

PPL Electric Utilities
Summer Readiness Overview
June 2016

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. 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 ground to sky 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 25 percent reduction in the number of tree-related outages in 2015, compared to the average of the previous 10 years. In 2016, 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 of causing damage to PPL power lines are identified and addressed. With the Emerald Ash Borer (EAB) 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.

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 has implemented several new initiatives to improve system resiliency in 2016. 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.

PPL Electric also partnered with a national research and development consortium and several large utilities on a storm hardening study that concluded at the end of 2015. PPL Electric is in the process of implementing or piloting several recommendations from the study, which include specification changes installing more resilient equipment, conducting post-storm inspections, and improving restoration practices.

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 2016, PPL Electric is implementing three-phase fusing and a pilot of single-phase tripping on three-phase lines. Currently, when a three-phase Smart Grid device trips, or goes out of service due to a fault, all three phases trip. This technology will allow a single-phase fault to only impact customers on that phase, which reduces permanent and momentary outages for the other two-thirds of the customers on that line.

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, 498 of the 665 communicating vacuum circuit reclosers planned for 2016 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.

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 new technology is dramatically improving the ability to quickly restore customers and complete automation is now in use on all feeders, system-wide.

PPL Electric recently completed a system wide rollout of FISR (Fault Isolation and Service Restoration) technology. FISR identifies faulted sections and quickly develops an optimized restoration plan, then automatically executes that plan. Customers typically can be restored within five minutes from the start of the outage. This milestone is an industry first and looks to significantly reduce overall outage durations. 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 activity. However, the company will be embarking on a new pilot program related to LTC (Load Tap Changer) transformers on its distribution network. Currently PPL Electric only utilizes an LTC design on the transmission network as part of the company's voltage regulation strategy. The move toward using LTC transformers on the distribution system will enable improved voltage regulation that will allow the organization to better meet any voltage conservations that may be required. PPL Electric will initially pilot this approach in 2016, with the first LTC transformer anticipated to be installed by the end of the third quarter.

f. Any Other Relevant Continual Improvement Activity

PPL Electric has several other noteworthy reliability improvement activities. For example, PPL Electric initiated a program to identify and remediate situations for customers experiencing multiple "momentary" interruptions. This program is focused on targeting areas experiencing multiple momentaries in order to decrease the number of these service interruptions, which will ultimately decrease the number of permanent outages. Projects under this program include replacing deteriorated/defective equipment, hot spot tree trimming, protection evaluation, and animal guarding.

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 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 2013, 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 monthly 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.

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. For the summer of 2016, PPL Electric is evaluating the opportunity to commission an additional helicopter to run patrols on the transmission system so the company can aggressively identify and address any potential reliability concerns prior to the start of the storm season.

PPL 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 utility is evaluating how best to use them. 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 reliability of service. Because capturing inspection data is critical to effective asset management, PPL Electric started an initiative to digitize airbreak and voltage regulator inspections and capture data in a mobile web app that is accessible by all crew mobile units, and will soon be available on iOS or Android devices. In total, the digital inspection form assesses roughly 25 condition parameters of an airbreak switch, and 15 characteristics of a voltage regulator. 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 data from these inspections will provide asset condition data to make data-driven maintenance and replacement decisions on airbreak switches and voltage regulators. Future plans include 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 2015, the summer peak on the PPL Electric system was 6,684 MWh, well below the all-time summer peak of 7,554 MWh recorded in July 2006. PPL Electric experienced no issues during the 2014 peak. The 2016 winter peak of 6,902 MWh was well below the all-time summer 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, due to the ongoing investments in reliability, capacity upgrades and customer adoption of energy efficiency and conservation opportunities.

D. 2014/2015 STORM UPDATE AND LESSONS LEARNED

PPL Electric experienced a higher than average number of storm events in 2015 when compared to the benchmark period of 1994-1998. One storm in 2015 was PUC-reportable and all customers were restored within 26 hours. There were 19 events that were not reportable but required the opening of one or more area emergency centers to manage restoration efforts. Currently, there are two PUC-reportable storms on record for 2016, and four non-reportable storms.

