CASE 13-E-0529

NEW YORK STATE
DEPARTMENT OF PUBLIC SERVICE STAFF REPORT

INVESTIGATION OF THE SEPTEMBER 2013 ELECTRIC OUTAGE OF A PORTION OF METRO-NORTH RAILROAD'S NEW HAVEN LINE

NOVEMBER 2014

This Report was prepared by assigned Staff of the Department of Public Service and does not necessarily represent the views of the Public Service Commission or of the individual Commissioners

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1.0 EXECUTIVE SUMMARY

On Wednesday, September 25, 2013, at 5:22 am, a single Consolidated Edison Company of New York (Con Edison) underground, pressurized, oil-filled, pipe-type electric cable supplying power at 138,000 volts (138 kV) to a Metro-North Railroad (MNRR) substation located in Mount Vernon, New York catastrophically failed. This cable failure crippled rail service on approximately an 8.3 mile stretch of MNRR's New Haven Line, one of MNRR's busiest commuter rail lines, creating hardships and disruptions to the lives of over 125,000 daily commuters of this rail line for the next twelve days.

Based on the New Haven Line's regional importance to the population and economy, Department of Public Service Staff (Staff) began an independent examination of the outage to review both its root cause and what steps, if any, could have been taken to avoid the incident and/or reduce its severity.

The MNRR Mount Vernon substation is normally supplied by two independent Con Edison 138 kV electric cables (also known as feeders), with each one capable of supplying 100% of the electric needs should the other one fail or be otherwise unavailable.[1] One of these cables is designated 38W09 and the other is designated 38W10. On September 13, 2013, one cable, 38W10, had been intentionally removed from service by Con Edison at the request of MNRR to facilitate the first phase of a planned major rebuild of MNRR's Mount Vernon substation. Discussions between Con Edison and MNRR surrounding the timing of the outage of cable 38W10 had been underway for months. Con Edison and MNRR agreed that, to complete the necessary work, cable 38W10 would need to be unavailable for approximately 30 days. Further, due to the nature of the work that involved relocating the terminal ends of cable 38W10, it could not readily be returned to service, if needed, once work commenced.

Staff's investigation found that prior to removing cable 38W10 from service, MNRR and Con Edison had not assembled a formal, agreed-upon contingency plan should the one remaining cable 38W09 become unavailable. . The actions described by Con Edison involved essentially two steps: 1) the use of diesel locomotives and buses by MNRR to handle the thousands of daily commuters that would be stranded; and 2) the use of an electric supply source or "tie" from the nearest easterly neighboring Cos Cob substation in Connecticut supplied by Connecticut Light & Power (CL&P) to power the 8.3 mile section of track normally powered by the Mount Vernon substation.[2] Regarding step one, MNRR

[1] In electric system design this is referred to as an N-1 or single contingency design. "N" here represents the number of critical electric elements (in this case cables) supplying the load (customer) and the "-1" represents the number of those elements that could be lost or unavailable (contingency) without interrupting electric service; however that also means that once an element is lost or unavailable an N-0 design situation exists, so that the loss of the remaining element results in the complete loss of electric service.

[2] Because the New Haven Line up to the Mount Vernon substation from the east is powered by a high voltage alternating current overhead catenary system and the track west of and south of the portion served by Mount Vernon

personnel informed Staff that without electric service it would be impossible to provide anything close to 100% service to commuters of the New Haven Line with diesel locomotives and buses.

As for the second step, Staff found that in the preceding thirty six years that Con Edison has had an agreement to provide electric service to the Mount Vernon substation, this electric tie to the Cos Cob substation had only been tested once. [3] The tie was operated for a test on July 25, 1996, with power flowing from Mount Vernon to Cos Cob, not in the direction it would have been feeding on September 25, 2013. Based on that test, MNRR concluded that the tie was only capable of providing a "rescue" service to move trains caught in the dead section between the Connecticut and the New York portions and could not provide any level of regular service. On September 25, 2013, the tie was used to rescue one stranded train, followed by MNRR then testing the tie by trying to move a ten-car test train. The tie failed this test and any further use of the tie was halted.

