New Jersey
Board of Public Utilities

June 23, 2015 "Bow Echo" Weather Event:
Report and Recommendations on the Response and Restoration of Electric Utility Outages

Division of Reliability and Security
August 26, 2015

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Executive Summary

On June 23, 2015, at approximately 6:00 p.m., a severe weather event with an unusually intense and uncertain line of storms struck the service territories of Atlantic City Electric (ACE) and Public Service Electric and Gas (PSE&G), interrupting service to over 400,000 customers in Southern New Jersey[1]. Damage from the weather event was caused mainly by a strong "bow echo," which is characterized as a quick-developing line of storms with extreme and sustained straight line winds, as well as damaging wind gusts.

In this case, the intensity of the storm was concentrated in the ACE service territory and included wind gusts between 60 - 75 miles per hour. The force of the weather event caused massive damage to the electric utility's transmission and distribution systems. ACE reported damage which included the loss of 17 transmission circuits, 5 substations, over 130 broken poles, and hundreds of transformers. The storm also damaged over 250,000 feet of overhead conductors in ACE's service territory, mainly due to fallen trees.

The damage to the transmission system caused by the intensity of the bow echo was so severe in the western part of ACE's service territory that the utility was required to undertake load shedding measures in the eastern part of its service territory. The load shedding was an action directed by PJM Interconnection (PJM) to control for real time transmission overloads. As a result, the load shedding added to the number of outages in the Cape May district where there was little physical damage from the storm.

In addition to the load shedding problems, restoration efforts were made more difficult early on in the damage assessment and restoration process as a result of a wireless/cellular communications outage. ACE's efforts were complicated by a Verizon wireless service outage which lasted approximately 12 hours. As a result, ACE was unable to use its mobile dispatching system to distribute outage and trouble call information. ACE was forced to utilize its manual, paper-driven backup processes to document damage assessment information and restoration completions. ACE was also forced to use its backup 2-way radio system and mobile radios to communicate with field crews. The restoration was also hampered because of a second, less severe, but impactful weather event that traveled through ACE's service territory on Saturday, June 27th.

Board of Public Utilities (Board or BPU) Staff began a review of the response and restoration efforts immediately after full recovery from the event. On July 22, 2015, at the regularly scheduled Board Agenda meeting, Board Staff presented its preliminary report highlighting a number of issues impacting the utilities' response and restoration in the areas of the weather event forecast; the weather event's impact on utility infrastructure in the ACE and PSE&G service territories; complications due to Verizon's wireless outage; communication issues with public officials, Board Staff and customers out of service; and compliance with Board directives.

At the Board's July 22nd meeting, the Board directed Staff to continue its review of ACE's overall storm response with a focus on the company's communication with customers and local

[1] Although ACE and PSE&G were both impacted by the June 23, 2015 weather event, PSE&G experienced fewer service interruptions and sustained less damage to its infrastructure. PSE&G was, therefore, able to restore service at a quicker pace and as a result this report will focus on ACE's response and restoration efforts.

officials. The Board also directed Staff to determine if previously ordered preparedness and response enhancements were effective and achieved the improvements envisioned by the Board. Furthermore, Staff was directed to review and work with ACE to improve emergency communication efforts, and to work with all of the electric distribution companies to identify and develop contingency plans for the potential for wireless outages during a power restoration event.

In this report, Board Staff addresses each of the issues raised by the Board in its July 22, 2015 Board Agenda meeting concerning the response and restoration of electric utility outages following the June 23, 2015 bow echo weather event.

The report makes several recommendations. They include: a recommendation which addresses the electric utility sector's planning for backup communications; a recommendation for earlier identification by all electric utilities of "last to be recovered" areas during large scale outages; a recommendation for ACE to improve its communication and information plans for public officials; a recommendation for ACE to establish a more effective protocol in communicating with the Board's Emergency Management Staff; and a recommendation for ACE to revise its process of determining situational awareness and global Estimated Times of Restoration (ETR) to ensure these critical estimates are informed with the best available information.

