Richard B. Miller
Assistant General Counsel

September 1, 2015

By Email

Honorable Kathleen H. Burgess
Secretary
State of New York Public Service Commission
Three Empire State Plaza
Albany, NY 12223-1350

Re: Cases 13-E-0030, *et al*: Con Edison's Electric, Gas, and Steam Rates – Con Edison's Storm Hardening and Resiliency Collaborative Phase Three Report

Dear Secretary Burgess:

In accordance with Ordering Clause 9 of the Public Service Commission's ("Commission") February 21, 2014 *Order Approving Electric, Gas and Steam Rate Plans in Accord with Joint Proposal* in the above referenced proceedings, as extended ("Rate Order"),[1] Consolidated Edison Company of New York, Inc. ("Con Edison") is filing its *Storm Hardening and Resiliency Collaborative Phase Three Report*.

During June through August 2015, Con Edison, Department of Public Service Staff, and a number of Active Parties met in the Storm Hardening and Resiliency Collaborative to review Con Edison's storm resiliency plans. This Report describes the resiliency work that Con Edison is currently performing and presents for the Commission's consideration Con Edison's proposed plans for resiliency work during the remainder of 2015 and for 2016. The Report also provides status reports regarding related collaborative initiatives, including the methane emissions reduction initiative, the climate change vulnerability study, and risk assessment and cost benefit modeling. Finally, the report responds to other requirements in the Commission's February 5, 2015 *Order Adopting Storm Hardening and Resiliency Phase II Report Subject to Modifications*.

This Phase III Report details the Company's plans and expenditures for the remainder of the rate plan as approved by the Rate Order. Consequently, this Phase III Report is the final storm

[1] Case 13-E-0030, *Order Adopting Terms of Joint Proposal to Extend Electric Rate Plan*, issued and effective June 19, 2015.

Consolidated Edison Company of New York, Inc.
4 Irving Place New York NY 10003 212 460 3389 212 677 5850 fax millerrich@coned.com

hardening report to be filed by Con Edison with the Commission. The Company anticipates that going forward it will incorporate resiliency planning into its regular operations and will seek approval for such expenditures as part of future rate case filings.

Very truly yours,

Attachment

cc: Active Parties: Cases 13-E-0030, 13-G-0031, 13-G-0032 (email)

Storm Hardening and Resiliency Collaborative Phase Three Report

Consolidated Edison Company of New York Inc.

September 1, 2015

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I. Introduction

A. Storm Hardening and Resiliency Guiding Principles

On October 29, 2012, Superstorm Sandy (Sandy) struck our region, devastating communities and our energy systems. The storm brought historic flooding and sustained high-speed wind. The damage to the electric system caused service outages to over 1,115,000 customers – five times the number of outages caused by Hurricane Irene in 2011. One-third of our steam customers lost service, and another 4,200 customers experienced gas outages. Sandy was an unprecedented storm that has changed the way our region and Consolidated Edison Company of New York ("Con Edison" or "the Company") plan for and respond to natural disasters.

To protect our customers, the region, and energy systems from future natural disasters, Con Edison filed electric, gas, and steam rate cases on January 25, 2013 (Cases 13-E-0030, 13-G-0031, and 13-S-0032) ("rate cases") that included proposals for a $1 billion capital investment for years 2013 through 2016 to mitigate impacts of future extreme weather.

Con Edison's storm hardening investments are intended to reduce and mitigate total customer outages by reducing the impact of wind/flood damage and improving restoration. We have made investments and plan to continue making investments guided by the following four principles:

1. **Protect infrastructure –** Relocate and protect equipment to minimize exposure to wind and water infiltration.

2. **Harden components –** Strengthen equipment to withstand water inundation and tree damage.

3. **Mitigate impact –** Improve flexibility to allow for advanced flow controls around damaged equipment.

4. **Facilitate restoration –** To identify location and description of

damaged equipment, install remote monitoring and improve communications to expedite information flow.

These initiatives will improve the resiliency of Con Edison's electric, gas, steam distribution systems and steam and electric generation stations by making delivery and generation structures and equipment more resistant to weather-induced failure and by reducing the time for restoring service to customers.[1] As the 2015 New York State Energy Plan recognizes, "In light of the realities of extreme weather events, a changing climate and the hazards they present, major utilities like Consolidated Edison (Con Edison) have already begun identifying the threats and investing in resources to address them."[2]

B. The Storm-Hardening and Resiliency Collaborative

In the 2013 rate cases, at the recommendation of the Department of Public Service Staff ("Staff"), Con Edison convened a collaborative of interested parties to consider:

- The Company's storm hardening proposals and related recommendations of the rate case parties,
- The storm hardening design standard for various aspects of the Company's system, and
- Whether and how climate change impacts should be incorporated into the storm hardening design standard.

