



**Grid of the Future Project**

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Eastern & Central Regions of the Commonwealth of Pennsylvania

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Tab A. Personnel, Tab B. Fringe, Tab D Equipment, and Tab F Contractual, of the Budget Justification Workbook of this document may contain business sensitive, trade secrets, proprietary, or otherwise confidential information that is exempt from public disclosure. Such information shall be used or disclosed only for evaluation purposes or in accordance with a financial assistance agreement between the submitter and the Government. The Government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source. [End of Notice].

## Project Overview

PPL Electric Utilities Corporation (PPL Electric or the Company), a regulated utility company responsible for transmission and distribution of electricity, is proposing the Grid of the Future Project (Project), which includes \$99 million of smart grid investments. **These interrelated, innovative investments include a combination of information technology (IT) and operational technology (OT) focused on creating a self-healing electric grid that will catalyze the unified Grid of the Future goal to reduce outages, increase resilience, improve customer affordability, maximize grid flexibility, and enables federal and state objectives of a clean energy transition.** The OT and IT investments in this Project portfolio were purposely selected by the Project's prime applicant and grant recipient, PPL Electric, a regulated utility, and team member, affiliate and services company, PPL Services Corporation (PPL Services) (PPL Electric, together with PPL Services, the Project Team) together to maximize their benefits and synergies.<sup>1</sup>

PPL Electric has built a portfolio that accommodates a rapidly evolving electric grid balancing strong grid resiliency, low customer costs, and high reliability all while embracing two-way power flow from distributed energy resources (DER). These interrelated investments include smart OT devices, like automation on the Company's urban underground Low-Tension Networks, predictive failure monitoring devices, and intelligent single-phase devices which enable real-time control of the grid and two-way communication and power flow on the grid.

It also includes cutting-edge IT infrastructure that will push PPL Electric's industry-leading smart grid capabilities even further. These investments include a next-generation Advanced Distribution Management System (ADMS), Advanced Energy Management System (AEMS), Asset Hub, and Digital Twin. Together, this suite of IT investments will gather data in a centralized hub capable of using artificial intelligence (AI) and machine learning (ML) to understand grid events such as outages, load changes, and DER fluctuations and then seamlessly and automatically identify their locations, reroute power, and initiate restoration safely and automatically in real-time. The combination of this IT and OT investment will result in a grid tailored to the PPL Electric service territories to expand DER and embrace the load impacts from electrification.

This portfolio enables communities within PPL Electric's service territory to pursue climate goals, including Electric Vehicle (EV) adoption, carbon reduction, and the use of carbon-free electricity. The push for clean energy is intensifying as the U.S. federal government announced policy goals to achieve carbon-free electricity by 2035.<sup>2</sup> State and local governments are pushing for significant economy-wide Greenhouse Gas (GHG) reductions, including the Commonwealth of Pennsylvania, targeting a 26% reduction from 2005 to 2025 and an 80% reduction by 2050.<sup>3</sup> As such, building the Grid of the Future is essential to the clean energy transition.

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<sup>1</sup> PPL's affiliates ("Affiliate Applicants") are also submitting applications for federal funding under DE-FOA-0002740 Topic Area 2 to support AEMS, ADMS, Asset Hub, and Digital Twin, which are enterprise-wide systems. The Project Team assures there will be no duplication of federal funding: each Affiliate Applicant only includes each Affiliate's cost ration for these enterprise-wide line items. In this instance, the Project Team only includes the cost of AEMS, ADMS, Asset Hub, and Digital Twin allocated to PPL Electric. Furthermore, each Affiliate Applicant submits its cost share proposal does not include duplicative federal funding. In summary: there is no potentially duplicative federal funding risk; awarding more than one Affiliate Applicant will not result in duplicative federal funding.

<sup>2</sup> [White House](#). "FACT SHEET: Biden Harris Administration Races to Deploy Clean Energy that Creates Jobs and Lowers Costs." 2022 January.

<sup>3</sup> [Pennsylvania Energy Programs Office](#). "Clean Energy Program Plan." 2022 December.

As Pennsylvania's communities push toward a cleaner energy future, PPL Electric is working with the Pennsylvania Department of Transportation (PennDOT) to advance the state's commitment to the National Electric Vehicle Infrastructure (NEVI) Formula Program to expand EV use. Pennsylvania signed a multi-state agreement in 2020 committing to 30percent of new medium-duty and heavy-duty truck sales being zero-emission vehicles by 2030.<sup>4</sup> Ultimately, the state aims to make electric vehicles the majority of truck sales by 2030. Critical to accomplishing these ambitious targets are improvements to the resilience and reliability of the grid to support the influx of EVs on the roads. Additionally, PPL Electric has worked to support its communities' efforts to create Climate Action Plans (CAPs), which include EV adoption as a goal. With GRIP funding, PPL Electric will make investments that will accelerate and enable the achievement of its electrification goals in three ways: (1) supporting federal, state, and community clean energy and carbon reduction goals, (2) positioning the grid as an enabler for EV adoption, electrification, and DER, and (3) investing in infrastructure that supports economic development and advanced manufacturing in Pennsylvania.

The drive to achieve EV adoption coincides with increased storm frequency within PPL Electric's service territory. This frequency can jeopardize the achievement of the state's electrification goals. PPL Electric experienced 36 storms in 2022, its second-highest annual storm count on record. 2022 is just one year after a record 42 storms in 2021. Tropical Storm Ida alone caused more than 1,200 cases of interruptions and affected over 85,000 customers, resulting in PPL Electric's largest restoration effort in recent history. In addition to the threats to resilience and reliability highlighted by the storms mentioned above, PPL Electric has also seen a significant impact from non-storm weather-related outages. In 2022, the Company experienced its highest annual "grey sky days," with more than 60 weather-related outages with no actual storm event.

Improvements to the grid's reliability and resiliency positively impact attracting businesses to PPL Electric's service area, which can lead to equipment and product damage, reduced employee productivity, and lost revenue. According to the United States Department of Energy (DOE), electricity disruptions cost Americans \$150 billion every year.<sup>5</sup> Continuing to provide stable infrastructure will position PPL Electric to meet the reliability expectations of existing and prospective businesses throughout its service territories.

PPL Electric is committed to supporting the DOE goals of reducing carbon emissions and mitigating climate change. The Project addresses these priorities by utilizing a combination of IT and OT to increase grid flexibility. These IT and OT investments will interact with each other, greatly increasing the magnitude of overall benefits of this portfolio and enabling more carbon-free generation and greater EV charging capability.

## **Background**

PPL Electric has a proud history of innovation and successful project implementations. Over the past twenty years, the Company has deployed two rounds of Advanced Metering Infrastructure (AMI) which allows for power outages to be identified automatically and immediately. The Company has also established an industry-leading Advanced Distribution Management System (ADMS) which facilitates Fault Isolation and Service Restoration (FISR). Deployed as an industry-leading technology in 2015, ADMS and FISR control 7,800 smart devices,

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<sup>4</sup> [PennDOT](#). "National Electric Vehicle Infrastructure (NEVI) Formula Program." January 2023.

<sup>5</sup> [Department of Energy](#). "The Smart Grid: An Introduction."

creating a self-healing grid, preventing 1.6 million outages automatically for PPL Electric customers, including those in PPL Electric's Disadvantaged Communities (DAC). In 2019, PPL Electric implemented an industry-leading Distributed Energy Resources Management System (DERMS) which led to enabling the monitoring and management of more than 4,000 customer-owned Distributed Energy Resources (DERs). Standing up PPL Electric's DERMS has involved deploying thousands of DER management devices which facilitate the management and monitoring of DERs, improving power quality and reducing overall costs for both PPL Electric and its customers.

Notably, PPL Electric has implemented all these improvements without raising distribution rates. Maintaining affordability has improved access to reliable electricity across the service territory. PPL Electric is looking for funding from the Infrastructure Investment and Jobs Act's (IIJA) Grid Resilience & Innovation Partnerships Program (GRIP) to accelerate its continued modernization and improvement of the grid.

PPL Electric has a total of 975 census tracts in its service territory<sup>6</sup> of which 202 are defined as DACs (approximately 21 percent).<sup>7</sup> These DACs represent 835,000 people across the entire service territory, which serves 4.3 million people in 1.5 million households. These households include 42% that are below 200% of the federal poverty level.<sup>8</sup> IIJA will help the Company make significant efforts to accelerate existing outreach initiatives to make greater impacts.

### **Climate Resilience Strategy**

PPL Electric has hardened its infrastructure against extreme weather and will continue this strategy through future investments. A primary objective of the Grid of the Future Project is to build on past investments and further equip the Company's grid with self-healing capabilities to better respond to and prevent disruptions. This will ensure that customers impacted by the portfolio experience fewer outages. Several investments focus on grid visibility so PPL Electric can collect better data about asset performance and optimize performance to improve resiliency.

