDCs submit semiannual program report
Annually starting 09/30/2022	EDCs submit final annual program report
05/31/2026	Program ends

Evaluation, Measurement, and Verification

The EM&V requirements will be detailed in PPL Electric Utilities' Evaluation Plan, which will be submitted to the SWE for review. PPL Electric Utilities and its EM&V CSP will conduct annual evaluations of each component in compliance with all Pa PUC requirements and the Evaluation Framework. As part of this process, the EM&V CSP will review a sample of participant rebate applications and CSP records to verify quantity, efficiency level, and qualifying equipment. The EM&V CSP will follow all applicable methods in the TRM and the Evaluation Framework to calculate energy savings and peak demand reduction.

For the Custom component, PPL Electric Utilities anticipates conducting annual impact and process evaluations (activities vary by year).

The EM&V CSP will develop an evaluation plan and sampling protocol that fits the Custom component and all associated delivery channels. The EM&V CSP will review a sample of participant and CSP records to verify quantity, efficiency level, and qualifying equipment. On-site assessment may be included as a verification activity. The EM&V CSP will also develop an evaluation plan and sampling protocol that fits the Custom component and develop site-specific EM&V plans to meet Act 129 evaluation requirements.

Administrative Requirements

The Non-Residential CSP will administer and provide operational management of the Custom component. PPL Electric Utilities will provide oversight and operational support to establish effective deployment.

Estimated Participation

Table 50 and Table 51 show the order of magnitude participation estimates for the Large and Small C&I Custom component. Actual quantities will vary, and PPL Electric Utilities will manage the component to stay within budget.

Table 50. Pa PUC Table 8-Large C&I Custom Projected Participation [1]

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total[2]
Custom Combined Heat and Power	Energy Savings (MWh/year)	8,805	8,805	14,949	14,949	14,949	62,458
	Demand Reduction (MW)	1.274	1.274	2.163	2.163	2.163	9.035
	Projected Participation	3	3	5	5	5	22
Custom HVAC Optimization	Energy Savings (MWh/year)	160	160	160	160	160	801
	Demand Reduction (MW)	0.077	0.077	0.077	0.077	0.077	0.386
	Projected Participation	105	105	105	105	105	524
Compressed Air Retrofit	Energy Savings (MWh/year)	11,413	11,869	12,782	12,782	12,782	61,629
	Demand Reduction (MW)	1.443	1.500	1.616	1.616	1.616	7.790
	Projected Participation	35	36	39	39	39	187
Custom Horticultural Lighting	Energy Savings (MWh/year)	432	432	432	432	432	2,160
	Demand Reduction (MW)	0.089	0.089	0.089	0.089	0.089	0.446
	Projected Participation	1	1	1	1	1	7
Custom VFD Improvements	Energy Savings (MWh/year)	15,243	17,148	17,783	17,783	17,783	85,739
	Demand Reduction (MW)	1.998	2.248	2.331	2.331	2.331	11.239
	Projected Participation	33	37	39	39	39	187
Custom Refrigeration	Energy Savings (MWh/year)	3,068	3,452	3,580	3,580	3,580	17,260
	Demand Reduction (MW)	0.247	0.278	0.288	0.288	0.288	1.389
	Projected Participation	33	37	39	39	39	187
Custom Process Improvement	Energy Savings (MWh/year)	24,968	28,089	49,206	49,206	49,206	200,676
	Demand Reduction (MW)	2.690	3.026	5.300	5.300	5.300	21.617
	Projected Participation	33	37	66	66	66	268

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total[2]
Custom HVAC	Energy Savings (MWh/year)	19,041	21,421	22,214	22,214	22,214	107,104
	Demand Reduction (MW)	2.575	2.897	3.004	3.004	3.004	14.486
	Projected Participation	33	37	39	39	39	187
Custom Solar	Energy Savings (MWh/year)	1,258	1,258	1,258	1,258	1,258	6,291
	Demand Reduction (MW)	0.373	0.373	0.373	0.373	0.373	1.865
	Projected Participation	1	1	1	1	1	7

[1] To show numerical values in the Pa PUC Table 8 tables, deviation from the standard use of decimals throughout Section 3 may have been applied.
[2] Total values may not equal the sum of all program year values due to rounding.

Table 51. Pa PUC Table 8-Small C&I Custom Projected Participation [1]

Measure	Metric	PY13	PY14	PY15	PY16	PY17	Total [2]
Custom Combined Heat and Power	Energy Savings (MWh/year)	2,935	2,935	11,372	11,372	14,307	42,922
	Demand Reduction (MW)	0.425	0.425	1.645	1.645	2.070	6.209
	Projected Participation	1	1	4	4	5	15
Custom HVAC Optimization	Energy Savings (MWh/year)	569	569	569	569	569	2,843
	Demand Reduction (MW)	0.274	0.274	0.274	0.274	0.274	1.370
	Projected Participation	372	372	372	372	372	1,859
Compressed Air Retrofit	Energy Savings (MWh/year)	2,283	2,739	3,652	3,652	3,652	15,978
	Demand Reduction (MW)	0.289	0.346	0.462	0.462	0.462	2.020
	Projected Participation	7	8	11	11	11	49
Custom Horticultural Lighting	Energy Savings (MWh/year)	432	432	432	432	432	2,160
	Demand Reduction (MW)	0.089	0.089	0.089	0.089	0.089	0.446
	Projected Participation	1	1	1	1	1	7
Custom VFD Improvements	Energy Savings (MWh/year)	3,176	3,811	5,081	5,081	5,081	22,229
	Demand Reduction (MW)	0.416	0.500	0.666	0.666	0.666	2.914
	Projected Participation	7	8	11	11	11	49
Custom Refrigeration	Energy Savings (MWh/year)	511	895	1,023	1,023	1,023	4,475
	Demand Reduction (MW)	0.041	0.072	0.082	0.082	0.082	0.360
	Projected Participation	6	10	11	11	11	49
Custom Process Improvement	Energy Savings (MWh/year)	4,161	7,282	8,323	8,323	8,323	36,412
	Demand Reduction (MW)	0.448	0.784	0.897	0.897	0.897	3.922
	Projected Participation	6	10	11	11	11	49
Custom HVAC	Energy Savings (MWh/year)	3,173	5,554	6,347	6,347	6,347	27,768
	Demand Reduction (MW)	0.429	0.751	0.858	0.858	0.858	3.756
	Projected Participation	6	10	11	11	11	48
Custom Solar	Energy Savings (MWh/year)	1,258	1,258	1,258	1,258	1,258	6,291
	Demand Reduction (MW)	0.373	0.373	0.373	0.373	0.373	1.865
	Projected Participation	1	1	1	1	1	7

[1] To show numerical values in the Pa PUC Table 8 tables, deviation from the standard use of decimals throughout Section 3 may have been applied.
[2] Total values may not equal the sum of all program year values due to rounding.

4 Management and Implementation Strategies

4.1 Overview of EDC Management and Implementation Strategies

PPL Electric Utilities has over a decade of successfully managing and implementing its EE&C programs. It will apply this knowledge and experience, lessons learned, and best practices and will rely on the strong relationships it has built to deliver programs in Phase IV. Programs will be effectively managed by PPL Electric Utilities' EE&C staff and implemented by qualified CSPs.

4.1.1 Services to Be Provided by EDCs, Consultants, Trade Allies, and CSPs

For its implementation strategy, PPL Electric Utilities relies on qualified CSPs, preferred partners, trade allies, and other entities engaged in energy efficiency to promote, deliver, and support the deployment of its programs. PPL Electric Utilities' EE&C Plan will use CSPs to manage delivery of its residential, low-income, and non-residential (small and large C&I) programs. PPL Electric Utilities will use another CSP to provide EM&V services and will issue an RFP for a CSP to coordinate the sale of peak demand into the PJM FCM.

PPL Electric Utilities also depends on trade allies and other market partners to engage customers, promote the programs, evaluate projects, furnish and install energy efficient equipment, and provide ancillary energy efficiency services. PPL Electric Utilities will draw on the expertise available from trade allies, such as contractors and retailers, to support the local economy and allow customers to interact with the trade allies of their choice.

Conservation Service Providers

CSPs are individuals or firms registered with the Pa PUC that, pursuant to contract with EDCs, provide consultation, design, administration, management, and/or implementation services related to the delivery of EE&C program components. PPL Electric Utilities anticipates that CSPs will have a major role in delivering its Phase IV programs and their respective components.

As indicated in Table 52, implementation CSP roles involve the delivery of programs and their associated components and cross-program activities. PPL Electric Utilities will train its implementation CSPs on reporting requirements, use of the Company's data management and tracking system, customer service requirements, QA/QC standards, and protocols for addressing quality issues should they arise.
PPL Electric Utilities will require all implementation CSPs to submit data and reports that include customer data and detailed information on installed measures and incentive transactions to support EM&V, tracking against the Plan budgets and goals, and reporting to the Commission.

To facilitate implementation of the Phase IV EE&C portfolio, PPL Electric Utilities will engage two CSPs—one will deliver the Residential and Non-Residential (small C&I and large C&I) Programs and one will deliver the Low-Income Program. Each will be responsible for implementing all program components in their designated sector(s), including overseeing subcontractors. An EM&V CSP will be responsible for independently evaluating the entire portfolio of EE&C programs and functions.

Table 52. Program Conservation Service Provider Implementation Roles and Responsibilities

<table>
<tr><th colspan="4">Program Function</th></tr>
<tr><td>Portfolio Planning</td><td colspan="3" rowspan="4">PPL Electric Utilities</td></tr>
<tr><td>Research & Development</td></tr>
<tr><td>Marketing Strategy</td></tr>
<tr><td>CSP Management & Coordination</td></tr>
<tr><td>Trade Ally Network Management</td><td rowspan="7">Residential CSP</td><td rowspan="7">Low-Income CSP</td><td rowspan="7">Non-Residential CSP</td></tr>
<tr><td>Marketing & Advertising</td></tr>
<tr><td>Customer Intake & Routing</td></tr>
<tr><td>Project Delivery</td></tr>
<tr><td>Application Review & Approval</td></tr>
<tr><td>Incentive Processing</td></tr>
<tr><td>Customer Care</td></tr>
<tr><td>QA/QC</td><td colspan="3" rowspan="2">Implementation CSPs, PPL Electric Utilities, and EM&V CSP</td></tr>
<tr><td>Measurement & Verification</td></tr>
<tr><td>Program Tracking</td><td colspan="3">PPL Electric Utilities</td></tr>
<tr><td>Evaluation and Pa PUC Annual/Mid-Year Reports</td><td colspan="3">EM&V CSP</td></tr>
</table>

PPL Electric Utilities will hire other companies, not classified as CSPs, to perform functions such as providing/hosting the tracking system, legal support, and marketing and advertising (overarching or specific campaigns other than the marketing and advertising provided by each implementation CSP).

Trade Allies

Trade allies provide products and services directly to customers in support of program components but are not under contract to PPL Electric Utilities. Examples of the types of trade allies PPL Electric Utilities will use to deliver its program components are:

- ***Lighting and other contractors, retailers, distributors/dealers and installers*** that provide sales, equipment or building diagnostics, audits, maintenance, and installation services for energy efficient equipment, such as lighting, energy management systems and controls, HVAC, water heaters, insulation, commercial and industrial equipment, and appliances. These trade allies will inform customers about PPL Electric Utilities' applicable programs and rebates; provide essential information for customers to understand the costs and benefits of equipment or services and encourage customers to take advantage of PPL Electric Utilities' program components.
- ***Residential and commercial builders,*** **developers, remodelers, contractors, architects, engineers, or other market participants** that design, develop, and build residential and commercial buildings and that will deliver services to support the Energy Efficient Home component and applicable Efficient Equipment components.
- ***Technical engineering and energy services firms*** that install energy efficiency projects for small and large C&I customers.

Market Partners

Market partners are independent entities that may provide support or services to PPL Electric Utilities' customers, typically in an effort to achieve mutually beneficial results or to serve mutual target populations. Market partners are not generally supported by Company funding and are not under contract to the Company. For example, schools that engage with PPL Electric Utilities' Student Energy Efficient Education component are considered market partners because they act as a conduit for reaching the school community, but they do not receive a direct financial benefit. Stakeholders and community based organizations are also market partners.

Preferred Partners
Preferred partners are service providers with whom the CSP has an agreement to perform services for a specific program component.

4.1.2 Performance, Technology, Market, and Evaluation Risks and Risk Management Strategies

As described previously, the MWh compliance targets set forth in the Implementation Order are lower than the Phase III goals, but the MW goals are higher and must be met within the same average cost cap. This means that the Phase IV program acquisition cost is slightly higher than in Phase III ($0.246 annual kWh compared to $0.20 in Phase III).

Though this slight improvement in acquisition cost could be expected to alleviate some risk associated with delivery of PPL Electric Utilities' EE&C portfolio and improve its ability to achieve its savings targets, as of the time of this Plan's development, the U.S. is facing unprecedented challenges and uncertainties that could significantly alter the program delivery environment.

PPL Electric Utilities has identified the following market risks:

- **Economic conditions.** The advent of the COVID-19 pandemic, and associated economic impacts, could have significant implications for PPL Electric Utilities' portfolio. As the pandemic has continued to pervade across the U.S., utilities and their customers in all sectors are facing related challenges on multiple fronts:
  - **Residential sector.** Although restrictive stay-at-home orders have been lifted in Pennsylvania, residential customers continue to be wary of participating in programs that involve at-home contractor visits. Many utilities, including PPL Electric Utilities, have introduced program modifications to protect customer health and safety (such as curbside appliance recycling pickup, expanded access to efficient products through mail or other alternative methods, and virtual energy audits), but programs that have historically relied on direct measure installation have seen significant reductions in participation. Furthermore, many residential customers have suffered job losses, wage disruptions, and evictions. Declining economic conditions now—or uncertainty about the future—may be limiting customers' ability to invest in nonessential efficiency upgrades.
  - **Low-income sector.** Lower-income individuals have borne a greater share of economic hardship than any other customer class; the COVID-19 pandemic is creating a larger low-income population and worsening the conditions for those

already existing below the poverty line. In light of this situation, these customers will probably need help to reduce their utility bills more than in typical years, yet they face the same risks and concerns about direct engagement with contractors in their homes.

  - **Small commercial sector.** COVID-19 has had a profound, disruptive effect on businesses across the U.S. Small businesses have particularly suffered, with more than 100,000 businesses closed across the country. These conditions significantly reduce the population of potential PPL Electric Utilities program participants, and they are expected to create long-term adverse economic ripples across the state.

- **Supply disruptions**. In addition to the potentially catastrophic economic effects of the COVID-19 pandemic, equipment industry representatives are reporting supply chain disruptions that have implications for PPL Electric Utilities' programs. There are indicators that the pandemic has affected retail purchasing habits. Lighting sales are declining at traditional utility partner retailers like big box stores and shifting to grocery and drug stores while many other product sales are moving online. At the same time, industrial production in China has fallen significantly, affecting many efficient products such as lighting, thermostats, and other high-efficiency equipment.
- **Market dynamics.** In nearly every industry, customer choice, personalized services, and competitive pricing have become the norm. Customers are increasingly demanding that their service providers offer a variety of simple, low-cost options from which to customize their engagement experience and to communicate with them using a variety of digital and traditional platforms. To keep pace, the utility industry must continue to offer value, customized solutions, a personalized experience, and, increasingly, a total digital engagement solution. Additionally, reaching key energy decision-makers in non-residential sectors can present a special challenge to PPL Electric Utilities and its CSPs. Rental properties—both residential and commercial—entail barriers associated with split incentives.
- **Changing equipment standards.** Changing building codes and new equipment standards tend to lower baseline energy use, thereby reducing the potential savings from affected measures. The 2020 Phase IV Energy Efficiency and Peak Demand Reduction Market Potential Study illustrates this phenomenon. For example, lighting savings, which has historically been among the lowest cost resources, is expected to diminish in the residential sector and to a lesser extent in the small C&I and large C&I sectors. The 2020 Potential Study cited regulatory uncertainty impacting lighting savings resulting from the U.S. Energy Independence and Security Act of 2007 ("EISA") and, more recently, the DOE's December 2019 final determination that rescinds EISA and leaves

the current efficiency standards for light bulbs in place.[29] Despite the December 2019 action, multiple lawsuits filed against DOE's decision, possible changes to the DOE in 2021, and a rapidly transforming lighting market will almost certainly extend and may exacerbate the market uncertainty around the potential for lighting savings.

- **Distributed energy resources and storage.** A growing share of customers have installed distributed energy solutions, and more are planning to do so in the next few years. A recent study found that although only 4% of consumers currently own a rooftop solar system, 34% expressed interest in getting one.[30] Meanwhile, as storage costs decline, downstream meter storage will likely accelerate the rate of solar adoption, which will, in turn, impact utilities' load growth projections.
- **Focus on climate policy.** In light of differing priorities at the federal level, many states are enacting their own climate goals and policies. Twenty states and the District of Columbia have adopted specific greenhouse gas reduction targets and are experimenting with policies including carbon pricing, emission limits, and steps to promote cleaner transportation alternatives. The Pennsylvania Climate Action Plan, developed by the Climate Change Advisory Committee and submitted to Governor Wolf in 2019, recommends legislative changes to the General Assembly necessary to reach a goal of 26% reduction in greenhouse gas emissions by 2025 and 80% reduction by 2050, as required by the Pennsylvania Climate Change Act of 2008. The implications of any legislative action as a result of these recommendations on PPL Electric Utilities' ability to achieve its EE&C Plan objectives are as yet unknown. As state-level energy and environmental policy continues to evolve and become increasingly intertwined, PPL Electric Utilities expects to engage with its stakeholders, policymakers, and regulators to help ensure it can make a meaningful contribution to any future energy policy while still continuing to provide safe, affordable energy services to its customers.

4.1.3 Plans to Address Human Resource and Contractor Resource Constraints

PPL Electric Utilities' EE&C Plan balances program component delivery needs and resource allocation across an experienced pool of internal staff, CSPs, trade allies, and market partners. PPL Electric Utilities' professional staff has extensive experience and a proven record of success managing the CSPs that deliver program components and engaging with trade allies.

Over more than 10 years, PPL Electric Utilities has developed a robust network of trade allies to provide the services, and the EE&C Plan continues to emphasize ongoing contractor recruitment, outreach, and

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[29] *See* U.S. Department of Energy, 2019. "Department of Energy Issues Final Determination for General Service Incandescent Lamps, Finds More Stringent Standards Are More Costly to the American People and Not Economically Justified." DOE news release, December 20. https://www.energy.gov/articles/department-energy-issues-final-determination-general-service- incandescent-lamps-finds-more.

[30] Association of Energy Service Professionals and Essense Partners. *Distributed Energy Resources*. Part 3 of 4. October 2017.

training to maintain continued success. PPL Electric Utilities offers training so contractors are up to date on the latest technologies, program rules, and rebates being offered. Through its market research and engagement efforts, the Company frequently solicits feedback from its customers and contractors, especially contractors who meet face to face with customers, and this feedback has provided valuable insights on gaps in contractor resources that can be quickly resolved.

The Company will assign managers and support staff to oversee its CSPs and the programs and their associated components. PPL Electric Utilities regularly evaluates workloads and staffing needs and makes adjustments if necessary.

A description of PPL Electric Utilities' EE&C Plan management structure and an organizational chart are provided in Section 4.2.1.

4.1.4 Early Warning System

PPL Electric Utilities continually monitors program performance (such as savings and costs) through its tracking database, the CSPs' tracking systems, and management oversight. PPL Electric Utilities and its EM&V CSP also regularly solicit customer and trade ally feedback and conduct other market research to monitor the portfolio's compliance with the Company's other corporate objectives. These mechanisms provide the means for promptly identifying programs or components that are not meeting their objectives.

4.1.5 Implementation Schedule with Milestones

On July 2, 2020, PPL Electric Utilities issued a competitive RFP for implementation CSPs, and on July 16 2020, issued a competitive RFP for an EM&V CSP. At the time of this filing, PPL Electric Utilities has selected its Residential, Low-Income, Non-Residential and EM&V CSPs. Most of the Phase IV program components are continuing from Phase III, and implementation will continue uninterrupted to facilitate the transition for customers and trade allies. Table 53 lists the key schedule milestones for the EE&C Plan.

Table 53. PPL Electric Utilities' Phase IV Implementation Schedule and Milestones

Schedule	Milestones
11/30/2020	Phase IV EE&C Plan submitted to the Pa PUC
06/01/2021	Launch of all Phase IV energy efficiency programs
Annually starting 01/15/2022	EDCs submit semiannual program reports
Annually starting 09/30/2022	EDCs submit final annual program reports
05/31/2026	Programs end

4.1.6 Stakeholder Engagement

PPL Electric Utilities is committed to obtaining stakeholder input and consensus and to keeping customers, stakeholders, and the general public informed about the results of the energy efficiency programs and progress toward Plan goals. It meets regularly with its CSPs and trade allies to review Plan progress, consider new products and services, and/or identify opportunities to improve EE&C programs.

PPL Electric Utilities intends to continue to meet with other interested stakeholders as needed but not less than twice annually until May 31, 2026, to discuss progress, review results, and solicit input for possible changes to the EE&C Plan during Phase IV. The Company also provides Act 129 information, including its EE&C Plan and semiannual and annual reports, in a dedicated stakeholder section on www.pplelectric.com. Additionally, the Company shares success stories with customers, trade allies, and the public by publishing and distributing case studies.

4.2 Executive Management Structure

4.2.1 Structures for Addressing Portfolio Strategy

PPL Electric Utilities staff will design, implement, and manage programs and associated components; oversee sector and cross-functional CSPs; and support the requirements of delivery, such as marketing, advertising, and customer education.

PPL Electric Utilities' **Director – Customer Service Project Management** is responsible for PPL Electric Utilities' Act 129 energy efficiency programs, non-Act 129 regulatory programs, and innovation delivery including the PPL Electric Utilities energy efficiency website.

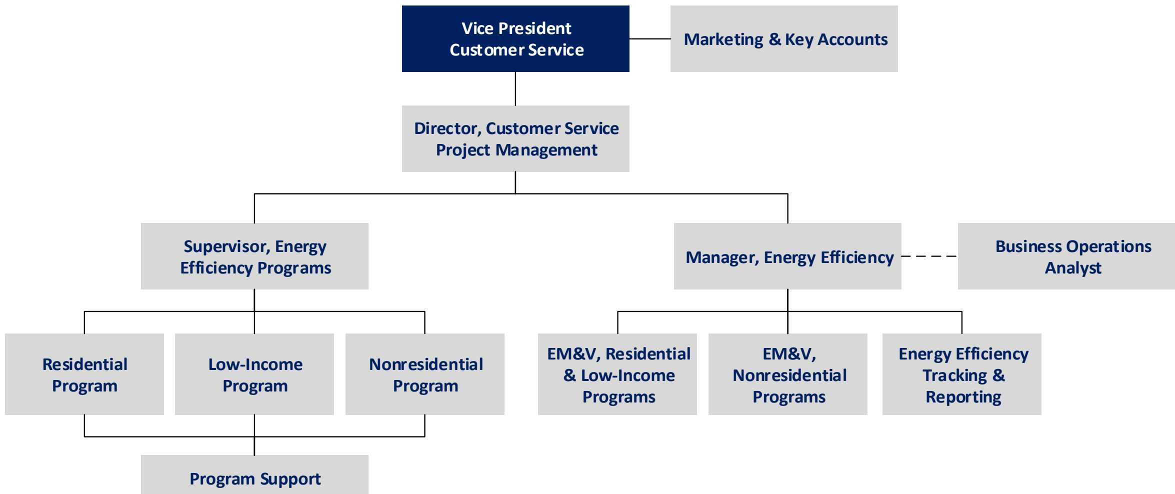
PPL Electric Utilities' **Manager – Energy Efficiency** has overall responsibility for the development, implementation, operation, evaluation, reporting, and compliance of PPL Electric Utilities' Act 129 energy efficiency programs.