The Collaborative Parties participated in a series of meetings beginning on July 8, 2013 to exchange and discuss information, ideas, and proposals on many of the resiliency-related issues that the parties presented in testimony filed in the rate cases. In addition to the three areas mentioned above, workgroups of the Collaborative discussed and examined the following topics:

- Development of analytical models for risk assessment and cost/benefit analysis of proposed storm hardening projects,
- Examination of alternative resiliency strategies to hardening the grid, including microgrid projects, sited distributed generation, energy efficiency, demand response, and alternative meters; and

[1] Throughout this report, the word "resiliency" refers to resistance of the Company's facilities to weather–induced failure or the ability to restore service following a weather-induced service outage.

[2] *The Energy to Lead:* 2015 New York State Energy Plan, at 13 (June 30, 2015).

- Mitigation of the climate impacts of gas distribution system methane losses.

1. Con Edison's Storm Hardening and Resiliency Collaborative Report

On December 5, 2013, following the completion of the Collaborative' s deliberations, Con Edison filed with the Commission, its *Storm Hardening and Resiliency Collaborative Report* ("Phase One Report"). The Phase One Report summarized the work of the Collaborative, including the topics and issues examined by its several working groups.

With regard to storm hardening and resiliency, the Phase One Report described the work that Con Edison had performed to strengthen its energy systems during 2013 and presented for the Commission's consideration Con Edison's proposed plans for resiliency work to commence during 2014 to 2016. The Phase One Report provided detailed scope and cost information about the Company's resiliency work plans for 2014, which had been reviewed in detail in the Collaborative, particularly by Staff.

The Phase One Report discussed Con Edison's adoption of a storm hardening design standard that reflects the most current flood plain maps issued by the Federal Emergency Management Agency ("FEMA") plus the addition of three feet. Con Edison is designing flood protection projects to be commenced during 2014 through 2016 based on the 1% annual flood hazard elevation (100 year floodplain) established by FEMA Maps 100-year floodplain (the most recent version is December 2013) plus three feet of freeboard ("FEMA plus three feet").

The Company has been monitoring for changes in base flood elevations and for updates in climate change forecasts and sea level rise projections made by the New York City Panel on Climate Change ("NYPCC") or other similar organizations. Every five years, beginning in 2018, or sooner if warranted, the Company will consider revision of the flood protection design standard to reflect such changes. [3]

The Phase One Report also described Con Edison's redesign of its Risk Assessment and Project Prioritization Model, which assesses and ranks storm hardening projects according to reduction in vulnerability of customers and critical infrastructure to an electric service outage due to flooding or wind damage. The redesigned model incorporates a storm surge inundation prediction model developed by the New York City Mayor's Office of Long Term Planning and Sustainability.

The Company committed in the Phase One Report to conduct a study to identify the long-term impacts of climate change on its energy systems and measures that the Company might undertake to address those long-term impacts.

The Phase One Report also included proposals to:

- Develop an economic cost/benefit model for assessing storm hardening projects,
- Conduct an initiative to reduce natural gas distribution system methane emissions by quantifying emissions from and reducing the backlog from Type 3 leaks, and
- Examine potential alternative strategies incorporating distributed energy resources to achieve resiliency or mitigation of the impact of future extreme weather, including heat and storms, on Con Edison's customers, including distributed generation, microgrids, energy efficiency, demand response, electric vehicles, energy storage, and time-differentiated pricing for rates.

[3] Based on 24 global climate model ("GCM") projections, the NYPCC states that New York City sea level is likely to rise over the next several decades. NYPCC states that, relative to the 2000 to 2004 base period, the middle range of GCM projections (25th to 75th percentile) projects sea level rise of 4 to 8 inches by the 2020s and 11 inches by the 2050s. NYPCC states that the "high estimate" of GCM projections (90th percentile) projects sea level rise of 11 to 24 inches by the 2020s and 31 inches by the 2050s. New York City Panel on Climate Change, *Climate Risk Information 2013: Observations, Climate Change Projections, and Maps*, June 11, 2013, http://www.nyc.gov/html/planyc2030/downloads/pdf/npcc_climate_risk_information_2013_report.pdf

C. The Commission's 2014 Rate Order

The Commission's *Order Approving Electric, Gas and Steam Rate Plans in Accord with Joint Proposal*, issued February 21, 2014 in Cases 13-E-0030, *et al.* ("2014 Rate Order"), adopted, subjected to understandings and changes stated in the 2014 Rate Order, the terms of the Joint Proposal filed in that proceeding. [4] The 2014 Rate Order commended the Collaborative as "a unique process and a far-sighted approach" that "has provided a valuable focus for innovative approaches to the 21st Century challenges to the utility system."[5] The Commission adopted the Joint Proposal recommendations for Collaborative phases two and three. The 2014 Rate Order addressed the specific Phase One Report proposals as follows:

- The Collaborative parties will review planned storm hardening projects and expenditures for the second and third rate years during collaborative discussions commencing in June 2014 (for second rate year projects) and in June 2015 (for third rate year projects), and Con Edison will file a report with the Commission on these discussions and Con Edison's recommended projects by September 2, 2014 ("September 2, 2014 filing") and September 1, 2015, respectively. Following the Commission's review of Con Edison's report and the parties' comments, the Commission will determine any modifications to the planned storm hardening projects for the rate years.[6]
- Con Edison will conduct a comprehensive climate change vulnerability study with participation of collaborative parties. The Commission stated that rapid developments in climate science forecasts require ongoing review of the Company's storm hardening design standard, and the Company's study of long-term climate impacts is expected to provide a longer-range basis for ongoing review and the data needed to revisit the standard if indicated. Recommendations related to this study or a progress report will be provided in the September 2, 2014 filing.[7]
- Con Edison will continue the development and expansion of its risk assessment model and will develop a cost/benefit model for future storm hardening and resiliency capital investment that assesses and compares the relative benefits and costs of resilience of utility infrastructure measures and alternative resilience measures. The model should consider risks and probabilities of future climate events, the expected useful life of assets, and

[4] 2014 Rate Order, Ordering Clause 1, p. 73. The Joint Proposal is contained in Appendix C to the 2014 Rate Order.
[5] 2014 Rate Order, pp. 64, 67.
[6] 2014 Rate Order, pp. 69, 74-75.
[7] 2014 Rate Order, pp. 67, 71, 75.

social cost factors, such as, the impact of outages of varying duration on affected customers and the potential risk to critical facilities. Recommendations related to this initiative or a progress report will be provided in the September 2, 2014 filing.[8]

- The Collaborative parties will continue to investigate technologies for quantifying methane emissions from Type 3 (non-hazardous) leaks and will propose a program to further reduce the backlog of such leaks. Recommendations related to this initiative or a progress report will be provided in the September 2, 2014 filing.[9]

With regard to the examination of alternative resiliency approaches incorporating distributed energy resources, the 2014 Rate Order stated that these issues would be considered in the upcoming REV proceeding rather than in the Collaborative.[10] The Joint Proposal, however, had proposed that Con Edison undertake with collaborative input three projects involving alternative resiliency strategies, and the 2014 Rate Order directed Con Edison to undertake these projects and report to the Commission within six months of the date of the 2014 Rate Order:[11]

- Develop non-traditional programs to meet load growth in the Company's electric networks in Brooklyn,
- Consider elimination of the single customer limitation in Con Edison's offset tariff to expand its availability for operators of microgrids, and
- Develop a time-sensitive rate pilot.

Con Edison submitted reports to the Commission on August 21, 2014 regarding non-traditional programs to meet load growth in the Company's electric networks in Brooklyn and a time-sensitive rate pilot project.[12]

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[8] 2014 Rate Order, pp. 67-68, 71, 75. The 2014 Rate Order states that the Commission expects to develop a single, consistent cost/benefit approach during the course of the "generic regulatory framework proceeding" that was subsequently established in Case 14-M-0101 (Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision).

[9] 2014 Rate Order, pp. 70-71.

[10] 2014 Rate Order, pp. 68-69. ("The broader issues of the role of alternative resilience strategies such as distributed generation and microgrids are encompassed in this anticipated generic enquiry.")

[11] 2014 Rate Order, pp. 69-70.

[12] The Joint Proposal provided that the Company would consider the elimination of the single customer limitation in the offset tariff as an element of an implementation plan addressing a report on the feasibility of microgrids for infrastructure that would be issued by NYSERDA in April 2014. Con Edison reported to the Commission, by letter

D. Phase II Report and Commission Order

The Phase Two Report described in detail the storm hardening and resiliency work Con Edison was currently performing. It also presented for Commission approval the Company's proposals for work and forecasts during and through 2015 and 2016. The Phase Two Report contained information regarding Con Edison's current and proposed future storm hardening and resiliency work on its systems including: protecting costal networks from storm surges and water infiltration; the use of submersible transformers to provide continuity of service; addressing the needs of its overhead electric distribution system; substation protection to provide continuity of service; gas transmission and distribution systems to prevent infiltration of water; steam generating and distribution systems to provide continuity of service; its buildings and other facilities; and, the telecommunications systems it uses to monitor and control its energy generating and distribution systems. In addition, the Phase Two Report provided status reports on related collaborative matters such as the methane emissions reduction collaborative, the climate change vulnerability study and the Company's risk assessment and cost benefit modeling performed to direct its storm hardening and resiliency efforts.