### **Alignment with Community Priorities**

PPL Electric has followed its well-established process to engage in outreach, training, and co-marketing with trade allies and community-based organizations, as well as with city officials, state officials, and community leaders. These discussions have helped PPL Electric understand the priorities and challenges of the community so that it can manage its portfolio to serve the best interest of its customers, specifically by prioritizing reliable, resilient service.

PPL Electric's commitment to engaging with the community on these types of programs is further demonstrated by its partnership with the Commonwealth of Pennsylvania on a separate program funded by IIJA. PPL Electric has partnered with PennDOT, the Pennsylvania Department of Environmental Protection (PA DEP), and the Eastern Pennsylvania Alliance for Clean Transportation (EP-ACT) to host five in-person, educational stakeholder sessions in communities in the PPL Electric service territory highlighting the state plan for the NEVI Formula Program.

The push for decarbonization and reducing environmental impact is important to Pennsylvania's state policies. In advancing these policies, PPL Electric has worked with its communities to support their climate action plans (CAPs). To date, four communities in PPL Electric's service territory have built roadmaps to reduce GHG emissions and mitigate climate

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<sup>6</sup> Department of Energy, "Energy Justice Mapping Tool" 2022 December

<sup>7</sup> Department of Energy, "Energy Justice Mapping Tool" 2022 December

<sup>8</sup> Ibid

change, including the cities of Bethlehem and Lancaster, Cumberland County, and Carlisle Borough. An additional 12 communities are in various stages of CAP development.

**Community Benefits Plan: Job Quality and Equity and Maximizing benefits across DACs**

PPL Electric has established a grant office to facilitate the rollout of IJIA funding along with grant requirements and reporting associated with the implementation process. This office has coordinated with the community engagement team to identify DACs and evaluate the priorities and challenges they face. This proposal delivers grid benefits to communities and supports them with economic development. During Project implementation, the grant office and its community engagement team will leverage existing community relationships to help DAC residents receive employment opportunities and other benefits. In addition, reliable infrastructure will enable the development and support of new businesses in DACs and thereby drive job growth.

**Technical Description, Innovation, and Impact**

PPL Electric's IJIA proposal seeks interrelated investments tailored to support the priorities identified by the DOE in its Smart Grid FOA9. PPL Electric identified these projects based on its needs, resources and capabilities, shovel-readiness, and potential partnerships. The Smart Grid Grant objectives prioritized by the Company include:

- Increase the capacity of existing transmission facilities or the capability of the transmission system to reliably transfer increased amounts of electric energy.
- Prevent faults that may lead to wildfires or other system disturbances.
- Integrate variable renewable energy resources at the transmission and distribution levels.
- Facilitate the aggregation and integration (edge-computing) of electric vehicles and other grid-edge devices or electrified loads.

PPL Electric is prepared to begin implementing its portfolio after receiving IJIA funding. The Company has dedicated resources to advance the efficient execution of IJIA implementation plans, permitting, and land rights, and capturing stakeholder support. The preparation PPL Electric has done to tailor its application demonstrates the Company's commitment to GRIP priorities and opportunities for modernization and accessibility that funding will enable.

PPL Electric's proposed portfolio has been thoughtfully put together by examining customer and grid benefits, its business needs, shovel-readiness, and the Smart Grid Grant objectives. The assets included within the portfolio work in tandem to improve reliability and resiliency by expanding upon PPL Electric's existing Smart Grid.

**The Project will deliver more than 5,000 devices to improve grid flexibility over five years**

PPL Electric has a deep history of leveraging IT in combination with its OT assets. The Company rolled out an initial ADMS system in conjunction with over 7,200 smart devices that automatically restored 1.6 million customers. Additionally, the Company installed dynamic line rating (DLR) sensors which, while tied to the Company's Transmission Management System (TMS), allows for the ratings of transmission lines to vary depending on factors such as outside temperature and weather. This industry-leading technology has saved the Company over \$10 million through avoided transmission line upgrades. PPL Electric has a history of leading industry success and with the support of IJIA GRIP Smart Grid Funding, will continue to leverage its combination of IT and OT capabilities.

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<sup>9</sup> [DE-FOA-0002740 Amendment 2](#). "Grid Resilience and Innovation Partnerships." November 29, 2022; page 24.

PPL Electric’s investments include a combination of hardware and software components that work seamlessly together to deliver grid flexibility to the transmission and distribution systems and deliver significant customer benefits. Additionally, these investments allow the Company to build on its success in leading smart grid innovation throughout the industry.

<b>Investment</b>	<b>Brief Description</b>
<b>Advanced Distribution Management System (ADMS)</b>	An enterprise software platform used by the utility to command and control the electric distribution system, including outage management and system operations. This will be an upgrade on PPL Electric’s current ADMS, allowing for incremental integration for DERMS, and additional DER integration. This new ADMS will also be capable of harnessing AI and ML to improve resilience and reliability as well as the capability to support EV adoption.
<b>Advanced Energy Management System (AEMS)</b>	An enterprise software platform used to command and control the electric transmission system including outage restoration and system operations. The upgrade also allows for dynamic line ratings (DLR), smart alerting of system issues, and automated restoration.
<b>Digital Twin</b>	An updated GIS system that includes an integrated and automated design toolset that creates a digital representation of the electric grid with every asset and subcomponent. The Digital Twin assembles geospatial information on grid assets and manages the numerous relationships and interactions between grid components, such as electrical connectivity, communication, asset-specific customer risk identification, and physical connection.
<b>Asset Hub</b>	A centralized multi-tiered asset data platform across the enterprise capable of ingesting and storing high velocity and granularity asset data from sensors and grid devices. This Asset Hub architecture includes an asset repository, data lake for storage, and ingests many types of rich data, and can use AI. When combined with the digital twin, this enables data-driven automated decision-making managing every asset on the network.
<b>Single-Phase Smart Recloser</b>	Install up to 250 smart recloser protective devices on single-phase taps to sectionalize end-of-line outages from the rest of the network (self-healing) and provide telemetry to operations, ultimately improving reliability.
<b>Predictive Failure Monitoring</b>	Install sensors on 12kV distribution circuits to monitor system conditions and detect failing equipment to repair or replace equipment before it impacts customer reliability.
<b>Low-Tension Network (LTN) Automation<sup>10</sup></b>	The LTN is a secondary underground network commonly found in dense urban areas which align closely with DACs. This system is interconnected to other parts of the distribution system to support the loading of an area. The LTN includes equipment such as protectors, transformers, relays, monitors, cables, and sensors to enable grid automation capabilities.

The software components of PPL Electric’s proposal are industry-leading, cutting-edge solutions to grid flexibility. ADMS and Digital Twin solutions establish an electrical connectivity model, asset relationships, and operational capability to utilize the Company’s hardware investments listed to their full potential. Additionally, the Asset Hub allows storage of asset data and adoption of ML that permits optimized investments in the future. The smart grid hardware works seamlessly with the software to deliver benefits to PPL Electric’s customers. Its proposed investments work in tandem to allow the Company to monitor field assets and feed operational data into the software. These utilize the software solutions to improve automatic restoration through ADMS, system visibility through Digital Twin, and asset investments through Asset Hub.

### **Single-Phase Smart Recloser**

#### *Description of Technology Used*

PPL Electric plans to install 250 single-phase smart reclosers, which work in coordination with the ADMS software platform to sectionalize end-of-line outages from the rest of the network and improve operational telemetry. These single-phase reclosers are remotely operated and

<sup>10</sup> [PPL](#). LTN is commonly known as a “Secondary Network.”

controlled and will be installed on the single-phase distribution system to increase reliability for residential and small commercial customers. ADMS works with smart devices, such as reclosers, to elevate existing single-phase infrastructure to the same level of remote capabilities as the 3-phase system. This allows PPL Electric to upgrade and improve upon its existing infrastructure, especially in rural areas, in a cost-effective and efficient way. The devices will employ advanced relay control equipment, low-maintenance vacuum interrupters, and cellular communication hardware designed for secure data transmission.

#### *Project Goals, Anticipated End Goals and Expected Outcomes*

This program seeks to deploy and catalyze technology solutions that increase the flexibility, efficiency, reliability, and resilience of the electric power system through the widespread installation of single-phase, remotely operable, protective devices. There is a particular focus on enhancing the system's capabilities to meet the following objectives: using single-phase reclosers to de-energize only the smallest amount of customers possible during an outage while also appropriately isolating a fault that may lead to wildfires, equipment damage or a public safety risk. Single-phase reclosers will support the aggregation and integration (edge-computing) of electric vehicles and other grid-edge devices or electrified loads.

Between 2014 and 2022, PPL Electric installed approximately 4,400 three-phase smart reclosers. PPL Electric's ADMS controlled the three-phase reclosers and had a powerful effect – saving 1.6 million customer outages between 2015 and today. The implementation of single-phase smart reclosers is the next step in PPL Electric's Distribution Automation strategy in leveraging the full capability of ADMS with smart devices.