PPL Electric Utilities' **Program Manager** staff manages each program and the respective program implementation CSPs. PPL Electric Utilities' Key Account Managers support and help promote the Non-Residential Program.

PPL Electric Utilities also has staff responsible for EE&C program administration, operational and technical support, program planning, and evaluation.

Figure 3 summarizes PPL Electric Utilities' EE&C management structure.

Figure 3. PPL Electric Utilities EE&C Plan Management Structure



4.2.2 Approach to Overseeing the Performance of Subcontractors and Implementers

PPL Electric Utilities oversees its CSPs to confirm they meet the requirements of their contracts and performance expectations and, as needed, will modify programs and components (e.g., design, incentives, measures, marketing) to meet its savings, costs, cost-effectiveness, and customer satisfaction objectives. PPL Electric Utilities' oversight process includes the following elements:

- ***Sector-level CSPs.*** To reduce administrative costs and provide sufficient accountability for objectives, PPL Electric Utilities will use two CSPs that will have overall responsibility for their program and program components.
- ***PPL Electric Utilities staff.*** PPL Electric Utilities management and program staff are responsible for confirming that each program meets its objectives. They will continually monitor performance and oversee each program CSP.
- ***EM&V CSP.*** PPL Electric Utilities' EM&V CSP will provide independent evaluations of program components to verify impacts (such as savings, costs, and cost-effectiveness) and to determine if components are operating effectively.

4.2.3 Administrative Budget

Administrative costs include all utility costs to develop, implement, and manage the Plan, excluding payments to customers/trade allies (rebates and incentives). Administrative costs consist of all expenses associated with PPL Electric Utilities' labor and materials, CSP labor and material, marketing, QA/QC, EM&V, tracking systems, legal services, and the SWE. The cost of goods and services provided to low-income and other customers at no cost is classified as incremental measure costs, with offsetting incentives, as directed by the 2021 TRC Test Order.

4.3 Conservation Service Providers

4.3.1 Selected CSPs and Basis for Selection

PPL Electric Utilities issued RFPs for three sector-level implementation CSPs (for Residential, Non-Residential, and Low-Income) and one CSP to provide EM&V. PPL Electric Utilities conducted its RFP processes in accordance with the procedures approved by the Commission. At the time this EE&C Plan was submitted, PPL Electric Utilities was preparing the implementation CSP contracts.

4.3.2 Work and Measures Being Performed by CSPs

See Section 4.1.1 for a description of the work and measures being performed by CSPs. The CSPs' roles are also described within each individual component description in Section 3.

4.3.3 Pending RFPs

PPL Electric Utilities will solicit bids from qualified third-party vendors to provide technical support to nominate a portion of its peak demand reduction as a capacity resource in PJM's FCM. PPL Electric Utilities intends to issue the RFP in the third quarter of 2021.

5 Reporting and Tracking Systems

PPL Electric Utilities' reporting and tracking system protocols are described below.

5.1 Semiannual and Annual Reports

PPL Electric Utilities will provide semiannual, annual, and *ad hoc* reports to the Commission and the SWE in accordance with the schedule, format, and content prescribed by the Commission and the SWE. PPL Electric Utilities expects the schedule, format, and content to be comparable with Phase III reports.

5.2 Project Management Tracking System

5.2.1 Overview of Data Tracking System

PPL Electric Utilities will continue to use its tracking database to record energy efficiency transactions and calculate reported savings. PPL Electric Utilities uses its corporate accounting system to track all energy efficiency cost information at the program-component level and its tracking database and its corporate business intelligence system for internal analysis and internal reporting on energy efficiency activities. PPL Electric Utilities will modify these management and tracking systems as necessary to incorporate Phase IV changes to program components, reports to the Commission and the SWE, data extracts, and other requirements.

5.2.2 Software Format, Data Exchange Format, and Database Structure

PPL Electric Utilities' information system is based on a commercially available database platform, which enables program implementation CSPs to record and track all the data necessary to calculate energy savings impacts at all levels. Examples of data fields the system captures include these:

- Participant contact information
- Measure name
- Measure type
- Measure life and installed cost
- Number of measures installed
- Building and space type
- Space heating, cooling, and water heating fuel types
- Rebate amount
- Existing conditions and equipment

The information system will include the features and capabilities described below.

Database Structure

- Allows for multiple levels of data resolution (e.g., measure, project, premise, customer site, sector, program type, CSP).
- Allows users to navigate through layers of data (e.g., measures, project, program, component).
- Provides a place to store electronic documents related to program participants and other functions.
- Provides a straightforward interface for adding programs and components.

Functionality

- Records energy efficiency transaction information such as customer account number, unique record ID, installation date of the measure, description and parameters of the measure (e.g., quantity, size, efficiency rating, end use), program and component name, customer, sector, and data required to calculate savings, as well as other required information about each transaction
- Allows CSPs to file transactions via a secure web link or other secure method.
- Calculates and allocates reported gross savings to the program and component, customer sector, and reporting period.
- Allows data extracts to be securely exported to external parties such as PPL Electric Utilities' EM&V CSP and the SWE.

Data Quality Control

- Has intelligent use of drop-down lists, menus, and keyboard shortcuts.
- Allows data parameters (e.g., maximum/minimum) to be set for each data element to avoid erroneous entries.
- Checks for and alerts users to possible duplicate data entry before posting data.
- Provides an audit trail for all corrected data entry errors, deletions, etc.
- Tracks transactions and workflow.
- Generates standard and customized reports for PPL Electric Utilities' day-to-day portfolio analysis and management.

5.2.3 Mechanism for Access for Commission and Statewide EE&C Plan Evaluator

PPL Electric Utilities' information system provides accessibility to external parties through the following features.

- Is accessible through the Internet or direct links, as appropriate, and will be traceable, that is, maintaining a log of users' access.
- Controls access via security rights assigned to each user or groups of users.
- Allows for appropriate security (e.g., releases, encryption) of customer data.
- Allows varying levels of security-controlled access by PPL Electric Utilities staff, program CSPs, and system administrators. Direct access (read-only) is not recommended for Commission personnel, the SWE, or PPL Electric Utilities' EM&V CSP because they would need significant training to understand the system. PPL Electric Utilities provides data extracts to those parties instead.

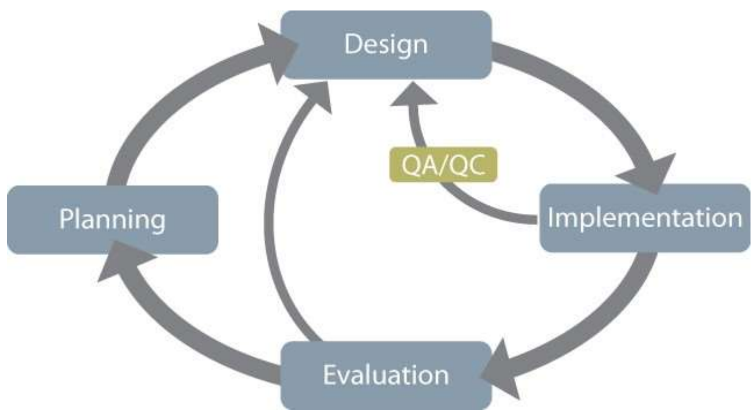
6 Quality Assurance and Evaluation, Measurement, and Verification

6.1 Quality Assurance/Quality Control

6.1.1 Approach to Quality Assurance and Quality Control

PPL Electric Utilities will use a continuous improvement process ("CIP") as the framework for managing its Phase IV portfolio. The basic principle of CIP, illustrated in Figure 4, is establishing effective QA/QC and EM&V procedures to track program and component activities, monitor performance and progress toward targets, and take corrective actions when warranted. The process integrates QA/QC procedures with implementation activities and allows feedback to flow back into the design and delivery processes. The CIP will consist of three essential elements—activity tracking, QA/QC, and process and impact evaluations.

Figure 4. PPL Electric Utilities' Continuous Improvement Process



QA/QC is integral to the design and delivery of all program components in PPL Electric Utilities' EE&C Plan. The QA procedures establish standards to follow during the planning and design phases to proactively promote consistency and avoid errors. QC activities and inspection points during the implementation and evaluation phases help guide the repair of errors and identification of areas for improvement. Activities and procedures that comprise QA and QC are described in greater detail below.

Quality Assurance

QA procedures comprise proactive activities that occur throughout the program lifecycle to align processes with objectives, avoid risk, and promote efficiency. At PPL Electric Utilities, QA includes activities to confirm that the Company's program and component rules and requirements are documented and current, its CSPs and participating trade allies are properly licensed and trained and maintain high quality standards in all customer interactions, and all data captured are accurate and sufficient to allow for rigorous energy savings analysis.

These activities include, but are not necessarily limited to, the following:

- Developing component-level logic models and process maps that document the goals, processes, and expected outcomes associated with key activities.
- Implementing training protocols that describe training procedures and requirements for key stakeholders, such as CSPs and trade allies.
- Applying rigorous screening and qualifying protocols to CSPs, trade allies, and field staff that interact directly with customers.
- Documenting data collection protocols, including data and customer information needed to track activities and calculate savings for each component.
- Summarizing CSPs' gross energy savings calculation methods that are reported at the measure and/or project level to support consistency and accuracy across each component.

Quality Control

PPL Electric Utilities conducts QC to test and verify that component activities adhere to industry best practices and established QA procedures and conform to performance expectations at the program, component, and portfolio levels. In conducting QC activities, PPL Electric Utilities addresses operational procedures, data and records, and measure installation, as described below.

- Ongoing tracking of component activities and costs.
- Reviewing all data and records to confirm that the proper data are collected consistently, resources are allocated appropriately, and performance can be measured accurately. For measure-based components, this activity involves verifying the collection of all information (including signatures, dates, and project-specific data) required to verify customer eligibility, calculate incentive payments, estimate and report energy savings and peak demand reduction, and confirm that recommended measures were installed.
- Conducting follow-up calls to participants to evaluate their satisfaction with the rendered services and to identify opportunities to improve the effectiveness of energy efficiency programs.
- Conducting post-installation inspections of an appropriately sized, random sample of all participants to confirm that program-reported measures were installed, installation followed best practice procedures, and measures function as expected.

6.1.2 Procedures for Measure and Project Installation Verification, Quality Assurance and Control, and Savings Documentation

PPL Electric Utilities documents and tracks all component, program, and portfolio activity through its participant tracking database, which can record and/or calculate reported gross energy savings. The Company designed the tracking system with input interfaces customized to individual components and coordinated with EM&V personnel so that they collect appropriate data to feed into the evaluation processes and to meet the needs of the SWE. PPL Electric Utilities trains implementation CSPs to use the tracking system. In cases where a turnkey CSP delivers all aspects of a component, the Company will expect that the CSP track all activity via secure Internet access or upload. CSPs may also collect and store additional data required for evaluation in their internal tracking systems.

Section 3 contains summary information about EM&V approaches specific to each component. The EM&V CSP will develop detailed EM&V plans describing all evaluation activities and sampling plans for the impact and process evaluations.

6.1.3 Process for Collecting and Addressing Feedback

Customers may submit suggestions, comments, and complaints by telephone, by email, and in writing. PPL Electric Utilities publishes telephone numbers, addresses, and an email link on its website and on applications. PPL Electric Utilities and CSPs are responsible for following up, in a timely manner, on all comments and complaints. The Company requires CSPs to keep a log of complaints and resolutions, which they regularly provide to PPL Electric Utilities.

PPL Electric Utilities, in conjunction with the EM&V CSP, will implement an evaluation plan for each component. The EM&V CSP typically conducts ongoing customer and periodic trade ally surveys as part of the impact and process evaluations. The EM&V CSP will provide survey results and findings to PPL Electric Utilities on a regular basis.

PPL Electric Utilities and implementation CSPs may also conduct customer satisfaction surveys in addition to those conducted by the EM&V CSP.

6.2 Planned Market and Process Evaluations

The Pa PUC and the SWE are responsible for conducting formal baseline studies and market potential studies. If requested by PPL Electric Utilities, the EM&V CSP may also conduct market potential or baseline studies.

The EM&V CSP will conduct process evaluations for the Phase IV portfolio of components. These process evaluations are a principal component of PPL Electric Utilities' CIP, allowing the Company to monitor the progress of individual components and provide timely feedback to internal and external stakeholders. These evaluations also provide the necessary context for interpreting impact evaluation results. For each program in the Plan, the EM&V CSP will focus the process evaluation on improving component operations and delivery efficiency.

A primary objective of the process evaluations is to assess which processes work well and which present challenges or may be improved. The EM&V CSP begins process evaluations by creating a logic model for each program, describing the component theory in terms of its goals, processes, outcomes, and metrics that enable assessment performance relative to its objectives.

PPL Electric Utilities uses the results of process evaluation activities, benchmarking, and market effects studies to assess the components' effectiveness in terms of market reach, measure adoption, and customer satisfaction. These activities and evaluations uncover opportunities to improve market penetration and identify barriers that may impede participation and the adoption of efficiency measures.

The main sources of data for the process evaluation will be documentation reviews, logic models, interviews with internal PPL Electric Utilities program staff and with CSPs and key market actors, secondary research, and participant and nonparticipant surveys. Key market actors will vary from component to component and may include equipment vendors, contractors, distributors, and retailers.

The EM&V CSP will survey participants and, where necessary and specified in the Evaluation Plan, will survey a comparable sample of nonparticipants. The EM&V CSP will design and execute survey sample plans to meet criteria for statistical confidence and precision specified in the Act 129 Evaluation Framework.

For each component, the EM&V CSP may stratify samples, as appropriate, by customer sector, market segment, technology, geographic area, and project size (i.e., savings) so samples are representative of the population. The EM&V CSP will implement the process evaluations in a manner that provides timely feedback to planners and CSPs and that allows enough time to implement any recommended changes. Process evaluation activities will vary by component and by program year, as needed to provide desired information.

6.3 Strategy for Coordinating with the Statewide EE&C Plan Evaluator

PPL Electric Utilities expects that, for Phase IV, the SWE will develop an Evaluation Framework, requirements for the Evaluation Plan, a process for creating savings protocols for new measures (not currently in the TRM), standard formats for semiannual and annual reports, and standard formats for data requests and data extracts. The Implementation Order provides a reporting calendar with dates when the reports and data must be provided to the SWE. PPL Electric Utilities and its EM&V CSP shall strive to adhere to those requirements or request approval for exceptions.

Impact evaluations will serve as the principal means of verifying the installation of EE&C measures and quantifying the resulting energy and demand impacts. Methods for measuring and verifying savings can vary by measure, according to the TRM and Evaluation Framework. Methods can also vary by program, component, and sector. The Evaluation Plan for each program details the evaluation methodology and sampling and verification plans. The EM&V CSP will submit these plans to the SWE for review and approval and will adjust them where required by the SWE. The EM&V CSP will update the evaluation plans annually, if needed, and provide them to the SWE for review.

The SWE and the Commission may call quarterly evaluation group meetings for all EDCs and their evaluators. The SWE may also call *ad hoc* working group sessions to discuss TRM protocols, net savings approaches, or other Act 129 matters. PPL Electric Utilities and the EM&V CSP will attend these meetings to provide input and stay informed of the SWE's activities and decisions.

PPL Electric Utilities and its EM&V CSP may also contact the SWE with requests for clarification of TRM protocols, decisions, net savings approaches, or any other relevant matter. The communications among all parties will remain open and flexible.

7 Cost Recovery Mechanism

7.1 Total Annual Revenues as of December 31, 2006

Section 2806.1(g) of the Public Utility Code requires that the total cost of any EE&C Plan cannot exceed 2% of the EDC's total annual revenue as of December 31, 2006. PPL Electric Utilities' total annual revenues for calendar year 2006 were approximately $3 billion. Accordingly, the 2% cost cap established by Act 129 is approximately $61.5 million.

In its Implementation Order, the Commission stated that the 2% budgetary cap applies to the EDC's annual budget and not to the budget for the entire Phase IV.[31] In addition, the Commission determined that certain implementation costs recoverable under Act 129 are not subject to the 2% cost cap, including PPL Electric Utilities' share of the costs for the SWE.

7.2 Plan to Fund the EE&C Measures, Including Administrative Costs

PPL Electric Utilities will spend most of its $307.5 million budget to implement its EE&C Plan during Phase IV.[32] This budget also includes costs PPL Electric Utilities incurs to develop and modify its EE&C Plan. The Implementation Order states that EDCs should be permitted to recover the incremental cost incurred to design, create, and obtain Commission approval of an EE&C Plan. The Company proposes to amortize and recover those deferred costs ratably over the 60-month life of its Phase IV EE&C Plan (June 1, 2021, through May 31, 2026).

7.3 Data Tables

The tables on the following pages provide cost data for each program. Cost-effectiveness calculations by program are provided in Section 8. The table captions make reference to the corresponding table numbers provided in the EE&C Plan Template.

Tables in this section include the following:

- Table 54: Pa PUC Table 10 –Summary of EE&C Costs
- Table 55: Pa PUC Table 11 – Allocation of Common Costs to Applicable Customer Sector
- Table 56: Pa PUC Table 12 – Summary of Portfolio EE&C Costs

[31] Implementation Order at 11.

[32] $307.5 million is the allowable budget under PPL Electric Utilities' Act 129 cost cap. In addition to this cost, PPL Electric Utilities expects to incur approximately $5 million for its share of the SWE's cost, which are not subject to the cost cap.

Table 54. Pa PUC Table 10 - Summary of EE&C Costs[1]

Portfolio											
EE&C Program	Cost Elements ($) [3]							Total Cost	Expected Acquisition Cost [2] ($/MWh)	Levelized Cost [3] ($/MWh)	Expected Acquisition Cost ($/MW)
	Incentives	*CSP Program Design*	*CSP Administrative*	*CSP Delivery Fees*	*CSP Marketing*	*EDC Administrative*	*EDC Other*[4]				
Residential	$39,293,184	$ 46,000	$ 3,523,563	$18,287,542	$2,496,277	$ 1,100,000	-	$64,746,566	$ 395.05	$ 69.02	$ 1,904,993
Low-Income	$23,061,500	-	$4,030,500	$12,958,000	-	$ 1,100,000	$750,000	$41,900,000	$ 650.32	$ 119.00	$ 4,642,198
Small C&I	$52,422,270	$128,786	$4,378,092	$17,324,983	$2,034,357	$550,000	-	$76,838,488	$ 133.81	$ 40.41	$ 894,967
Large C&I	$57,689,951	$100,776	$4,343,105	$20,883,928	$2,338,595	$ 550,000	-	$85,906,355	$ 107.35	$ 48.11	$ 806,064
Sector Total	**$172,466,905**	**$275,562**	**$16,275,260**	**$69,454,453**	**$6,869,229**	**$3,300,000**	**$750,000**	**$269,391,409**	**$ 168.08**	**$ 48.43**	**$ 1,144,180**

[1] Common Costs are not included in this table
[2] The numerator in the acquisition cost calculation is the full direct program cost. Acquisition costs based on first-year savings.
[3] Levelized costs are lifetime. Appendix A of the 2021 TRC Test Order provides formulas to calculate levelized cost. See 2021 TRC Test Order, available at http://www.puc.pa.gov/pcdocs/1648126.docx.
[4] Represents Health & Safety Pilot Program's costs

Table 55. Pa PUC Table 11 - Allocation of Common Costs to Applicable Customer Sector

Common Cost Element	**Total Cost ($)**	**Basis for Cost Allocation**	**Sector Cost Allocation ($)**		
			Residential (Including Low-Income)	**Commercial/ Industrial -- Small**	**Commercial/ Industrial -- Large**
Advertising & Marketing	$10,400,000	% of Direct Program Cost	$4,117,360	$2,966,080	$3,316,560
Phase IV Tracking System/Technical Support	$7,800,000	% of Direct Program Cost	$3,088,020	$ 2,224,560	$2,487,420
EE&C Phase IV Plan Development	$1,100,000	% of Direct Program Cost	$435,490	$313,720	$350,790
Evaluation and Measurement	$15,000,000	% of Direct Program Cost	$5,938,500	$4,278,000	$4,783,500
Plan Management	$2,400,000	% of Direct Program Cost	$950,160	$684,480	$765,360
Major Accounts	$1,400,000	% of Direct Program Cost (excluding residential)	-	$660,950	$739,050
Statewide Evaluator	$5,000,000	% of Direct Program Cost	$1,979,500	$1,426,000	$1,594,500
Totals	**$ 43,100,000**		**$16,509,030**	**$12,553,790**	**$14,037,180**

Table 56. Pa PUC Table 12 - Summary of Portfolio EE&C Costs

Portfolio	Total Sector Portfolio-Specific Costs	Total Common Costs	Total of All Costs
Residential (Including Low-Income)	$106,646,566	$16,509,030	$123,155,596
Commercial/Industrial -- Small	$76,838,488	$12,553,790	$89,392,278
Commercial/Industrial -- Large	$85,906,355	$14,037,180	$99,943,535
Totals	**$269,391,409**	**$43,100,000**	**$312,491,409**

7.4 Tariffs and Cost Recovery Mechanism

Section 2806.1(k)(1) of the Public Utility Code authorizes EDCs to recover the costs of their EE&C Plan through a reconcilable adjustment clause under Section 1307 of the Public Utility Code

Because all programs in PPL Electric Utilities' EE&C Plan will benefit both shopping and non-shopping customers, the Company designed its cost recovery mechanism to be non-bypassable. The ACR-IV will be calculated separately for PPL Electric Utilities' three major customer classes—residential, small C&I, and large C&I. For residential customers, PPL Electric Utilities will apply the cost recovery mechanism as a cents per kWh component of the distribution charge. For small C&I customers, the Company will apply the cost recovery mechanism as a cents per kWh charge as a separate line item on the customers' bill. For large C&I customers, PPL Electric Utilities will apply the cost recovery mechanism as a dollars per kW charge, as a separate line item on the customers' bill, where the demand (kW) is a customer's PJM peak load contribution (which may change yearly).

PPL Electric Utilities proposes to calculate the ACR-IV on an annual basis according to the projected program costs that it anticipates it will incur during that Phase IV program year. PPL Electric Utilities proposes an annual reconciliation of the ACR-IV for each of its three major customer classes. Specifically, each year PPL Electric Utilities will compare actual ACR-IV revenues to actual expenses and will recover or refund any over or under-collections in the next ACR-IV application year.

In addition to the annual reconciliation, upon determination that a customer class's ACR-IV rate, if left unchanged, would result in a material over- or under-collection of Phase IV Act 129 costs incurred or expected to be incurred during the current 12-month period, the Company, in its discretion, may file with the Commission for an interim revision of the ACR-IV rate.

7.5 Cost Recovery Mechanism to Ensure Approved Measures Are Financed by Corresponding Customer Class

Section 2806.1(a)(11) of the Public Utility Code requires that EE&C measures be paid for by the same customer class that receives the energy and conservation benefits of those measures. PPL Electric Utilities will directly assign costs to the customer class that received the benefits of the EE&C measures whenever those costs can be directly assigned.

However, some costs, such as common costs and/or portfolio-level costs, relate to EE&C measures that are applicable to more than one customer class or that provide systemwide benefits. In Phases I, II, and III, the Commission directed PPL Electric Utilities to allocate those costs, and general administrative costs, using reasonable and generally acceptable cost of service principles that are commonly utilized in base rate proceedings. In Phase IV, as in Phases I, II, and III, PPL Electric Utilities proposes to allocate such costs using an allocation factor equal to the percentage of the total actual EE&C costs directly assigned to each customer class.