The Commission found that the Phase Two Report reflected the collaborative discussions. In the Phase II Order, the Commission adopted Con Edison's storm hardening and resiliency plans for 2014 through 2015, subject to certain modifications. The Commission did not approve the Company's 2016 plans. The Commission stated that it expected the 2016 plans for electric to be addressed in the Company's then current electric rate case and the 2016 storm hardening and resiliency plans for gas and steam to be addressed in this Phase Three Report and

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dated August 20, 2014 to the Secretary, that NYSERDA had not yet issued its report and that the Company's consideration of the single customer limitation in its offset tariff has been held in abeyance pending issuance of the report. Subsequently, on January 6, 2015, NYSERDA issued the report and the Commission granted the parties' request for an extension to January 6, 2016 file Con Edison's proposed implementation plan. Meanwhile, this Collaborative has met twice and a third meeting is scheduled for September 2015.

any future rate cases for these utility services. Subsequently, Con Edison entered into an agreement to extend the electric rate plan for an additional year and the Commission noted accordingly that the 2016 electric expenditures would also be considered in the Phase III report.[13]

E. Overview of Con Edison's Storm Hardening and Resiliency Collaborative Phase Three Report

Con Edison's *Storm Hardening and Resiliency Collaborative Phase Three Report* ("Phase Three Report") is filed in compliance with the 2014 Rate Order's requirement (Ordering Clause 9) for the September 1, 2015 filing and the Commission's Phase II Order. It is the final Collaborative report. The Company is requesting approval for each of its services, electric, gas and steam. This report contains the following:

- A detailed presentation of Con Edison's planned storm hardening and resiliency projects to be conducted during the remainder of 2015 and 2016, including project scope, rationale and cost forecasts.
- Con Edison's work performed through 2014-15 and the actual costs for projects through 2014.
- A status report on Con Edison's ongoing Climate Change Vulnerability Study.
- A status report on Con Edison's Storm-Hardening Risk Assessment Model and development of a Storm-hardening Cost/Benefit Models.
- A status report on Con Edison's ongoing project to develop technology to quantify methane emissions from Type 3 gas leaks.
- A status report on the single customer limitation in the Company's standby tariff applicable to distributed generation deployed in front of the meter.[14]

As stated in the first bullet above, this Phase Three Report contains a detailed presentation of changes in Con Edison's projects and forecasts since the last report. As will

[13] Case 15-E-0050, Order Adopting Terms Of Joint Proposal To Extend Electric Rate Plan, at 7 (June 19, 2015).
[14] Staff issued on July 28 its Straw Proposal on Track Two of the Reforming the Energy Vision proceeding that addressed regulatory and tariff issues, including standby rates for Distributed Generation. Case 14-M-0101, Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision. Con Edison will file comments on the Track II proposal and no further update is provided within the body of this report.

happen with any project, actual costs and forecasts are updated to provide the latest estimates. Accordingly, the costs for some of the projects that the Commission approved in its Phase II Order are now different for both 2015 and 2016. Con Edison is accordingly requesting here that the Commission approve all of the projects listed and this report contains the final forecasted costs for the Company's Storm Hardening Plan for each of its services.[15] In accordance with the currently effective rate plans, actual costs in excess of the rate plan amounts for each of the Company's services, electric, gas and steam, will be deferred for later recovery. The Company notes that there the costs for some services are currently expected to be higher than previously forecasted, but that the total amount of the entire Storm Hardening Plan over the three years is approximately the same as was approved by the Commission in the 2014 Rate Order.

II. Organization of Phase Three Storm Hardening and Resiliency Collaborative

The 2014 Rate Order invited the Company, Staff and other participants to manage the collaborative process to most effectively and efficiently realize the scope of the Phase Three collaborative initiatives.[16] The Company and Staff established a Phase Three collaborative schedule with interested parties in early May, 2015. The parties decided to conduct collaborative activities in a series of weekly meetings of all interested parties in June 2015. Each meeting focused primarily on Con Edison's 2015-16 storm hardening and resiliency infrastructure plan and an update on 2015-16 storm hardening activities in one or more operational area, e.g., gas infrastructure or electric overhead infrastructure. In addition, Con Edison reported on the ongoing Climate Change Vulnerability Study and on its progress in refining its risk analysis model and in comparing its economic cost benefit model for assessing storm hardening and

[15] As provided in further detail in this report, some of the costs that the Commission approved for 2015 will now be spent in 2016 and be part of that forecast. The Company, however, is not seeking here the approval of its 2016 forecast separate and distinct from its entire three year forecast for each service.
[16] 2014 Rate Order, p. 71.

resiliency projects to the one used by New York City. Con Edison prepared and circulated meeting agendas in advance of each meeting. Con Edison hosted each meeting and offered a WebEx presentation for the convenience of parties not attending in person.