#### *Anticipated end product*

The single-phase reclosers are vital for a smart grid. They provide PPL Electric with increased visibility and allow for fault isolation, fully automated switching, and rerouting of power in the event of outages. The devices also enable better coordination than traditional single-phase devices. The single-phase devices in this proposal will provide benefits to about 28,000 customers. In terms of end goals and outcomes, single-phase reclosers will contribute to System Average Interruption Frequency Index (SAIFI), System Average Interruption Duration Index (SAIDI), and Momentary Average Interruption Frequency Index (MAIFI) improvements.

#### *Innovation, impacts, and market impacts*

The advanced relay technology that is part of the single-phase reclosers will reduce system disturbances by accurately identifying, responding, and reporting problems on the single-phase system. The increased visibility will allow PPL Electric to identify and adapt to customer needs on the distribution system as more grid-edge technology is employed. Additionally, the single-phase reclosers provide better coordination for the system than can be achieved from traditional single-phase protection devices, such as fuses. Increasing the remote operability of the single-phase distribution system allows for future advances in automatic restoration and the rerouting of power, a technology that is currently limited to larger three-phase circuits.

Single-phase reclosers enable additional future investments to be made by PPL Electric. By installing the single-phase reclosers, the Company can prepare for implementation of single-phase FISR, which quickly identifies the location of a fault and isolates it to minimize customer impact. PPL Electric cannot explore implementation of future FISR projects without reclosers.

#### *Project Impacts*

PPL Electric expects the single-phase reclosers to support a clean energy transition by created better reliability and operator visibility to react more quickly to disturbances. The benefits of single-phase recloser implementation, mainly for customers in rural areas with low customer

concentration, is estimated to be a reduction of 520,000 CMI per year, assuming saving 20 minutes per outage because the fault locating abilities will significantly reduce crew patrol time. An additional, non-quantifiable benefit is enhanced system visibility for grid operators so they can proactively find and identify problems on the grid before they cause a permanent outage, indirectly saving more CMI. When a transient fault occurred on the single-phase system, such as a tree branch or a tracking insulator, a single-phase recloser will trip and reclose causing a momentary interruption. Historically, the Company would not be notified about this momentary interruption because single-phase reclosers have not had remote reporting. These new devices will communicate constantly with ADMS, notify operators when a momentary has occurred and provide data that can be used to locate and identify the momentary's cause, allowing for proactive repairs before a permanent interruption occurs.

### **Predictive Failure Monitoring**

#### *Description of Technology Used*

Predictive Failure Monitoring (PFM) allows PPL Electric to detect electrical signatures and disturbances, classify the equipment type, then locate and make repairs on the system prior to a failure resulting in an outage. Proactive repairs improve system reliability while reducing cost and resources needed. For example, these monitors can detect a conductor splice nearing failure. Without the technology, the splice would fail and cause customer outages. Identifying equipment when it is failing, but not yet failed, allows to extend the useful life of healthy equipment rather than traditional, cyclical replacement based on age or other similar factors.

Additionally, PFM has the potential to detect vegetation encroachment on electrical facilities. This allows for a new approach for vegetation projects and possibly improves the strategy in the future so that vegetation issues are captured and handled before an outage occurs or the maintenance cycle for trimming is reached.

This technology is necessary because as equipment begins to fail, electrical and component degradation occurs and may potentially cause the equipment to become a conductive path to ground with current flowing through it. As this occurs, an indication of the degradation is emitted. This emittance is present in a form of a radio frequency. The radio frequency can be picked up and the frequency type identified by nearby sensors. Different types of failures emit different levels of radio frequency. The time it takes for this radio frequency to travel in both directions is then used to pinpoint a location down to the nearest couple of feet.

#### *Project Goals, Anticipated End Goals and Expected Outcomes*

Installing 5,000 PFM sensors across the distribution network provides greater visibility into system health and improves customer safety and reliability. This technology will prevent disruptions to customers and the overall grid operation, thereby improving customer satisfaction and reliability. The ability to classify equipment failures based on severity greatly improves the work optimization process. PFM allows critically damaged equipment to be replaced immediately while non-critical repairs can be added to the standard work procedure, reducing the cost and resources needed for emergency repairs. It also maximizes the asset life expectancy by replacing equipment before it fails but leaving it in service as long as it is healthy and reliable regardless of age or similar identifier. This technology can also greatly reduce the number of emergency repairs across the system as degrading equipment is detected prior to failing.

#### *Anticipated end product*

End goals of PFM are to reduce and/or eliminate outages associated with equipment failures and vegetation encroachment issues, thereby improving reliability and reducing costs. Because of the



capability to determine fault location for all other types of faults, PFM will allow repair crews to eliminate patrol time and instead complete repairs quickly, improving CAIDI and SAIDI.

#### *Innovation, impacts, and market impacts*

PFM is an innovative solution that proactively identifies issues on the grid to prioritize repair work orders, maximizes the life of the asset, and makes the repair before a negative impact to customers. Historical data from sensors across the system can be used to determine which equipment tends to fail more regularly. Using sensor data, the equipment can be purchased as needed, preventing large stockpiles of unused material. Sensor data analysis may yield a classification system that determines which equipment drives the creation of work orders and for the dispatch of crew with the correct resources required to make the repair. Data returned from PFM has the capability to draw a correlation to asset health or life expectancy of the asset.

PFM is a prime example of PPL Electric's ability to leverage OT with IT assets. Sensors can identify faults through advanced fault locating. Sensors identify fault signatures associated with failing equipment. The fault signature data is then transmitted from these monitors to the Asset Hub, and using developed algorithms, triggers the appropriate crew to correct the asset at the defined location. The ability to pinpoint the location of an outage can increase the response time by repair crew, to accelerate restoration, and decrease outage durations.

#### *Project Impacts*

PFM provides customers and communities with a full array of benefits, including support for the clean energy transition with increased reliability and visibility, allowing for quicker response to changes on the grid. The sensors decrease outage frequency by identifying issues proactively and allowing repair under energized conditions repair with no customer impact. Additionally, fault locating capabilities of the sensors allow for more efficient response times for crews when there is an issue, reducing outage length. PFM also provides safety benefits for both employees and customers. The sensors scan work zones prior to performing work on a section of line that may be subject to failure. Furthermore, the sensors also reduce the risk of property damage because of vegetation related issues, equipment failures, fire reduction, or simply failed conductors that could fall to the ground and could, in some instances, give rise to a public safety concern depending on the situations.

The project expands on a successful pilot completed by PPL Electric. It involves 14 sensors monitoring the 3-phase backbone of a distribution line in Lehigh County. The pilot has identified eleven different pieces of failing equipment and one vegetation encroachment section have been detected and located across two distribution circuits prior to resulting in any permanent outages. After evaluating each of these issues, the Company estimates about 9,500 customers would have been impacted by a permanent outage. Of these customers, PPL Electric estimates 7,900 customers would have been restored between 1 and 5 minutes due to FISR; however, approximately 1,500 customers would sustain a permanent outage greater than 5 minutes for up to a few hours or more depending on time of day or degree of failure. PPL Electric estimates \$70,000 in avoided labor costs and believes that the pilot results indicate that a larger deployment will generate greater customer benefits and provide increased affordability.

#### **Low-Tension Network (LTN) Automation**

##### *Description of technology used*

Underground secondary networks are found in many major cities across the country and PPL Electric has (7) of these systems in (6) of our cities, which we refer to as the Low-Tension Network

(LTN). This program encompasses upgrades to PPL Electric's distribution system through the installation of advanced technologies including major underground equipment upgrades, fiber optic cable, secondary monitoring, and primary circuit fault indication. As part of these upgrades, all the network protectors will be retrofitted with advanced relays that will communicate asset vitals back to the Advanced Distribution Management System (ADMS). The network protector relays, and other sensors communicate through the installed fiber system back to the substation remote terminal unit (RTU). From there data is routed back to ADMS and Asset Hub. Additionally, all network transformers will be retrofitted with analog pressure, temperature, and oil level sensors. Finally, secondary monitoring is being installed on the secondary cables throughout the network to predict cable failures for proactive and reactive replacements.

LTN leverages IT investments made possible with IIJA funding. Currently, PPL Electric's LTN is not modeled in ADMS or mapped within the Company's GIS. The use of digital twin technology will allow the Company to model the entire LTN thereby including it with the rest of the distribution system within ADMS. This investment establishes a connectivity model, so GIS information can be used by the ADMS technology to remotely operate and receive fault locations. Additionally, the LTN automation sensors send data to asset hubs to better plan maintenance and capital investment on PPL Electric's equipment.

#### *Project Goals, Anticipated End Goals and Expected Outcomes*

The program's objective is to bring smart grid capabilities to the underground networks in PPL Electric's DACs. The investment creates an LTN system that has no unplanned primary circuit outages or equipment failures providing highly reliable service to customers while using automation and telemetry that is visible to PPL Electric's system operators and reduces safety exposure to employees and communities. When complete, the automated system will allow remote switching and monitoring to help prevent failures, faults, and unplanned outages. This will improve affordability while enabling future DER on the LTN system and supporting EV growth in the inner city with better data visibility.