7.6 Phase IV Cost Accounting

PPL Electric Utilities will account for Phase IV costs separately from those incurred in prior phases using separate and distinct account numbers that break out charges by program, sector, and cost category (e.g., incentives, CSP costs, and payroll). The Company will use different account numbers for Phase IV from those used in prior phases. Any costs associated with energy efficiency measures installed and operable on or before May 31, 2021, will be accounted for as Phase III costs. Any costs associated with energy efficiency measures installed and operable after May 31, 2021, will be accounted for as Phase IV costs.

7.7 PJM FCM Cost Recovery

PPL Electric Utilities will nominate a portion of the expected peak demand savings in its Phase IV program into PJM's FCM. PPL Electric Utilities will update the annual report template to include and clearly show FCM proceeds or penalties. Cost recovery will be assigned by the customer class that provides the capacity and will be adjusted to reflect the proceeds or penalties from this activity.

8 Cost-Effectiveness

8.1 Plan Cost-Effectiveness as Defined by the Total Resource Cost Test

The cost-effectiveness of the portfolio was demonstrated in data presented in Section 3 and in Table 59 and Table 60 for each program in the EE&C Plan, PPL Electric Utilities determined cost-effectiveness in accordance with the Commission's 2021 TRC Test Order.

PPL Electric Utilities began assessing the cost-effectiveness of each program in the Plan by creating a valuation of the total resource benefits ("TRC Benefits") over the life of each conservation measure, for a maximum of 15 years as directed in the 2021 TRC Test Order. The Company also determined each program's total resource costs ("TRC Costs") using the SWE Team Incremental Measure Cost Database and program delivery and administration costs. The 2021 TRC Test Order indicates that the portfolio of programs is cost-effective if its TRC Benefits exceed its TRC costs or the benefit/cost ratio is at least 1.0, as shown by the following equations:

$$\text{TRC Benefits} - \text{TRC Costs} \geq 0$$

or

$$\text{TRC Benefits}/\text{TRC Costs} \geq 1$$

The TRC Benefits data in this EE&C Plan are estimates based on the planning assumptions in this EE&C Plan. The Company will complete a cost-effectiveness evaluation using actual program results as part of its yearly evaluations.

8.1.1 Calculation of Avoided Costs of Supplying Electricity

PPL Electric Utilities calculated the avoided costs of delivered electricity for a 15-year planning horizon in three segments, using the SWE avoided cost calculator, as follows:

- ***Years 1-4 (June 2021-May 2025).*** The Company used the NYMEX Electricity Futures Price at the PJM West Hub as of September 1, 2020, and applied a locational basis adjustment from PJM West Hub to the Company's Zone.
- ***Years 5-10 (June 2025-May 2031).*** PPL Electric Utilities used NYMEX Henry Hub Natural Gas Futures and the EIA AEO Natural Gas Price Forecast for Mid-Atlantic Region as of September 1, 2020, converted to electric prices using an on-peak and off-peak heat rate and spark spread.
- ***Years 11-15 (June 2031-May 2036).*** PPL Electric Utilities used Middle Atlantic Natural Gas Prices for Electric Power from the Energy Information Administration Annual Energy Outlook, Energy Prices by Sector and Source, converted to electric prices using the on-peak and off-peak heat rate and including on-peak and off-peak spark price spreads.

The Company estimated avoided generation capacity costs using PJM base residual auction results for 2021/2022. Subsequent years are inflated by 2% as specified in the 2021 TRC Test Order. Avoided T&D costs for PY13 are from the SWE Demand Response Potential study, with the subsequent years escalated by 2% as specified in the 2021 TRC Test Order. The assumptions used to calculate avoided costs are summarized by sector in Table 57.

Table 57. Main Assumptions Used in Avoided Costs and TRC Calculations

Discount Rates (Nominal)	Utility Discount Rate	5.00%
	Participant Discount Rate	5.00%
	Societal Discount Rate	5.00%
	TRC Discount Rate	5.00%
Line Losses[1]	**Energy**	
	Residential	108.75%
	Commercial (Small C&I)	108.75%
	Industrial (Large C&I)	104.20%
	Demand	
	Residential	108.75%
	Commercial (Small C&I)	108.75%
	Industrial (Large C&I)	104.20%
T&D Prices[2]	Average BLS Escalator	-
	Transmission & Distribution ($/kW-year 2021-2022)	$121.21
	Transmission Only ($/kW-year 2021-2022)	$0.00

[1] Line losses are consistent with those provided in the 2021 TRM Volume 1 Table 1-4. The line loss factor in this table represents meter to the generator.
[2] T&D prices are consistent with those provided on page 47 (Table 2) of the 2021 TRC Test Order.

Table 58 shows PPL Electric Utilities' calculated avoided costs of delivered electricity for a 15-year planning horizon.

Table 58. Overall Avoided Costs (All Sectors)

Program Year	Electric Energy Avoided Costs ($/kWh)					Capacity Avoided Costs ($/kW-Year)		
	Winter		Summer		Yearly	Generation	T&D	Transmission Only
	On Peak	Off Peak	On Peak	Off Peak	Average			
2022	$0.04	$0.03	$0.03	$0.02	$0.03	$52.32	$121.21	$0.00
2023	$0.04	$0.03	$0.03	$0.02	$0.03	$41.70	$123.63	$0.00
2024	$0.04	$0.03	$0.03	$0.02	$0.03	$42.54	$126.11	$0.00
2025	$0.04	$0.03	$0.03	$0.02	$0.03	$43.39	$128.63	$0.00
2026	$0.04	$0.03	$0.03	$0.02	$0.03	$44.26	$131.20	$0.00
2027	$0.04	$0.03	$0.03	$0.02	$0.03	$45.14	$133.83	$0.00
2028	$0.05	$0.04	$0.04	$0.02	$0.04	$46.04	$136.50	$0.00
2029	$0.05	$0.04	$0.04	$0.03	$0.04	$46.97	$139.23	$0.00
2030	$0.06	$0.04	$0.04	$0.03	$0.04	$47.90	$142.02	$0.00
2031	$0.06	$0.05	$0.04	$0.03	$0.05	$48.86	$144.86	$0.00
2032	$0.06	$0.05	$0.04	$0.03	$0.05	$49.84	$147.75	$0.00
2033	$0.06	$0.05	$0.04	$0.03	$0.05	$50.84	$150.71	$0.00
2034	$0.07	$0.05	$0.04	$0.03	$0.05	$51.85	$153.72	$0.00
2035	$0.07	$0.05	$0.05	$0.03	$0.05	$52.89	$156.80	$0.00
2036	$0.07	$0.05	$0.05	$0.03	$0.05	$53.95	$159.93	$0.00
2037	$0.07	$0.06	$0.05	$0.03	$0.05	$55.03	$163.13	$0.00
2038	$0.08	$0.06	$0.05	$0.03	$0.05	$56.13	$166.40	$0.00
2039	$0.08	$0.06	$0.05	$0.04	$0.05	$57.25	$169.72	$0.00
2040	$0.08	$0.06	$0.05	$0.04	$0.06	$58.40	$173.12	$0.00
2041	$0.08	$0.06	$0.05	$0.04	$0.06	$59.56	$176.58	$0.00

8.1.2 Measure Data

PPL Electric Utilities obtained estimates of savings, incremental cost, and measure life for this EE&C Plan primarily from the TRM, the Pennsylvania Incremental Cost Database, and the SWE's Energy Efficiency Market Potential Study. The Company compiled data for new measures not found in the TRM from secondary sources, including the California Database for Energy Efficiency Resources ("DEER").

8.1.3 Program Benefit Components

The benefits used in the TRC calculation include the full value of time and seasonally differentiated generation, transmission and distribution, and capacity costs, and they account for avoided line losses. To capture the full value of time and seasonal impacts of each program measure, PPL Electric Utilities adjusted hourly (8,760) system-avoided costs by the hourly load shape of the end user affected by the measure. The Company included quantifiable non-energy benefits, such as water savings.

8.1.4 Cost Components

The cost component of the TRC analysis includes the incremental measure costs/participant costs and direct utility costs. Incremental measure costs are the expenses associated with installing energy efficiency measures and ongoing operation and maintenance costs, where applicable.

EDC costs consist of expenses associated with development, delivery, and ongoing operation, and fit into the four categories listed here.

EDC Labor, Material, and Supplies

- Costs to administer energy efficiency program components include (but are not limited to) PPL Electric Utilities' fully loaded incremental personnel costs, employee expenses, office supplies, and external legal costs.

Customer Incentives

- Rebates or other incentives paid to customers or trade allies (by PPL Electric Utilities or CSPs) for implementing measures.
- Incentive payments from PPL Electric Utilities to LED manufacturers and retailers who, in turn, discount those products at the point of sale.

CSP Labor, Materials, and Supplies

- Costs associated with performing implementation tasks, including (but not limited to) lead intake, customer service, rebate application processing and problem resolution, equipment installation inspections, and individual component reporting. CSPs' marketing costs are segregated under the next category, Marketing.

Marketing

- EDC and CSP expenditures related to promotion of EE&C program components include, but are not limited to, the production of energy efficiency literature, advertising, promotion and promotional items, displays, events, and communications. Advertising encompasses all forms of media, such as direct mail, print, radio, and the Internet.
- Costs associated with training and educating the trade ally community, including training associated with delivering, marketing, and promoting its programs and components, as well as best practices training (e.g., quality installation training). This category also includes vendor recruitment and coordination costs. Trade allies include, but are not limited to, HVAC contractors, weatherization contractors, equipment and product dealers, installers, and C&I auditors. Trade allies may also include community groups and trade associations.

PPL Electric Utilities also categorizes costs as follows:

- **Direct costs.** These costs are directly related and charged to a specific component. PPL Electric Utilities will assign costs directly to program components where possible.
- **Common costs (also known as portfolio-level costs).** These costs are applicable to more than one customer class, are applicable to more than one component or program, or provide portfolio-wide benefits.
- **EDC costs.** These costs—the four categories described above—are incurred by PPL Electric Utilities and include all direct and common costs. These costs are in the Plan budget and include the SWE costs that are not subject to the funding cap.
- **Participant costs.** These costs are incurred by the customer, such as for the purchase and installation of efficient measures. Often, the participant cost is determined by subtracting Act 129 EE&C incentives from the incremental cost of the measure. PPL Electric Utilities uses participant costs only in the TRC evaluation.

8.2 Data Tables

The tables on the following pages provide TRC benefits data for each program component and sector. Note that tables in this section are numbered sequentially, but table formats are based on those provided in the Commission EE&C Plan Template. Each table caption includes a reference to the corresponding table number provided in the EE&C Plan Template.

Tables in this section include these:

- Table 59. Pa PUC Table 13A – Gross TRC Benefits, By Program and Total Portfolio
- Table 60. Pa PUC Table 13B – Net Benefits, By Program and Total Portfolio

Table 59. Pa PUC Table 13A – Gross TRC Benefits, By Program and Total Portfolio

Portfolio	NTGR & TRC Ratio			TRC Costs By Program Per Year ($000)				TRC Benefits By Program Per Year ($000)				
Program	Program Year	NTGR	TRC[1,2]	Incremental Measure Cost: Paid by EDC	Incremental Measure Cost: Paid by Participants	Program Administration Cost	Total TRC Costs [2]	Capacity Benefits	Energy Benefits	Fossil Fuel and Water Benefits	O&M Benefits	Total TRC Benefits
Residential	PY13	1	1.12	$8,601	$7,770	$5,041	$21,412	$11,984	$11,516	$539	$0	$24,039
Residential	PY14	1	1.13	$8,138	$7,451	$4,871	$20,460	$11,400	$11,164	$514	$0	$23,079
Residential	PY15	1	1.09	$6,877	$5,375	$4,585	$16,837	$9,129	$8,614	$563	$0	$18,306
Residential	PY16	1	1.10	$6,310	$4,559	$4,379	$15,248	$8,353	$7,837	$569	$0	$16,759
Residential	PY17	1	1.10	$5,972	$4,366	$4,234	$14,572	$7,984	$7,553	$516	$0	$16,053
Residential	Total	1	1.11	$35,900	$29,520	$23,109	$88,529	$48,850	$46,684	$2,700	$0	$98,235
Low-Income	PY13	1	0.54	$4,432	$0	$3,403	$7,835	$1,733	$2,186	$303	$0	$4,221
Low-Income	PY14	1	0.55	$4,393	$0	$3,475	$7,868	$1,750	$2,257	$302	$0	$4,310
Low-Income	PY15	1	0.56	$4,347	$0	$3,577	$7,924	$1,785	$2,346	$300	$0	$4,432
Low-Income	PY16	1	0.57	$4,140	$0	$3,517	$7,657	$1,734	$2,324	$284	$0	$4,342
Low-Income	PY17	1	0.57	$3,646	$0	$3,149	$6,795	$1,524	$2,084	$242	$0	$3,851
Low-Income	Total	1	0.56	$20,958	$0	$17,121	$38,079	$8,527	$11,197	$1,430	$0	$21,155
Small C&I	PY13	1	1.59	$10,208	$29,987	$4,348	$44,544	$31,742	$42,138	-$6,852	$3,594	$70,622
Small C&I	PY14	1	1.61	$10,211	$31,428	$4,487	$46,126	$32,764	$44,983	-$6,801	$3,445	$74,391
Small C&I	PY15	1	1.53	$9,690	$36,148	$4,620	$50,458	$34,455	$48,595	-$8,994	$3,138	$77,193
Small C&I	PY16	1	1.56	$8,970	$33,544	$4,398	$46,912	$32,506	$46,719	-$8,689	$2,852	$73,387
Small C&I	PY17	1	1.56	$8,577	$33,380	$4,335	$46,292	$32,011	$46,883	-$9,401	$2,666	$72,159
Small C&I	Total	1	1.57	$47,656	$164,487	$22,188	$234,332	$163,478	$229,318	-$40,737	$15,695	$367,754
Large C&I	PY13	1	1.04	$11,270	$57,869	$4,763	$73,902	$25,639	$55,058	-$6,409	$2,371	$76,659
Large C&I	PY14	1	1.06	$11,183	$59,177	$4,907	$75,267	$25,792	$57,718	-$6,315	$2,256	$79,451
Large C&I	PY15	1	1.07	$10,632	$66,558	$5,482	$82,673	$26,283	$68,360	-$7,895	$2,040	$88,787
Large C&I	PY16	1	1.10	$9,934	$62,670	$5,291	$77,895	$24,856	$66,609	-$7,658	$1,839	$85,645
Large C&I	PY17	1	1.13	$9,425	$59,554	$5,186	$74,164	$24,016	$65,635	-$7,577	$1,730	$83,804
Large C&I	Total	1	1.08	$52,444	$305,828	$25,628	$383,900	$126,585	$313,380	-$35,855	$10,236	$414,347
Total			**1.21**	**$156,958**	**$499,835**	**$88,047**	**$744,840**	**$347,441**	**$600,579**	**-$72,461**	**$25,931**	**$901,490**

[1] The TRC ratio will reflect the lifetime TRC, not an annual TRC ratio.
[2] Does not include common portfolio costs; whereas Tables 2 and 3 do include common costs.

Table 60. Pa PUC Table 13B - Net Benefits, By Program and Total Portfolio

Portfolio	NTGR & TRC Ratio			TRC Costs By Program Per Year ($000)				TRC Benefits By Program Per Year ($000)				
Program	Program Year	NTGR	TRC[1,2]	Incremental Measure Cost: Paid by EDC	Incremental Measure Cost: Paid by Participants	Program Administration Cost	Total TRC Costs [2]	Capacity Benefits	Energy Benefits	Fossil Fuel and Water Benefits	O&M Benefits	Total TRC Benefits
Residential	PY13	0.79	1.07	$8,601	$4,909	$3,394	$16,905	$8,727	$8,883	$519	$0	$18,130
Residential	PY14	0.79	1.08	$8,138	$4,675	$3,299	$16,113	$8,271	$8,595	$494	$0	$17,360
Residential	PY15	0.79	1.02	$6,877	$2,988	$3,219	$13,084	$6,401	$6,459	$527	$0	$13,387
Residential	PY16	0.79	1.03	$6,310	$2,388	$3,122	$11,821	$5,805	$5,823	$529	$0	$12,157
Residential	PY17	0.79	1.02	$5,972	$2,272	$3,028	$11,272	$5,510	$5,566	$476	$0	$11,553
Residential	Total	0.79	1.05	$35,900	$17,232	$16,063	$69,194	$34,714	$35,327	$2,545	$0	$72,586
Low-Income	PY13	1.00	0.54	$4,432	$0	$3,403	$7,835	$1,733	$2,186	$303	$0	$4,221
Low-Income	PY14	1.00	0.55	$4,393	$0	$3,475	$7,868	$1,750	$2,257	$302	$0	$4,310
Low-Income	PY15	1.00	0.56	$4,347	$0	$3,577	$7,924	$1,785	$2,346	$300	$0	$4,432
Low-Income	PY16	1.00	0.57	$4,140	$0	$3,517	$7,657	$1,734	$2,324	$284	$0	$4,342
Low-Income	PY17	1.00	0.57	$3,646	$0	$3,149	$6,795	$1,524	$2,084	$242	$0	$3,851
Low-Income	Total	1.00	0.56	$20,958	$0	$17,121	$38,079	$8,527	$11,197	$1,430	$0	$21,155
Small C&I	PY13	0.70	1.52	$10,208	$20,884	$1,807	$32,900	$22,426	$29,807	-$4,806	$2,490	$49,917
Small C&I	PY14	0.70	1.54	$10,211	$22,052	$1,945	$34,209	$23,240	$31,971	-$4,769	$2,386	$52,828
Small C&I	PY15	0.70	1.46	$9,690	$25,789	$2,228	$37,707	$24,638	$34,830	-$6,455	$2,173	$55,185
Small C&I	PY16	0.70	1.50	$8,970	$23,950	$2,200	$35,119	$23,266	$33,515	-$6,243	$1,975	$52,514
Small C&I	PY17	0.70	1.49	$8,577	$23,918	$2,234	$34,729	$22,952	$33,687	-$6,791	$1,846	$51,694
Small C&I	Total	0.70	1.50	$47,656	$116,593	$10,414	$174,663	$116,522	$163,810	-$29,065	$10,870	$262,138
Large C&I	PY13	0.70	1.00	$11,270	$42,403	$2,181	$55,854	$18,453	$40,505	-$4,619	$1,642	$55,982
Large C&I	PY14	0.70	1.02	$11,183	$43,470	$2,339	$56,993	$18,601	$42,541	-$4,551	$1,563	$58,154
Large C&I	PY15	0.70	1.04	$10,632	$49,203	$3,055	$62,889	$19,048	$50,703	-$5,766	$1,413	$65,398
Large C&I	PY16	0.70	1.06	$9,934	$46,362	$3,038	$59,334	$18,036	$49,447	-$5,599	$1,273	$63,157
Large C&I	PY17	0.70	1.09	$9,425	$44,063	$3,051	$56,539	$17,431	$48,731	-$5,541	$1,198	$61,818
Large C&I	Total	0.70	1.04	$52,444	$225,501	$13,664	$291,609	$91,569	$231,926	-$26,076	$7,089	$304,509
Total			**1.15**	**$156,958**	**$359,326**	**$57,261**	**$573,545**	**$251,332**	**$442,261**	**-$51,165**	**$17,960**	**$660,388**

[1] The TRC ratio will reflect the lifetime TRC, not an annual TRC ratio.
[2] Does not include common portfolio costs; whereas Tables 2 and 3 do include common costs.

9 Plan Compliance and Other Key Issues

9.1 Plan Compliance Issues

9.1.1 Variety of EE&C Measures with Equitable Distribution

PPL Electric Utilities' EE&C Plan offers a variety of measures and distributes costs and energy savings equitably across all customer sectors. The Company's process for developing the Plan, including an overview of the considerations and steps taken to help ensure compliance with the Implementation Order, is described in Section 1.2 and Figure 2 in Section 3.1.2 shows that PPL Electric Utilities will offer each a range of energy efficiency and demand reduction measures to serve all customers. PPL Electric Utilities included education, which is fundamental to understanding and making informed choices about energy efficiency, as an element of all program components.

Program components for residential customers (including low-income) comprise approximately 39% of the total cost and 14% of the total savings projected in this Plan. Program components for non-residential customers comprise approximately 61% of the total cost and 86% of the total savings.

These proportions demonstrate an equitable distribution of savings among customer sectors and are reasonably close to the percentages of market potential attributable to the sectors and the percentage of total PPL Electric Utilities revenue attributable to each sector. The percentage of residential (including low-income) cost is greater than the percentage of residential savings (and vice versa for non-residential) because the component acquisition cost is higher for residential (including low-income) than for non-residential, primarily because the component acquisition cost of low-income is much higher than for non-low-income components.

9.1.2 Manner in which the EE&C Plan Will Achieve Requirements Under 66 Pa. C.S. §§ 2806.1(c) & (d)

By its Implementation Order, the Commission requires PPL Electric Utilities to achieve 3.3% energy savings by May 31, 2026, which equates to 1,250,157 MWh/year. The Commission also requires PPL Electric Utilities to achieve 72,509 MWh/year of energy savings from the low-income sector and to achieve 229 MW of peak demand reduction during Phase IV. PPL Electric Utilities designed its Plan to achieve all of these objectives. As previously described, the Company designed the Plan to exceed the 1,250,157 MWh/year and 229 MW targets by approximately 44% MWh[33] and 10% MW, respectively, to allow for uncertainties, such as evaluation results that are not available until significantly after the conclusion of each program year.

[33] Includes 200,000 MWh/year of carryover program savings from Phase III

9.1.3 Manner in which the EE&C Plan Will Achieve Low-Income Requirements

The Implementation Order requires that a minimum of 72,509 MWh/year of the total required reductions come from the Low-Income customer sector. Consistent with Phase III, these savings may not accrue from low-income participation in general Residential Program components.

All low-income measures will be available at no cost to low-income customers. Though low-income customers can participate in Residential Program components, these specific measures are offered exclusively to the low-income sector. These measures comprise 17.19% of the total measures offered. As required under Act 129, this exceeds the fraction of the electric consumption of the utility's low-income households divided by the total electricity consumption in the PPL Electric Utilities territory (9.95%).

Table 61. Low-Income Sector Compliance (Number of Measures)[1]

	Low-Income Sector	All Sectors	Percentage Low-Income	Goal: Low-Income Measures as % of All Measures Offered
Number of measures offered	22	128	17.19%	9.95%

[1] Act 129 includes a provision requiring EDCs to offer a number of energy efficiency measures to low-income households that are "proportionate to those households' share of the total energy usage in the service territory." 66 Pa.C.S. §2806.1(b)(i)(G).

PPL Electric Utilities designed its Low-Income Program to achieve the Commission's low-income set-aside target through the Phase IV program.

9.1.4 Funds Allocated to Experimental Equipment or Devices

All of the measures in this Plan are proven technologies that are commercially available and technically sound, and most, if not all, are in the TRM, will be added to the TRM, or will be treated as custom measures. As was done in Phase III, the Company will submit descriptions of any pilot programs or proposed technology additions to the Pa PUC and stakeholders prior to implementation. Table 62 shows the funds PPL Electric Utilities allocated to pilots, new technology, and experimental equipment by customer sector.

