

PPL Electric Utilities
Summer Readiness Overview
June 2017

SUMMARY

For PPL Electric Utilities (PPL Electric), summer readiness means the company must respond effectively to summer storms as well as provide reliable electricity every day for 1.4 million customers.

In addition to traditional preparation activities, such as vegetation management and equipment inspections, PPL Electric is taking innovative steps to strengthen its system and improve service for customers. These include the installation of smart grid devices, the use of automated power restoration, improvements to its online outage map, and more proactive sharing of outage and restoration information with customers.

Detailed below are various actions undertaken or plans for enhancements to ensure summer readiness.

A. RELIABILITY ENHANCEMENT PROGRAMS

a. Enhanced Vegetation Management

PPL Electric's vegetation management program utilizes industry best practices and seeks to improve the reliability of the electric transmission and distribution systems by preventing outages from vegetation located on easements and rights-of-way (ROW), and minimizing outages from vegetation located adjacent to ROW. Trees are generally the most common cause of storm-related power outages, so vegetation management is critical to keeping the system reliable.

In 2013, PPL Electric launched more comprehensive trimming on multi-phase circuits, and accelerated its efforts to identify and remove trees outside of the ROW that have the potential to cause outages. These efforts, combined with several years of more comprehensive tree trimming on higher voltage lines, have resulted in a reduction in the number of tree-related outages, compared to the average of the previous 10 years. In 2017, these initiatives continue with the expectation of further reductions in vegetation-related service interruptions.

The company also has a Hazard Tree Program, where trees that are at risk to cause damage to PPL power lines are identified and addressed. With the emerald ash borer infestation in Pennsylvania, PPL Electric is taking measures to remove all ash danger trees on the company's transmission lines. Additionally, for the distribution system, dead or declining ash trees are targeted as part of the Hazard Tree Program during cycle maintenance. These preventive measures have been established in all regions for both transmission and distribution circuits.

b. Storm Hardening

The overall intent of storm hardening initiatives is to reduce pole breaks and damage due to vegetation, which can lead to extended repair time. PPL Electric will continue implementing several initiatives to improve system resiliency in 2017. These initiatives include changes to

engineering instructions and construction specifications to enhance the reliability of the distribution system during storms. For example, steel poles and fiberglass crossarms are replacing wood poles and crossarms for certain types of applications; taller poles are now used in locations where heavier equipment is installed; and remote service kits are installed to improve restoration times for residential customers in rural areas.

c. Fuses/Reclosers/Automatic Switches

In 2015, PPL Electric began full implementation of a 10- year plan to replace existing three-phase hydraulic reclosers with communication-enabled vacuum circuit reclosers. This allows for remote operation of these devices, in addition to remote monitoring to facilitate the move toward condition based maintenance. These devices play a crucial role in reducing the number of customers interrupted by an outage and allow a majority of customers to be back in service before permanent repairs can be made.

In 2017, PPL Electric continued to roll out three-phase fusing and single-phase tripping on three-phase lines. Prior to this approach, when a three-phase smart grid device trips, or goes out of service due to a fault, all three phases trip. Under the new approach a single-phase fault only impacts customers on that phase, which reduces outages for the other two-thirds of the customers on that line. While single phase tripping is not appropriate for all locations, PPL Electric is actively implementing this reliability enhancement.

d. Smart Grid

The company continues to invest in its Smart Grid initiative. Results from these investments have been impressive. For a pilot program conducted in Dauphin and Cumberland counties, a 35 to 50 percent reduction in customer minutes interrupted versus non automated circuits in the same geographic area was realized. Another project conducted in the Pocono region saw outage durations reduced by an average of 30 percent. As of the beginning of May, 412 of the 490 communicating vacuum circuit reclosers planned for 2017 have been installed on PPL Electric's system, with the remaining planned for installation by mid-summer. These devices will allow for automatic sectionalizing and reclosing, in addition to identifying fault locations, which helps reduce outage duration times.

280 communicating vacuum circuit reclosers became single-phase trip/single-phase lockout in May. This added functionality will result in up to two-thirds fewer customers downstream of these devices experiencing outages.

PPL Electric implemented an advanced Distribution Management System (DMS) in 2014, which is a software solution that provides system operators real-time situational awareness of how the system is performing. One of its groundbreaking features is the ability for the software to detect a fault from smart sensors on the distribution system and quickly develop and execute an optimized restoration plan. This technology is dramatically improving the ability to quickly restore customers, particularly in conjunction with our FISR (Fault Isolation and Service Restoration) technology, which is now in use on all feeders, system-wide.