Throughout the remaining course of the program, isolating 2024 and beyond, PPL Electric plans to upgrade 205 vaults in total. New network protectors will be installed in 46 vaults, new network transformers in 26 vaults, and 205 vaults will have telemetry equipment installed to provide the remote communication capabilities as described. The LTN project also will improve crew safety as the data relayed back to system operators will be able to troubleshoot problems prior to any truck rolls and, the addition of remote racking to network protectors will allow for isolation from the secondary grid to be performed from outside of a confined space. The combined reduction in unplanned outages, as well as safety and efficiency improvements for crews, will result in both a reduction of operations and maintenance costs and a positive impact across the Company's service territories for our customers as they will suffer less disruptions through the prevention of unplanned outages and remote troubleshooting capacities.

#### *Innovation, impacts, and market impacts*

The implementation of the Low-Tension Network automation will have a profound impact for PPL Electric and its customers. By implementing this Project, PPL Electric can advance its Smart Grid in several ways. LTN automation includes full modelling of the system in ADMS as well as the capability for remote switching. With the enhancement of real-time asset vitals available remotely, there will be opportunities to make more reliable proactive decisions about equipment maintenance and replacement that will prevent failures. After the equipment is upgraded with the advanced sensors and relays, PPL Electric can invest more into monitoring which will be installed on the primary and secondary cables at junction points. This will monitor power flow and identify disturbances in the system that are indicative of failing conductor, allowing for

proactive replacements and preventative maintenance of the cable backbone of these LTNs. Collectively, these technological enhancements of LTNs are intended to improve system reliability while reducing operational and maintenance costs by identifying issues and addressing issues before they result in a failure.

### **Advanced Distribution Management System**

#### *Description of Technology Used*

The purpose of ADMS is to advance the enterprise software platform to command and control the electric distribution system, including outage management and system operations. PPL Electric needs an upgrade to its ADMS to gain all benefits of smart grid functionality, including automation and advanced DER functionality.

A modern smart grid consists of sensors and controllable devices deployed in the field with communication capabilities. ADMS is the system that all such devices communicate with, to provide a real-time display of the energy grid to operators. Additionally, ADMS is capable of automatically calculating how and sending signals to devices to re-route power when an interruption occurs. ADMS also can model the DER devices that are installed on the electric grid to make decisions. Upgrading PPL Electric's first-generation ADMS with the proposed investment that combine Distribution Management System with the Outage Management System into a single product allows for seamless integration of this functionality.

#### *Project Goals, Anticipated End Goals and Expected Outcomes*

ADMS enterprise software platform increase reliability, power quality and control of DER integration. It will command and control the electric distribution system, including outage management and system operations. The goal of this investment is to upgrade the PPL Electric ADMS system so the Company can recognize all benefits of smart grid functionality, including automation and advanced DER functionality.

Standing up an ADMS system that combines outage management, device management, real time operations, and DER allows PPL Electric to achieve best-in-class monitoring and control of all assets. Additionally, the ADMS system would offer advanced features that would benefit all customers including FISR (Fault Isolation and Service Restoration), VVO (Volt-Var Optimization), and optimized DER contributions.

#### *Innovation and Impacts*

PPL Electric intends to upgrade the existing ADMS system which combines outage management, device management, real-time operations, and DER allows PPL Electric to achieve best-in-class monitoring and control of all assets. Additionally, the ADMS system would offer advanced features that benefit all customers including FISR (Fault Isolation and Service Restoration), VVO (Volt-Var Optimization), and optimized DER contributions.

With improved ADMS, customers would experience optimized voltages using VVO. Integration of customer-owned DER devices would become faster while maximizing their contributions. Integration of ADMS with OMS results in a streamlined product capable of managing all grid devices and managing events within a single platform.

#### *Interaction of ADMS with other Topic Area 2 Investments*

ADMS technology will have many benefits on other investments PPL Electric is pursuing in Topic Area 2. For example, single-phase reclosers and ADMS will work in partnership to elevate single-phase systems. ADMS will have full, automatic control over the single-phase distribution system using single-phase reclosers so parts of the grid can be sectionalized if needed. ADMS will allow for better coordination enabling the Company to upgrade its existing single-phase devices to similar capabilities available to three-phase devices without having to conduct significant replacements. ADMS will enable LTN automation by pushing the capabilities of PPL Electric's

secondary network. This will allow for the improved location of faults up to 48 hours, saving the labor of up to 8 full-time employees. Finally, digital twin will establish electrical connectivity model that feeds into ADMS enabling PPL Electric to model its secondary network.

## **Advanced Energy Management System**

### *Description of Technology Used*

An enterprise software platform that allows command and control the electric transmission system including outage restoration and system operations. In addition, the upgrade will allow for dynamic line ratings (DLR), smart alerting of system issues, and automated restoration.

#### *Project Goals, Anticipated End Goals and Expected Outcomes*

AEMS will deliver customer benefits through increased reliability and affordability. The purpose of AEMS is to advance the enterprise software platform to command and control the electric transmission system, including outage restoration and system operations. PPL Electric needs an upgrade to its AEMS to gain all benefits of dynamic line ratings (DLR), smart alerting of system issues, and automated restoration.

In addition to improving load control, the proposed AEMS investments enable DLR, which increases transmission's electricity transfer capacity. DLR enables actively varying the presumed capacity of transmission lines in real-time in response to sensor inputs of environmental and weather conditions. This increased monitoring allows grid operators to reduce system congestion and safely optimize asset utilization.<sup>11</sup> Implementing DLR may increase transmission line transfer capacity by up to 25%, based on project studies conducted by the DOE.<sup>12</sup>

### *Innovation, impacts, and market impacts*

When AEMS combined with smart devices on the transmission system, PPL Electric will be able to expand to the transmission system the same level of innovation that its successfully implemented on its distribution system. The Project brings the ability to improve operational transfer capacity, integrate DER impacts on the distribution system with transmission and, with the integration of AEMS with OMS, deliver a streamlined product capable of managing all grid devices and managing events within a single platform.

## **Asset Hub**

### *Description of Technology Used*

PPL Electric needs to optimize investments in asset infrastructure to provide best-in-class grid maintenance and reliability for its customers. Asset Hub investments will create a centralized data platform capable of ingesting and storing high velocity and granular asset data from platforms, sensors, and grid devices. Modern grid assets including breakers, reclosers, switches, and many others provide near-real-time data to grid operators for real-time decision making. This Project aims to collect that data, along with "nameplate" data (manufacturer, installation date, location, etc.) and store it in a PPL Electric Data Lake, where it will be combined with asset data from other PPL utilities to increase the sample size, improving decision quality.

#### *Project Goals, Anticipated End Goals and Expected Outcomes*

Asset Hub will generate customer benefits through improved reliability and cost optimization, which will drive affordability. PPL Electric's investment in Asset Hub services creates a centralized data platform across the PPL Corporation utility enterprise. With Asset Hub, the entire PPL Electric grid will be capable of ingesting and storing information at a high velocity. This technology allows for the intake of granular asset data using platforms, sensors, and grid devices that will equip the Company with specific, accurate information to track grid performance.

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<sup>11</sup> IRENA "Dynamic Line Rating: Innovation Landscape Brief", 2020

<sup>12</sup> US Department of Energy "[Improving Efficiency with Dynamic Line Ratings](#)", 2017

By collecting granular data for each PPL Electric asset and combining it with asset data from other PPL utilities, advanced analytics including ML and AI can be used to enable data-driven action recommendations for each asset. This platform can be used for statistical analysis through ML and AI to identify trends in asset performance and health. This allows prioritized maintenance and replacement decisions to address assets prior to failure, resulting in increased reliability and optimized use of rate payer dollars. For example, utilizing data from relays and monitors on a substation breaker that is sent to the Asset Hub, the Company can optimize maintenance timing and get the most life out of the breaker. Optimizing the life and maintenance of equipment allows investment to be made elsewhere in system, improving system reliability for customers.

#### *Innovation, impacts, and market impacts*

Asset Hub enhances statistical analysis through ML and AI to identify trends in asset performance and health. PPL Electric would use this data platform to collect asset data at a more granular level and combine with similar data from other PPL utilities. By moving to a more proactive predictive failure model with ML and AI. Failing equipment can be replaced in a controlled manner prior to causing a system event. This approach results in reducing customers risk to a momentary or permanent outage. Other benefits will be increased customer reliability, reduced outage time, and reduced momentary interruptions.

#### *Interaction of Asset Hub with other Topic Area 2 Investments*

The combination of Asset Hub and Predictive Failure Monitoring generates telemetry data from devices that can determine if action is needed to better manage assets proactively, rather than reactively. The sensors and monitors installed during the LTN Automation Upgrade project will have the same impact. Asset Hub and ESRI together will enhance connectivity models to understand the relationship between assets and customer risk to optimize investment in our grid.