Table 62. PPL Electric Utilities Funds Allocated to Pilots, New Technology, and Experimental Equipment

Sector	Allocated Funds
Residential and Low-Income	$3 million
Small C&I and Large C&I	$3 million
Total	**$6 million**

PPL Electric Utilities will track and limit expenditures on measures determined as experimental to help ensure that no more than 2% of Act 129 funds are allocated for this purpose.

9.1.5 How the EE&C Plan Will Be Competitively Neutral to All Distribution Customers

As described in Section 9.1.1, each customer class has an opportunity to choose among a range of programs, components, and measures. All program components are available to customers regardless of whether they receive default generation service from PPL Electric Utilities or obtain competitive supply from an electric generation supplier. Based on their contracted generation supply rate, competitive-supply customers may experience different monthly bill savings than default generation service customers as a result of participating in one of PPL Electric Utilities' programs.

9.2 Other Key Issues

9.2.1 How EE&C Plan Will Lead to Long-Term, Sustainable Energy Efficiency Savings

PPL Electric Utilities designed its five-year portfolio of EE&C Plan programs to satisfy the performance requirements set forth in Act 129 and the Commission's Implementation Order. Many of the measures installed under the program components will continue to perform and produce savings well beyond the term of the Plan. In addition, as described throughout the Plan, PPL Electric Utilities will encourage customers to take a comprehensive approach to energy efficiency and peak demand reduction by offering education and incentives designed to implement multiple measures and to take a whole-home/building approach.

Furthermore, PPL Electric Utilities program components have and will continue to stimulate demand for energy efficient and peak demand reduction products and encourage distributors and retailers to stock such equipment. For example, PPL Electric Utilities launched a midstream program for C&I lighting in Phase III. This innovative delivery channel encouraged lighting distributors to stock and promote efficient lighting technologies by providing them with incentives that they could pass onto the end user. The program was a success, with the number of participating distributors increasing throughout the phase. PPL Electric Utilities plans to build upon the success of this delivery channel by expanding midstream offerings to residential HVAC and pool pump measures in Phase IV.

9.2.2 How EE&C Plan Will Leverage and Utilize Other Financial Resources

PPL Electric Utilities encourages customers to maximize financial resources that are external to Act 129 funding. The Company monitors funding resources, such as state and federal rebates, tax credits, and equipment manufacturers' incentives that might benefit customers, to help offset some of their capital outlay for installing energy efficient products in addition to Act 129 EE&C incentives. The Company includes information about external resources in its annual program training and in regular updates to its CSPs, trade allies, and market partners, and provides relevant information to customers on its website and in relevant materials.

9.2.3 How PPL Electric Utilities Will Address Consumer Education

PPL Electric Utilities understands that educating customers about the value of energy efficiency and peak demand reduction is critical to achieving its goals, and it includes education as a key element of all its Phase IV program components. PPL Electric Utilities and its CSPs treat every customer touch point as an opportunity to provide customer education (see Section 3 for details).

9.2.4 How PPL Electric Utilities Will Provide Information on Federal and State Funding Programs

PPL Electric Utilities provides information about federal and state funding for EE&C on its energy efficiency website. Funding, including tax credits, has significantly diminished since the start of Act 129.

9.2.5 How PPL Electric Utilities Will Provide the Public with Information about Program Component Results

PPL Electric Utilities is committed to keeping customers, stakeholders, and the general public informed about the results of the energy efficiency program components and progress toward Plan goals. PPL Electric Utilities hosts a dedicated section on www.pplelectric.com that provides Act 129 information, including semiannual and annual evaluation reports. The Company will periodically meet with stakeholders to review results, provide semiannual and annual reports to stakeholders, and post those reports on its website. Additionally, PPL Electric Utilities shares customer success stories with customers, trade allies, and the public by publishing and distributing case studies.

9.2.6 How PPL Electric Utilities Will Report Savings Attained from Government, Non-profit, and Institutional (GNI) Customers

PPL Electric Utilities' Non-Residential Program will be offered to all large C&I and small C&I customers, including government and educational institutions and master metered low-income multifamily buildings. As part of annual reporting, PPL Electric Utilities will report two separate and distinct GNI energy savings numbers: (1) savings that are achieved from GNI customers that PPL Electric classifies as Small C&I customers and (2) savings that are achieved from GNI customers that PPL Electric classifies as Large C&I customers.

Appendix A: Approval of CSP Contracts

PPL Electric Utilities filed its EM&V CSP contract for Pa PUC approval on November 30, 2020. In addition, PPL Electric Utilities is currently negotiating implementation CSP contracts to implement the Residential, Non-Residential, and Low-Income Programs.

Appendix B: Calculations of Annual Savings and Costs

The PPL Electric Utilities Phase IV Plan includes tables showing calculations of savings and costs for each program and program year (see Section 7.3). Please refer to Table 54 (Pa PUC Table 10) in the Plan for portfolio specific assignment of EE&C costs. Table 55 (Pa PUC Table 11) provides detail on the allocation of common costs to applicable customer sectors. Table 56 (Pa PUC Table 12) provides a summary of portfolio EE&C costs.

Section 8 of the Plan provides a complete overview of program costs and benefits. The Plan includes cost-effectiveness calculations by program and program year in Section 8.2. Specifically, Table 59 (Pa PUC Tables 13A) and Table 60 (Pa PUC Tables 13B) show TRC benefits by program and program year for each sector.

Appendix C: Calculations Methods and Assumptions

PPL Electric Utilities based its savings and cost estimates on experience from Phase I, Phase II, Phase III, the TRM, and input from stakeholders and trade allies. The CSPs generated measure cost data using a variety of sources, including the SWE's Phase IV incremental cost database, Phase III program data, and for data not found in the incremental cost database, the CSPs used secondary sources, including the DOE's Technical Support Documents and other state-wide TRMs.

Many variables can impact the cost and effectiveness of a measure or program, and these variables led to numerous TRM changes during Phase I, Phase II, and Phase III that influenced program savings, acquisition cost, and TRC test results. In Phase IV, PPL Electric Utilities will use the experience and knowledge gained from prior phases to monitor and adjust measures and programs that help ensure the optimum balance of cost and benefits.

In most instances, the sector-level CSPs based their Phase IV savings calculations on the current TRM algorithms and industry practices. For measures that were not in the TRM, PPL Electric Utilities worked with the sector-level CSPs or used its experience gained from delivering programs in prior phases to calculate measure- and program-level savings, such as the average savings per lighting retrofit or custom project.

The CSPs based incentive and rebate levels on the percentage of incremental cost or the first-year unit-energy and unit-demand savings potential from the Market Potential Studies, online research, and conversations with installation contractors, as well as prior phase experience. These incentive and rebate amounts ranged, on average, from 25% to 75% of the incremental cost of a measure. Some measures require a higher incentive to motivate customer action, while others can have a lower incentive because market transformation and other factors can affect customer behavior.

Marketing and advertising costs for Phase IV consist of two components:

- Sector-level CSPs calculated costs required for individual program and cross-sector marketing to generate sufficient participation to meet the Act 129 targets, based on their implementation experience and knowledge of PPL Electric Utilities' market.
- PPL Electric Utilities allocated a portion of common costs for overarching marketing and advertising campaigns. This entails developing consistent messaging and branding guidelines, conducting market research to contribute to targeted messaging strategies, and providing direction and oversight to support sector-level CSP marketing efforts.

Finally, administrative costs include all utility costs to develop, implement, and manage the Plan, except payments to customers/trade allies (rebates and incentives). These costs include PPL Electric Utilities labor and materials, CSP labor and material, marketing, QA/QC and EM&V, tracking systems, legal, and the SWE costs.[34] These Phase IV costs were based on PPL Electric Utilities wage rates; tracking system cost from prior phases; and EM&V costs from prior phases to reflect efficiencies, lessons learned, and revisions to prior phase systems and processes to increase Phase IV operational efficiency.

[34] PPL Electric Utilities' share of the SWE costs is not subject to the Act 129 cost cap.

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Abstract: Distribution reliability indices and factors that affect their calculations are defined in this guide. The indices are intended to apply to distribution systems, substations, circuits, and defined regions.
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Introduction

This introduction is not part of IEEE Std 1366-2012, IEEE Guide for Electric Power Distribution Reliability Indices.

This guide was originally developed in 1998 to create indices specifically designed for distribution systems. Other groups have created indices for transmission and industrial systems, but none were available for distribution. This group will continue working in this area by refining the information contained in this guide.

This guide was updated in the 2003 revision to clarify existing definitions and to introduce a statistically based definition for classification of Major Event Days. The working group created a methodology, 2.5 Beta Method, for determination of Major Event Days. Once days are classified as normal or Major Event Days, appropriate analysis and reporting can be conducted.

This 2012 revision of the guide clarified several of the definitions and introduced two new indices. The new indices are CELID-s and CELID-t, customers experiencing long interruption durations (both single and total). A section was also added to explain the investigation of catastrophic days.

Contents

IEEE Guide for Electric Power Distribution Reliability Indices

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1. Overview

1.1 Introduction

This full-use guide has been updated to clarify existing definitions, introduce two additional reliability indices, and add a discussion of Major Event Days and catastrophic days (see 5.3).

1.2 Scope

This guide identifies distribution reliability indices and factors that affect their calculation. It includes indices, which are useful today, as well as ones that may be useful in the future. The indices are intended to apply to distribution systems, substations, circuits, and defined regions.

1.3 Purpose

The purpose of this guide is twofold. First, it is to present a set of terms and definitions which can be used to foster uniformity in the development of distribution service reliability indices, to identify factors which affect the indices, and to aid in consistent reporting practices among utilities. Secondly, it is to provide guidance for new personnel in the reliability area and to provide tools for internal as well as external comparisons. In the past, other groups have defined reliability indices for transmission, generation, and distribution but some of the definitions already in use are not specific enough to be wholly adopted for distribution. Users of this guide should recognize that not all utilities would have the data available to calculate all the indices.

2. Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary: Glossary of Terms and Definitions*[1] should be consulted for terms not defined in this clause.

connected load: Connected transformer or metered demand (to be clearly specified when reporting) on the circuit or portion of circuit that is interrupted. When reporting, the report should state whether it is based on an annual peak or on a reporting period peak.

customer: A metered electrical service point for which an active bill account is established at a specific location.

customer count: The number of customers either served or interrupted, depending on usage.

distribution system: That portion of an electric system that delivers electric energy from transformation points on the transmission system to the customer.

NOTE—The distribution system is generally considered to be anything from the distribution substation fence to the customer meter. Often the initial overcurrent protection and voltage regulators are within the substation fence and are considered part of the distribution system.[2]

forced outage: The state of a component when it is not available to perform its intended function due to an unplanned event directly associated with that component.

interrupting device: A device to stop the flow of power, usually in response to a fault. Operation of the device can be accomplished by manual, automatic, or remotely operated methods. Examples include circuit breakers, line reclosers, line fuses, disconnect switches, sectionalizers, and/or others.

interruption: The total loss of electric power on one or more normally energized conductors to one or more customers connected to the distribution portion of the system. This does not include any of the power quality issues such as: sags, swells, impulses, or harmonics. *See also:* **outage**.

interruption duration: The time period from the initiation of an interruption until service has been restored to the affected customers.

NOTE—The process of restoration may require restoring service to small sections of the system until service has been restored to all customers. See 4.3.2 for a step-restoration example. Each of these individual steps should be tracked, collecting the start time, end time, and number of customers interrupted for each step.

interruptions caused by events outside of the distribution system: Outages that occur on generation, transmission, substations, or customer facilities that result in the interruption of service to one or more customers. While generally a small portion of the number of interruption events, these interruptions can affect a large number of customers and may last for a long time.

lockout: When a reclosing interrupting device is in the open position and no further operations of that device are allowed without manual intervention.

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[1] *IEEE Standards Dictionary: Glossary of Terms and Definitions* is available at http://shop.ieee.org.
[2] Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

Major Event: Designates an event that exceeds reasonable design and or operational limits of the electric power system. A Major Event includes at least one Major Event Day. *See also:* **Major Event Day**.

Major Event Day (MED): A day in which the daily system System Average Interruption Duration Index (SAIDI) exceeds a Major Event Day threshold value. For the purposes of calculating daily system SAIDI, any interruption that spans multiple calendar days is accrued to the day on which the interruption began. Statistically, days having a daily system SAIDI greater than T_{MED} are days on which the energy delivery system experienced stresses beyond that normally expected (such as during severe weather). Activities that occur on Major Event Days should be separately analyzed and reported.

NOTE—See Major Event Day classification in 3.5.

momentary interruption: The brief loss of power delivery to one or more customers caused by the opening and closing operation of an interrupting device**.**

NOTE—Two circuit breaker or recloser operations (each operation being an open followed by a close) that briefly interrupt service to one or more customers are defined as two momentary interruptions**.**

momentary interruption event: An interruption of duration limited to the period required to restore service by an interrupting device.

NOTE 1—Such switching operations must be completed within a specified time of five minutes or less. This definition includes all reclosing operations that occur within five minutes of the first interruption.

NOTE 2—If a recloser or circuit breaker operates two, three, or four times and then holds (within five minutes of the first operation), those momentary interruptions shall be considered one momentary interruption event.

outage: The loss of ability of a component to deliver power.

NOTE 1—An outage may or may not cause an interruption of service to customers, depending on system configuration.

NOTE 2—This definition derives from transmission and distribution applications and does not apply to generation outages.

planned interruption: The loss of electric power to one or more customers that results from a planned outage.

NOTE 1—This derives from transmission and distribution applications and does not apply to generation interruptions.

NOTE 2—The key test to determine if an interruption should be classified as a planned or unplanned interruption is as follows: If it is possible to defer the interruption, then the interruption is a planned interruption; otherwise, the interruption is an unplanned interruption.

planned outage: The intentional disabling of a component's capability to deliver power, done at a pre-selected time, usually for the purposes of construction, preventative maintenance, or repair.

reporting period: The time period from which interruption data is to be included in reliability index calculations. The beginning and end dates and times should be clearly indicated. All events that begin within the indicated time period should be included. A consistent reporting period should be used when comparing the performance of different distribution systems (typically one calendar year) or when comparing the performance of a single distribution system over an extended period of time. The reporting period is assumed to be one year, unless otherwise stated.

step restoration: The process of restoring all interrupted customers in stages over time.

sustained interruption: Any interruption not classified as a part of a momentary event. That is, any interruption that lasts more than five minutes.

total number of customers served: The average number of customers served during the reporting period. If a different customer total is used, it must be clearly defined within the report.

unplanned interruption: The loss of electric power to one or more customers that does not result from a planned outage.

3. Definitions of reliability indices

3.1 Basic factors

The basic factors defined below specify the data needed to calculate the reliability indices.

NOTE—The subscript ‘i’ denotes an interruption event.

CI	Customers interrupted
CMI	Customer minutes of interruption
CN	Total number of distinct customers who have experienced a sustained interruption during the reporting period
$\mathbf{CN_{(k\geq n)}}$	Total number of customers who have experienced *n* or more sustained interruptions during the reporting period
$\mathbf{CN_{(k\geq S)}}$	Total number of customers that experienced S or more hours duration
$\mathbf{CN_{(k\geq T)}}$	Total number of customers that experienced T or more hours duration
$\mathbf{CNT_{(k\geq n)}}$	Total number of customers who have experienced *n* or more sustained interruptions and momentary interruption events during the reporting period
E	Event
$\mathbf{IM_i}$	Number of momentary interruptions
$\mathbf{IM_E}$	Number of momentary interruption events
k	Number of interruptions experienced by an individual customer in the reporting period
$\mathbf{L_i}$	Connected kVA load interrupted for each interruption event
$\mathbf{L_T}$	Total connected kVA load served
$\mathbf{N_i}$	Number of interrupted customers for each sustained interruption event during the reporting period
$\mathbf{N_{mi}}$	Number of interrupted customers for each momentary interruption event during the reporting period

$\mathbf{N_T}$	Total number of customers served for the area
$\mathbf{r_i}$	Restoration time for each interruption event
$\mathbf{T_{MED}}$	Major Event Day threshold

3.2 Sustained interruption indices

3.2.1 SAIFI: System Average Interruption Frequency Index

The System Average Interruption Frequency Index (SAIFI) indicates how often the average customer experiences a sustained interruption over a predefined period of time. Mathematically, this is given in Eq. (1).

$$\text{SAIFI} = \frac{\sum \text{Total Number of Customers Interrupted}}{\text{Total Number of Customers Served}} \tag{1}$$

To calculate the index, use Eq. (2).

$$\text{SAIFI} = \frac{\sum N_i}{N_T} = \frac{CI}{N_T} \tag{2}$$

3.2.2 SAIDI: System Average Interruption Duration Index

The System Average Interruption Duration Index (SAIDI) indicates the total duration of interruption for the average customer during a predefined period of time. It is commonly measured in minutes or hours of interruption. Mathematically, this is given in Eq. (3).

$$\text{SAIDI} = \frac{\sum \text{Customer Minutes of Interruption}}{\text{Total Number of Customers Served}} \tag{3}$$

To calculate the index, use Eq. (4).

$$\text{SAIDI} = \frac{\sum r_i N_i}{N_T} = \frac{CMI}{N_T} \tag{4}$$

3.2.3 CAIDI: Customer Average Interruption Duration Index

The Customer Average Interruption Duration Index (CAIDI) represents the average time required to restore service. Mathematically, this is given in Eq. (5).

$$\text{CAIDI} = \frac{\sum \text{Customer Minutes of Interruption}}{\text{Total Number of Customers Interrupted}} = \frac{CMI}{CI} \tag{5}$$

To calculate the index, use Eq. (6).

$$\text{CAIDI} = \frac{\sum r_i N_i}{\sum N_i} = \frac{\text{SAIDI}}{\text{SAIFI}} \tag{6}$$

3.2.4 CTAIDI: Customer Total Average Interruption Duration Index

The Customer Total Average Interruption Duration Index (CTAIDI) represents the total time in the reporting period that average customers who actually experienced an interruption were without power. This index is a hybrid of CAIDI and is similarly calculated, except that those customers with multiple interruptions are counted only once. Mathematically, this is given in Eq. (7).

$$\text{CTAIDI} = \frac{\sum \text{ Customer Interruption Durations}}{\text{Total Number of Distinct Customers Interrupted}} \tag{7}$$

To calculate the index, use Eq. (8).

$$\text{CTAIDI} = \frac{\sum r_i N_i}{\text{CN}} = \frac{CMI}{CN} \tag{8}$$

NOTE—In tallying Total Number of Customers Interrupted, each individual customer should be counted only once regardless of the number of times interrupted during the reporting period. This applies to definitions provided in 3.2.4 and 3.2.5.

3.2.5 CAIFI: Customer Average Interruption Frequency Index

The Customer Average Interruption Frequency Index (CAIFI) gives the average frequency of sustained interruptions for those customers experiencing sustained interruptions. The customer is counted once, regardless of the number of times interrupted for this calculation. Mathematically, this is given in Eq. (9).

$$\text{CAIFI} = \frac{\sum \text{ Total Number of Customer Interruptions}}{\text{Total Number of Distinct Customers Interrupted}} \tag{9}$$

To calculate the index, use Eq. (10).

$$\text{CAIFI} = \frac{\sum N_i}{\text{CN}} = \frac{CI}{CN} \tag{10}$$

3.2.6 ASAI: Average Service Availability Index

The Average Service Availability Index (ASAI) represents the fraction of time (often in percentage) that a customer has received power during the defined reporting period. Mathematically, this is given in Eq. (11).

$$\mathrm{ASAI} = \frac{\text{Customer Hours Service Availability}}{\text{Customer Hours Service Demand}} \tag{11}$$

To calculate the index, use Eq. (12).

$$\mathrm{ASAI} = \frac{N_T \times (\text{Number of hours/yr}) - \sum r_i N_i}{N_T \times (\text{Number of hours/yr})} \tag{12}$$

NOTE—There are 8 760 hours in a non-leap year and 8 784 hours in a leap year.

3.2.7 CEMI_n: Customers Experiencing Multiple Interruptions

The Customers Experiencing Multiple Interruptions Index (CEMI_n) indicates the ratio of individual customers experiencing *n* or more sustained interruptions to the total number of customers served. Mathematically, this is given in Eq. (13).

$$\mathrm{CEMI}_n = \frac{\text{Total Number of Customers that experienced n or more sustained interruptions}}{\text{Total Number of Customers Served}} \tag{13}$$

To calculate the index, use Eq. (14).

$$\mathrm{CEMI}_n = \frac{CN_{(k \geq n)}}{N_T} \tag{14}$$

NOTE—This index is often used in a series of calculations with *n* incremented from a value of 1 to the highest value of interest.

3.2.8 CELID: Customers Experiencing Long Interruption Durations

The Customers Experiencing Long Interruption Durations Index (CELID) indicates the ratio of individual customers that experience interruptions with durations longer than or equal to a given time. That time is either the duration of a single interruption (s) or the total amount of time (t) that a customer has been interrupted during the reporting period. Mathematically, the Single Interruption Duration equation is given in Eq. (15) and the Total Interruption Duration equation is given in Eq. (17).

Single Interruption Duration:

$$\text{CELID-t} = \frac{\text{Total Number of Customers that experienced S or more hours duration}}{\text{Total Number of Customers Served}} \tag{15}$$

To calculate the index, use Eq. (16).

$$\text{CELID-s} = \frac{CN_{(k \geq S)}}{N_T} \tag{16}$$

Total Interruption Duration:

$$\text{CELID-t} = \frac{\text{Total Number of Customers that experienced T or more hours duration}}{\text{Total Number of Customers Served}} \quad (17)$$

To calculate the index, use Eq. (18).

$$\text{CELID-t} = \frac{CN_{(k \geq T)}}{N_T} \quad (18)$$

3.3 Load based indices

3.3.1 ASIFI: Average System Interruption Frequency Index

The calculation of the Average System Interruption Frequency Index (ASIFI) is based on load rather than customers affected. ASIFI is sometimes used to measure distribution performance in areas that serve relatively few customers that have relatively large concentrations of load, predominantly industrial/commercial customers. Theoretically, in a system with homogeneous load distribution, ASIFI would be the same as SAIFI. Mathematically, this ASIFI is given in Eq. (19).

$$\text{ASIFI} = \frac{\sum \text{Total Connected kVA of Load Interrupted}}{\text{Total Connected kVA Served}} \quad (19)$$

To calculate the index, use Eq. (20).

$$\text{ASIFI} = \frac{\sum L_i}{L_T} \quad (20)$$

3.3.2 ASIDI: Average System Interruption Duration Index

The calculation of the Average System Interruption Duration Index (ASIDI) is based on load rather than customers affected. Its use, limitations, and philosophy are stated in the ASIFI definition in 3.3.1. Mathematically, ASIDI is given in Eq. (21).

$$\text{ASIDI} = \frac{\sum \text{Connected kVA Duration of Load Interrupted}}{\text{Total Connected kVA Served}} \quad (21)$$

To calculate the index, use Eq. (22).

$$\text{ASIDI} = \frac{\sum r_i L_i}{L_T} \quad (22)$$

3.4 Other indices (momentary)

3.4.1 MAIFI: Momentary Average Interruption Frequency Index

The Momentary Average Interruption Frequency Index (MAIFI) indicates the average frequency of momentary interruptions. Mathematically, this is given in Eq. (23).

$$\text{MAIFI} = \frac{\sum \text{Total Number of Customer Momentary Interruptions}}{\text{Total Number of Customers Served}} \tag{23}$$

To calculate the index, use Eq. (24).

$$\text{MAIFI} = \frac{\sum IM_i N_{mi}}{N_T} \tag{24}$$

3.4.2 MAIFI$_E$: Momentary Average Interruption Event Frequency Index

The Momentary Average Interruption Event Frequency Index (MAIFI$_E$) indicates the average frequency of momentary interruption events. This index does not include the events immediately preceding a sustained interruption. Mathematically, this is given in Eq. (25).

$$\text{MAIFI}_E = \frac{\sum \text{Total Number of Customer Momentary Interruption Events}}{\text{Total Number of Customers Served}} \tag{25}$$

To calculate the index, use Eq. (26).

$$\text{MAIFI}_E = \frac{\sum IM_E N_{mi}}{N_T} \tag{26}$$

3.4.3 CEMSMI$_n$: Customers Experiencing Multiple Sustained Interruption and Momentary Interruption Events

The Customers Experiencing Multiple Sustained Interruption and Momentary Interruption Events Index (CEMSMI$_n$) is the ratio of individual customers experiencing *n* or more of both sustained interruptions and momentary interruption events to the total customers served. Its purpose is to help identify customer issues that cannot be observed by using averages. Mathematically, this is given in Eq. (27).

$$\text{CEMSMI}_n = \frac{\text{Total Number of Customers Experiencing n or More Interruptions}}{\text{Total Number of Customers Served}} \tag{27}$$

To calculate the index, use Eq. (28).

$$\text{CEMSMI}_n = \frac{CNT_{(k \geq n)}}{N_T} \tag{28}$$

3.5 Major Event Day classification

The following process—Beta Method—is used to identify Major Event Days (MED), provided that the natural log transformation of the data results closely resembles a Gaussian (normal) distribution. Its purpose is to allow major events to be studied separately from daily operation, and in the process, to better reveal trends in daily operation that would be hidden by the large statistical effect of major events. For more technical detail on derivation of the methodology, refer to Annex B.