Con Edison stated that it had internal notifications, dating back to 2001, for previously scheduled outages on cables 38W09 and 38W10. All of these notifications mention the use of buses and diesel locomotives as a contingency in the event of a total loss of supply to MNRR's Mount Vernon substation. Con Edison informed Staff that they could not locate the original communication from MNRR outlining their contingency plan to use buses and diesel locomotives. In addition, Con Edison stated that the contingency use of the tie to Cos Cob was discussed during regularly scheduled calls throughout the planning phase for the rebuild of MNRR's Mount Vernon substation. On the other hand, MNRR advised Staff that information regarding the limitations of substitute diesel locomotives and buses was communicated to Con Edison personnel in discussions and regularly scheduled calls prior to the removal of cable 38W10 from service. Also, MNRR advised Staff that it did not regard the electric tie as a contingency for providing regular rail service in the event of loss of the 38W09 cable, given that its utility was limited to train rescue.

Staff's investigation found that neither MNRR nor Con Edison could produce any documentation (e.g., meeting notes, emails, phone logs, etc.) that would support their respective claims regarding discussions of the efficacy of the use of buses, diesel trains, and the Cos Cob tie.

Staff's investigation found that the actions discussed above and used on September 25, 2013 were inadequate. It was incumbent on MNRR to develop and have in place a realistic contingency plan, agreed

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substation is powered by a lower voltage third rail direct current system, the nearest electric support would have to come from an easterly substation, Cos Cob, in Connecticut, supplied by CL&P.

[3] Because of safety and Con Edison concerns regarding the integrity of its electric system, the agreement between Con Edison and MNRR stipulates that the tie is to always remain "open" or de-energized, and has very strict notifications rules and steps that need to be followed by both MNRR and Con Edison in the operation of the Cos Cob tie.

to by Con Edison, ahead of the planned outage. The planning for this outage had been months in the making. MNRR knew that with the above actions it could not provide meaningful service to its commuters should power be lost. Instead, MNRR proceeded with the single feeder supply source assuming the remaining feeder would not fail. This assumption was no doubt based on the historical reliability of Con Edison's high voltage underground oil-filled pipe-type electric cables in general and these cables supplying the Mount Vernon substation in particular.

Although MNRR had requested that cable 38W10 be removed from service for its substation upgrade needs, Staff found no direct evidence that Con Edison had questioned or sought information regarding a contingency plan. Con Edison simply assumed that old information covering prior planned outages of these cables--contained in an historic planning document--would suffice as a "contingency plan" for this phase of the Mount Vernon substation rebuild. In addition, Staff learned that Con Edison could not locate the original agreement that describes such a proposed "plan." The only documentation is in the e-mail. Last, Con Edison took those steps in that document at face value, which Staff finds is unacceptable considering the potential harm caused by an extended interruption to a rail line as busy and as critical to the region as the New Haven Line.

Staff assessed both the cable failure's root cause and examined what steps, if any, could have been taken to avoid the incident and/or reduce its severity. In order to facilitate this phase of the investigation, Con Edison hired two recognized expert forensic consultants: USi, to examine the cause of cable failure; and Lucius Pitkin (LPI), to perform metallurgical examinations of the damaged steel pipe that houses the cable and pressurized oil and to perform computer based thermal modeling.[4] In order to ensure and maintain the integrity of the investigation, Con Edison developed a strict protocol for obtaining and handling the damaged sections of cable and pipe from the field, the subject of the forensic examination, and preserving the chain of custody. Further, Con Edison also implemented a process for notifying and inviting Staff, MNRR, and the New York Power Authority (NYPA) [5] to the consultants' facilities before the start of any forensic related actions were performed on the cable or pipe sections. These visits provided Staff, MNRR, and NYPA unfettered access to examine the damaged sections, observe and understand the forensic related actions taken, and openly discuss with both consultants their thoughts and observations.