### **Digital Twin**

#### *Description of Technology Used*

The Digital Twin is advanced software that enables PPL Electric to collect, store, and perform system simulations, which enable the Company to recognize the full benefits of a Smart Grid System. PPL Electric plans to install and upgrade the Company's existing GIS and design toolset which optimizes ADMS and other smart capabilities. This investment includes mapping the grid's assets to create a digital representation of the grid and onboarding the Environmental System Research Institute (ESRI) Utility Network Management and Automated Utility Design (AUD) design tool extension to conduct fully modeled design solutions. The combination of the data from the Asset Hub, updated GIS information, and ESRI's utility network model creates a digital map of the electrical grid – a system model of both the physical grid layout and the different interactions (e.g., electrical, mechanical, communication) of each component on the grid.

#### *Project Goals, Anticipated End Goals and Expected Outcomes*

The Digital Twin will boost affordability through improved reliability and lower operating costs. IT will also support the clean energy transition by expanding the grid's capacity for DER. The objective of Digital Twin IT investments is to create an updated Geographic Information System (GIS) with an integrated and automated design toolkit. This asset will allow for the creation of digital representation of the electric grid, including a look into the performance of every infrastructure asset and component on the grid.

By implementing an advanced GIS system, PPL Electric will recognize benefits including location-based data capturing with a system that integrates substations and distribution circuits which allows the Company to identify optimal locations for smart grid components and manage

smart grid deployment/operations. Populating this GIS system through an integrated design tool enables simulations of the introduction of new assets, and ultimately increases system reliability by fully recognizing the benefits of smart grid. This system will act as an input to the Asset Hub.

*Innovation, impacts, and market impacts*

The digital twin technology provides PPL with the capability to manage asset information at a more granular level, leading to more accurately pinpoint and remediate failing assets, reduce operation costs, and support full application of ADMS functionality.

Automated Utility Design (AUD) is a leading utility design application in the Autodesk suite. AUD will enable PPL Electric designers to run virtual grid simulations to understand the implications of introducing new assets to the grid. This will enable improved system visibility and a more comprehensive view of power flows. This capability will improve planning and integration of new assets to the existing energy grid, analysis of all assets, subcomponents, and relational data, and enablement of potential two-way power flow.

*Interaction of ESRI with other Topic Area 2 Investments*

Digital Twin will work with ADMS to establish electric connectivity model for the grid, including transmission, for all substations that are not currently included in one connectivity model. This coordination will improve volt/var optimization and enable future transmission and distribution FISR as current FISR devices will not work for a substation outage due to a lack of data. Digital Twin will exchange geographic information with AEMS so the AEMS can facilitate the flow of DER from distribution feeders to the transmission grid, allowing for two-way power flow.

Currently, PPL Electric's LTN's are not modeled in GIS models due to limitations; therefore, PPL Electric has no visibility into these networks. In future GIS models, a connectivity model will be included to allow for system modeling. LTN automation will work with ESRI technology to create more efficient system planning, especially in DACs.

**Portfolio Feasibility and Impact of DOE Funding**

PPL Electric is recognized as an industry leader and forward thinker regarding developing a Smart Grid. The Company has deployed a robust smart grid system on the three-phase backbone over the past 15 years. This experience will be instrumental in the rollout of a single-phase smart grid system. For its Enterprise IT investments, PPL Electric has deep and broad experience managing implementations such as ADMS, AEMS, Digital Twin and Asset Hub. Several examples of similar implementation projects are DMS implementation in 2015, ADMS first-generation deployment in 2021, and INFOR Work Management Suite deployment in 2022.

Additionally, PPL Electric has already tested the feasibility of Predictive Failure Monitoring through a small-scale test pilot of 14 sensors, monitoring the 3-phase backbone of a distribution line conducted in the Lehigh County, Pennsylvania in PPL Electric's service territory. The results to date indicate success. Similarly, the Company has started upgrades to its LTN network that provide the experience necessary to execute its investments on that system. Specifically, it has completed 54 work orders on this system in 2022 alone and has started fiber installation in Lehigh County and in the Harrisburg area. Finally, PPL Electric has significant experience installing reclosers on its three-phase system. That experience translates effectively to being able to execute similar investment on its single-phase system.

Without DOE funding, this scope will not be executed in the next five years. Acceleration allows the Company to be more strategic in its investments and resources. Enterprise IT investments would be significantly delayed along with customers benefits created by expanded capabilities like DLR, improved

DER integration, and big-data advantages. Additionally, LTN automation execution would be delayed beyond the 5-year period and investments and benefits associated with predictive failure monitoring and single-phase reclosers would be eliminated.

## Workplan

### Project Objectives

The Project deploys \$99 million in smart grid investment to make the PPL Electric grid self-healing. The investments made with the support of DOE funding will allow for more efficient, real-time data collection. The enhanced visibility of the grid will equip PPL Electric with the resources necessary to mitigate, prepare for, and respond to potential disruptions. Doing so will maximize customer value while also making the overall grid more resilient.

PPL Electric selected these investments based on analysis of the Project's customer and community benefits. The Company has identified investments that both support the priorities identified by the DOE in its Smart Grid Grants program, both now and into the future – through upgrading the Company's electric to a true Smart Grid<sup>7</sup>. The Project accomplishes this by deploying advanced IT systems and smart OT devices that accelerate grid flexibility, reliability, and efficiency. SMART goals for the portfolio to be achieved by the end of five year include:

SMART Goals	Value
Installed Smart Devices	Approximately 5,400
Install Automatic Switches	34
Enhanced Distribution Circuits	150
Total DAC Customers Impacted	Approximately 284,000
<i>Data Migration and Platform Configurations Completed</i>	4
<i>Performed End-to-End Software Testing Completed</i>	4
<i>% of Users Migrated to ADMS, AEMS, and Digital Twin</i>	100%
<i>Host community meetings (Community Benefits Plan)</i>	3 (beginning, middle, end of project)
<i>Educational Partnerships (Community Benefits Plan)</i>	3 institutions
<i>School Engagement (Community Benefits Plan)</i>	3 school districts/year

### Technical Scope Summary

The Project includes enhancing 150 distribution circuits, installing 354 automatic switches and reclosers, upgrading secondary equipment, and implementing new IT software to accelerate grid flexibility, reliability, and efficiency. Information about the implementation of the six projects within the portfolio are as follows:

Performance Period	Activities Summary	Go/No-Go Decisions	Milestones Achieved
P1, 2024-2025	<b>Work Scope:</b> <ul style="list-style-type: none"> <li>38 telemetered 1PH VCR installations</li> <li>Design and procure for 50% of LTN installations; begin construction</li> <li>Engineering refinement and vendor contracting for PFM</li> </ul> <b>Expected Results:</b> <ul style="list-style-type: none"> <li>Benefits realized for 38/150 1PH installed</li> </ul>	DOE Go/No-Go Decision – 1	M1.1 M1.2 M1.3 M1.4
P2, 2025-2026	<b>Work Scope:</b> <ul style="list-style-type: none"> <li>37 telemetered 1PH VCR Installations</li> <li>Design and procure for 50% of LTN installations; continue construction1-year PFM case study data reviewed</li> </ul>	DOE Go/No-Go Decision – 2	M2.1 M2.2 M2.3 M2.4

	<b>Expected Results:</b> <ul style="list-style-type: none"> <li>• Benefits realized for 75/150 1PH installations</li> <li>• Benefits realized for 25% of LTN customers</li> <li>• Benefits realized for 15/30 PFM circuits installed</li> </ul>		
P3, 2026-2027	<b>Work Scope:</b> <ul style="list-style-type: none"> <li>• 38 telemetered 1 PH VCR installations</li> <li>• Continued construction f LTN installations</li> <li>• Full 30 PFM circuit pilot data shared; compile lessons learned and future plans or directive</li> <li>• Onboard all users to ADMS, AEMS, and Digital Twin</li> </ul> <b>Expected Results:</b> <ul style="list-style-type: none"> <li>• Benefits realized for 113/150 1PH installations</li> <li>• Benefits realized for 50% of LTN customers</li> <li>• Benefits realized for 30/30 PFM circuits installed</li> </ul>	DOE Go/No-Go Decision – 3	M3.1 M3.2 M3.3 M3.4
P4, 2027 - 2028	<b>Work Scope:</b> <ul style="list-style-type: none"> <li>• 37 telemetered 1PH VCR installations</li> <li>• Design and procurement of XX completed project locations</li> <li>• Construction closeout for XX project locations</li> </ul> <b>Expected Results:</b> <ul style="list-style-type: none"> <li>• Benefits realized for 150/150 1PH installed</li> <li>• Benefits realized for 75% of LTN customers</li> </ul>	DOE Go/No-Go Decision – 4	M4.1 M4.2 M4.3 M4.4
P5, 2028-2029	<b>Work Scope:</b> <ul style="list-style-type: none"> <li>• Design and procurement completed for all project locations</li> <li>• Construction closeout for all project locations</li> </ul> <b>Expected Results:</b> <ul style="list-style-type: none"> <li>• Benefits realized for 100% of LTN customers</li> </ul>	DOE Go/No-Go Decision – 5	M5.1 M5.2 M5.3 M5.4

### WBS and Task Description Summary

The Project utilizes a standardized workplan to execute OT programs. The six major phases of PPL OT programs include: planning, program development, engineering, construction planning, construction, and closeout. Each phase will be completed for each program site location. During the planning phase, the Company will review existing assets and locations to determine design specifications, program locations, timeframes, and set budgets. The second phase is the Project development phase. This phase involves detailed scoping the Project and includes preliminary engineering, risk management, scheduling, and budgeting. The third phase, engineering, comprises of developing and completing designs, ordering material, and performing a constructability assessment. The fourth phase is the construction planning phase. This phase involves establishing a construction schedule, acquiring and signing contracts with contractors, and completing the acquisition of material. The fifth phase is construction. This phase involves the process of physically performing the construction, testing, and commissioning. The sixth and final phase of Project is closeout. This phase involves post-construction activities, environmental cleanup, and back-office reconciliation. OT Project sites will be “batched” to optimize field resource availability, Project design’s material lead times, and location proximity.