A MED is a day in which the daily system SAIDI exceeds a threshold value, T_{MED}. The SAIDI index is used as the basis of this definition since it leads to consistent results regardless of utility size, and because SAIDI is a good indicator of operational and design stress. Even though SAIDI is used to determine the MEDs, all indices should be calculated based on removal of the identified days.

In calculating daily system SAIDI, any interruption that spans multiple days is accrued to the day on which the interruption begins.

The MED identification T_{MED} value is calculated at the end of each reporting period (typically one year) for use during the next reporting period, as follows:

a) Collect values of daily SAIDI for five sequential years, ending on the last day of the last complete reporting period. If fewer than five years of historical data are available, use all available historical data until five years of historical data are available.
b) Only those days that have a SAIDI/Day value will be used to calculate T_{MED} (do not include days that did not have any interruptions).
c) Take the natural logarithm (ln) of each daily SAIDI value in the data set.
d) Find α (Alpha), the average of the logarithms (also known as the log-average) of the data set.
e) Find β (Beta), the standard deviation of the logarithms (also known as the log-standard deviation) of the data set.
f) Compute the MED threshold, T_{MED}, using Eq. (29).

$$T_{MED} = e^{(\alpha+2.5\beta)} \tag{29}$$

g) Any day with daily SAIDI greater than the threshold value T_{MED} that occurs during the subsequent reporting period is classified as a MED.

Activities that occur on days classified as MEDs should be separately analyzed and reported.

3.5.1 An example of using the MED definition to identify major events and subsequently calculate adjusted indices that reflect normal operating performance

The following example illustrates the calculation of the daily SAIDI, calculation of the MED threshold T_{MED}, identification of MEDs, and calculation of adjusted indices.

Table 1 gives selected data for all interruptions occurring on a certain day for a utility that serves 2 000 customers.

Table 1—Interruption data for March 18, 1994

Date	Time	Duration (min)	Number of customers	Interruption Type
Mar 18, 1994	18:34:30	20.0	200	Sustained
Mar 18, 1994	18:38:30	1.0	400	Momentary
Mar 18, 1994	18:42:00	513.5	700	Sustained

Note that although the third interruption (at 18:42:00) was not restored until the following day, its total duration counts in the day that the interruption began. Note also that SAIDI considers only sustained interruptions.

For March 18, 1994, daily SAIDI (assuming a 2 000 customer utility) is given in Eq. (30).

$$\text{SAIDI} = \frac{(20 \times 200) + (513.5 \times 700)}{2000} = 181.73 \text{ min} \qquad (30)$$

One month of historical daily SAIDI data is used in the following example to calculate the MED threshold T_{MED}. Five years of historical data is preferable for this method, but printing that many values in this guide is impractical, so only one month is used to illustrate the concept. The example data is shown in Table 2.

Table 2—One month of daily SAIDI and ln(SAIDI/day) data

Date	SAIDI/day (min)	ln(SAIDI/day)	Date	SAIDI/day (min)	ln(SAIDI/day)
Dec 1, 1993	26.974	3.295	Dec 17, 1993	0.329	-1.112
Dec 2, 1993	0.956	-0.046	Dec 18, 1993	0	This day is not included in the calculations since no customers were interrupted.
Dec 3, 1993	0.131	-2.033	Dec 19, 1993	0.281	-1.268
Dec 4, 1993	1.292	0.256	Dec 20, 1993	1.810	0.593
Dec 5, 1993	4.250	1.447	Dec 21, 1993	0.250	-1.388
Dec 6, 1993	0.119	-2.127	Dec 22, 1993	0.021	-3.876
Dec 7, 1993	0.130	-2.042	Dec 23, 1993	1.233	0.209
Dec 8, 1993	12.883	2.556	Dec 24, 1993	0.996	-0.004
Dec 9, 1993	0.226	-1.487	Dec 25, 1993	0.162	-1.818
Dec 10, 1993	13.864	2.629	Dec 26, 1993	0.288	-1.244
Dec 11, 1993	0.015	-4.232	Dec 27, 1993	0.535	-0.626
Dec 12, 1993	1.788	0.581	Dec 28, 1993	0.291	-1.234
Dec 13, 1993	0.410	-0.891	Dec 29, 1993	0.600	-0.511
Dec 14, 1993	0.007	-4.967	Dec 30, 1993	1.750	0.560
Dec 15, 1993	1.124	0.117	Dec 31, 1993	3.622	1.287
Dec 16, 1993	1.951	0.668			

NOTE—The SAIDI/day for December 18, 1993 is zero, and the natural logarithm of zero is undefined. Therefore, December 18, 1993 is not considered during the analysis.

The value of α, the log-average, is the average of the natural logs, and equals -0.555 in this case.

The value of β, the log-standard deviation, is the standard deviation of the natural logs, and equals 1.90 in this example.

The value of $\alpha + 2.5\beta$ is 4.20.

The threshold value T_{MED} is calculated by $e^{(4.20)}$ and equals 66.69 SAIDI minutes per day. This value is used to evaluate the future time period (e.g., the next year).

Table 3 shows example SAIDI/day values for the first month of 1994.

Table 3—Daily SAIDI data, January 1994

Date	SAIDI/Day	Date	SAIDI/Day
Jan 1, 1994	0.240	Jan 17 1994	5.700
Jan 2, 1994	0.014	Jan 18, 1994	0.109
Jan 3, 1994	0.075	Jan 19, 1994	0.259
Jan 4, 1994	2.649	Jan 20, 1994	1.142
Jan 5, 1994	0.666	Jan 21, 1994	0.262
Jan 6, 1994	0.189	Jan 22, 1994	0.044
Jan 7, 1994	0.009	Jan 23, 1994	0.243
Jan 8, 1994	1.117	Jan 24, 1994	5.932
Jan 9, 1994	0.111	Jan 25, 1994	2.698
Jan 10, 1994	8.683	Jan 26, 1994	5.894
Jan 11, 1994	0.277	Jan 27, 1994	0.408
Jan 12, 1994	0.057	Jan 28, 1994	237.493
Jan 13, 1994	0.974	Jan 29, 1994	2.730
Jan 14, 1994	0.150	Jan 30, 1994	8.110
Jan 15, 1994	0.633	Jan 31, 1994	0.046
Jan 16, 1994	0.434		

The SAIDI/day on January 28, 1994 (237.49) exceeds the example threshold value (T_{MED} = 66.69), indicating that the distribution system experienced stresses beyond that normally expected on that day. Therefore, January 28, 1994 is classified as a MED. The SAIDI/day for all other days was less than T_{MED}, indicating that normal stresses were experienced on those days.

To complete the example, indices should be calculated for two conditions:

1) All events included
2) MEDs removed

In most cases, utilities will calculate all of the indices they normally use (e.g., SAIFI, SAIDI, and/or CAIDI). For this example, only SAIDI will be shown. The SAIDI for 1994 for condition 1) above (all events included) is given in Eq. 31.

$$\text{SAIDI} = \sum \text{Daily SAIDI} = 287.35 \tag{31}$$

The SAIDI for 1994 for condition 2) above (MEDs removed), for separate reporting and analysis, is given in Eq. 32.

$$\text{SAIDI} = \sum \text{Daily SAIDI with the MEDs removed} = 49.86 \tag{32}$$

4. Application of the indices

Most utilities store interruption data in large computer databases. Some databases are better organized than others for querying and analyzing reliability data. The following subclause will show one sample partial database and the methodology for calculating indices based on the information provided.

4.1 Sample system

Table 4 shows an excerpt from one utility's customer information system (CIS) database for feeder 7075, which serves 2 000 customers with a total load of 4 MW. In this example, Circuit 7075 constitutes the "system" for which the indices are calculated. More typically, the "system" combines all circuits together in a region or for a whole company.

Table 4—Interruption data for 1994

Date	Time	Time on	Circuit	Event code	Number of customers	Load kVA	Interruption type
Mar 17	12:12:20	12:20:30	7075	107	200	800	S
Apr 15	18:23:56	18:24:26	7075	256	400	1 600	M
May 5	00:23:10	01:34:29	7075	435	600	1 800	S
Jun 12	23:17:00	23:47:14	7075	567	25	75	S
Jul 6	09:30:10	09:31:10	7075	678	2 000	4 000	M
Aug 20	15:45:39	20:12:50	7075	832	90	500	S
Aug 31	08:20:00	10:20:00	7075	1 003	700	2 100	S
Sep 3	17:10:00	17:20:00	7075	1 100	1 500	3 000	S
Oct 27	10:15:00	10:55:00	7075	1 356	100	200	S

NOTE 1—Interruption type S = sustained; M = momentary

NOTE 2—Total customers served = 2 000

The total number of customers who have experienced a sustained interruption is 3 215. The total number of customers experiencing a momentary interruption is 2 400.

Table 5—Extracted customers who were interrupted

Name	Circuit number	Date	Event code	Duration (min)
Willis, J.	7075	Mar 17, 1994	107	8.17
Williams, J.	7075	Apr 15, 1994	256	0.5
Willis, J.	7075	Apr 15, 1994	256	0.5
Wilson, D.	7075	May 5, 1994	435	71.3
Willis, J.	7075	Jun 12, 1994	567	30.3
Willis, J.	7075	Aug 20, 1994	832	267.2
Wilson, D.	7075	Aug 20, 1994	832	267.2
Yattaw, S.	7075	Aug 20, 1994	832	267.2
Willis, J.	7075	Aug 31, 1994	1003	120
Willis, J.	7075	Sep 3, 1994	1100	10
Willis, J.	7075	Oct 27, 1994	1356	40

Table 6—Interruption device operations

Record number	Device	Date	Time	Number of operations	Number of operations to lockout
1	Brk 7075	Apr 15	18:23:56	2	3
2	Recl 7075	Jul 6	09:30:10	3	4
3	Brk 7075	Aug 2	12:29:02	1	3
4	Brk 7075	Aug 2	12:30:50	2	3
5	Recl 7075	Aug 2	13:25:40	2	4
6	Recl 7075	Aug 25	08:00:00	2	4
7	Brk 7075	Sep 2	04:06:53	2	3
8	Recl 7075	Sep 5	11:53:22	3	4
9	Brk 7075	Sep 8	15:25:10	1	3
10	Recl 7075	Oct 2	17:15:19	1	4
11	Recl 7075	Nov 12	00:00:05	1	4

From Table 6, it can be seen that there were eight circuit breaker operations that affected 2 000 customers. Each of them experienced eight momentary interruptions. There were 12 recloser operations that caused 750 customers to experience 12 momentary interruptions. Some of the operations occurred during one reclosing sequence. To calculate the number of momentary interruption events, count only the total number of reclosing sequences. In this case, there were five circuit breaker events (records 1, 3, 4, 7, and 9) that affected 2 000 customers. Each of them experienced five momentary interruption events. There were six recloser events (records 2, 5, 6, 8, 10, and 11) that affected 750 customers, and each of them experienced six momentary interruption events.

4.2 Calculation of indices for a system with no Major Event Days

The equations in 3.5, and definitions in Clause 2, should be used to calculate the annual indices (see Eq. (33) through Eq. (46), below). In the example below, the indices are calculated by using the equations in 3.2 and 3.4 using the data in Table 4 and Table 5, assuming there were no MEDs in this data set.

$$\mathrm{SAIFI} = \frac{200 + 600 + 25 + 90 + 700 + 1500 + 100}{2000} = 1.61 \tag{33}$$

$$\mathrm{SAIDI} = \frac{(8.17\times 200)+(71.3\times 600)+(30.3\times 25)+(267.2\times 90)+(120\times 700)+(10\times 1500)+(40\times 100)}{2000} = 86.11\ \mathrm{min} \tag{34}$$

$$\mathrm{CAIDI} = \frac{\mathrm{SAIDI}}{\mathrm{SAIFI}} = \frac{86.110}{1.6075} = 53.57\mathrm{min} \tag{35}$$

To calculate CTAIDI and CAIFI, the number of customers experiencing a sustained interruption is required. The total number of customers affected (CN) for this example can be no more than 2 000. Since only a small portion of the customer information table is shown, it is impossible to know CN; however, it is likely that not all of the 2 000 customers on this feeder experienced an interruption during the year. An arbitrary number of customers, 1 800, will be assumed for CN (for your calculations, actual information should be used) since the interruption on September 3 shows that at least 1 500 customers have been interrupted during the year.

$$\text{CTAIDI} = \frac{(8.17\times200)+(71.3\times600)+(30.3\times25)+(267.2\times90)+(120\times700)+(10\times1500)+(40\times100)}{1800} = 95.68\,\text{min} \tag{36}$$

$$\text{CAIFI} = \frac{200+600+25+90+700+1500+100}{1800} = 1.79 \tag{37}$$

$$\text{ASAI} = \frac{8760\times2000 - (8.17\times200+600\times71.3+30.3\times25+267.2\times90+120\times700+10\times700+10\times1500+40\times100)/60}{8760\times2000} = 0.999836 \tag{38}$$

$$\text{ASIFI} = \frac{800+1800+75+500+2100+3000+200}{4000} = 2.12 \tag{39}$$

$$\text{ASIDI} = \frac{(800\times8.17)+(1800\times71.3)+(75\times30.3)+(500\times267.2)+(2100\times700)+3000(6)+200\times40}{4000} = 444.69 \tag{40}$$

CTAIDI, CAIFI, CEMI_n, CELID-s, CELID-t, and CEMSMI_n require detailed interruption information for each customer. The database should be searched for all customers who have experienced more than n interruptions that last longer than five minutes. Assume n is chosen to be five. In Table 5, customer J. Willis experienced seven interruptions in one year, and it is plausible that other customers also experienced more than five interruptions, both momentary and sustained.

For this example, assume arbitrary values of 350 for $CN_{(k\geq n)}$, 90 for $CN_{(k\geq S)}$, 40 for $CN_{(k\geq T)}$, and 750 for $CNT_{(k\geq n)}$. The number of interrupting device operations is given in Table 6 and is used to calculate MAIFI and MAIFI_E. Assume the number of customers downstream of the recloser equals 750. These numbers would be known in a real system.

$$\text{CEMI}_5 = \frac{350}{2000} = 0.175 \tag{41}$$

$$\text{CELID-s(4)} = \frac{90}{2000} = 0.045 \tag{42}$$

$$\text{CELID-t(6)} = \frac{40}{2000} = 0.02 \tag{43}$$

$$\text{MAIFI} = \frac{8\times2000+12\times750}{2000} = 12.5 \tag{44}$$

$$\text{MAIFI}_E = \frac{5\times2000+6\times750}{2000} = 7.25 \tag{45}$$

$$\text{CEMSMI}_5 = \frac{750}{2000} = 0.375 \tag{46}$$

Using the above sample system should help define the methodology and approach to obtaining data from the information systems and help calculate the indices.

4.3 Examples

This subclause illustrates two concepts—momentary interruptions and step restoration—through the use of examples.

4.3.1 Momentary interruption example

To better illustrate the concepts of momentary interruptions and sustained interruptions and the associated indices, consider Figure 1 and Eq. (45) through Eq. (47). Figure 1 illustrates a circuit composed of a circuit breaker (B), a recloser (R), and a sectionalizer (S).

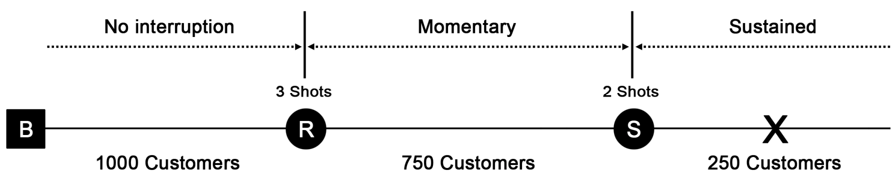

Figure 1—Sample system two

For this scenario, 750 customers would experience a momentary interruption event (two momentary interruptions), and 250 customers would experience a sustained interruption. Calculations for SAIFI, MAIFI, and $\mathrm{MAIFI_E}$ on a feeder basis are shown in Eq. (47) through Eq. (49) below. Notice that the numerator of MAIFI is multiplied by two because the recloser took two shots, however, $\mathrm{MAIFI_E}$ is multiplied by one because it counts only the fact that a series of momentary events occurred.

$$\mathrm{SAIFI} = \frac{250}{2000} = 0.125 \tag{47}$$

$$\mathrm{MAIFI} = \frac{2 \times 750}{2000} = 0.75 \tag{48}$$

$$\mathrm{MAIFI_E} = \frac{1 \times 750}{2000} = 0.375 \tag{49}$$

4.3.2 Step restoration example

The following case illustrates the step restoration process. A feeder serving 1 000 customers experiences a sustained interruption. Multiple restoration steps are required to restore service to all customers. Table 7 shows the times of each step, a description and associated customers interrupted, and minutes they were affected in a timeline format.

Table 7—Example for a feeder serving 1 000 customers with a sustained interruption

Time from initial fault (min)	Description	Customers remaining interrupted	Customers restored
—	The initial fault occurs, the feeder breaker opens, and all 1 000 customers are interrupted. Switches are opened along the feeder.	1 000	—
45	The feeder breaker is closed, but only 500 customers are restored.	500	500
60	Through closing a switch, an additional 300 customers are restored.	200	800
70	An additional incident occurs which causes the feeder breaker to open, interrupting the 800 customers previously restored.	1 000	—
90	The feeder breaker is closed, and restores 800 customers.	200	800
120	Permanent repairs are completed and the remaining 200 customers are restored. The outage event is concluded.	—	1 000
Totals		N/A	1 800

Figure 2 illustrates the example described in Table 7. Note that both the block of 500 customers and the block of 300 customers experience two interruptions during this event.

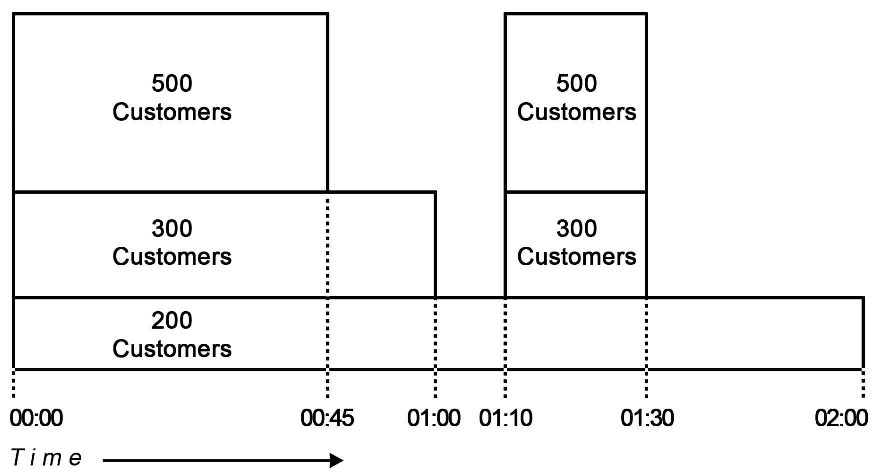

Figure 2—Step restoration time chart

Table 8 enumerates the CI and CMI for the example.

Table 8—Restoration steps for the example

Time	Interruption duration (min)	CI	CMI
00:00-00:45	45	500	22 500
00:00-01:00	60	300	18 000
01:10-01:30	20	800	16 000
00:00-02:00	120	200	24 000
	Total	1 800	80 500

Example SAIFI = 1 800/1 000 = 1.8 interruptions

Example CAIDI = 80 500/1 800 = 44.7 min

Example SAIDI = 80 500/1 000 = 80.5 min

5. Information about the factors that affect the calculation of reliability indices

5.1 Rationale behind selecting the indices provided in this guide

One view of distribution system performance can be garnered through the use of reliability indices. To adequately measure performance, both duration and frequency of customer interruptions must be examined at various system levels. The most commonly used indices are SAIFI, SAIDI, CAIDI, and ASAI, which all provide information about average system performance. Many utilities also calculate indices on a feeder basis to provide more detailed information for decision making. Averages give general performance trends for the utility; however, using averages will lead to loss of detail that could be critical to decision making. For example, using system averages alone will not provide information about the interruption duration experienced by any specific customer. It is difficult for most utilities to provide information on a customer basis. This group believes the tracking of specific details surrounding interruptions, rather than averages, may be accomplished by improving tracking capabilities. To this end, the working group has included not only the most commonly used indices, but also indices that examine performance at the customer level (e.g., $CEMI_n$ and the CELIDs).

5.2 Factors that cause variation in reported indices

Many factors can cause variation in the indices reported by different utilities. Some examples are differences in:

— Level of automated data collection

— Geography

— System design

— Data classification (e.g., Are major events in the data set? Planned interruptions?)

To ensure accurate and equitable assessment and comparison of absolute performance and performance trends over time, it is important to classify performance for each day in the data set to be analyzed as either day-to-day or MED. Not performing this critical step can lead to false decision making because MED performance often overshadows and disguises daily performance. Interruptions that occur as a result of outages on customer-owned facilities, or loss of supply from another utility, should not be included in the index calculation.

5.3 Major Event Days and catastrophic days

When using daily SAIDI and the 2.5β method, there is an assumption that the distribution of the natural log values will most likely resemble a Gaussian distribution, namely a bell-shaped curve. As companies have used this method, a certain number of them have experienced large-scale events (such as hurricanes or ice storms) that result in unusually sizable daily SAIDI values. The events that give rise to these particular days, considered “catastrophic events,” have a low probability of occurring. However, the extremely large daily SAIDI values may tend to skew the distribution of performance toward the right, causing a shift of the average of the data set and an increase in its standard deviation. Large daily SAIDI values caused by catastrophic events will exist in the data set for five years and could cause a relatively minor upward shift in the resulting reliability metric trends. While significant study was undertaken to develop objective methods for identifying and processing catastrophic events (in order to eliminate the noted effect on the reliability trend), the methods that were developed, in order to be universally applied, caused for many utilities, catastrophic events to occur far too often to accept as being reasonable. In addition, the elimination of catastrophic events from the calculation of the major event threshold caused, in some utilities, a rather large increase of days identified as MEDs in the following five years. It is recommended that the identification and processing of catastrophic events for reliability purposes should be determined on an individual company basis by regulators and utilities since no objective method has been devised that can be applied universally to achieve acceptable results.