PPL Electric continues to monitor and refine its usage of FISR 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. Enhancements to our Smart Grid device relay programming have led to more consistent results. In addition, further improvements have been made in the technology that analyzes the severity and location of a fault, enabling field forces to more rapidly respond to the trouble location.

e. Conservation Voltage Reduction (CVR) activity

PPL Electric does not currently utilize voltage conservation reduction activity. However, in 2016, PPL Electric embarked on a pilot program for utilizing Load-Tap Changing (LTC) power transformers on its distribution system as part of the company's voltage regulation strategy. The move toward using LTC transformers on the distribution system has provided improved voltage regulation that allows the company to better-meet any voltage conservations that may be required.

In 2016, PPL Electric installed LTC transformers at five of its distribution substations as part of this pilot program. For future years, the company plans to continue this program at substations that require on-site voltage regulation.

f. Any Other Relevant Continual Improvement Activity

PPL Electric has several other noteworthy reliability improvement activities. For example, PPL Electric pioneered a momentary outage task force and program to investigate and mitigate the causes of multiple momentary outages in 2016. This program will reduce momentary outages for customers, and should also reduce permanent outages which may have eventually been caused by the conditions that were causing the momentary outages. Projects under this program include replacing deteriorated/defective equipment, hot spot tree trimming, protection evaluation, and animal guarding.

Additionally, PPL Electric has a program to address customers experiencing multiple interruptions (CEMI). Under this program all customers have their interruption count monitored on a rolling 12 month basis and appropriate remediation strategies are developed.

B. PREVENTATIVE MAINTENANCE PROGRAMS

a. Capacitor Inspections

PPL Electric utilizes analytics to identify blown fuses on capacitor banks. In addition, PPL Electric is monitoring voltage for all substation buses and investigates issues in near real-time. This monitoring catches capacitor banks that are not operating as expected. PPL Electric also performs line patrols and expanded operational reviews in order to catch issues or blown fuses on capacitor banks. Finally, with the mass installation of smart devices on the system, voltage sensing capabilities on the system are rapidly increasing.

b. Vegetation Management

As previously stated, the company continues to see the reduction of tree-related outages due to a more comprehensive vegetation management program initiated several years ago. It is anticipated further improvements for customer reliability will occur.

Distribution System Maintenance - PPL Electric continues regular tree-trimming cycles for all aerial distribution lines. Lines are trimmed every four years in the southern half of the service territory, and every five years in the more rural northern service territory. Some lines are trimmed more frequently based on need. The company also refined its prioritization tool to more effectively rank the order of circuits trimmed throughout the year, to maximize the impact of the trimming program and minimize tree related outages. In addition, PPL Electric has increased the removal of hazard trees from outside transmission and distribution corridors and ground to sky trimming and clearing is performed on multi-phase distribution lines wherever possible.

Bulk Electric System Maintenance (BES) – PPL Electric maintains more than 1,500 miles of BES transmission lines over a recurring four-year period. Line clearances are maintained between overhead power lines and any vegetation.

138kV Electric System Maintenance – PPL Electric maintains approximately 385 miles of 138kV transmission lines over a recurring four-year period. In residential areas, non-compatible vegetation is removed from the PPL Electric ROW on customer property. Whenever feasible, trees and other vegetation that is compatible with high-voltage transmission lines are not disturbed.

69kV Electric System Maintenance – PPL Electric maintains approximately 3,100 miles of 69kV transmission lines over a recurring four-year period. In 2012, PPL Electric began implementing a new standard of clearing ROW on 69kV transmission lines to improve reliability. The new standard requires clearing to the full extent of the ROW on all 69kV lines and this effort was completed at the end of 2015.

c. Substation Inspections

Distribution substations receive a five-week visual inspection and an annual infrared inspection. Transmission substations receive a quarterly visual inspection and an annual infrared inspection, the exception being the 500kV substations which receive quarterly infrared inspection. In addition to visual and infrared inspections, distribution and transmission substation equipment receive various forms of routine testing performed throughout the year.

d. Aerial Patrols

Helicopter patrols on the transmission line include routine patrols, comprehensive patrols, and annual infrared inspections. The routine patrols occur during early summer to look for larger potential issues on the transmission system. In addition, a forester typically participates to identify potential danger trees. These flights give a once-a-year look at the entire system. The comprehensive patrols are flown on one quarter of the system every year, thus every line is inspected every four years. Comprehensive patrols typically take place after the routine patrol, and the object of these patrols is to look for damaged equipment. Infrared patrols are performed in the early winter to scan all splices and connectors on the transmission line. Corrective action is taken if any hot spots are found.