Weather Event and Storm Impact

On the evening of June 23, 2015 a line of severe storms, associated with a cold front, moved through southern Pennsylvania, New Jersey, Delaware and Maryland. These storms were accompanied with high winds and heavy rainfall. This weather event was predicted to impact New Jersey three days out, with uncertainty as to where the actual impact and intensity of the storm would be felt.

The storm system initially started in Pennsylvania and strengthened as it moved eastward and crossed over the Delaware River. As the storm strength continued to increase a "bow echo" developed, defined by the National Weather Service Office as "a radar echo which is linear but bent outward in a bow shape. Damaging straight-line winds often occur near the "crest" or center of a bow echo." The center/crest of the bow in this system passed over parts of Gloucester County where the brunt of the storm was felt. The hardest hit areas included East Greenwich, Greenwich, and Wenonah.

The following day, on June 24, 2015, the National Weather Service completed a survey and determined that the damage was associated with a macroburst/straight line winds, defined as "a convective downdraft with an affected outflow area of at least 2.5 miles wide and peak winds lasting between 5 and 20 minutes. Intense macrobursts may cause tornado-force damage up to EF3 intensity" that occurred over East Greenwich Township.[2] These weather events are difficult to predict.

Public Service Electric & Gas (PSE&G) Service Territory Impact: The storm crossed PSE&G's service territory beginning at 6:00 p.m. on June 23, 2015. The infrastructure damage to PSE&G occurred in the company's Southern Division with reported tornado-force wind gusts recorded in the area, and a report of a tornado that did not touch ground. A total of 159,713 customers experienced extended interruptions, with the majority occurring in Burlington, Camden and Gloucester counties. Although ACE and PSE&G were both impacted by the June 23rd weather event, PSE&G did not sustain damage to its transmission lines or substations, and experienced fewer service interruptions. PSE&G was able to restore service within 5 days.

Atlantic City Electric (ACE) Service Territory Impact: The bow echo that struck ACE's service territory at approximately 6:30 p.m. included wind gusts between 60 - 75 miles per hour, as well as reports of funnel clouds. This resulted in massive damage to the utility's transmission and distribution systems, interrupting service to over 259,000 customers. The damage to the system included the loss of 17 transmission circuits, 5 substations, over 130 broken poles, including more than 10 transmission poles, and hundreds of transformers. The storm also resulted in over 250,000 feet of damaged or downed overhead conductors, mainly due to fallen trees. ACE is the primary focus of this Staff report.

[2] The EF-Scale rates the strength of tornadoes in order of increasing intensity. An EF3 can have wind speeds of up to 165 mph.

Pre-Storm Preparations

As previously discussed, the June 23, 2015 weather event was predicted to impact New Jersey three days prior with uncertainty as to where the actual impact and severity would be felt. ACE reported that the company received an updated weather forecast at 2:20 p.m. on Tuesday, June 23rd, indicating that the storm was gaining strength and not travelling north as expected. Upon receiving the update, ACE took the following measures in preparation for a potential storm event[3]:

- Held six extra trouble men.
- Held six extra 4 man crews.
- Staffed six extra store keepers (store keepers are authorized to issue materials to line crews).

It appears from Staff's review that the ACE pre-storm measures were appropriate. Up until the early afternoon of June 23rd, the weather updates for the day presented a scenario for a typical summer storm. Weather outlooks from both the National Weather Service and ACE's weather forecasting service were also predicting a storm path into northern New Jersey. However, weather events such as macrobursts and bow echoes are not as easy to forecast and prepare for such as a typical Nor'easter or even a derecho. Unlike the June 23rd bow echo event, a derecho, defined as "a long-lived, rapidly moving line of intense thunderstorms that produces widespread damaging winds in a nearly continuous swath." can travel over 250 miles, propagating towards an area, allowing for more advance notice for those areas in the path of the derecho. The same holds for large winter storms and tropical events which are more predictable and warrant significant preparedness efforts, although, the impact of these storms are sometimes minimal.