[4] For additional background information on Con Edison's consultants, please see their websites at USi - http://www.usi-power.com/; Lucius Pitkin - http://www.luciuspitkin.com/

[5] MNRR is a NYPA energy supply customer and Con Edison delivers this energy via its transmission system. NYPA also offers services to its customers including energy efficiency programs, engineering expertise, construction expertise and overall project management. For this project, NYPA was retained to provide design construction and management services to MNRR.

In order to remove from service cable 38W10, an oil-filled pipe-type cable, and perform the relocation of its terminal ends per MNRR's requirements, Con Edison first de-energized the cable and then performed a "freeze operation"[6] on cable 38W10.[7] A location near MNRR's Mount Vernon substation was selected for excavation to expose the two independent, adjacent cables and a freeze operation was initiated on 38W10. The forensic consultants concluded that the twelve-day freeze operation that commenced on 38W10 on September 13, 2013 in all likelihood led to the compromise of the oil in the adjacent cable 38W09 by sufficiently cooling the soil that surrounded both cable 38W09 and 38W10. In other words, the unexcavated soil surrounding both cables became cold enough to unintentionally freeze the oil in adjacent cable 38W09, severely compromising the dielectric capabilities of the oil[8] and leading to the catastrophic failure on the morning of September 25, 2013.

Con Edison has an extensive network of approximately 624 miles of pressurized, oil-filled, pipe-type cables. Con Edison also has a long history of installing and operating and maintaining these types of cables that dates back to the early 1940s. Staff's investigation found that Con Edison has performed hundreds of freeze operations without incident (since 2001, the Company performed approximately 18 freeze operations annually). There were several factors, however, that made this freeze operation atypical, thereby contributing to the cause of failure.

First, the soil and subsurface conditions of the freeze location provided conditions that facilitated the cooling of the soil to a temperature sufficient to freeze the oil in the pipe housing cable 38W09. Per LPI, a large section of bedrock just beneath the cables and the surrounding soil created a barrier that permitted the local pooling of water and the subsequent freezing of soil. This condition, thus, created a highly localized frozen environment between the frozen cable 38W10 and the operating cable 38W09, resulting in a significant oil temperature drop for cable 38W09. LPI's thermal analysis results indicate

[6] To repair or otherwise perform work on oil-filled pipe-type cables, it has long been an established practice by electric utilities to excavate and shore up the area surrounding the buried pipe, erect temporary protective cover, apply the appropriate freeze hardware that allows for the freezing agent (liquid nitrogen in this case) to continually surround a section of pipe which causes a section of the oil within the pipe to freeze. This frozen section of oil will then prevent oil upstream of the freeze from migrating downstream to where the work is being performed. Otherwise, to perform work, thousands of gallons of oil would need to be drained, risking contamination and unnecessary complications of refilling and pressurizing the pipe following repairs.

[7] Freeze operations on oil-filled pipe-type cables have been performed for at least 60 years within the electric industry. Staff's research found a discussion of freeze operations for undertaking repairs to pipe-type cables in the following 1954 publication: Skrotzki, "Electric Transmission and Distribution," Copyright, 1954.

[8] The pressurized oil contained in a pipe-type cable forms part of an electrical insulation system along with the oil-impregnated paper insulation surrounding the copper conductors. The two together provide the electrical insulation to electrically isolate and prevent the energized cable conductors that form the cable assembly from "short-circuiting" or "faulting" to each other or to the steel pipe. In short, when the cable is energized it is critical that the oil be in a fluid state to be an effective electrical insulator. Also, at the same time, the oil helps transfer the heat generated by the current carried by the cable to the pipe and surrounding earth.

that on about the eleventh day after the freeze operation commenced—coincident with the date of failure—the temperature of feeder 38W09 dropped sufficiently, approaching the freeze temperature of the dielectric oil.