The Collaborative parties held the following meetings:

Date	Topic
June 2, 2015	Substation Projects, Steam and Electric Generating Station Projects, Steam Distribution Projects, Electric Distribution Projects, Facilities Projects
June 9, 2015	Gas System Projects and Tunnel Projects
June 17, 2015	Telecommunications Projects, Risk Analysis and Cost Benefit Modeling, Climate Change Vulnerability Study

The presentations provided by the Company at each of the above meetings are attached to this Phase Three Report as follows:

Appendix A: Substations and Steam Operations Presentation

Appendix B: Electric Distribution Presentation

Appendix C: Facilities Presentation

Appendix D: Gas System and Tunnels Projects Presentation

Appendix E: Telecommunication Projects Presentation

Appendix F: Risk Assessment and Cost Benefit Models Presentation

Appendix G: Climate Change Vulnerability Study Presentation

The methane emission reduction collaborative has been conducted in a series of meetings/ conference calls October 1, 2014 and January 6, January 13, February 5, March 30, and June 1, 2015.

Con Edison also circulated a draft of this Phase III report to the Collaborative on August 3, 2015 to provide an opportunity for comments, requesting that such comments by provided by

August 17. Department of Public Service Staff and New York City provided comments on the report. Con Edison held a final conference call meeting of the Collaborative on August 25 to discuss the Company's responses to the Staff and City comments and to provide an additional opportunity for any other Collaborative participant to provide comments on the report.

III. Overview of Con Edison's Planned Storm-Hardening and Resiliency Projects for 2014 through 2016

Con Edison initially presented its 2014 to 2016 electric, gas, and steam systems storm hardening projects in its January 25, 2013 rate case filings as updated on March 25, 2013. Since these filings, the Company has performed engineering reviews that have refined project scopes and designs and have enabled the Company to develop more precise cost estimates for these projects. The Company also adjusted project designs to accommodate the FEMA plus three feet flood protection design standard that the Company adopted in July 2013. This Phase Three Report reflects updated storm hardening project scopes, designs, and costs resulting from Con Edison's ongoing work to plan, design, and budget the deployment of these measures. As shown in the table below, the currently forecasted overall 2014 to 2016 cost of the electric, gas, and steam systems storm hardening projects is expected to be approximately the same as the total reflected in the Company's electric, gas, and steam rate plans.[17]

[17] The sum of $975.5 includes expenditures for electric storm hardening expenditures in 2016 as projected in the rate cases. Con Edison's initial Electric Rate Plan covers the period of 2014 through 2015 but it was subsequently extended to cover an additional year. Con Edison's Gas and Steam Rate Plans cover the period of 2014 through 2016.

	2014-16 (Rate Plans) ($ millions)	2014 Actual	2015 Current Projection	2016 Current Projection	2014-16 Current Projection
Coastal Networks	172.0	31.7	36.6	38.5	106.8
Submersible Transformers	35.2	45.3	30.0	27.6	102.9
Overhead Distribution	242.0	42.1	94.5	80.1	216.7
Electric Transmission	8.9	3.5	3.1	2.0	8.7
Substations	210.0	24.0	92.8	151.5	268.3
Electric Generation	55.5	1.8	5.9	30.0	37.7
Gas and Tunnels	143.3	8.3	23.1	86.4	117.8
Steam Generation	92.0	8.1	25.4	35.0	68.5
Steam Distribution	0.0	4.7	5.7	0.0	10.4
Facilities	10.0	0.0	5.0	5.0	10.0
Telecom System	6.6	1.3	2.7	2.6	6.6
Total	975.5	170.8	324.8	458.7	954.3

This Phase Three Report describes and provides scope and cost information for each project. Material changes from projects costs reflected in the electric, gas, and steam rate plans are identified and explained in this report. Justification, scope and cost information for new projects are also provided.

IV. Electric System Storm Hardening

This section addresses projects to storm harden Con Edison's electric power system, including the network distribution system, the overhead distribution system, and substations. The costs of these projects are reflected in Con Edison's Electric Rate Plan except as noted herein.

A. Coastal Networks Storm Hardening

1. Coastal Networks Storm Hardening Objectives

Category 1 or 2 hurricane flooding caused by rain and coastal storm surges could cause major damage to Con Edison's underground electric infrastructure, particularly in low-lying areas, as was experienced in Sandy. The coastal networks in Brooklyn, Manhattan, and Queens could be submerged in several feet or more of salt-water. Severe flooding in underground networks and at substations can cause customer outages. Outages also occur when specific flood-prone networks are preemptively de-energized when severe flooding is predicted, as was the case during Sandy, in order to prevent damage to Company equipment and customer equipment, and to protect the public from electric hazards.