Workforce Deployment

ACE's service territory is divided into four separate operating districts: Cape May, Glassboro, Pleasantville and Winslow. While Cape May experienced minimal damage from the storm, each district was impacted by the weather event. ACE began deploying additional company crews to each of the four districts at 12:00 a.m. on June 24, 2015. Within 24 hours after the storm passed, the workforce deployed by ACE increased from 125 FTEs (Full Time Equivalent) to over 800 FTEs[4]. That number eventually grew to over 1,600 FTEs by Sunday June 28th.

For this weather event, ACE appears to have quickly ramped-up its workforce using the following resources to restore service:

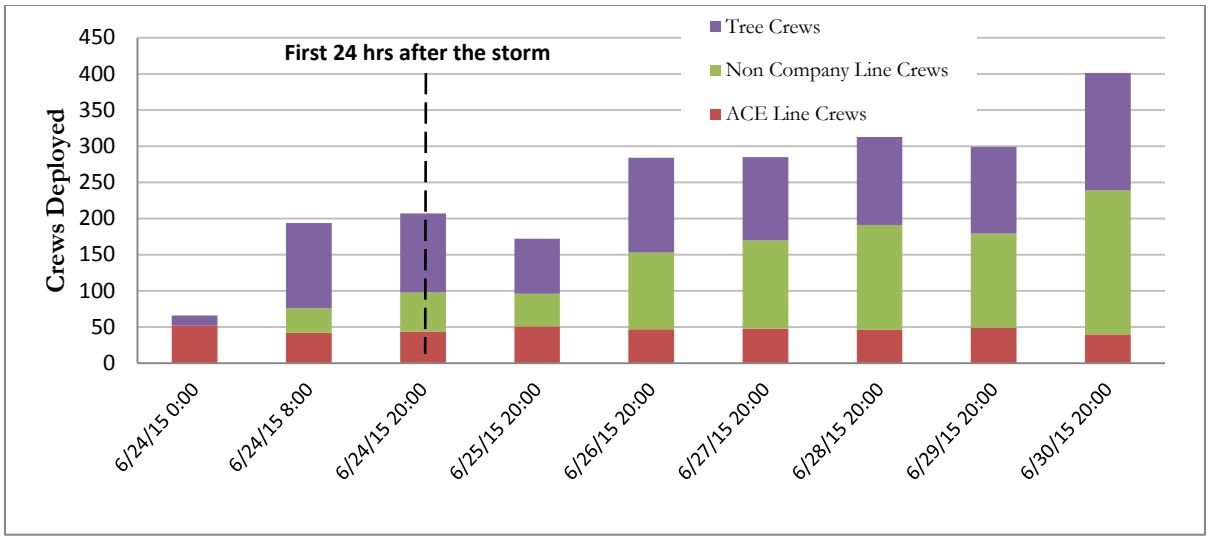
- Internal (ACE) line personnel.
- Other PHI (parent company) utility personnel.
- Mutual Aid personnel.

[3] The added measures were in addition to the 15 first responders working outage calls in the region.
[4] Full-time equivalent or FTE is a unit that indicates the workload of an employed person in a way that makes workloads comparable. In this context, 1 FTE is the equivalent of a full-time worker.

- Tree personnel.
- Support personnel (company staff processing outage orders).

The following graph illustrates the workforce deployment throughout the restoration process.

Figure 1: Workforce Deployment – total crews deployed through 6/30/15



Supplemental Crew Acquisitions

During a large-scale event, the scope of the emergency and the volume of assets impacted can severely tax the resource capabilities of a company. Mutual aid agreements are the avenue by which the electric utilities can cope with the magnitude of such events. During the June 23, 2015 weather event, ACE first requested assistance from contractors at 8:00 p.m. on June 23rd and began receiving crews at 7:00 a.m. on June 24, 2015. The first mutual aid call was held at 9:00 p.m. on June 23rd and the first mutual aid crews arrived at 10:00 a.m. on June 24th. In total, 224 mutual aid crews were brought in to assist ACE in its restoration efforts.

Post Weather Event Communication

During a large-scale outage, delays in providing accurate disruption and restoration information can impact the overall understanding of the outage situation, which impacts decision-making for emergency management personnel, public officials and impacted customers. Following the widespread utility outages in 2011 and 2012, the Board initiated an investigation of electric utility storm preparedness and response efforts which resulted in 2 Board Orders (post Irene and Sandy Orders). The Board Orders included new emergency preparedness, response and restoration directives, including directives on how utilities should communicate with public officials, emergency management personnel, and impacted customers during a major outage event.