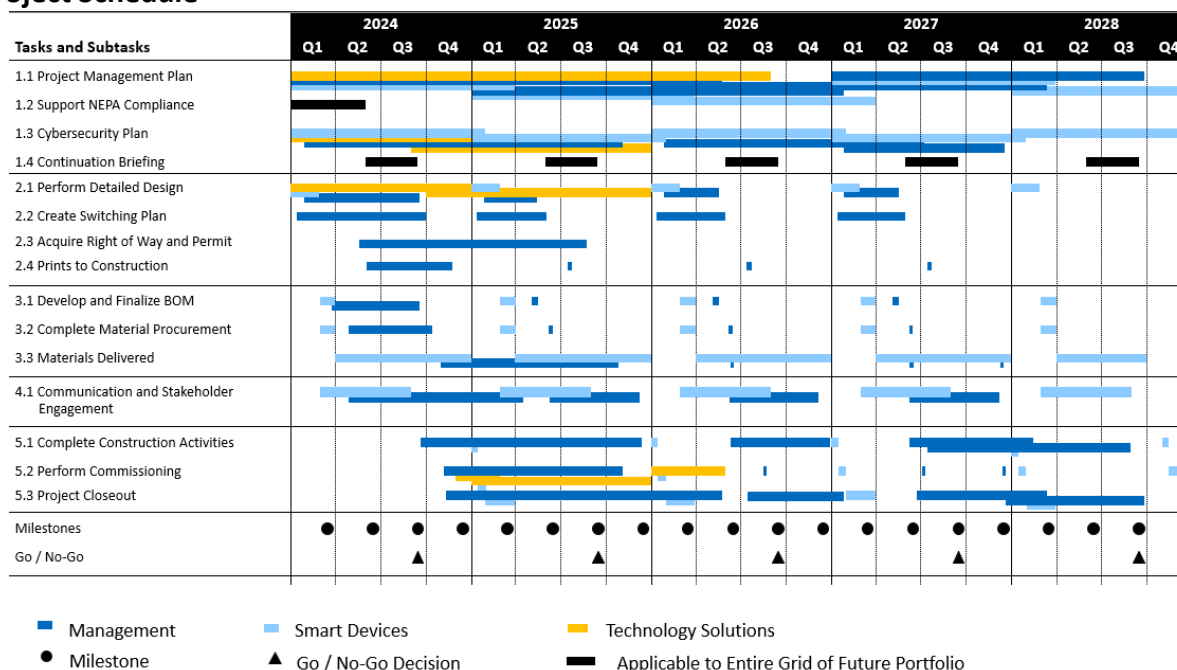
Like OT Project, IT programs will deploy using a waterfall methodology in which planning, scheduling, and testing are prioritized in order to ensure that the implementation of IT initiatives do not negatively impact active operations or cause impairments to critical information systems. A collection of internal inter-department experts will be utilized over the life of the Project to accomplish tasks best suited to their skillset and produce the Project deliverables outlined in the Statement of Project Objective (SOP) which provides a description of all key activities.



In parallel with executing the communication and engagement strategy, Project batches will undergo a detailed design process. During this process, the engineers and project managers will review existing assets and locations to determine design specifications, acquire any necessary permits and rights-of-way, and issue detailed work requests for construction. As the design process is concluding, procurement specialists start the procurement process, by working to finalize bills of materials and issue purchase orders with contracted vendors. The procurement process is completed when materials are delivered to a Company storage site. Third-party partners and project managers within the Company support the construction process through material installation and commissioning along with the completion of formal Project closeout documentation. Throughout the Project, the Company continuously tracks progress and ensures the outcomes of each Project meet its respective objective across the portfolio of investments.

In addition to the processes described above, the Company will use a holistic cybersecurity framework to ensure security assurance of its technology and software initiatives through the Project lifecycle. The team will incorporate the DOE’s “security by design” principles to manage security risks posed by internal employees, supply chain vendors, and third-party groups involved with the Project as well as from external actors. Specific plans and methodologies will be further developed and committed to in the Company’s Cybersecurity Plan.

### Project Schedule



### Milestone Summary

The Company anticipates a series of milestones spanning the design, procurement, and construction Project development tasks. Each performance period will have a design, procurement, and construction milestone correlated to the projected number of sites the Company plans to work on during that period. For the technical milestones the count of smart devices deployed, number of feet reconductored and the count of circuit ties completed.

Milestone	Period	Measure	Verification Method
M1.1	Q1 2024	25% design completed for 1PH 25% design completed for PFM 100% design completed for Digital Twin	Review of applicable materials logs and detailed designs sent to construction
M1.2	Q2 2024	75% design completed for 1PH 75% design completed for PFM 100% procurement for Digital Twin	Review of applicable materials logs and detailed designs sent to construction
M1.3	Q3 2024	100% design completed for 1PH & PFM 25% procurement completed for 1PH & PFM 1 Go/No-Go Decision and internal review for Digital Twin	Review of applicable materials logs and detailed designs sent to construction and Go / No-Go reports
M1.4 Technical	Q4 2024	25% design completed for LTN 100% design completed for 4 IT projects 75% procurement for 1PH & PFM 25% internal review of 1PH & PFM 100% installation of Digital Twin 3 internal reviews for go/no-go Decisions on all projects	Review of applicable detailed designs sent to construction, and materials logs
M2.1	Q1 2025	100% procurement for 1PH & PFM 75% internal review for 1PH & PFM 25% installation completed of 1PH 50% installation completed for PFM	Review of applicable detailed designs sent to construction, materials logs, and project closeout documents
M2.2	Q2 2025	100% design completed for LTN 100% procurement of ADMS 100% internal review of 1PH, PFM, ADMS 25% installation of ADMS	Review of applicable detailed designs sent to construction, materials logs, and project closeout documents
M2.3	Q3 2025	75% procurement completed for LTN 100% procurement completed of AEMS 75% internal review of LTN 100% internal review of AEMS 3 internal reviews for go/no-go Decisions on all projects	Review of applicable detailed designs sent to construction, materials logs, Go / No-Go reports, and project closeout documents
M2.4 – Technical	Q4 2025	100% internal review of LTN	Review of applicable detailed designs sent to construction
M3.1	Q1 2026	75% installation of 1PH 100% installation of PFM 100% procurement of Asset Hub 100% internal review of Asset Hub	Review of applicable detailed designs sent to construction and project closeout documents
M3.2	Q2 2026	75% installation of ADMS	Review of applicable detailed designs sent to construction, material logs
M3.3	Q3 2026	75% installation of AEMS 3 internal reviews for go/no-go Decisions on all projects	Review of applicable detailed designs sent to construction, material logs, and Go / No-Go reports
M3.4 – Technical	Q4 2026	100% installation of LTN	Review of applicable detailed designs sent to construction, material logs
M4.1	Q1 2027	100% installation of 1PH 75% installation of Asset Hub	Review of applicable detailed designs sent to construction and project closeout documents
M4.2	Q2 2027	100% installation of ADMS	Project closeout documents
M4.3	Q3 2027	100% installation of AEMS	Project closeout documents and Go / No-Go reports

		2 internal reviews for go/no-go Decisions on LTN and Digital Twin	
M4.4 - Technical	Q4 2027	100% installation of Asset Hub	Project closeout documents
M5.1	Q1 2028	Project implementations complete	N/A
M5.2	Q2 2028	Project implementations complete	N/A
M5.3	Q3 2028	Project implementations complete	N/A
M5.4 - Technical	Q4 2028	Project implementations complete	N/A

### Go/No-Go Decision Points

The Project portfolio has three types of Go/No-Go decision criteria that occur throughout the portfolio duration. Each program within the Project portfolio will go through these applicable decision points and if it does not pass the decision point, individual Project site and/or component will be pulled from going forward. The Company intends to meet with the DOE to review the outcome of the evaluation of these types of decision points annually.