PPL Electric remains committed to restoring customers as safely and quickly as possible. The company has enhanced its storm and emergency response through the use of industry best practices, drill exercises, and after action reviews. PPL Electric continues to strengthen communications with state agencies, emergency organizations, other utilities and customers. The company is also working to more effectively manage estimated restoration times (ERTs) and operations. The company continues to collaborate with other Pennsylvania electric utilities and benchmark with industry leaders to improve emergency response.

Other emergency preparedness highlights include:

- **Technology Applications** – The company has improved restoration strategy development and restoration response efficiency with an event dashboard and smart device applications. PPL Electric’s Storm Event Manager tool now displays information on emergency orders of power outages and critical problems called in by local law enforcement agencies and other emergency response personnel. A restore application (Restore App) enables contractors and companies that provide assistance to be assigned outage cases by the company’s outage management system.
- **Damage Assessment** – The company has improved the process that initiates assessments and has streamlined the field assessment process. Future improvements in 2016 include the implementation of a damage assessment tool in the Restore App. It will combine 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.
- **Key Process Ownership** – The company has realigned key tasks to directors and managers to ensure a high level of preparedness and a prompt response. Among the key assignment areas are damage assessment, resource management, staging sites and onboarding of mutual assistance crews.
- **Extreme Weather Response** – The company has improved its proactive, pre-emptive action plans to address extreme heat and extreme cold conditions and to limit the effects that extreme weather has on the transmission and distribution systems.
- **Communication Escalation** – The company has simplified and streamlined communication escalation processes to ensure consistent and timely internal and external communications during significant events.

E. 2016 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.

More than 68 load-based and reliability projects on the transmission and distribution systems are planned for 2016, strengthening 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 reconducting several older transmission lines.
- Completion of planned 69-kV transmission upgrades.
- Improved lightning protection on targeted transmission facilities.
- Helicopter and drone patrols for transmission line inspections (comprehensive and routine).
- 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 needed.

c. Event Preparedness

PPL Electric has strengthened 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. Small-focus drills 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 support of this planning, PPL Electric is incorporating training as part of its plan for 2016. PPL Electric is conducting a minimum of 30 small focus drills to practice areas for improvement, 12 tabletop exercises and functional exercises.

e. Personnel Sufficient

PPL Electric believes it has sufficient personnel, and at this time there are no plans to hire additional personnel.

F. STORM RESPONSE

a. Outage Restoration Strategy

PPL Electric's restoration strategy remains unchanged: the highest priority is given to public health and safety facilities, such as hospitals, 911 call centers, and other vital facilities and critical infrastructure. Once those crucial services are restored, the focus shifts to restoring trouble cases that will bring the most customers back on line as quickly and safely as possible.

b. Communications and Outreach

PPL Electric recognizes the need to provide accurate, timely, and frequent status updates and other helpful information about storms to all of those affected. The company is driven to develop and deliver information in a consistent and timely manner to various audiences. This includes providing periodic updates to the Pennsylvania Public Utility Commission's (PUC) Emergency Preparedness Liaison Officer (EPLO) and proactive media outreach. It also includes direct contact with customers using PPL Alerts, automated telephone messages and broadcast e-mails, the PPL Electric mobile-ready web site, and expanded communication within social media outlets. For larger events, the company hosts conference calls with public officials.

PPL Electric is a co-leader of the PUC's Critical Infrastructure Interdependency Working Group, which helps improve restoration communication and coordination efforts between utilities and emergency agencies.

PPL Electric also continues to work closely with county emergency management agencies to assess priorities and establish communication between PPL Electric and affected communities.

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

PPL Electric is associated with 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. PPL Electric has cultivated strong working relationships with industry leaders as well. Many of the initiatives highlighted in this report were identified via best-practices discussions, including key process ownership, the event management dashboard, web-based applications, and the exercise regimen.

d. Any Other Relevant Continual Improvement Activity

Refinement of all-hazards response continues to be a focal point in 2016 as a way to ensure that PPL Electric is ready to respond to more than just weather events. PPL Electric has expanded action plans for all roles that would be involved in the activation of the emergency response organization beyond storms. PPL Electric continues to update the company's business continuity plans to support the company's 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.