Communication with Local Officials

Early on in the restoration process, ACE was criticized for not being more proactive in its communication efforts with local public officials. The timing of the storm in the early evening hours of June 23rd, combined with the wireless outage in the morning of June 24th hampered ACE's ability to achieve a solid situational awareness of the full system impact from the weather event. ACE should have communicated these challenges more clearly and aggressively to public officials early in the damage assessment and restoration process.

In after action discussions with the company, it appears their external liaisons and public affairs communication team did not execute the most effective emergency outreach to the affected community representatives and elected officials when it was most needed --- the morning of June 24th.

Communication with BPU Emergency Management Staff

While it is important to understand that the June 23, 2105 weather event was not typical of most summer storms, and the brunt of the storm impacted the electric utility in the evening hours, presenting challenges to the damage assessment process, those challenges needed to be communicated to the Board's emergency management Staff as soon as possible. ACE's communication with Board Staff immediately after the storm and early on the following day was slow initially and spotty. ACE should have more clearly conveyed to the Board's emergency management personnel its inability to get good situational awareness.

Communication with Customers

Given the uncertain nature of the bow echo weather event as it developed quickly over ACE's service territory, no pre-storm communication was conducted by ACE's public affairs team. The first weather alert was posted to ACE's website after the brunt of the storm had passed, around 7:30 p.m. on June 23rd, with more than 640,000 page views on ACE's website.

The following day, on June 24th, ACE began messaging to its customers (radio spots, website, mobile apps, social media, etc.); however, early on in the restoration process, there was confusion from impacted communities about the general outage situation, especially the hardest hit areas in Gloucester County. Information about the potential for long duration outages, and where those long outages would persist, should have been conveyed earlier in the process. While the ACE press release on June 24th did identify a global ETR (Estimated Time of Restoration) and the releases were progressively more informative, they did not identify where prolonged outages could be expected until the press release on Sunday June 28th. Those areas which were last to be recovered should have been identified quicker and outreach to those affected communities should have been done in a more direct and tactical fashion.

Restoration of Service

During past significant weather events in New Jersey, electric restoration efforts by the electric utilities have taken 4 to 7 days to restore all customers. Hurricane Irene took 7-8 days before all of the approximately 1 million peak outages were fully restored. The October 2011 Snowstorm took 7 days before all peak outages were fully restored, and in the case of Superstorm Sandy, despite having the largest utility workforce ever mobilized in New Jersey, full restoration of the approximately 2.8 million peak customer outages affected by the storm took 14 days.

For comparative purpose, Superstorm Sandy, which impacted over 200,000 customers in ACE's service territory, took 7-8 days before full restoration was completed.

In terms of executing an effective restoration plan, unlike major winter weather events, tropical storms, or even derechos, summers thunderstorms in general present weather patterns which can change quickly and are difficult from a preparedness standpoint. PSE&G did take measures the afternoon of Tuesday June 23rd to hold and stage crews, and ACE similarly held a complement of trouble men and crews when the weather forecasts began to identify a potential for "a strengthening storm" in the southern region.

At peak, the total number of ACE customers out of service reached 259,372, with the hardest hit areas in the Glassboro and Winslow districts. Within 24 hours after the storm passed, nearly all of the 80,000 plus customer outages in the Cape May district were fully restored. Most of the customers in Cape May lost service initially not because of physical damage to the infrastructure, but as a result of a load shedding condition caused by the instability of the transmission system damaged by the storm. The load shedding was an action directed by PJM Interconnection (PJM) to control for real time transmission overloads. Many of these customers were quickly restored; however, when the system was stabilized and switching could occur.

Soon after the storm passed, ACE was able to deploy significant resources quickly and effectively, reducing the number of outages in the first 4 days of restoration from a peak of over 259,000 to fewer than 40,000. However, on Saturday June 27th, heavy rains and high winds hampered the restoration process, knocking out power to an additional 16,000 customer. Full restoration of all customers was completed on Tuesday afternoon June 30th.