Annex A

(informative)

Bibliography

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Annex B

(informative)

Major event definition development

B.1 Justification and process for development of the 2.5 β methodology

A statistical approach to identifying MEDs was chosen over the previous definitions because of the difficulties experienced in creating a uniform list of types of major events, and because the measure of impact criterion (i.e., percent of customers affected) required when using event types resulted in non-uniform identification. The statistical methodology should more fairly identify major events for all utilities. Some key issues had to be addressed in order to consider this work successful. These issues include:

— Definition must be understandable and easy to apply.

— Definition must be specific and calculated using the same process for all utilities.

— Must be fair to all utilities regardless of size, geography, or design.

— Entities that adopt the methodology will calculate indices on a normalized basis for trending and reporting. They will further classify the MEDs separately and report on those days through a separate process.

Daily SAIDI values are preferred to daily Customer Minutes of Interruption (CMI) values for MED identification because the former permits comparison and computation among years with different numbers of customers served. Consider the merger of two utilities with the same reliability and the same number of customers. CMI after the merger would double, with no change in reliability, while SAIDI would stay constant.

Daily SAIDI values are preferred to daily SAIFI values because SAIDI values are a better measure of the total cost of reliability events, including utility repair costs and customer losses. The total cost of unreliability would be a better measure of the size of a major event, but collection of this data is not practical.

The selected approach for setting the MED identification threshold, known as the “Two Point Five Beta” (2.5β) method (since it is using the log-normal SAIDI values rather than the raw SAIDI values), is preferred to using fixed multiples of standard deviation (e.g., “Three Sigma”) to set the identification threshold because the former results in more uniform MED identification among utilities with different sizes and average reliabilities. The β multiplier of 2.5 was chosen because, in theory, it would classify 2.3 days per year as major events. If significantly more days than this are identified, they represent events that have occurred outside the random process that is assumed to control distribution system reliability. The process and the multiplier value were evaluated by a number of utilities with different sized systems from different parts of the United States and found to correlate reasonably well to current major event identification results for those utilities. A number of alternative approaches were considered. None was found to be clearly superior to the 2.5β method.

When a major event occurs that lasts through midnight (for example, a six hour hurricane which starts at 9:00 p.m.), the reliability impact of the event may be split between two days, neither of which would exceed the T_{MED} and therefore be classified as a MED. This is a known inaccuracy in the method, which is accepted in exchange for the simplicity and ease of calculation of the method. The preferred number of years of data (five) used to calculate the MED identification threshold was set by trading off between the desire to reduce statistical variation in the threshold (for which more data is better) and the desire to see the effects of changes in reliability practices in the reported results, and to limit the amount of data which must be archived.

B.1.1 Remarks

To generate the example data used in 3.5.1, values of α and β were taken from an actual utility data set, and then daily SAIDI/day values were artificially generated using a log normal distribution with these values of α and β. The daily SAIDI values were then adjusted to illustrate all aspects of the calculation (e.g., a day in Table 2 was assigned a SAIDI value of zero, and a day in Table 3 was assigned a SAIDI value higher than the computed threshold).

This annex provides a technical description and analysis of the 2.5β method of identifying MEDs in distribution reliability data. The 2.5β method is a statistical method based on the theory of probability and statistics. Fundamental concepts such as *probability distribution* and *expected value* are highlighted in italics when they are first used and provided with a short definition. An undergraduate probability and statistics textbook can be consulted for definitions that are more complete.

B.2 2.5β method description

See 3.5 of this guide for the detailed procedure for identifying MEDs. The short version is presented here. A threshold on daily SAIDI is computed once a year as follows:

a) Assemble the five most recent years of historical values of SAIDI/day. If less than five years of data is available, use as much as is available.
b) Discard any day in the data set that has a SAIDI/Day of zero.
c) Find the natural logarithm of each value in the data set.
d) Compute the average (α, or Alpha) and standard deviation (β or Beta) of the natural logarithms computed in step a).
e) Compute the threshold $T_{MED} = \exp(\alpha + 2.5 * \beta)$.
f) Any day in the next year with SAIDI > T_{MED} is a MED.

B.3 Random nature of distribution reliability

The reliability of electric power distribution systems is a *random process*, that is, a process that produces random values of a specific *random variable*. A simple example of a random process is rolling a die. The random variable is the value on the top face of the die after a roll, which can have integer values between one and six.

In electric power distribution system reliability, the random variables are the reliability indices defined in this guide. These are evaluated on a daily or yearly basis and take on values from zero to infinity.

B.4 Choice of SAIDI to identify Major Event Days

Four commonly used reliability indices are:

a) System Average Interruption Duration Index (SAIDI)
b) System Average Interruption Frequency Index (SAIFI)

c) Customer Average Interruption Duration Index (CAIDI)

d) Average Service Availability Index (ASAI)

These indices are actually measures of unreliability, as they increase when reliability becomes worse.

An ideal measure of unreliability would be customer cost of unreliability—the dollar cost of power outages to a utility's customers. This cost is a combination of the initial cost of an outage and accumulated costs during the outage. Unfortunately, the customer cost of unreliability has so far proven impossible to estimate accurately. In contrast, the reliability indices above are routinely and accurately computed from historical reliability data. The ability of an index to reflect customer cost of unreliability indicates the best one to use for MED identification.

Duration-related costs of outages are higher than initial costs, especially for major events, which typically have long duration outages. Thus, a duration-related index will be a better indicator of total costs than a frequency-related index like SAIFI or MAIFI. Because CAIDI is a value per customer, it does not reflect the size of outage events. Therefore, SAIDI best reflects the customer cost of unreliability, and is the index used to identify MEDs. SAIDI in minutes/day is the random variable used for MED identification.

The use of CMI per day was also considered. Like SAIDI, CMI is a good representation of customer cost of unreliability. In fact, SAIDI is just CMI divided by the number of customers in the utility. The number of customers can vary from year to year, especially in the case of mergers, and multiple years of data are used to find MEDs. Use of SAIDI accounts for the variation in customer count, while use of CMI does not. Therefore, SAIDI is preferred.

B.5 Probability distribution of distribution system reliability

B.5.1 Probability density functions and probability of exceeding a threshold value

MEDs will be days with larger SAIDI values. This suggests the use of a threshold value for daily SAIDI. The threshold value is called T_{MED}. Days with SAIDI greater than T_{MED} are MEDs. As the threshold increases, there will be fewer days with SAIDI values above the threshold. The relationship between the threshold and the number of days with SAIDI above the threshold is given by the *probability density function* of SAIDI/day.

The probability density function gives the probability that a specific value of a random variable will appear. For example, for a six-sided die, the probability that a one will appear in a given roll is one-sixth, and the value of the probability density function of one is one-sixth for this random process.

The probability that a value greater than one will occur is the sum of the probability densities for all values greater than one. Since each value has a probability density of one-sixth for the example, this sum is simply five-sixths. As the threshold increases, the probability decreases. For example, for a threshold of four, there are only two values greater than four, and the probability of rolling one of them is two-sixths, or one-third.

In the die rolling example, the random variable can have only discrete integer values. SAIDI/day is a continuous variable. In this case, the sum is replaced by an integral. The probability p that any given day will have a SAIDI/day value greater than a threshold value T is the integral of the probability density function from the threshold to infinity as shown in Eq. (B.1):

$$p(\mathrm{SAIDI} > T) = \int_T^{\infty} pdf(\mathrm{SAIDI})\, d\mathrm{SAIDI} \tag{B.1}$$

Graphically, the probability is the area under the probability density function above the threshold, as shown in Figure B.1.

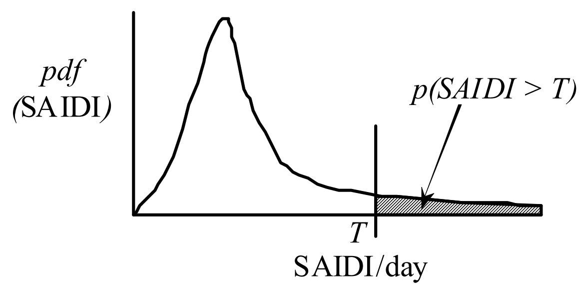


Figure B.1—The area under the probability density of function pdf (SAIDI)

If any given day has a probability *p* of being a MED, then the *expected value* [see Eq. (B.2)] of the number of MEDs in a year is the probability multiplied by the number of days in a year, as shown in Eq. (B.2):

$$E(MED\,/\,year) = 365 \cdot p(\mathrm{SAIDI} > T_{MED}) \tag{B.2}$$

For example, if p = 0.1, then the expected number of MEDs in a year is 36.5. This does not mean that exactly 36.5 MEDs will occur. The actual number will vary due to the randomness of the process.

Using the die rolling example, the probability of getting a six in any roll is one-sixth. Therefore, the expected number of sixes in six rolls is one. However, if the die is rolled six times, there could be six sixes, or zero sixes, or any number in between. As the number of trials goes up, the number of sixes will approach one-sixth of the number of rolls, but for small numbers of rolls, there will be some variation from the expected value.

B.5.2 Gaussian, or normal, distribution

The expected number of MEDs per year can be computed for any given threshold if the shape of the probability density function is known. The shape of the probability density function is called the *probability distribution*. Specific types of shapes have specific names. The most well known is the *Gaussian distribution*, also called the *normal distribution,* or bell curve, shown in Figure B.2.

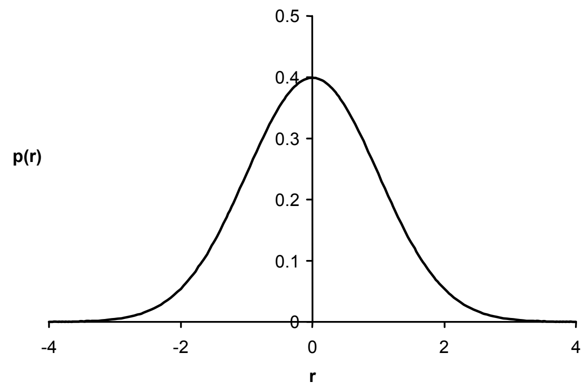


Figure B.2—Gaussian, or normal, probability distribution

The Gaussian distribution is completely described by its *mean*, or average value, (μ or Mu) and its *standard deviation* (σ or Sigma). The average value is at the center of the distribution (at 0 on the *x*-axis in Figure B.2), and the standard deviation is a measure of the spread of the distribution.

An important property of the Gaussian distribution is that the probability of exceeding a given threshold is a function of the number of standard deviations the threshold is from the mean. Eq. (B.3) expresses this concept in mathematical terms:

$$T_{MED} = \mu + n\sigma \tag{B.3}$$

The threshold is n standard deviations greater than the mean, and the probability of exceeding the threshold, $p(\text{SAIDI} > T_{MED})$, is a function only of n, and not of the mean and standard deviation. Values for this function are found in tables in the backs of probability textbooks and in, for example, standard spreadsheet functions. Table B.1 gives the probability of exceeding the threshold for different number of standard deviations n.

Table B.1—Probability of exceeding a threshold for the Gaussian distribution

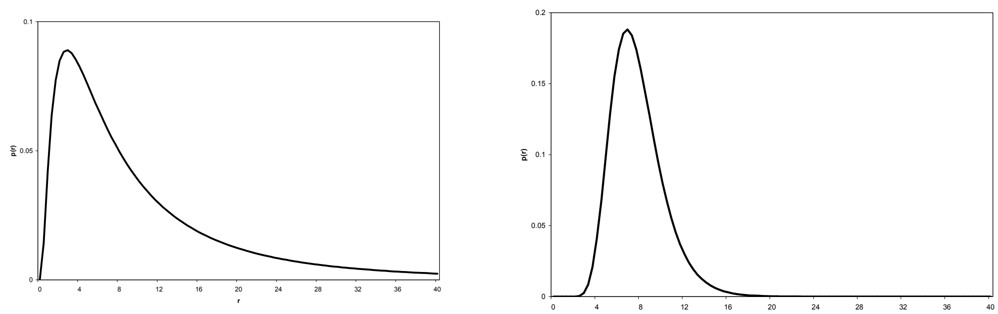
n	*p*
1	0.15866
2	0.02275
3	0.00135
6	9.9×10^{-10}

B.5.3 Three sigma

The term *three sigma* is often used loosely to designate a rare event. It comes from the Gaussian probability distribution. As Table B.1 shows, the probability of exceeding a threshold that is three standard deviations more than the mean is 0.00135, or about one and one-half tenths of one percent. If daily SAIDI had a Gaussian probability distribution, it would be relatively easy to agree on a three sigma definition for the MED threshold, T_{MED}. SAIDI does not have a Gaussian distribution. It has approximately a log-normal distribution.

B.6 Log-normal distribution

The random variable in the Gaussian distribution has a range from -∞ to ∞. In real life, many quantities, including distribution reliability, can only be zero or positive. This causes the probability distribution to skew, bunching up near the zero value and having a long tail to the right. The degree of skew depends on the ratio of mean to standard deviation. When the standard deviation is small compared to the mean, the log-normal distribution looks like the Gaussian distribution, as shown in Figure B.3(b). When it is large compared to the mean, it does not, as shown in Figure B.3(a). Daily reliability data usually has standard deviation values far larger than the mean.



(a) (b)

Figure B.3—Log-normal distributions: (a) Mean less than standard deviation (b) Mean greater than standard deviation

The usual way of determining if a set of data has a log-normal probability distribution is to take the natural logarithm of each value in the data set and examine the histogram. If the histogram looks like a Gaussian distribution, then the data has a log-normal distribution. Figure B.4 shows a histogram of the natural logs of daily SAIDI data for an anonymous utility. The histogram is approximately normally distributed, so the data is approximately log-normally distributed. Roughly a dozen utility data sets have been examined, and all are approximately log-normally distributed. No non-log-normally distributed utility data has so far been found. In addition, Monte Carlo simulation models of the distribution reliability process produce log-normally distributed data. Therefore, utility daily reliability is approximately log-normally distributed.

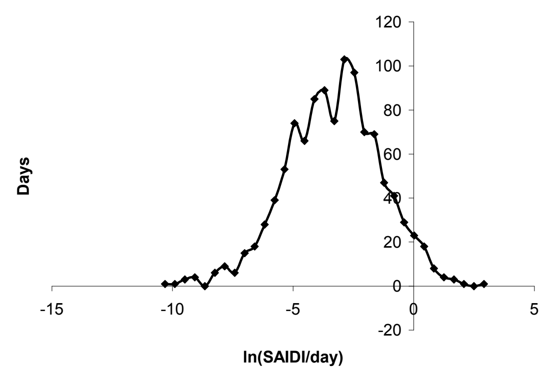


Figure B.4—Histogram of the natural logs of three years of daily SAIDI data from anonymous utility two supplied by the Distribution System Design Working Group

A consequence of the log-normality of daily reliability data is that the three sigma conditions no longer hold. In particular, the probability of exceeding a given threshold is no longer independent of the values of the average and standard deviation of the distribution. This means that using a method such as three sigma would result in significantly different numbers of MEDs for utilities with different average values of reliability, or with different standard deviation values. This seems inequitable.

Fortunately, the logarithms of log-normal data have a Gaussian distribution. If the average of the logarithms of the data is called α, or Alpha, and the standard deviation of the logarithms of the data is called β, or Beta, then α and β are the mean and standard deviation of a Gaussian distribution, and a threshold on the log of the data can be set that is independent of the values of α and β. Eq. (B.4) and Eq. (B.5) show these concepts mathematically.

$$\ln(T_{MED}) = \alpha + k\beta \tag{B.4}$$

$$T_{MED} = \exp(\alpha + k\beta) \tag{B.5}$$

The probability of exceeding T_{MED} is a function of k, just as it was a function of n in the Gaussian example. Table B.2 gives these probabilities as well as the expected number of MEDs for various values of k.

Table B.2—Probability of exceeding T_{MED} as a function of multiples of β

k	*p*	MEDs/yr
1	0.15866	57.9
2	0.02275	8.3
2.4	0.00822	3.0
2.5	0.00621	2.3
3	0.00135	0.5
6	$9.9\text{x}10^{-10}$	3.6E-07

B.6.1 Why 2.5?

Given an allowed number of MEDs per year, a value for k is easily computed. However, there is no analytical method of choosing an allowed number of MEDs/year. The chosen value of k = 2.5 is based on consensus reached among Distribution Reliability Working Group members on the appropriate number of days that should be classified as MEDs. As Table B.2 shows, the expected number of days for k = 2.5 is 2.3 MEDs/year. In practice, the experience of the committee members, representing a wide range of distribution utilities, was that more than 2.3 days were usually classified as MEDs, but that the days that were classified as MEDs were generally those that would have been chosen on qualitative grounds. The performance of different values of k were examined, and consensus was reached on k = 2.5.

B.7 Fairness of the 2.5β method

It is likely that reliability data from different utilities will be compared by utility management, public utilities commissions, and other interested parties. A fair MED classification method would classify, on average, the same number of MEDs per year for different utilities.

The two basic ways that utilities can differ in reliability terms are in the mean and standard deviation of their reliability data. Differences in means are attributable to differences in the environment between utilities, and differences in operating and maintenance practices. Differences in standard deviation are mostly attributable to size. Larger utilities have inherently smaller standard deviations.

As discussed above, using the mean and standard deviation of the logs of the data (α and β) to set the threshold makes the expected number of MEDs depend only on the multiplier and thus should classify the same number of MEDs for large and small utilities, and for utilities with low and high average reliability.

This is not the case for using the mean and standard deviation of the data without taking logarithms first. The expected number of MEDs varies with the mean and standard deviation. This variation occurs because of the log-normal nature of the reliability probability distribution.

Experience with the 2.5β method has shown that it is better than using mean and standard deviation, but it is not perfect. The number of MEDs identified per year is significantly higher than expected, and the average number of MEDs varies somewhat from utility to utility, with size affecting the value. These effects appear because the probability distribution of distribution system reliability is only approximately log-normal. Significant differences appear in the right hand tail of the distribution, which in general contains more probability than a perfect log-normal distribution. This "fat tail" effect accounts for the larger-than-predicted number of identified MEDs. The effect of utility size is less clearly understood.

Despite these issues, the 2.5β method of MED identification is much closer to the ideal fair process than using a Gaussian distribution, using the heuristic definitions that preceded it, or any other method proposed to date. It has been carefully tested and has been broadly accepted by the utilities in the Distribution Design Working Group and many other utilities and regulators that have adopted this guide.

B.8 Five years of data

From a statistical point of view, the more data used to calculate a threshold, the better. However, the random process producing the data changes over time as the distribution system is expanded and operating procedures are varied. Using too much historical data would suppress the effects of these changes.

The addition of another year of data should have a low probability of changing the MED classification of previous years. A result from order statistics gives the probability that the *k*th largest value in *m* samples will be exceeded *f* times in *n* future samples. It is given in Eq. (B.6):

$$p_{f|m,k,n} = \frac{k}{n+k-f} \frac{\binom{m}{k}\binom{n}{f}}{\binom{n+m}{n+k-f}} \tag{B.6}$$

For example, if $M = 3$ years of data, then $m = 1\ 095$ samples. If $f = 3$ MEDs/year, then the largest non-MED is the $k = 1\ 095 - 9 = 1\ 086^{\text{th}}$ ordered sample. The probability of $f = 3$ days in the next year of $n = 365$ samples exceeding the size of the largest non-MED is found from the equation to be 0.194 (19.4%). In Figure B.5, p is plotted against M for several values of f.

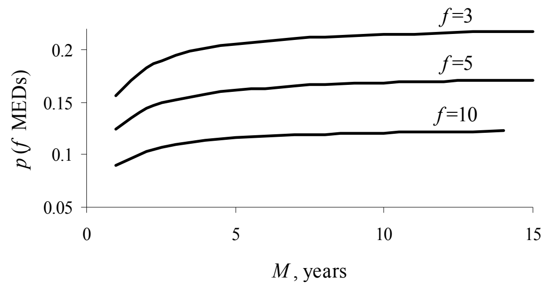


Figure B.5—Probability of exactly *f* new MEDs in the next year of data using *M* years of historical data

The consensus of the Design Working Group members was that five years was the appropriate amount of data to collect. The group felt that the distribution system would change enough to invalidate any extra accuracy from more than five years of data.

Annex C

(informative)

Internal data subset

C.1 Calculation of reliability indices for subsets of data for internal company use

Reliability performance can be assessed for different purposes. It may be advantageous to calculate reliability indices without planned interruptions in order to review performance during unplanned events. In another case, it may be advantageous to review only sustained interruptions. Assessment of performance trends and goal setting should be based on normal event days (neglecting the impact of MEDs). Utilities and regulators determine the most appropriate data to use for reliability performance monitoring. When indices are calculated using partial data sets, the basis should be clearly defined for the users of the indices. At a minimum, reliability indices based on all collected data for a reporting period and analyzed as to normal versus MED classifications should be provided. Indices based on subsets of collected data may be provided as specific needs dictate.

Using solar and storage to meet 100% of the electricity requirements of a distribution circuit

A case study for LG&E Highland 1103 circuit

LG&E
a PPL company

December 2018

Summary

This study evaluates the solar generation and energy storage requirements and associated economics of serving the electricity requirements of the LG&E Highland 1103 distribution circuit with local resources on a standalone basis, without connection to the power grid. This circuit has approximately 1,600 residential customers and 240 commercial customers that use approximately 20,500 MWh annually with a summer peak hourly demand of 8.9 MW. While the electricity consumption on the Highland 1103 circuit accounts for less than 0.4% of Jefferson County's total electricity consumption, its size and load characteristics are typical of many of LG&E's circuits and includes a customer mix that uses natural gas in their homes and businesses.

After evaluating a wide range of alternatives, this study shows that:

- While the technical challenges of using just local solar generation and energy storage to reliably serve the real-time electricity needs of customers on this circuit can likely be met, doing so would require a large geographic space (almost as large as the circuit footprint) that would result in land being used for solar panels and battery storage on a scale that would likely not be acceptable to the local community.

- Despite assuming customers would continue to use natural gas for space and water heating, the quantity of solar generation capacity required to be built would need to be about eight times greater than the summer hourly peak to generate enough energy to charge the batteries to reliably serve nighttime load and address extended periods of dense clouds and short days that are common during winters in Louisville.

- The cost of electricity would likely be two to five times higher over the 30-year study period as compared to continuing to take electricity from the LG&E system.

This study is an attempt to quantify, at a high-level, some of the technological and economic challenges associated with serving a typical distribution circuit with 100% locally generated renewable energy. In addition to the findings in this study, a number of questions, issues, and challenges were identified that were not addressed but were captured and documented for future consideration and included as part of this report.

Background

There is growing national interest in using renewable generation technologies to displace fossil-fuel generation in order to reduce CO_2 emissions.[1,2] Many advocates claim this can technically and economically be accomplished using existing renewable technologies in combination with current developments in storage technology.[3] Furthermore, some are interested in accomplishing this transition to 100% renewable generation via the use of microgrids based solely on distributed solar generation and battery storage.[4] This focus on local generation and storage development is often premised on the idea of creating local jobs and eliminating the need for central station power generation and its associated transmission grid.[5,6]

To understand and identify some of the challenges and issues that would need to be addressed in pursuing a local 100% solar/storage solution, this study used actual 2017 load and solar irradiance data for a representative LG&E distribution circuit to develop a range of possible technology and cost cases and compared the results to a range of costs of continuing with traditional utility grid service. The circuit that was selected is Highland 1103, which is located in the heart of Louisville. Figure 1 shows the geographic location (red rectangle) and electrical lines associated with this circuit.