PPL Electric received Federal Aviation Administration approval in early 2015 to use drones, or unmanned aerial vehicles, for power line inspections. They are being integrated into the overall transmission inspection program, and the company continues to look for opportunities

for drone use in the future. The drone program will not replace all storm damage assessment or line inspection by other methods.

e. Infrared Inspections

PPL Electric's infrared (IR) line inspections are a routine part of maintenance to identify potential equipment failures that cannot be detected from visual inspections. PPL Electric's IR inspection process is programmatically applied to all multi-phase lines adjacent to roadways on a two-year cycle. Inspections are conducted in the winter months to take advantage of the relatively high and consistent loads associated with heating demands; the colder weather also results in a lower ambient temperature for greater contrast. Consequently, repairs associated with the results of infrared scanning are completed before summer creating conditions for greater reliability. Supplementary infrared scanning may be conducted throughout the year. Circuits planned for load transfer may be scanned based on circuit performance indicators. Additionally, specific areas may be scanned to augment condition-based visual inspections.

f. Any other relevant continual improvement activity

PPL Electric has a wide portfolio of maintenance activities and continuously seeks to optimize maintenance cycles to maintain and improve reliability of service. Capturing inspection data is critical to effective asset management. PPL Electric has digitized airbreak and voltage regulator inspections and now records data in a mobile web app that is accessible by all crew mobile units. Examples of airbreak condition data include health of operating rods, insulators, loadbreak contacts, linkage, and other components. Voltage regulator condition focuses on number of tap changes and proper control settings.

The resultant data from these forms provide asset condition data to make data-driven maintenance and replacement decisions on airbreak switches and voltage regulators. The company continues collecting condition data for additional distribution assets and building health indices for each asset class.

C. CAPACITY PLANNING

PPL Electric regularly reviews reliability performance on a system wide, regional, local and circuit basis to identify needed improvements due to load or performance issues.

In 2016, the summer peak on the PPL Electric system was 6,991 MWh, well below the all-time summer peak of 7,554 MWh recorded in July 2006. PPL Electric experienced no issues during the 2016 peak. The 2017 winter peak of 7,201 MWh was well below the all-time winter peak of 7,884 MWh, which occurred in February 2015. Forecasted load for this summer is not projected to exceed the all-time peak.

PPL Electric does not foresee concerns with the system's delivery capacity during the upcoming summer based on its performance during previous winter cold spells, prior summer heat waves, the ongoing investments in reliability, capacity upgrades, and customer adoption of energy efficiency and conservation opportunities.

D. 2016/2017 STORM UPDATE AND LESSONS LEARNED

PPL Electric experienced a higher than average number of storm events in 2016 when compared to the benchmark period of 1994-1998. Four storms in 2016 were PUC-reportable while 20 were not reportable but required the opening of one or more area emergency centers to manage restoration efforts. The PUC-reportable storm events had all customers restored within 39 hours.

Currently, there are 5 PUC-reportable storms on record for 2017, and 2 non-reportable storms.

PPL Electric Utilities is committed to restoring customers as safely and as quickly as possible. The company continues to improve its storm and emergency response through the use of best practices, drills, and After Action Reviews, as well as benchmarking with other electric utilities and industry leaders. The company focused on improving communications with its customers, state agencies, emergency organizations, other utilities and the media. PPL Electric is also refining management of estimated restoration times (ERTs) and operations.

PPL Electric instituted the following enhancements to its storm and emergency preparations:

- Augmentation of centralized dispatching operations to drive CAIDI performance during periods of outage volume spikes.
- More proactive and frequent event planning conference calls.
- More frequent and proactive activation of our regional command centers.
- Development of an application to more accurately estimate the number of required restoration crews and damage assessors during an event.
- Greater use of damage assessors through the creation of our assessment strategy earlier in event planning process, and the streamlining of the call-out process for assessors to quickly and efficiently request and acquire assessment resources.
- Creation of a new emergency response organization role to support the latest technology applications used during storm restoration efforts.
- Development of a more accurate, robust outage prediction model, utilizing machine learning technology.

E. 2017 SUMMER READINESS

a/b. Capacity Additions and Transmission Preparedness

PPL Electric is making significant investments to maintain and improve reliability and meet increased demand on its transmission and distribution systems – continuing a trend of increased investment in system reliability. Additionally, substantial capital is being deployed for various large transmission expansion projects.

PPL Electric crews and contractors are building new substations and transmission lines, upgrading existing facilities, replacing older transmission lines and poles, improving distribution circuits, and upgrading technology for better, more efficient operation. These improvements will strengthen the system to effectively handle summer peak loads and improve overall reliability.

Almost 70 load-based and reliability projects on the transmission and distribution systems are planned to strengthen the network in time for peak summer demand. Additional system

modernization work is underway, as well as dozens of system improvements that will be completed through the remainder of the year.