Estimated Time of Restoration (ETR)

As part of the improvement measures directed by the Board Orders after Hurricane Irene and Superstorm Sandy, electric utilities are now required to provide a global ETR within 24 hours of the end of the event. The global ETR is meant to provide affected customers and public officials with a reasonable sense of the overall impact on the utility, and the expected duration of the recovery. As it performs damage assessment, the utility will then produce geographically specific ETRs to inform communities and eventually individual customers of the estimated restoration timeframe.

Even with technological advances, and improved capabilities to estimate the time required to fully recover from extensive infrastructure damage, ETRs in general are still estimates despite experience, better modeling and use of algorithms. Yet the community and public officials must still rely on these estimates to address family welfare issues, sheltering, and numerous other

concerns. There are implications for standby power, fueling, schools, businesses, food products and other elements of community functioning which are critically reliant on power.

It is important for electric utilities to provide well-reasoned ETRs, and rapidly refine them as necessary. Every affected customer and public official wants to see the utility execute the shortest recovery possible, and that expectation is warranted. However, the utility should make its best effort to provide a well-reasoned, global ETR, and make adjustment to the ETRs if warranted, with explanation. Customers and government officials in geographic areas which will be "last recovered" should be clearly informed so that contingency plans can be implemented. Regardless of how well electric utilities conduct a large scale recovery effort, inaccurate or ineffective communication will likely outweigh the positive aspects of that effort.

On June 24, 2015, approximately 24 hours after the bow echo weather event, ACE issued its global ETR stating that all customers would be restored by Sunday June 28th. In its June 26th press release, ACE reiterated its June 28th ETR indicating that "Atlantic City Electric expects to restore service to most customers by late tonight. Power restoration to all customers is expected by the end of day Sunday".

When compared to prior weather events, and based on Staff's review of this event with ACE's Incident Response Team, the utility's June 28th global ETR appears to have been an overly optimistic restoration timetable for a storm significant enough to disrupt service to over 259,000 customers.

As previously noted, Superstorm Sandy, impacted over 200,000 customers in ACE's service territory, and took up to 8 days before full restoration was completed. The derecho event of June 30, 2012, which impacted over 184,000 customers, took 9 days before all customers were fully restored. Unlike the June 23rd event, these recovery profiles were not hampered by a widespread systemic failure of wireless communications in the initial stages of damage assessment and recovery.

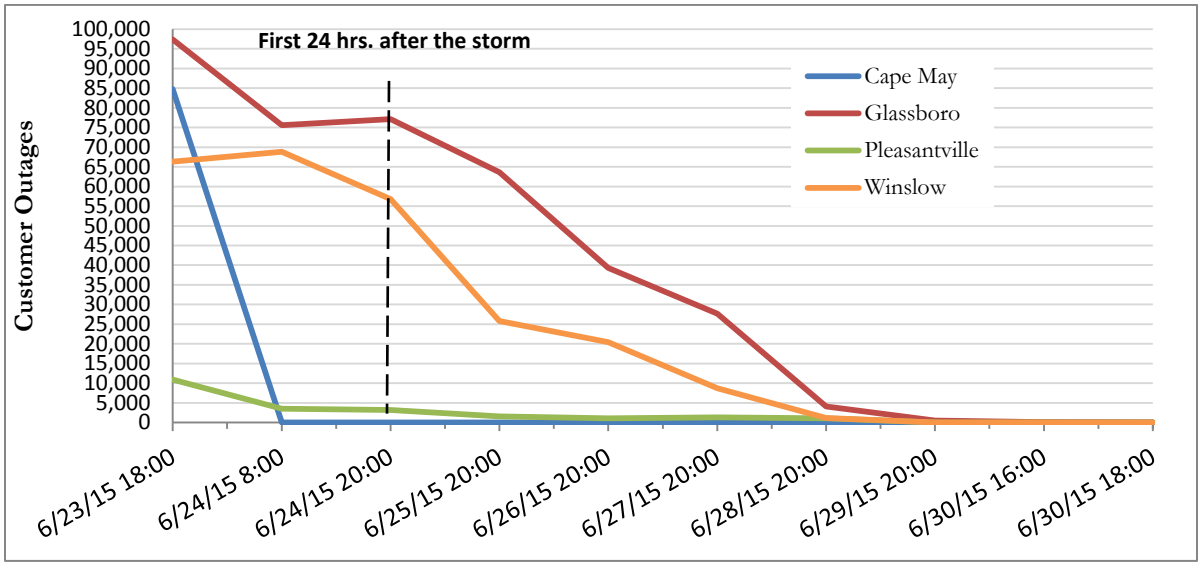
ACE's short, 5-day, timetable for full restoration may have been a reaction to early criticism of its perceived lack of preparedness for the fast-moving storm that so severely impacted its service territory, and from intense pressure for the company to respond quickly. Given the extent of the damage, as well as the early communications issues with its field personnel due to the wireless outage, ACE appears to have committed to an overly optimistic initial global ETR.