Second, MNRR's electric load pattern is much different from most of Con Edison's other customers. MNRR's electric loads rise and fall very rapidly, and are highest during the morning and evening rush hour periods. Further, for a number of hours between midnight and early morning the electric load is zero or near zero. This is unlike the load pattern behavior of Con Edison's other customers, whose daily load changes between highs and lows are more gradual, and with the lows never going below some minimum base value that is significantly above zero. The significance is that when electric power is supplied to customers, the electric current generates heat in the supply cables. So, if Con Edison is performing a freeze operation near an adjacent cable, the heat being generated because of customer loads on the operating cable would normally help prevent the oil from freezing. MNRR's load pattern allowed for periods of very low demand and hence very low heat production that increased the chances of the oil in 38W09 becoming frozen and, hence, compromising its dielectric properties.

Staff's review of Con Edison's freeze operations documentation did not reveal any violation of procedures when establishing the freeze on cable 38W10. However, Staff's review of the primary engineering specifications , found that the procedures were insufficiently prescriptive regarding the monitoring of an adjacent cable during a freeze operation, allowing too much discretion to Con Edison personnel establishing the freeze. Further, neither the assessment of the cable's electric load characteristics nor the monitoring of soil temperatures in the vicinity of the freeze are part of the specification document, two key steps that could have alerted Con Edison of potential problems.

Staff ultimately determined from its investigation that Con Edison did not violate any provision of the Public Service Law (PSL) or its associated regulations. Accordingly, there is no legal basis for Staff to seek penalties through the pursuit of an administrative enforcement action under Public Service Law (PSL) §25-a. In addition, Staff does not recommend pursuit of a prudence case. First, the standard of proof requires demonstration that the company, given the facts and circumstances at that time, failed to exercise reasonable business judgment. Second, such a case requires the occurrence of cost to ratepayers that would be subject to disallowance. Even if there was an occurrence of ratepayer costs, the facts do not support a conclusion of imprudence. Although the company, as noted in this report, should have required better contingency planning of its customer, that fact in and of itself does not provide the basis for a finding of imprudence.

2.0 FINDINGS AND RECOMMENDATIONS

- **Finding 1:**

MNRR and Con Edison had not developed a formal agreed upon contingency plan to facilitate MNRR's Mount Vernon substation upgrades. Con Edison produced information originally provided by MNRR years ago for other planned outages of these two cables, outlining two steps to be taken should the remaining cable 38W09 fail. We learned those steps could never have provided anything close to full service, as was proven on September 25, 2013. One step, the electric tie or connection to Cos Cob's CL&P substation, was known by MNRR to be incapable for providing useful service. Also, MNRR knew that the other step, the use of diesel locomotives and buses, was incapable of providing anything close to full service to its commuters.

Staff found no evidence that Con Edison, at any time, questioned or sought more clarity from MNRR regarding the efficacy of those two steps should the single cable 38W09 become unavailable during construction. Con Edison accepted this information at face value, not considering the serious ramifications of its inadequacy.

- **Recommendation:**

Neither Con Edison nor MNRR should remove from service cable 38W09 to complete further upgrades at Mount Vernon substation until both sides have developed a plan that would reasonably ensure that should a failure of the single cable occur, MNRR will be able to provide uninterrupted service to its commuters of the New Haven Line.[9]

- **Finding 2:**

An N-1 electric supply design for critical infrastructure customers such as railroad, subway, airport, water supply, and wastewater customers MNRR may be inadequate when one supply is intentionally removed from service for maintenance or other reasons. The large scale harm inflicted on the population and the regional economy when these services are compromised or unavailable warrants a higher degree of reliability and redundancy.

- **Recommendations:**

Con Edison should conduct a review of the current electric supply configurations for each of its railroad, subway, airports, water supply, and wastewater customers. Con Edison should determine whether design

[9] On April 10, 2014, Con Edison filed with the Staff a jointly developed contingency plan with MNRR for a planned 28-day outage of feeder 38W09 scheduled to commence on April 18, 2014. This outage was necessary to complete the second phase of upgrades at Mount Vernon. Staff reviewed the plan and notified Con Edison and MNRR by letter on April 17, 2014 that the plan was reasonable. The work was completed without incident and the feeder returned to service May 10, 2014.