Go/No-Go evaluation criteria: (1) design evaluation for Project sites to verify that Project designs are in line with the current state of PPL Electric's grid; (2) project site outage plan submission and construction window verification to confirm the applicable permits and permissions are in place to perform Project work; (3) material lead time evaluation so to ensure that Project materials are scheduled to be delivered in time for construction activity to begin.

Decision Point	Period	Measure	Verification
G/NG – 1	Q3 2024	3 total internal reviews: - 1 Tx and Dx design review for 3 projects - 1 Tx and Dx procurement review for 3 projects - 1 design review for 4 technology solution projects	G/NG Report
G/NG – 2	Q3 2025	3 total internal reviews: - 1 Tx and Dx design review for 3 projects - 1 Tx and Dx procurement review for 3 projects - 1 technology solution data assessment for 4 projects	G/NG Report
G/NG – 3	Q3 2026	3 total internal reviews: - 1 Tx and Dx design review for 3 projects - 1 Tx and Dx procurement review for 3 projects - 1 technology solution test case review for 4 projects	G/NG Report
G/NG – 4	Q3 2027	3 total internal reviews: - 1 Tx and Dx design review for 1 project (LTN) - 1 Tx and Dx procurement review for 1 project (LTN) - 1 review for digital twin	G/NG Report
G/NG – 5	Q3 2028	2 total internal reviews (if necessary): - 1 Tx and Dx design review for 1 project - 1 Tx and Dx procurement review for 1 project	G/NG Report

### Buy America Requirements for Infrastructure Projects

As a for-profit entity, PPL Electric is excluded from the GRIP program's Buy America Act and Build America, Buy America Act requirements. However, PPL Electric will try to voluntarily comply and procure materials, supplies, equipment, etc., from United States-based vendors to the extent possible, where available, and appropriate. PPL Electric will consider, to the extent possible, where available, and appropriate, contracting with Pennsylvania-based vendors who would support the creation and retention of local jobs based on impacts to Project scheduling, costs, resource availability, and flexibility for the duration of the Project.

## **Biennial Report to Congress**

If awarded, PPL Electric will comply with Biennial Report to Congress.

### **Project Management**

PPL Electric intends to leverage a Project Management Office for all portfolio investments, which provide standards, governance, quality control, and continuous improvement across the project lifecycle. It utilizes a standard playbook to provide consistency to the approach and accessibility to project management that supports good stewardship across projects that will be applied toward executing the Project. A dedicated Project Management Team (PMT) comprised of a Project Manager, Controls Specialist, and Scheduler will be responsible for project delivery success through the entire project lifecycle. The PMT will work together to support all aspects of the project in conjunction with various stakeholders throughout the project, including:

- Engineering Lead – Design deliverables and communicating design project risks to the Project Manager; identifies needed materials during design; provides inputs with the Project Manager to Supply Chain to facilitate the purchase order issuance process.
- Construction Lead – Execution of construction activities; collaborates with the Project Manager to ensure Construction has necessary materials, permits, and outages.

The Project Manager will lead the PMT and oversee the implementation and management of the Project, including scope, schedule, and budget. They will also facilitate communication between Project Team members, leadership, and steering committees. They will communicate, manage, and coordinate the mitigation of project risks with the support of the appropriate stakeholders, including identifying any lead time impacts to the critical path and working with various team members to mitigate these risks. They will coordinate functional project elements, including Corporate Communications, Economic Development, and Customer Commitment.

The Project Controls Specialist will manage and oversee project controls. They will provide guidance and consultation to the Project Manager regarding project processes and procedures. They will maintain the data structure necessary for project reporting. They will also be responsible for providing the DOE and internal reporting according to the stakeholder's needs.

The Project Scheduler will create and maintain the project schedule. The schedule will include all project-level activities and milestones with roles and resources identified. The schedule data will be used to report progress updates and risk identification. The data will also provide key measurements throughout the project's lifecycle and ultimately support the project's success. Updating the project schedule is a collaborative process between the Project Scheduler, Project Manager, Engineering Lead, Construction Lead, and other Functional Groups.

In addition to a robust team and set of procedures for managing the work, the Project Team employs a suite of work management systems to drive efficiencies across project design, planning, execution, and analysis, as well as provide project leadership with critical insights to maintain project schedules and mitigate risks, including:

Oracle Primavera (P6) manages the portfolio of project schedules while capturing activities, milestones, roles, and resources. The tool supports developing detailed project plans within individual schedules and provides easy visibility into future projects for planning requirements. Microsoft PowerBI merges data from P6, financial planning software, and additional sources to generate reports that allow project teams to track and monitor projects individually and across a portfolio and assess project risks. Additional asset reporting supports future replacement schedules and resource planning.

SharePoint Libraries support the storage of project documentation and foster faster collaboration between the Project Team members by reducing workflow bottlenecks and providing real-time access to document revisions and updates.

### **Risks & Mitigation Strategies**

The key risk with adopting new systems is technological change management. Though new systems provide great value to various parties, the integration process cannot cause service interruptions and the new systems cannot inhibit the functionality of existing systems. Furthermore, for Digital Twin and Asset Hub, it is imperative that no data is lost during the transition and that data is received and stored continuously through the new systems' adoption.

To reduce these risks, the PPL Electric would leverage existing relationships with vendors and internal teams including Information Technology, Engineering and Architecture, System Integrators, and Operators; these groups can support technological change management and optimize a portfolio that would be compatible with existing systems. PPL Electric would also leverage the system experience of its vendors and internal teams including IT Product Strategy, Engineering & Architecture, Product Development, Product Design, Engineering, Data Science, Asset Investment groups, Customer Service, System integration, Field Crews, and Mapping & Records to help to create a uniform standard of data quality and availability, which in turn may reduce costs, increase knowledge sharing, and optimize PPL Electric's smart grid investments.

PPL Electric recognizes and is focused on cybersecurity threats. The Company will mitigate these risks by utilizing a robust cybersecurity strategy, in alignment with industry standards. While investments that advance cybersecurity strategy are not included as part of this portfolio, they are actively considered. The Company is prepared to submit a Cybersecurity Plan (CSP) in preparation for an award if selected. The CSP would be heavily informed by industry standards and best practices, including guidance from the National Institute of Standards and Technology's (NIST) Cybersecurity Framework (CSF), the DOE Cybersecurity Capability Maturity Model (C2M2), and the Cybersecurity and Infrastructure Security Agency (CISA).

Risks associated with OT Project's implementation parallel those related to IT investments; it is critical to implement successful change management to avoid service interruptions. Added risks related to OT investments involve supply chain and labor. Specifically, procurement of materials for a large-scale project can be a particular challenging due to various local and global factors. Ineffective supply chains or resource constraints can increase lead times for materials and eventually lead to longer project construction and higher costs. Given these concerns, PPL Electric will utilize the experts on its procurement team and commit to conducting a detailed vendor selection process and include a full assessment of materials and timeline for procurement. Contracts would be negotiated based on a vendor's ability to meet grid modernization plans. Labor risks involve both internal and external workers. PPL Electric has already begun Project scoping with the objective of understanding internal labor requirements and intends to proactively communicate external labor requirements with vendors to secure needed resources and develop a cost-effective solution. From a project specific perspective, PPL Electric has extensive experience executing single-phase recloser and predictive failure monitoring projects at scale. This experience provides confidence that issues will not emerge during the engineering through construction phases of the Project.

## Technical Qualification and Resources

PPL Electric has an experienced leadership team with the expertise to execute its GRIP Project plan. The team has executed \$2.8 billion in transmission and distribution grid resilience and reliability projects since 2019. This is part of a longer trend in improving reliability as evidenced by PPL Electric's 92% reduction in transmission outages since 2012. The team includes:

**Stephanie Raymond:** President of PPL Electric, oversees electric delivery and customer service, as well as investments in infrastructure and technology to improve customers' service. This includes work to strengthen and modernize the grid and enable increased integration of DERs, including solar power and energy storage, which advance a cleaner energy future.

Prior to becoming President of PPL Electric in April 2021, Raymond served as Vice President of Distribution Operations since 2018. In that role, she oversaw the planning, engineering, construction, operations, and maintenance of PPL Electric's distribution grid. She ensured safe, reliable service to customers while delivering exceptional customer experience.

Before joining Distribution Operations, Raymond was Vice President of Transmission and Substations, where she led operations, planning, engineering, compliance, real estate, siting and permitting, project management, construction management, contract management, and new transmission business ventures. Raymond has a bachelor's degree in business administration and strategic management from California State University, Sacramento and completed the Stanford Graduate School of Business Executive Education Program.

**Dave Quier:** Vice President of Transmission & Substations for PPL Electric, overseeing the operations, planning, engineering, project & construction management, siting, real estate, and compliance to ensure safe, reliable, and exceptional service at a reasonable cost to customers. He also manages new transmission business ventures.

Prior to becoming Vice President, Quier was director of asset management for PPL Electric's Transmission and Substations team. In this role, he oversaw planning, system reliability, standards, strategic initiatives, regulatory policy, special projects, and capital development.