The underground network cable system is submersible; all primary and secondary network cables are fully insulated, and waterproof splices are used to connect them in every manhole and service box on the system. Network switches, called Network Protectors (NWP), are not submersible; a NWP is used to take a 120/208 volt or 265/460 volt distribution transformer out of service for routine work or during an emergency (a fault on the distribution feeder that supplies the associated transformer). Customers' switchgear is also typically not submersible.

There are three types of services, 120 volt, 460 volt, and High Tension. Commonly referred to as High Tension Vaults (HTVs), the latter is used for large facilities that have their own transformers; they do not have NWPs and cannot be removed from service directly by the Company. Extensive flooding of the networks, as experienced during Sandy, poses three threats: a safety concern (shock or electrocution) from submerged customer equipment at the 120 volt level; a fire concern due to cross phase arcing of submerged 460 volt equipment in the NWP vault room; and system sustainability issues from faulted HTV equipment causing network feeders to de-energize.

Con Edison began addressing this risk in 2005 based on lessons learned by electric utilities during Hurricane Katrina. The Company proactively began to require that interconnecting customers in flood-prone areas either install submersible electrical equipment, or raise critical equipment above the ground floor. By taking these steps, the Company not only mitigated the potential impact of a major flooding event on those customers' equipment, but also reduced the probability that the electric distribution system would be impacted by a fault current on the customers' side of the meter. Additionally, Con Edison began installing submersible transformers and network protectors as equipment in flood-prone areas was replaced or upgraded.

During Sandy, three coastal networks were taken out of service preemptively and 24 additional feeders in eight other coastal networks were shut down to de-energize 460 volt services. The three networks shut down (Bowling Green, Fulton, and Brighton Beach) have too many 460 volt services in the flood zones to simply remove the associated feeders from service; there would not be enough feeders remaining in service to supply the remaining network load. In addition, multiple network feeders de-energized due to faults on HTV equipment. It took five days to restore service, and 11 days to return to full contingency design (N-2), primarily because many NWP replacements were required. Our goal is to reduce these periods to 24 and 48 hours, respectively. To accomplish this, Con Edison is installing submersible units to eliminate the need for replacing these NWPs.

In the aftermath of Sandy, the Company further assessed the design basis for each underground electric network and developed strategies to further reduce the impact of flooding on underground equipment, including a plan to replace non-submersible equipment more proactively, rather than requiring such designs for only new installations and upgrades.

2. Coastal Network Storm Hardening Projects

a) 460V Submersible Network Protectors

Con Edison currently plans to install 407 newly designed submersible network protectors for the 460 volt services (which generally are used to supply larger buildings) in flood zones to protect them from saltwater damage. All 265/460V units in the FEMA 100 Year plus 3 feet zone will receive new, submersible network protectors. During flood events, these units will be opened in order to de-energize customer's equipment that is not submersible so that our feeders supplying the network protectors will remain in service. We installed 11 units in 2013 and 106 units in 2014. We currently plan to install 150 units in 2015 and 140 units in 2016

b) 120/208V Submersible Transformers

We plan to replace all 120/208 volt transformers in FEMA 2013 plus three feet flood zones with off-the-shelf submersible equivalents. The Company has identified a total of 903 transformers for replacement and plans to replace 456 units through 2016. We installed 106 units in 2013 and 150 units in 2014, and plan to install 100 units in 2015, and 100 units in 2016. The remaining units will be replaced in 2017, 2018, and 2019. Transformers are being replaced on a prioritized basis that reflects the following factors:

- Damage from Sandy
- Critical/essential customers

- Association with a feeder that is critical to network reliability

c) Isolation Switches (Bowling Green / Fulton Networks)

Smart-grid technologies provide tools that make the grid more flexible and responsive during extreme weather to minimize power outages. Smart-grid measures such as sectionalizing switches allow system operators to identify and isolate problem areas and rapidly bring power back to the surrounding areas, keeping more customers in service. To protect underground coastal networks vulnerable to corrosive salt-water flooding and minimize power outages, Con Edison is installing smart switches to reconfigure the most vulnerable underground networks to form separate flood areas. The Company is reconfiguring three networks in order to limit the impact of flooding to isolated parts of the networks and protect the rest of the networks. One reconfiguration is complete (Brighton Beach network in Brooklyn), and the reconfiguration of the Fulton and Bowling Green networks in lower Manhattan will be completed by the end of 2015. When the region is threatened by floods, operators will be able to preemptively isolate areas at risk while electricity continues to flow in the surrounding areas.