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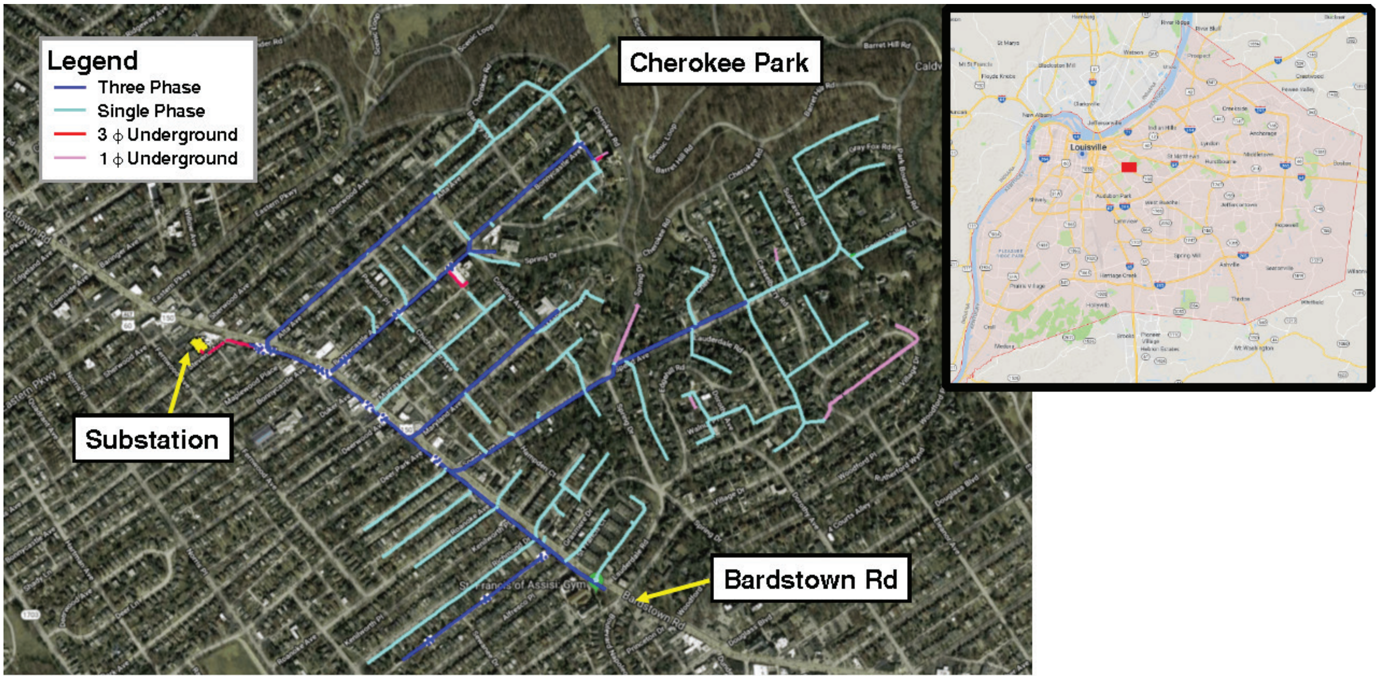
4 https://www.renewableenergyworld.com/articles/2017/08/100-percent-renewable-powered-microgrid-in-illinois-islands-from-the-grid-for-24-hours.html

5 A Resolution for 100% Clean Energy for Metro Louisville Operations by 2030 and Community-wide by 2035.

6 Distributed Generation of Electricity and its Environmental Impacts — https://www.epa.gov/energy/distributed-generation-electricity-and-its-environmental-impacts

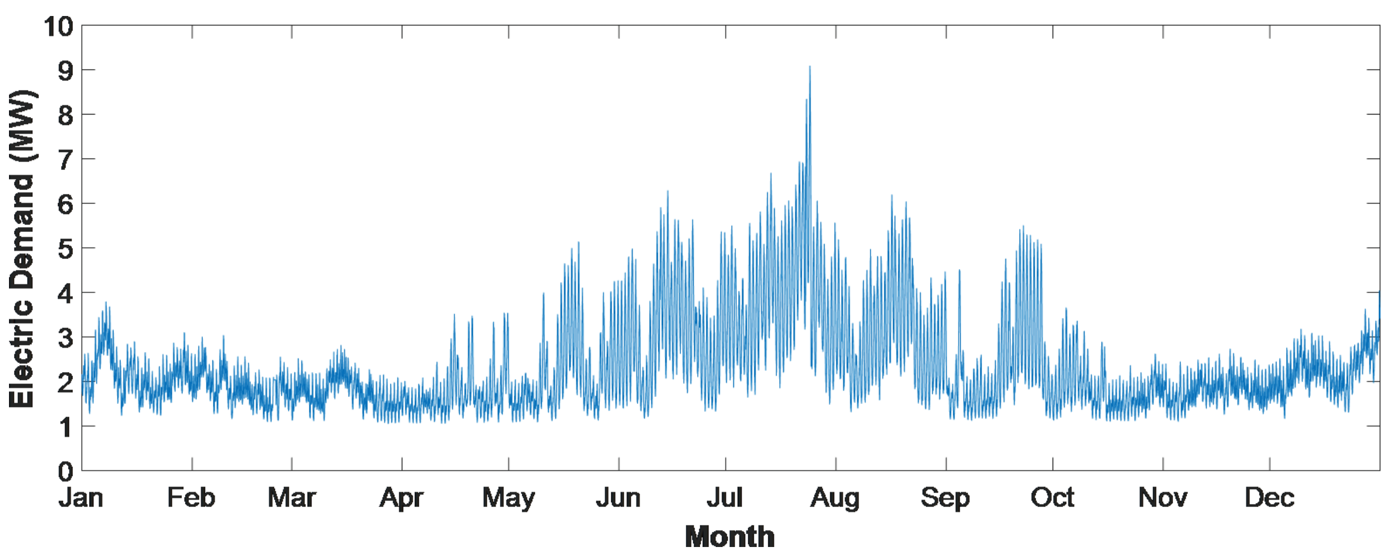
Figure 1: Google Earth Overview of Highland 1103 Circuit Distribution Infrastructure



LG&E operates 6,445 total miles of electric distribution lines making up 572 distribution circuits in and around Jefferson County serving approximately 411,000 electric customers.[7] Highland 1103 is a typical residential/small commercial circuit in that it has approximately 1600 residential customers and 240 small commercial customers, most of which also use natural gas, particularly for space and water heating. It is a 12.47kV circuit consisting of 9.26 total circuit miles (90% overhead, 10% underground and 30% 3 phase, 70% 1 and 2 phase).

Figure 2 displays the 5-minute load data on Highland 1103 for 2017 used in this study. It shows the summer peaking nature of the circuit as well as the lower winter electric demand due to natural gas space heating.

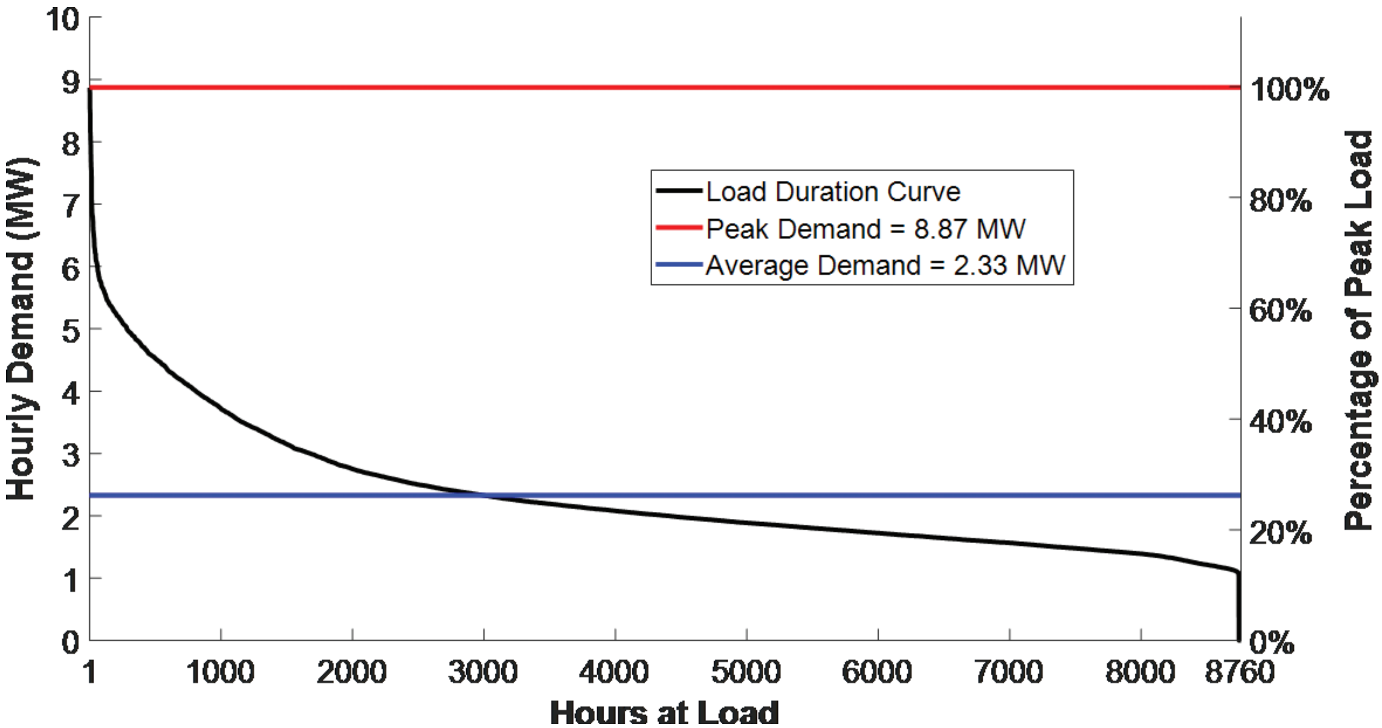
Figure 2: Five-Minute Electric Demand ("Load") for Highland 1103



[7] Data as of December 31, 2017. Includes pro-rata share of indirect or jointly owned assets.

Figure 3 displays average hourly electric demand in 2017 on Highland 1103 from highest to lowest in what is known as a load duration curve. The load duration curve shows that in 2017 the highest hourly load was 8.9 MW, the lowest hourly load was 1.04 MW, and the average hourly load was 2.3 MW. This circuit's load duration curve is typical for a summer peaking system with very high loads occurring in less than 500 hours of the year.

Figure 3: Load Duration Curve for Highland 1103

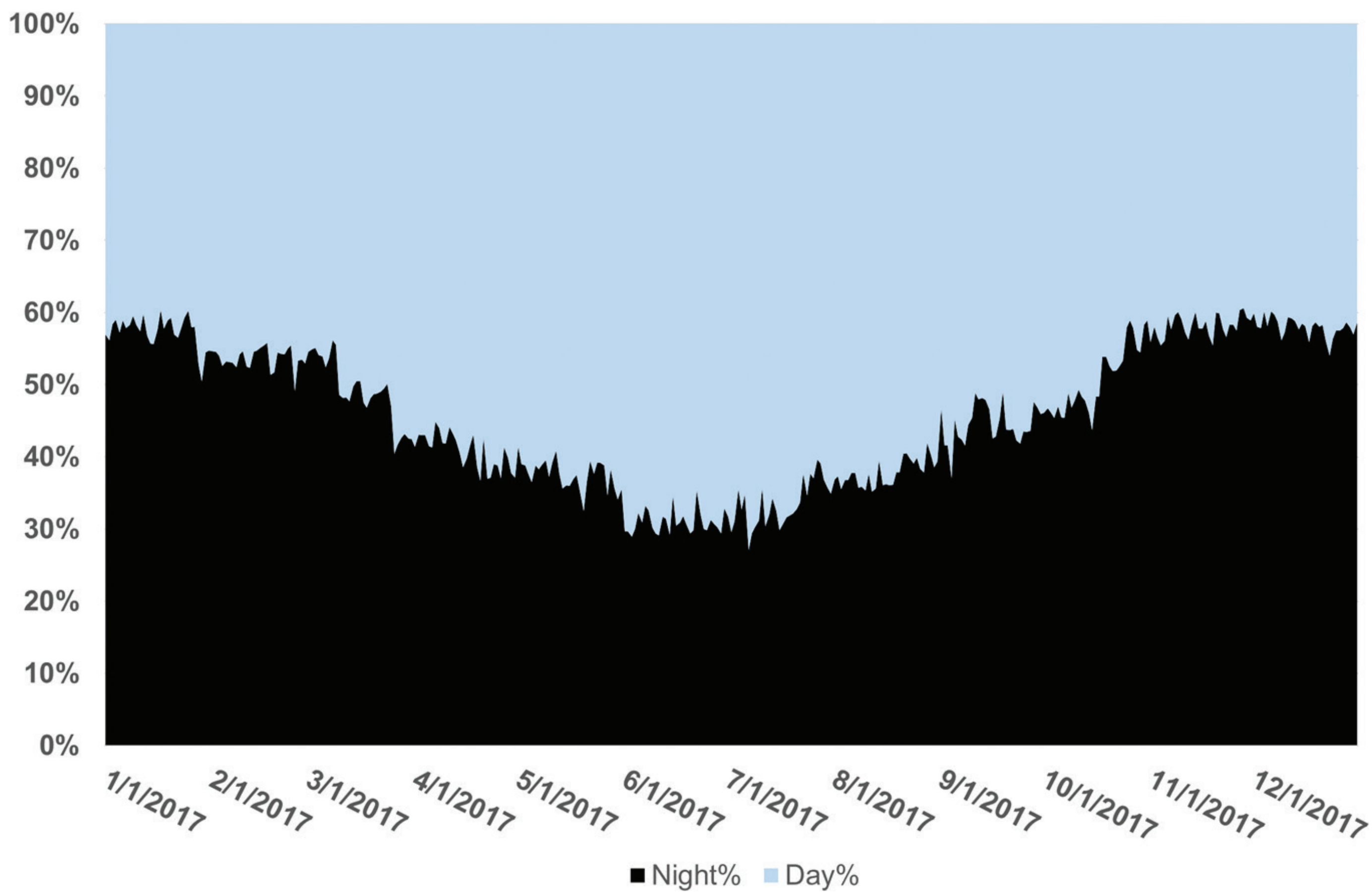


In 2017, base load generation (typically coal and combined cycle natural gas) satisfied the majority of the load shown in the load duration curve, and peaking generation capacity (simple cycle natural gas) served the peaks that only occur for a handful of hours in the year. If this circuit were to be served by 100% local solar generation then solar capacity would be needed to serve the peak hour and an additional amount of solar generation would be required to charge the energy storage required to meet customers' energy needs when the sun is down and on cloudy days. Therefore, much of the solar generation capability will be underutilized for a substantial portion of the year.

To further understand some of the challenges of just using local solar generation and energy storage, it is important to understand how much of Highland 1103 circuit's load occurs during daylight hours and nighttime hours. As shown in Figure 4, despite customers on this circuit predominately using natural gas for space heating, over 50 percent of their electricity is used during the night in winter months. Their usage at night decreases to around 35 percent to 40 percent in summer months as longer days and daytime air conditioning load increases the share of electricity used when the sun is up. Regardless of the season, the customers on this circuit use a substantial amount of energy when the sun is down, energy that must be stored in batteries.[8]

[8] The day/night energy profile of this circuit is comparable to the profile of the entire LG&E and KU system. See Figure 8 in PPL Corporation Climate Assessment at https://www.pplweb.com/wp-content/uploads/2017/12/Climate-Assessment-Report.pdf

Figure 4: Proportion of Energy Consumed during Daylight and Nighttime Hours for Highland 1103



Evaluation Methodology

This case study uses actual five-minute load for 2017 from Highland 1103 and actual five-minute solar irradiance data measured from a NOAA weather station located in Versailles, KY. While the solar irradiance data is from a site that is about 50 miles from Highland 1103, it is representative of regional solar conditions that are adequate for this high-level case study. In general, it should be noted that this is a high-level conceptual study and is not meant to represent a final or optimal engineering or economic design. To design and size the equipment for an actual "off-the-grid" project would require additional analysis and engineering associated with issues such as, but not limited to, load diversity over time, motor starting/stall currents, fault current sources, protection, and over/under voltage risks. Table 1 shows the major assumptions used in preparing this case study.

Table 1: Major Assumptions for Case Study

	Assumption	Low Range	High Range
Utility-scale solar	$/kW installed[9]	810 (installed in 2030)	951 (installed in 2020)
	Annual capacity factor	~17% on average	
	Land requirement — acres / MW	3.2 Acres/MW (DC), 3.84 Acres/MW (AC)	
	Useful life of panels	25 years	30 years
	Useful life of inverters	10 years	20 years
Roof-mounted solar	$/kW installed[9]	1,493 (2030 Dollars)	2,306 (2020 Dollars)
	Average system size (per roof)	5 kW	15 kW
	Annual capacity factor	~17% on average	
	Space requirement — sq. ft./kW	~60 ft^2/kW (DC), 72 ft^2/kW (AC)	
	Useful life of panels	25 years	30 years
	Useful life of inverters	10 years	20 years
Utility scale Li-ion storage	$/kWh installed[9]	327 (installed in 2030)	435 (installed in 2020)
	Peak energy delivery — kW	1,000 kW	
	Energy storage — kWh	4,000 kWh	
	Battery size	0.015 Acres/MWh[10]	
	Useful life	10 years	15 years
In home Li-ion storage	$/kWh installed[9]	476 (installed in 2030)	634 (installed in 2020)
	Peak energy delivery — kW	5 kW (RS)	15 kW (GS)
	Energy storage — kWh	13.5 kWh (RS)	40.5 kWh (GS)
	Battery size	~9.5 ft2 per 13.5 kWh[11]	
	Useful life	10 years	15 years
Average retail rate in 2017 — cents/kWh	Residential	10.90 cents/kWh	
	Commercial	9.28 cents/kWh	
Distribution-only rate in 2018 — cent/kWh	Residential	25% of average retail rate	
	Commercial	26% of average retail rate	
Future retail rate escalation		2%	5%
Cost of Capital		4.40% (100% Debt Financing)	7.58% (Utility Cost of Capital)

When considering utility scale energy storage applications, it is important to be aware of its size and proximity to other structures. Employing the large number of batteries that would be necessary for these cases will require a keen attention to location, spacing, and fire mitigation strategies.[12] Figure 5 shows a typical utility-scale lithium-ion battery site with a 30 MW, 120 MWh (4 hours at peak discharge rate) energy storage system consisting of twenty-four 40-foot containers and a dedicated switchgear/control room, which is much smaller than the system needed for this circuit.

[9] Source: NREL's 2018 ATB (https://atb.nrel.gov/).

[10] Includes spacing required per fire codes, inverter footprint, and associated electrical infrastructure. Assumed 2400 ft2 for 1 MW, 4 MWh block.

[11] Residential and small commercial energy storage is typically wall-mount. 9.5 ft2 indicates wall space required. Actual footprint is dependent on local fire and building codes.

[12] "Big Battery Boom Hits Another Roadblock: Fire-Fearing Cities" https://www.bloomberg.com/news/articles/2018-05-18/the-big-battery-boom-hits-another-roadblock-fire-fearing-cities

Figure 5: Typical 30 MW, 120 MWh Lithium-Ion Energy Storage Site[13]

For all cases analyzed in this study, it is assumed that LG&E's distribution system costs will be included since the system is being relied upon to deliver solar energy to end-users and charge batteries. Other than escalation uncertainty, these costs are the same across all cases and do not drive differences. Also, this case study does not address potential stranded generation and transmission system costs that would be associated with a larger system-wide study.

The study assessed the cost of investments based on i) LG&E's cost of capital and ii) the cost of 100% debt financing. As identified in the "Potential Issues" section below, there are a number of possible ways that behind-the-meter rooftop and storage investments might be financed if owned by the property owner as well as some legislative and regulatory changes that could impact how utility system solar and storage might be owned and financed. This case study is focused on the scope and scale of the technology investments required to be 100% renewables and off-the-grid, not on the financial engineering of specific cases.

This study looks only at the 5-minute load profile from 2017. It does not address how future changes in load or load shape might impact system sizing and cost. For example, weather patterns could alter hourly and daily load shape and energy and widespread charging of electric vehicles would impact both the amount of electricity consumed as well as the daily load shape. Similarly, no assumption is made regarding future rate design or direct load control that might attempt to alter the load shape and the quantity of energy consumed. Lastly, no material change is assumed in natural gas utilization in the homes and businesses on this circuit that would impact electrical load.

Alternative Technology Solutions

Through initial modeling using the Highland 1103 circuit's 5-minute load and corresponding weather measured in 2017, it was determined that 75 MW (AC) of photovoltaic solar accompanied by 300 MWh of energy storage would be required to satisfy 100% of all electric demand in 2017 on this distribution circuit. This study assumes no equipment failures and zero generation capacity margin (for potential load changes), both of which would need to be considered for an actual sizing study. Figure 6 and Figure 7 show estimated solar production overlaid with electrical demand for representative winter and summer weeks. These figures show the variability in solar production day to day as well as by season and illustrate the need for such large solar and energy storage systems for this distribution circuit. A large solar and battery system is required in order to remain off grid during the winter, when there are fewer daylight hours, skies are more frequently overcast, the sun doesn't shine as brightly in the sky, and the majority of electricity demand occurs during the night. During the summertime, however, generation from this same system will exceed the neighborhood's electricity needs. When solar generation exceeds electric demand, the excess energy will be stored in batteries to be used to meet electricity requirements when solar generation is inadequate.

[13] Source: San Diego Gas & Electric.