configurations similar to those present at MNRR's Mount Vernon substation also exist for members of these customer groups.[10]

If such N-1 configurations do exist, then prior to a planned outage of one of the electric supplies to a customer's facilities, regardless of whether the outage is requested by the customer or Con Edison and scheduled to last 12 hours or more, Con Edison should take the following steps:

a) Inform the customer of the risk of a total loss of supply should the remaining supply fail or otherwise become unavailable;
b) Ascertain whether the customer has an alternative electric supply and a contingency plan should both Con Edison electric supplies become unavailable;
c) If the customer has an alternative electric supply, the customer's senior management should provide in writing, with signature(s), a description of the alternative electric supply, its capability as a percentage of full service when compared with normal utility supply, the length of time that would be required to have the alternative supply providing service, its history of use and testing schedule;
d) If the level of service of the alternative supply or mitigation measures is less than 100% when compared with normal utility supply, the customer's senior management should affirm, with signature(s) that this a satisfactory circumstance for its customers and the governmental agency that oversees or regulates its operations;
e) If the customer does not have an alternative electric supply, then the customer working with Con Edison should develop a contingency plan to either provide an additional source of supply or other mitigation measures. The alternative supply or mitigation measures under no circumstance should provide no less than 50% of full service when compared with normal utility supply and should be able to be placed in service in no less than twelve hours following the total loss of supply. Further, the customer's senior management should affirm, with signature(s) that this a satisfactory circumstance for its customers and the governmental agency that oversees or regulates its operations;
f) Con Edison, at all times, should provide Staff with all of the above information two weeks prior to the intentional removal of an electric supply from service to a railroad, subway, airport, water supply or wastewater customer. Should circumstances arise that do not conform to the two week period, then the above information should be provided as soon as it is available, but no less than 24 hours prior to the outage.

[10] See December 10, 2013 letter from Chair Zibelman to President Ivey describing the customer type and design configuration review to be undertaken by Con Edison.

Con Edison must not simply accept a railroad, subway, airport, water supply, and wastewater customer's contingency plan for outages of power supplies or equipment requested by the customer. Con Edison needs to demonstrate that they understand the capabilities and limitations of the customer's proposed plan and potential consequences. Con Edison should also alert the customer and its own senior management if the proposed plan is found to be inadequate.

- **Finding 3:**

Con Edison's freeze procedures used by its personnel during repairs of its pressurized, oil-filled, pipe-type electric cables were not sufficiently prescriptive with regard to monitoring the temperature of an adjacent feeder. The procedures did not contain any instructions for monitoring the temperature of the affected soils surrounding the cables, nor did they provide an instruction for evaluating the load characteristics of the customer loads served by the adjacent cable.

- **Recommendations:**

Con Edison's freeze operation procedures, at a minimum, should be immediately revised to require the following:

1) temperatures of an adjacent cable(s) are to be continuously monitored at several locations to ascertain a satisfactory temperature profile along its exposed length;
2) temperatures of soils surrounding the cables are to be continuously monitored (the depth of soil penetration to be monitored to be provided by Con Edison engineering);
3) explicit instructions for personnel action to be taken in the event that the monitored temperatures of either the cable or soils are approaching dangerous levels (dangerous levels to be provided by Con Edison engineering); and
4) evaluations of the load characteristics are to be performed to assess atypical patterns or potential risks.

- **Finding 4:**

The Consultants' evaluation of the damaged feeder cable and pipe revealed that the failure occurred as a result of ionization and erosion of the cable insulation in the localized area where the dielectric oil had solidified from the freeze operation on the adjacent cable, and not from pre-existing weaknesses.

USi also examined cable sections remote from the failure location and found them to be in good condition and not showing any signs of long term deterioration. Further, results of the cable evaluation using industry accepted methods and standards indicated that the remaining life of the cable to be more than 40 years.

LPI’s evaluation of the pipe remote from the failure location using industry accepted methods and standards did not reveal any evidence of pre-existing damage or age-related degradation.

- **Recommendation:**

No action required.