The Fulton and Bowling Green networks were preemptively shutdown during Sandy although over half of the customers in those networks are outside of the flood zone and experienced no flood damage, including the New York – Presbyterian/ Lower Manhattan Hospital on Gold Street and the New York Stock Exchange on Wall Street. To avoid entirely shutting down the Fulton and Bowling Green networks during a future flood event, we are installing 20 isolation switches on network feeders in these two networks to allow the isolation of vulnerable flood zones from the customers on higher ground. Opening the switches in advance of a flood event will divide each network into an area that will remain energized and an area that will be de-energized. The net effect is that approximately half of the customers will remain in service, including the New York – Presbyterian/ Lower Manhattan Hospital on Gold Street and the Stock Exchange. This requires a new secondary boundary within the network and reinforcement of secondary and primary cable both to facilitate the de-energization plan and to expedite restoration as flood waters recede in the network and customers are ready to be restored.

d) Isolation Switches (13 Networks)

We will install similar isolation switches at additional locations in thirteen other networks in Manhattan to de-energize customer equipment associated with 69 high tension (13,800 volt) installations. This equipment resides in the FEMA 100 Year plus 3 feet zone, and during Sandy, some of the network feeders that energized this equipment failed while in service because of customer issues related to flooding. Feeder failures due to flooding in customer equipment can jeopardize the sustainability of these networks during high demand periods because these networks would be at or beyond their design criteria. This could potentially affect over 100,000 customers residing in these networks. In order to minimize this exposure, these isolation switches will be installed to de-energize and isolate the customer equipment. We installed 10 switches in 2014 and will install 20 in 2015 and 19 in 2016. These 49 switches will harden all 69 customer locations because some switches harden multiple customer locations. With the use of underground smart switches and submersible equipment, coastal networks will be designed to be available to be restored in 24 hours after they are preemptively de-energized to protect equipment; these measures will provide substantially faster service restoration than occurred following Sandy.

An updated white paper describing the scope and cost for each of the four programs to storm harden coastal networks is provided in Appendix H – Undergrounding-Overhead Whitepapers.

3. Coastal Networks Storm Hardening Project Cost Estimates

a) Costs Reflected in Electric Rate Plan

In the 2013 rate case, Con Edison presented plans to conduct four programs to storm harden the coastal networks from 2014 through 2016 at a total estimated cost of $207.2 million. The estimated costs for these programs for the period 2014 – 2016, reflected in the Electric Rate Plan, are summarized in the following table:

Coastal Networks (Rate Plan)* ($ millions)	2014	2015	2016	2014-2016 Cost (Rate Plan)
120/208V Submersible Transformers	15.0	10.0	15.0	40
460V Submersible Network Protectors	10.0	15.0	14.0	39
Isolation Switches (9 Networks)	19.0	30.0	23.0	72
Isolation Switches (Bowling Green / Fulton)	21.0	0	0	21
Subtotal	**65**	**55**	**52**	**172**
Submersible Transformers	12.5	11.3	11.4	35.2
Total	**77.5**	**66.3**	**63.4**	**207.2**

*Rate Plan period is 2014 and 2015

b) Updated Costs

During the Phase One Collaborative and in the Phase One Report, the Company presented updated costs for the coastal network storm hardening programs as shown in the following table:

Coastal Networks (Phase One Report) ($ millions)	2014	2015	2016	2014-2016 Cost (Phase One Report)
120/208V Submersible Transformers	22.5	15.0	22.5	60
460V Submersible Network Protectors	10.0	15.0	14.0	39
Isolation Switches (9 Networks)	19.0	23.0	23.0	65
Isolation Switches (Bowling Green / Fulton)	21.0	0	0	21
Subtotal	**72.5**	**53.0**	**59.5**	**185**
Submersible Transformers	12.5	11.3	11.4	35.2
Total	**85**	**64.3**	**70.9**	**220.2**

As a result of ongoing project development work, including incorporation of the new flood protection design standard, FEMA plus three feet, in late July 2013, Con Edison has refined the estimated costs of the coastal networks storm hardening projects.

The Company's projection of cost for each coastal networks storm hardening project is shown in the following table:

Coastal Networks (Phase Three Report) ($ millions)	2014 Actual	2015 Current Projection	2016 Current Projection	2014-2016 Current Projection
120/208V Submersible Transformers	9.3	9.2	14.0	32.5
460V Submersible Network Protectors	7.6	11.0	14.5	33.1
Isolation Switches (13 Networks)	9.8	15.9	10.0	35.7
Isolation Switches (Bowling Green / Fulton)	5.0	0.5	0.0	5.5
Subtotal	31.7	36.6	38.5	106.8
Submersible Transformer	45.3	30.0	27.6	102.9
Total	77.0	66.6	66.1	209.7

Con Edison's current 2014 to 2016 expenditure projection of $209.7 million is greater than the $207.2 million reflected in the Electric Rate Plan (including submersible transformers) mainly as a result of an increase to the submersible transformer project (*see* n.18, p. 22). In addition, the project to install switches to reconfigure boundaries of the Fulton and Bowling Green networks was accelerated, and $14 million, originally planned for 2014, was spent in 2013. These reductions are partially offset by the $20 million increase in the 120/208V Submersible Transformers program that was explained in the Phase One Report.[18] Transformer costs have been removed from the other programs and are all included under the submersible transformer line.