Figure 6: Representative Week in January 2017 Showing Solar Generation and Electric Demand

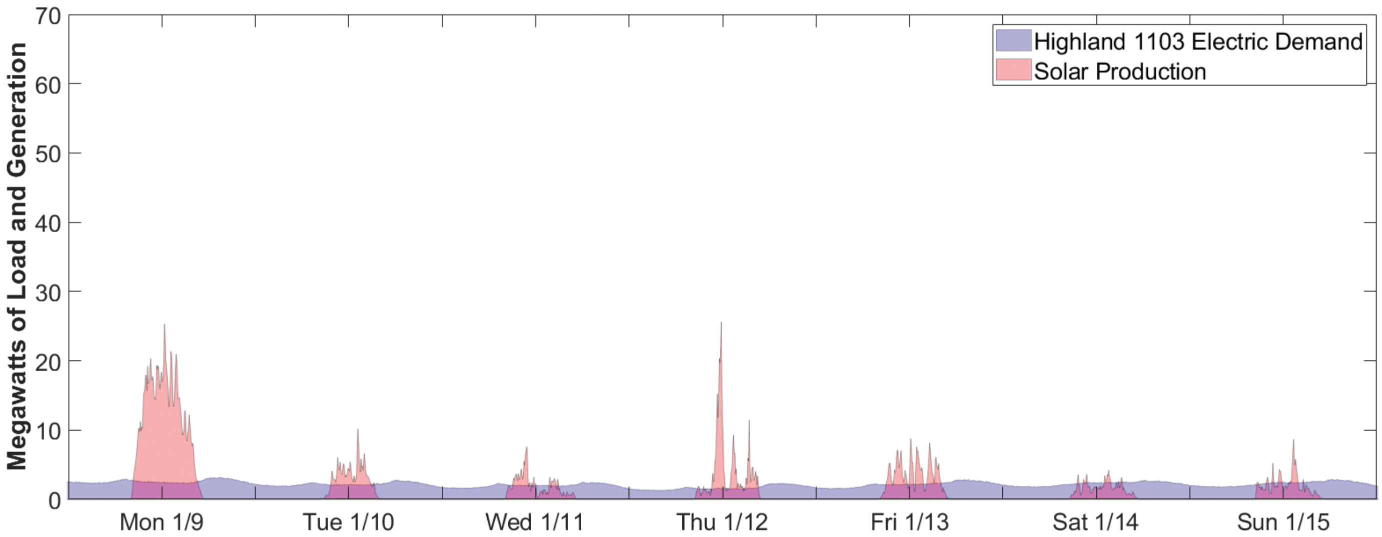
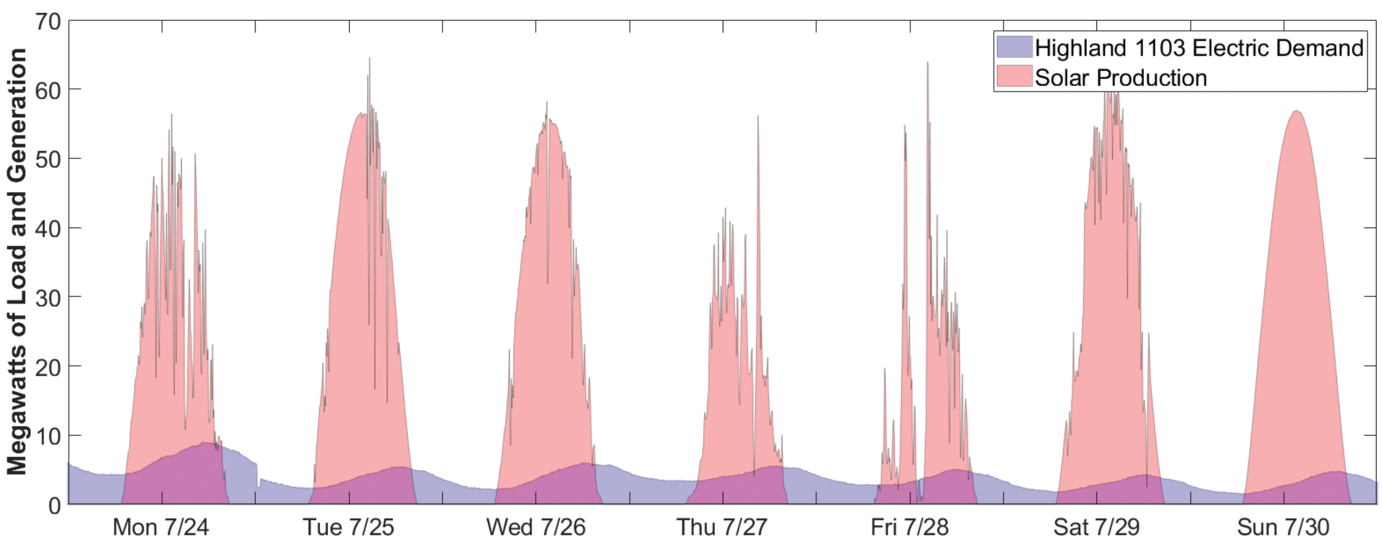


Figure 7: Representative Week in July 2017 Showing Solar Generation and Electric Demand



The study assumed each residential customer on the Highland 1103 circuit could install up to 5 kW of solar and up to 13.5 kWh of battery storage at their homes; non-residential customers were assumed to install up to 15 kW of solar and up to 40.5 kWh of battery storage. The range of results for the quantity of solar and storage technology is shown in Table 2. Note that the quantity of the required utility-scale battery storage is approximately two times the size of the typical storage facility shown in Figure 5.

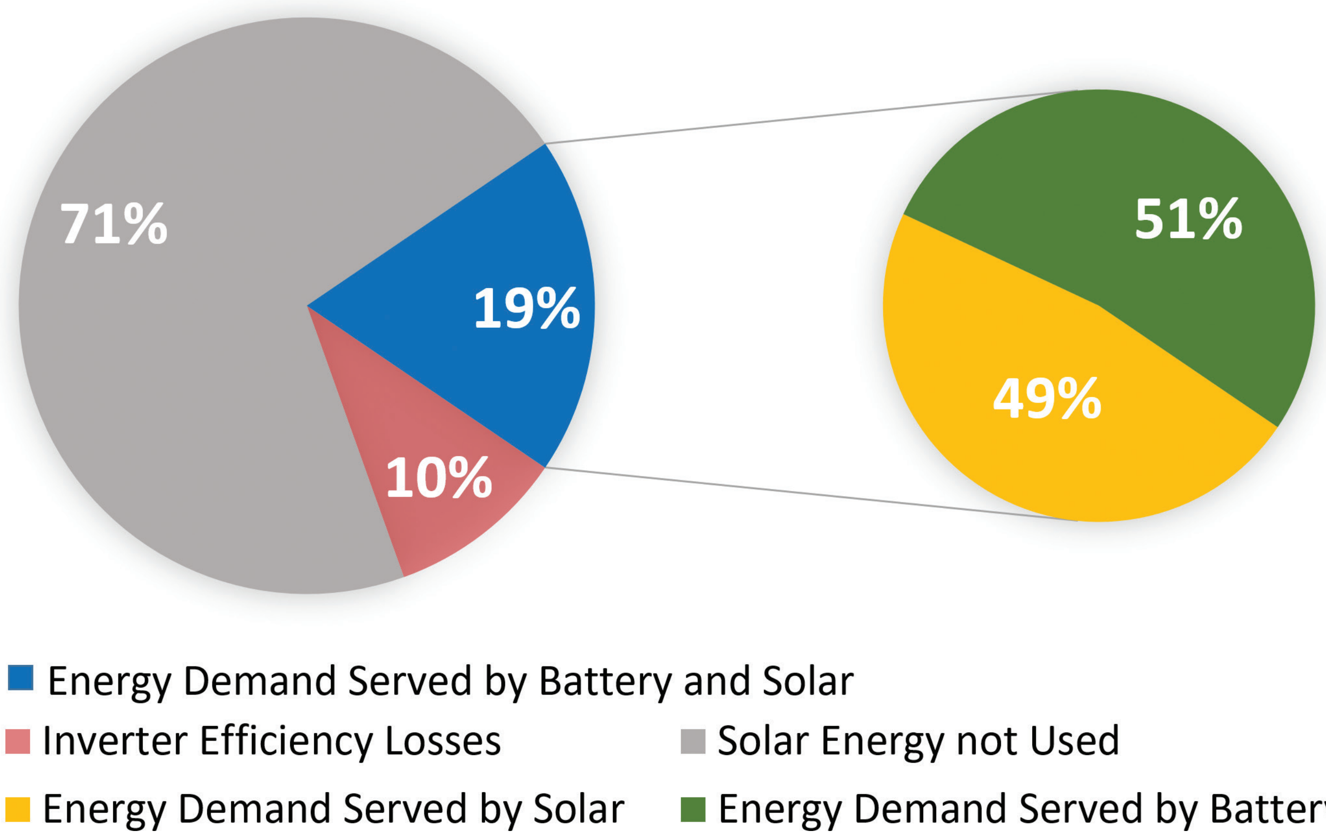
Table 2: Rooftop Solar/In-Home Storage Scenarios

% of Potential Rooftop Solar and In-Home Storage Capacity	Quantity of Solar and Battery Storage				Land Area Required for Utility-Scale Infrastructure (Acres)	Total Capital Cost $(millions)	
	Rooftop Solar (MW)	In-Home Storage (MWh)	Utility-Scale Solar (MW)	Utility-Scale Storage (MWh)		Nominal Cost in 2020	Nominal Cost in 2030
0%	0	0	75	300	293	202	159
50%	6	16	69	284	270	213	165
100%	12	32	63	268	246	224	172

Even assuming every home and business installs solar panels and storage, there is still a large need for utility scale solar generation and storage. In fact, the degree of home and business rooftop solar has a very limited impact on the quantity of utility scale solar required to reliably meet the circuit's energy needs. However, it does reduce the utility-scale infrastructure footprint by almost 50 acres which could be important in land constrained areas like Highland 1103.

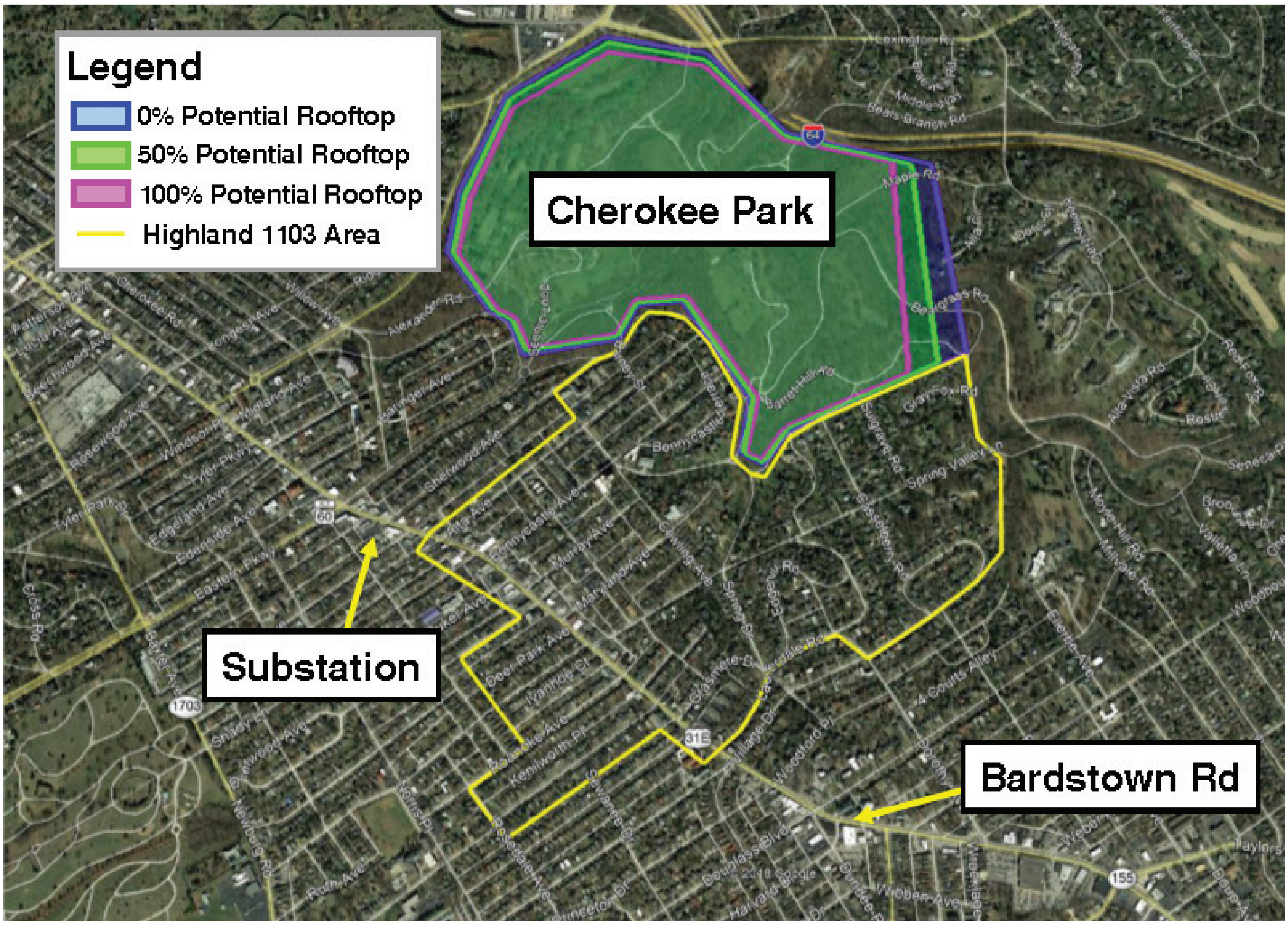
As shown in Table 2, approximately 75 MW of solar generating capacity is required to store sufficient energy to serve load during the winter when nights are longer and clouds are more prevalent. This capacity is approximately eight times larger than Highland 1103's summer peak of around 9 MW. This excess capacity can produce far more energy annually than is required to serve the customers' energy needs. In fact, as shown in Figure 8, approximately 71 percent of the potential solar energy would be unused. Figure 8 also shows that approximately 49 percent of the circuit's electricity would be generated directly by the solar panels with the remainder coming from storage. With so much energy flowing through storage, approximately 10 percent of solar generation would be consumed by inverter losses.

Figure 8: Distribution of Solar Energy Production



Because the interest in distributed solar and storage is often described in terms of local economic impact and reduced need for investment in transmission assets, it is important to understand the space requirements associated with isolating Highlands 1103 from the grid. Figure 9 shows the range of geographic space requirements for the three rooftop solar/in-home storage scenarios. The space required for the utility-scale facilities is large, even in the best-case use of rooftop solar/in-home storage. For this particular circuit, the only large vacant land area contiguous to the Highland 1103 circuit is Cherokee Park. LG&E is not recommending using the park in this manner but placing utility scale solar in other areas still impacts land use and would require additional electric lines to connect the facilities to this particular circuit. These costs are not included in this study.

Figure 9: Representative Land Use Required for Utility-Scale Solar and Battery Storage



Cost Comparison of Solar/Storage Cases to Remaining Connected to the Grid

Each of the rooftop solar with in-home storage scenarios in Table 2 were evaluated based on both LG&E's cost of capital (7.58%) as well as the cost of 100% debt financing (4.40%). The study was performed using NREL's cost forecasts for 2020 and 2030, which show continued future declines in both solar and energy storage costs.[14] In this study, the solar and battery storage systems were evaluated in a very favorable light. For example, all assets were assumed to have a useful life of 30 years, fixed operating costs for the solar and battery systems were ignored, and an inflation rate of zero percent was used to estimate nominal solar and battery storage costs in 2020 and 2030 from NREL's forecast. These and other assumptions are optimistic for the solar with storage concept (see "Favorability of Major Assumptions" for further discussion).

[14] NREL expects the costs of solar and battery storage to decline from 2020 to 2030 by 1.6% per year and 2.8% per year, respectively, in real terms.

In order to compare the cost of using 100% solar and storage to serve the electric load on the Highland 1103 circuit, the investments in solar and storage were levelized over 30 years and added to an estimate of the costs of maintaining and operating the existing distribution system that would still be required to serve load. These costs were then compared to a range of possible future costs of continuing to receive energy from the LG&E system. Note that the range of possible future LG&E costs are not predictions of future electricity prices but are meant to capture a range of possible future price paths over the next 30 years for comparing to the solar/storage off-grid cases.

Table 3 shows the levelized cost of electricity of serving the Highland 1103 load for all of the cases evaluated. These costs exclude the costs of operating and maintain the distribution system that would still be required. Not surprisingly, cases with a higher cost of capital have a higher levelized cost of electricity. The cases with rooftop solar and in-home battery storage require less land for utility infrastructure but are more expensive. Finally, the cost of installing the solar and battery systems in 2030 is less expensive than in 2020 due to the forecast of decreasing solar and battery storage costs.

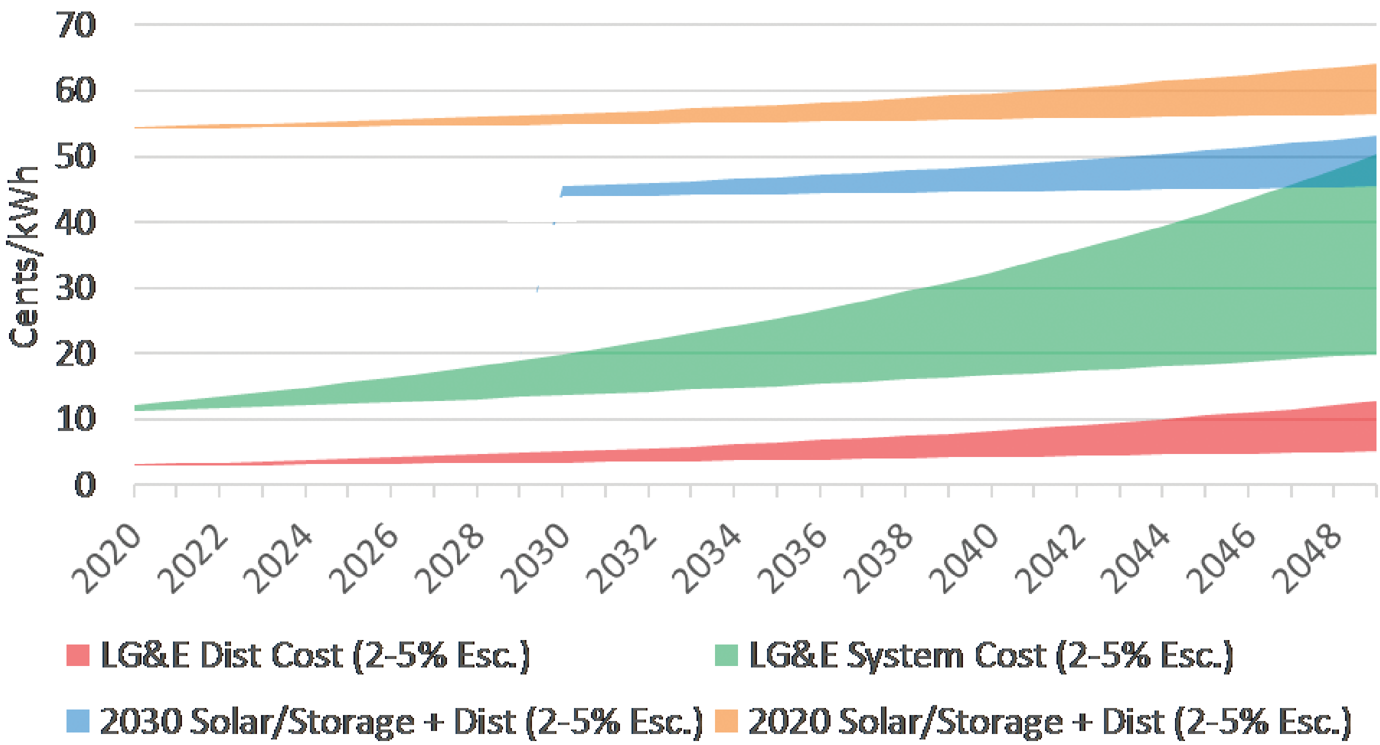
Table 3: Levelized Cost of Electricity excluding Distribution System Costs

Commission Year	Cost of Capital	% of Potential Rooftop Solar and In-Home Storage Capacity	Solar & Battery Storage System Cost Levelized Cost of Energy (cents/kWh)
2020	7.58%	0%	79.2
		50%	83.2
		100%	87.1
	4.40%	0%	51.4
		50%	54.0
		100%	56.6
2030	7.58%	0%	62.2
		50%	64.5
		100%	66.8
	4.40%	0%	40.4
		50%	41.9
		100%	43.3

Adding the cost of maintaining the distribution grid to the best 2020 and 2030 cases from Table 3 allows the comparison to a range of rate paths for staying on the existing LG&E grid. Figure 10 contains a range of rate paths for the LG&E distribution system in red and the entire LG&E system in green.[15] The ranges were created by escalating actual 2017 costs by 2 percent and 5 percent. The total costs for the best 2020 and 2030 cases were created by adding the range of distribution costs to the levelized costs in Table 3. This cost reflects the average cost of electricity for all customers on the Highland 1103 circuit.

[15] LG&E distribution system costs are assumed to grow proportionally with LG&E system costs.

Figure 10: Total Solar/Battery Storage Cost versus LG&E System Cost



As shown in Figure 10, the cost of isolating the Highland 1103 circuit from the grid and serving its electricity requirements with solar and battery storage is 2.5 to 3.5 times greater in 2030 than the LG&E system. Assuming LG&E's rates were to escalate at 5 percent annually, then it is possible that a solar and battery storage system installed in 2030 might be less expensive by the late 2040s. It should be noted that since 1990, LG&E average electricity rates have increased at an average rate of about 2.1 percent meaning that future rates would have to escalate at more than twice the historical rate in order for the solar and storage system to be even plausibly economical. The study also shows that with both solar generation and battery storage costs forecasted to decline, waiting as long as possible to make such investments would increase the probability of being economical compared to the LG&E system rates.

Favorability of Major Assumptions

In preparing the financial analysis for this study, a number of the operational and technology performance parameters were assumed to be favorable toward reducing the cost of using 100% solar generation and energy storage to serve Highland 1103. For example:

- The financial results presented assumed all panels, inverters, and batteries perform perfectly for 30 years. Based on what we know today, inverters and batteries are likely to have much shorter lives.
- The solar panels and battery storage were sized to exactly match 2017 actual load. Some contingency would need to be built in order to address load uncertainty and random equipment failure.
- No land cost was assumed for the utility scale solar generation and battery storage.

While recognizing that there would be incremental costs associated with addressing these issues in an actual project design, these items are also more uncertain and subject to change over time. Because the purpose of this case study was to evaluate the local solar generation and storage concept at a high-level, the Company did not want to distract from the study's fundamental purpose by explicitly trying to incorporate costs to address these issues.

Potential Issues Identified in Preparing this Case Study

As stated at the outset, this case study is a high-level analysis of the technology and financial implications associated with serving the load on a single LG&E distribution circuit. One of the benefits of preparing such a study is that it identified a number of issues and questions that a more detailed study would certainly need to address should such a project ever be considered in the future. Like this study, the questions and issues identified below are not meant to be exhaustive.

1. This study assumed that all roof-top solar and in-home storage was built overnight. In the real world, that would not occur so provisions (technical and financial) would need to be made to address changes (both increases and decreases) in the quantity of roof-top solar and in-home storage over time.

2. It was assumed that load (energy and shape) would be rather stable over 20 years. Provisions (technology and financial) would need to be put in place among the customers on the circuit to deal with material changes in load and load shape that would impact asset utilization and possibly cost recovery and future asset investment. Because the costs of this off-grid system are for all practical purposes fixed, changes in energy usage would not materially impact costs but could result in over- or under-collection of fixed costs. For example, unless load is forecasted to grow (say due to increased market penetration of electric vehicles or converting from natural gas to electric space heating), the economics of energy efficiency may not reduce overall costs but instead only shift fixed costs to other customers on the circuit depending on rate design.

3. Once such a system is created, the ability to undo it in the future may be limited or very expensive, so exit costs should be considered.

4. It was assumed for purposes of this study that all assets are owned and financed by LG&E but that may not have to be the case, particularly for roof-top solar and in-home storage. Some legal and regulatory issues would have to be addressed in this new type of system.

5. Because all assets were assumed to be owned and financed by LG&E there was no need to address compensation to individuals who invest their own funds in rooftop solar and in-house storage. However, in reality, it is highly likely that individual homeowners and business would invest their own funds and would seek compensation for contributions to supporting the circuit's load.

Conclusion

The declining cost of solar generation and projections of future cost declines for battery storage along with increasing focus on CO_2 emissions have raised the interest of both customers and utilities identifying opportunities to deploy these technologies. To date, the vast majority of applications of these technologies have focused on applications that still require connection to the national power grid, a grid that today relies heavily on fossil fuel resources to reliably meet customers' real time electricity needs. This study was a valuable exercise in identifying and evaluating the numerous technological, economic, land use, and transitional challenges that must be met in the future in order to scale solar and storage to the levels required to meet a sizable proportion of the nation's electricity needs.

The report was prepared by staff from the following departments at LG&E and KU Energy: Electrical Engineering & Planning, Technology Research & Analysis, Generation Planning, and Sales Analysis & Forecasting.