Since joining PPL in 2007, Quier has been instrumental in refocusing the distribution system automation strategy to improve reliability performance. This includes directing the efforts to fully deploy smart grid switches on PPL Electric's power grid. Quier is a licensed professional engineer who received a Bachelor of Science in electrical engineering from Lehigh University and a Master of Business Administration from Penn State University.

**Sal Salet,** Vice President of Distribution, has been responsible for leading the planning, engineering, construction, operations, and maintenance of PPL Electric's distribution grid since 2011, ensuring safe, reliable service along with exceptional customer experience. He has more over 11 years in the electric utility industry, starting in the Substation Engineering group as the Smart Grid Substation Lead. In this role, he led PPL's Smart Grid program and helped develop it into one of the most advanced systems in the country. His technical experience includes Smart Grid and Distribution Automation.

Since then, he has spent over 10 years in various leadership roles including, Distribution Design, Standards, Protection as well as the Director of Distribution Engineering and now Vice President of Distribution. He has a bachelor's degree in Electrical and Electronics Engineering from Penn State University and a Master of Business Administration from Saint Leo University. He is a licensed professional engineer in Pennsylvania.

**Steve Selkregg**, Director of Asset Management and Engineering, is responsible for directing strategic, tactical and business plan activities for the Company's distribution system engineering and planning, asset strategy, engineering and construction standards, field testing and commissioning, as well as Project and Construction Management.

He joined PPL Electric in 2013 as an engineer in Transmission Engineering. In 2015, after being the lead responsible engineer on various large transmission projects, he was promoted to T&S Design Supervisor, managing over 10 engineers designing and managing the design of various Transmission Line projects. In 2016, Selkregg was promoted to Project Engineering Manager, responsible for all Transmission and Substation engineering deliverables for the eastern part of PPL Electric's service territory. In this role, he oversaw internal and contract FTEs executing engineering deliverables to support over \$250 million of capital projects annually. In 2018 he transitioned to the Distribution organization, where he held both the Manager of Distribution Engineering and Manager of Planning and Asset Management. In these roles he managed numerous teams in executing engineering deliverables, scoping work, and leading strategic initiatives. In August 2022, he was promoted to his current role.

Selkregg is completing his master's degree in business administration from the DeSales University. He received his Bachelor of Engineering from Temple University.

**Joseph Lookup** has been Director of Transmission and Substation Asset Management since April 2021 and has over 15 years of experience in the electric utility industry. He joined PPL Corporation in 2011 as a senior engineer in Substation Engineering group. He was responsible for designing projects and managing quality of design of various contractor designs during his time in substation engineering. In 2013 he was promoted to project manager responsible for the project execution of large capital projects for substation and transmission lines. In 2014 Lookup was promoted to Senior Project & Contract Manager responsible for a group of engineers, project managers, and construction personnel responsible for over \$250-400 million of capital projects annually. In this role he oversaw a group that was responsible for project execution from conceptual design into construction and project close-out. In 2018 Lookup moved to Manager of Project Development and Standards focusing on project strategy, portfolio oversight, and technical standards. In this role he led a diverse group focused on driving financial and technical efficiencies optimizing project execution.

In his current role, his team is responsible for reliability, asset health and financial oversight of the transmission system. Its responsibilities include business and technical strategy, transmission planning, asset strategy, new project development, innovation and technology development, new customer development, and portfolio management.

**Jim Conrad**: Director of IT Product Team, has eight years of industry experience, including leadership roles in field, engineering, and operations areas at PPL Electric prior to joining PPL's IT Product Team in May 2022. His experience includes work on many new technologies including automated fault isolation, downed conductor detection, and DER Management. Jim has been involved in work performed on the Keystone Solar Futures Grant and holds a patent for a megavang design from his time in the Distribution Standards department. Prior to joining PPL Electric Utilities, Jim worked as an engineer for Lockheed Martin, working mainly on classified government programs. Jim holds a B.S. in Electric Engineering and a Master of Engineering in Systems Engineering, both from Penn State University.

**Chris Randle**, Vice President of Cybersecurity, has more than 20 years of experience in cybersecurity, creating and executing strategies that protect companies from cyber threats. He joined PPL Electric as the Director of Cybersecurity in 2019, being promoted in 2021. During this time, he successfully matured the cyber program and had zero incidents that resulted in power or data loss. He led the creation of multiple programs that resulted in robust protection for PPL Electric and its customers. A few of those programs include: the Security Operations Center, Third Party Risk, Cybersecurity Architecture, and Cybersecurity Risk Management.

He is responsible for the cyber safety of all PPL companies, spanning corporate systems, generation, transmission, distribution and gas. His responsibilities are focused on creating and managing the strategic success of cybersecurity and ensuring that it is aligned with PPL's overall strategy and safety goals, including Identity and Access Management, Privileged Access Management, Cloud Security, Risk Management, Incident Response, Cyber Monitoring, ICS/OT Security, and other key functions. Randle holds a bachelor's degree from the University of Alabama and an MBA from Webster University. He has also been CISSP certified since 2003.

#### **Time commitment of key team members**

Resource	Position	% of Time	Hours (2024-28)
Stephanie Raymond	President, PPL Electric	1%	100
Salim Salet	Vice President, Distribution Operations	2%	200
Angie Evans	VP and Chief DEI Officer	1%	100
Chris Randle	VP, Cybersecurity	2%	200
Jim Conrad	Director, Produce Portfolio	5%	500
Steve Selkregg	Director, Distribution Asset Management and Engineering	5%	500
Beth Johnson	Director, Regulatory Affairs	2%	200
Amit Hegde	Manager, Distribution of Design	10%	1,000
Vivian Younes	Manager, Distribution Project & Construction Mgmt	10%	1,000

#### **Evidence of demonstrated qualifications**

During their careers, members of this leadership team have executed similar projects for PPL Electric. The result of the projects executed has led to a 92% reduction in transmission SAIFI and a 72% reduction in transmission MAIFI since 2012. Examples of these investments include:

- **Analytics-Based Maintenance:** In March 2022, PPL Electric started a pilot testing predictive failure monitoring in a lab on a standalone distribution circuit. Initial results showed more than 75% success in identifying and classifying equipment types prior to failure. Next, the technology was tested on a live distribution circuit and, by December 2022, grew to 3 distribution circuits successfully locating a damaged conductor and a broken tie wire. Early identification helps prevent compromised wires from breaking and falling to the ground, preventing public safety hazards and permanent outages. In early 2023, the team is working to identify other hazard locations based on data received from this equipment to further show proof of concept and data acquired on a dynamic feeder compared to results from standalone lab test line equipment. This experience will drive successful execution of the predictive failure monitoring investment identified in this application.
- **Hardening Efforts:** PPL Electric's management has improved transmission system resilience & reliability by executing several key initiatives. The Company boosted its investment in steel poles, increasing the ratio of the total system from 45% steel in 2009 to 77% by 2022. Additionally, the Company has undergrounded 1,235 primary distribution line miles since



2012. It also successfully completed a battery storage project in 2019 on a worst performing rural section of line. The experience leads to successful outcomes in future hardening efforts.

- **Device Replacement and Installation:** Since 2009, the Company has replaced 82% of its circuit breakers, 72% of its relays and 52% of its transformers on its transmission system. Additionally, PPL Electric has installed dynamic line rating devices on three 230kV circuits, with all three going live on October 6, 2022, and maintaining full operations since. The Company's history of successful device replacement shows its capability of executing similar investments in the application's portfolio, including OCR replacement, transmission reclosers and adding DLR devices to its transmission lines.

#### **Teaming Partners on Prior Projects**

PPL Electric has a history of teaming with partners on many of these projects. Some key teaming partners have included some of the largest and most experienced engineering and construction firms. The partners have worked alongside PPL Electric to execute large resilience and reliability projects like those included in this application. PPL Electric's relationship with these partners ensures the capabilities required to execute the investments included in this portfolio.

#### **Equipment and Facilities**

PPL Electric keeps equipment inventory and facilities to ensure investment execution, including these projects. It has more than 1,100 fleet vehicles and over 900 employees capable of installing devices, managing construction, designing transmission and/or distribution systems.

The Company's supply chain maintains relationships with 1,100 vendors and handles \$1.2 billion in procurement each year. The supply chain team's experience and supplier relationships are demonstrated by its significant 2021 award for innovation in supply chain by creating a program to inventory steel structures for quicker delivery when there is an immediate need. The team's innovations and history show its capability in executing GRIP Program investments.

Additionally, PPL Electric has cutting-edge management systems. The Company has recently adopted this technology to achieve best-in-class workforce management that provides comprehensive and flexible solutions with utility-specific capabilities on a platform that is protected by world-class security. The improved capabilities around workforce scheduling and management will drive more efficient delivery of projects like those included in this proposal.

#### **FN: Technical Services from DOE/NNSA FFRDCs**

We are not requesting technical services from DOE/NNSA FFRDCs.