In terms of individual customer ETRs, the utility did develop geographically specific ETRs over time, although this was hampered by the wireless outage and its adverse effect on damage assessment and the data feeding its outage management system.

However, the company did not identify and message out where prolonged outages could be expected. Those areas which were last to be recovered should have been identified quicker. ACE was later forced to revise its ETR in the Sunday June 28th press release for full restoration of the remaining 5,000 customers without power to Monday; however, the remaining customers were not restored until Tuesday afternoon June 30th. The small storm of Sunday June 28th did hamper the restoration effort generally.

The following graph illustrates ACE's restoration timeline throughout the restoration process.

Figure 2: Restoration Timeline through 6:00 PM on 6/30/15



Restoration Issues: Verizon's Wireless Outage

Adding to the restoration challenges brought on by the unexpected force of the bow echo weather event, ACE also faced wireless/cellular communications problems early in the initial ramp-up of its restoration workforce. At approximately 6:00 p.m. on June 23, 2015, downed trees from the bow echo weather event damaged a fiber cable in Mt. Royal, New Jersey. The damaged fiber cable was part of Verizon's redundant fiber transport ring for southern New Jersey. No service was lost at this time; however, the cut fiber meant that Verizon had lost its fiber backup capability for its wireless network in southern New Jersey.

At approximately 1:00 a.m. on June 24, 2015, while repairs were ongoing in Mt. Royal, a second cut on Verizon's fiber ring knocked out service on the ring's primary transport path for southern New Jersey. The second fiber cut was caused by a pole/transformer fire in Chester, Pennsylvania and as a result knocked out service to Verizon's wireless network (both the primary and redundant paths were out of service at this point). Verizon's early estimates put the number of voice and data customers without service at roughly 500,000 in portions of Burlington, Atlantic, Cape May, Salem, Cumberland, Gloucester and Camden counties[5].

According to Verizon, the damaged cable required splicing of a 96 pair fiber bundle. The process of splicing individual fibers continued through the night and into the early afternoon of June 24, 2015, when service to the fiber transport ring was restored around 1:00 p.m.

[5] Initial news reports indicated that parts of New Jersey, Pennsylvania and Delaware were impacted by the fiber cuts. However, according to Verizon, Pennsylvania and Delaware are both served by a separate wireless network and did not lose wireless service as a result of damage to the fiber ring transport. Verizon customer outages in Pennsylvania and Delaware were unrelated to the fiber cut and likely a result of local isolated problems which occurred throughout the region as a result of the storm.

During the Verizon wireless outage, ACE was unable to use its mobile dispatching to distribute outage and trouble calls/orders to field crews. ACE was also unable to use its Mobile Data Terminals to accurately update the status of outages that had been restored and as a result there was a ripple effect and data delay on information sent to the OMS and the ACE website. For a period of 10 to 12 hours, ACE had to resort to manual, paper-driven backup processes to document damage assessment information and restoration completions. To communicate with crews in the field, ACE had to rely on its 2-way mobile radio system which is a backup to the wireless cellular devices.