Examples of key projects include:

- Rebuilding and reconductoring several older transmission lines.
- Completion of planned 69kV transmission upgrades.
- Improved lightning protection on targeted transmission facilities.
- Helicopter and drone patrols for transmission line inspections.
- Expansion and upgrades to bulk power substations (circuit breakers, transformers, capacitor bank replacements).
- Construction of new transmission substations and lines to relieve load on existing facilities and improve operational flexibility.
- Modification of transmission substations to improve reliability.
- Expanded right-of-way and clearance on targeted transmission lines where reliability improvement is targeted.

c. Event Preparedness

PPL Electric continues to strengthen its event exercise regimen through the implementation of a systematic approach to instruction, exercise, and knowledge retention. New concepts or changes are communicated through orientation sessions with key participants, followed by tabletop exercises to help employees put what they learn into practice. In addition, small-focus drills are done to measure personal understanding, knowledge retention, and effectiveness, and are repeated months later to address processes not frequently used in order to keep skills sharp. Finally, functional drills are conducted to test key processes from start to end and to ensure understanding and effective transitioning of responsibilities during multi-day events.

d. Training

Training is a key part of PPL Electric's storm readiness planning. In 2017 PPL Electric will conduct a minimum of 30 small focus drills to practice areas for improvement, 15 tabletop exercises and six functional exercises.

e. Personnel Sufficient

PPL Electric will have sufficient personnel to address any summer event.

F. STORM RESPONSE

a. Outage Restoration Strategy

PPL Electric's restoration strategy has remained consistent throughout its history. The utmost priority is given to public health and safety facilities, such as hospitals, 911 call centers, and other vital facilities and critical operations and the buildings associated with them. Once those crucial services are restored, the focus shifts to restoring trouble cases that will lead to

the restoration of the most customers as quickly and as safely as possible. Priority is also given to incidents involving downed electrical wires and blocked roads.

b. Communications and Outreach

PPL Electric recognizes the need to provide accurate, timely and frequent status updates and other helpful information about storms to everyone affected. The company is driven to develop and deliver that information in a consistent and timely manner. That includes providing periodic updates to customers, media, lawmakers the Pennsylvania Public Utility Commission and other stakeholders.

Customers can access PPL Electric's outage map on its website, which was redesigned in 2016 to offer additional functionality and improved navigation, and resizes automatically depending on the user's device. Customers are also provided with the information through outage alerts that provide proactive information about outages, their causes and the estimated restoration times. Alerts can be customized by customers and delivered by text, email, and recorded phone message.

In addition, regular status updates about storm damage and restoration efforts are provided via press releases and multiple social media outlets, including Facebook and Twitter. Company personnel work closely with county emergency management agencies to assess priorities and establish communication between PPL Electric Utilities and affected communities and for larger events, host conference calls with public officials.

c. Outage Restoration & Storm Response Best Practices Implemented and/or Identified For Future Implementation

PPL Electric has completed the final development and full implementation (started in 2016) of improved restoration strategy development and restoration response efficiency with upgrades to its event management system and smart device applications. A Storm Event Manager tool (STEM) provides timely information about emergency orders of all power outages and critical problems reported by local law enforcement agencies and other emergency response personnel. STEM also provides resource utilization metrics and geographic displays.

Development and implementation of the PPL Restore app was completed in 2016. This application allows for efficient assignment and processing of trouble orders to contractors and mutual assistance repair resources.

Other key functionality of the Restore app that was recently implemented was the damage assessment process. It combines asset management information and GPS positioning to make assessments more efficient and eliminate the need to enter information such as pole height and class, transformer size and conductor size.

PPL Electric Utilities is an active member in and leader of many industry organizations and working groups, including: the Pennsylvania Operations Best Practices group; the Association of Edison Illuminating Companies (AEIC); the North Atlantic Mutual Assistance Group (NAMAG); the Southeastern Electric Exchange (SEE); and the All Hazards Consortium/Fleet Response Working Group. Strong working relationships with industry

leaders have been developed and the company will continue to seek ways of improving those relationships and its roles with the organizations.

d. Any Other Relevant Continual Improvement Activity

In 2017 PPL Electric will continue to focus on refining its all-hazards response with the addition of black sky event planning, as a way to ensure that the company is ready to respond to all types of emergency events, not just those caused by the weather. Action plans for all roles associated with the activation of the emergency response organization beyond storms have been expanded and the company will continue to update its business continuity plans to support our all-hazards responses.

CONCLUSION

PPL Electric appreciates the opportunity to outline its programs, projects and activities in preparation for the peak demand and storms of the summer season.

Executing seasonal maintenance programs, along with strategic investments and system improvements, enables the company to deliver the safe, reliable power that customers expect.

Based on planning, execution of work plans, and storm response improvement initiatives, PPL Electric is confident that it is operationally ready for summer to meet customer needs and expectations.