Verizon's wireless service outage is a reminder for all utilities of the interdependencies that exist and continue to grow between the 2 industries. As utilities transition from paper driven processes and connect to commercial wireless networks enabling them to perform real-time, bidirectional communication with personnel and devices in the field, they become increasingly dependent on these networks. While the transition to wireless has improved the efficiency and effectiveness of utility emergency response and restoration, it also presents new challenges. Commercial communications systems are generally enabled via a combination of landline, wireless and/or cellular networks, and as such are often vulnerable to the same weather events that damage the utility infrastructure.

All utilities that rely on commercial wireless networks for their communications should begin to formalize and exercise their back up plan for communicating with their workforce in the event of an emergency, should they lose their primary means of communications used for collection and disseminating voice, data and text information.

Compliance with Prior Board Orders and Directives

As previously discussed, following the widespread utility outages in 2011 and 2012, the Board initiated an investigation of electric utility storm preparedness and response efforts that resulted in 2 Board Orders directing the electric utilities to implement improvement measures. The improvement measures outlined in the Board Orders fall into the following 5 categories:

- Preparedness Efforts
- Restoration and Response
- Post Event
- Underlying Infrastructure Issues
- Communications

In terms of compliance with the prior directives and initiatives of the Board to enhance weather preparedness, provide for more effective outage recovery, and improve communications, both PSE&G and ACE have demonstrated integration of the Board's directives into their planning, response and recovery for the weather event of June 23, 2015.

While the impacted utilities demonstrated compliance with improvement measures from previous weather related lessons learned, the nature of the bow echo weather event and the unexpected communications challenges early on, revealed gaps in ACE's emergency plan which led to a less than optimal execution of the overall restoration of service to its customers.

Based on Board Staff's review of the issues raised by the Board at its July 22nd Agenda meeting, and follow-up discussions with the electric utilities, Board staff is recommending, the electric utilities to incorporate lessons learned from the June 23, 2015 weather event into their emergency operations plan.

Recommendations

As discussed in the previous section, Board Staff's review of electric utility outages following the June 23, 2015 weather event has revealed a number of lessons learned with respect to certain procedural and operational gaps in the restoration efforts which are noted in this report. Specifically, they include: communication and outreach with public officials, Board Staff and impacted customers; internal electronic communications with field personnel; and updating ETRs. Board Staff held meetings with ACE and all the EDCs (collectively the four electric utilities are referred to as the "EDCs") to discuss the identified issues.

Based on those discussions, Board Staff recommends the following:

All Electric Utilities (EDCs)

EDC 1: The EDCs should formalize and exercise their back up communications plans used to collect and disseminate voice, data and text information to their workforce and in particular their field personnel during an emergency event or major outage.

EDC 2: During a major weather event, the EDCs should identify as soon as practicable, after the release of a global ETR, those areas or pockets of customers projected to be restored last in the restoration process. The information shall be made available to municipal officials in the communities where customers that are last to be restored are identified so they can prepare for an extended loss of service.

Atlantic City Electric (ACE)

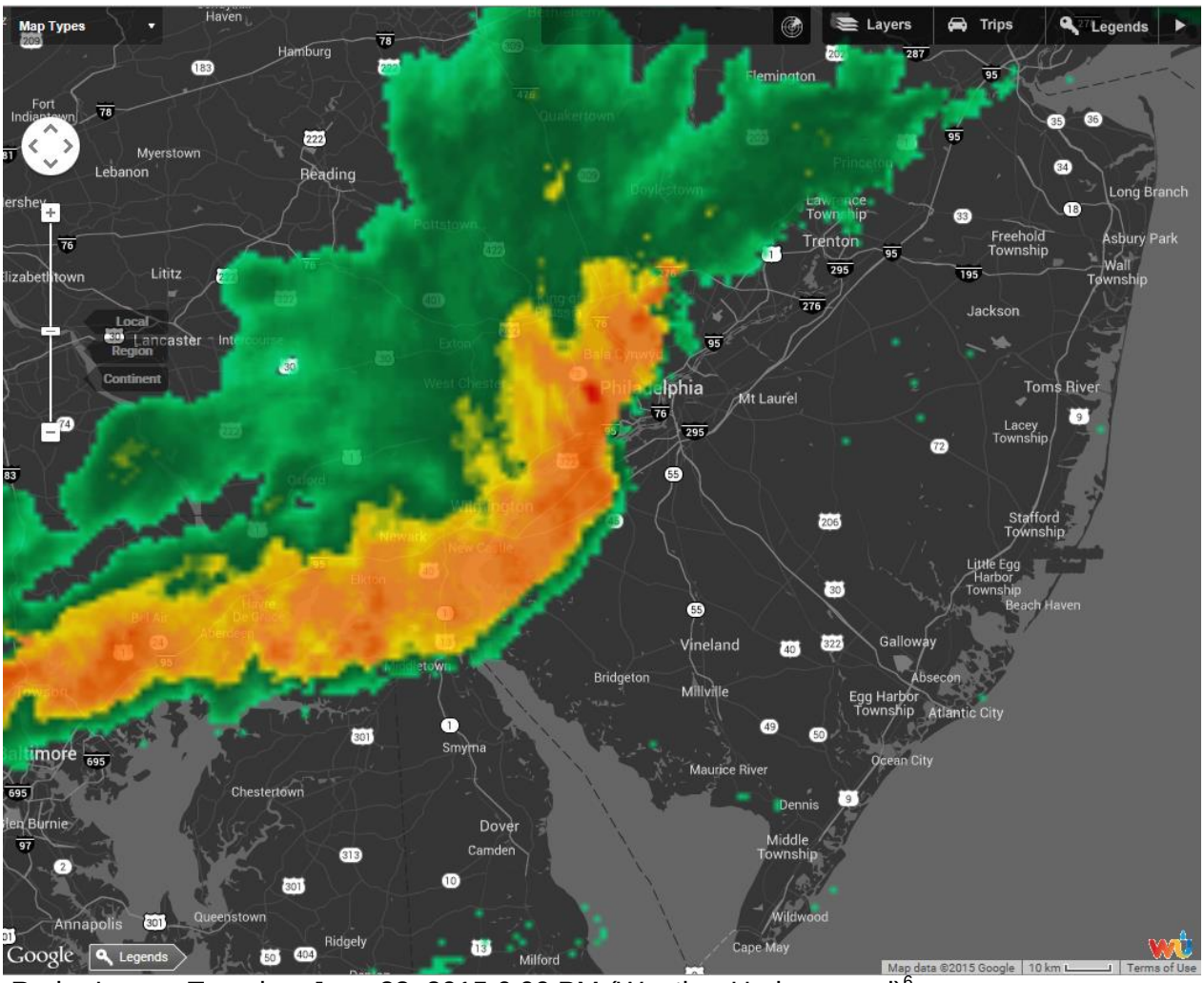
ACE Recommendation 1: ACE shall revise its emergency operations plan so as to improve outreach and dissemination of information to public officials impacted by a major weather/emergency event. ACE will clarify and confirm officials' contact information and preferences. During major outages, as defined in the company's Emergency Operations Plan as "Severe" or Catastrophic" Incidents, ACE will utilize these contacts and preferences to convey situational awareness to effected areas, regardless of the time of day.

ACE Recommendation 2: ACE shall work with BPU Emergency Management Staff on ways to improve coordination of outage information, particularly in the early stages of a major storm. In addition to the direct contact between BPU Staff and the Regulatory Liaison during a major event, ACE will add storm room Operations Leads to the list of ACE contacts.

ACE Recommendation 3: ACE shall reassess the methodology and processes employed to develop global Estimated Times of Restoration for major outages to ensure these global Estimates are based on the best available information on the extent of damage, immediately available workforce, arrival and deployment of mutual assistance workforce and materials. These Estimates should also reflect experience from past weather events and be informed by experienced restoration and operational personnel.

Appendix

Bow Echo Event Radar Imagery



Radar Image: Tuesday, June 23, 2015 6:00 PM (Weather Underground)[6]

[6] Weather Underground. (n.d.). *WunderMap*. Retrieved August 7, 2015, from Weather Underground: http://www.wunderground.com/wundermap/