[18] See Phase One Report, p. 17, which explained that after more detailed review and analysis the unit cost for submersible 120/208 volt transformer installations was increased from $100,000 to $150,000 due to the higher percentage of larger capacity 1000 kVA units to be replaced vs. 500 kVA units. There was also a realignment of costs from other areas.

B. Overhead Distribution System Storm Hardening

1. Overhead Distribution System Storm Hardening Objectives

The Company's design basis for the overhead system is consistent with the National Electric Safety Code (NESC). The NESC section 250B requires power facility structures to be designed to withstand specific combinations of ice and wind depending on loading class. Con Edison follows the Grade B design basis, which is the highest design grade in the NESC. Nonetheless, the overhead system remains vulnerable to failure due to the impact of high winds on vegetation. During a typical storm event, the overhead distribution system's main vulnerability is falling trees and tree limbs.

The Con Edison electric overhead distribution system has provided industry leading reliability on blue sky days due to the redundancy of its automatic loop and 4kV primary grid power delivery design. This redundancy and the ability for the system to automatically isolate faults and heal itself works to provide uninterrupted service to customers during events with one failure location. In storm events when widespread damage occurs, our system will automatically isolate damage, but this will not be enough to prevent outages if, for example, main supply feeds are unable to supply customers until field work and further isolation can be completed.

Con Edison's overhead system experienced severe damage from Irene and Sandy. Several additional storms, though smaller in scale, were also destructive, including the February 2010 snowstorm, the March 2010 nor'easter and the October 2011 snowstorm. Prior to 2010, the last year with more than one major, destructive storm was 2006. While a majority of customers were restored over several days, complete restoration of the overhead electric system took a week or more for each of these storms, primarily due to extensive damage caused by downed trees and tree limbs, and the multiple impacts of those trees on single electric feeder routes.

To avoid lengthy outages after future major weather events, we are further hardening the existing overhead system — both to reduce damage and to minimize the impact of any outages that do occur. The goal of Con Edison's overhead system storm hardening strategy is to make the grid stronger and also more flexible and responsive by mitigating each specific risk associated with the impact of high winds on vegetation. Our planned investments will reduce and mitigate customer outages on the overhead system. We will also reduce damage assessment time to improve recovery and response operations and thereby reduce outage duration. In addition to mitigating the impact of storm damage on customers, this work is expected to lower future restoration costs and increase the system's reliability on good weather days.

2. Overhead Distribution System Storm Hardening Projects

Con Edison's plan to storm harden overhead circuits involves four programs:

- reducing the number of customers served from each feeder segment
- installing isolation switches on small open wire spurs off the main circuit line
- improving resiliency on targeted supply circuits
- installing breakaway service connectors

a) Reducing Feeder Segment Size

Our overhead system upgrade plan will reduce storm impact to customers by reducing the number of customers served by a circuit segment to fewer than 500 customers wherever economically practical designs can be implemented.[19] By making this change, we will reduce the number of customers that are impacted as a result of a single point of damage on the system. We initially identified 634 circuit segments where we can deploy additional automatic devices to reduce circuit segment size, and the number of customers served by each segment. After further analysis and review, the Company has a goal of completing 576 locations by year-end 2016.

[19] "Economically practical" means that the cost of implementation is proportionate to the benefit provided. For example, where substantial reconfiguration would be required and the cost would be much higher for a single segment, the cost would be disproportionate to the benefit provided and Con Edison would not pursue the project.

Automatic isolation devices, such as fuses, reclosers, and Kyle switches, [20] operate automatically to isolate the extent of an outage and rapidly restore service to customers on the upstream side of the isolation device without the need for operator intervention. A typical Con Edison circuit runs for several miles in total. A failure at a certain point of the circuit will affect other customers on the same circuit depending on the location of the closest upstream protective device. Increasing the number of automatic protective devices per circuit limits the number of customers affected by a single event, such as a falling tree. In addition to the benefit of the automatic operation, having additional devices also allows greater flexibility in isolation and restoration when a failure does occur.

The Company is installing additional reclosers and sectionalizing switches (both SCADA-ready and manual) that are designed to reduce the number of customers between circuit segments. In case of permanent faults occurring on the overhead system, the additional reclosers and sectionalizing switches are designed to reduce the number of customers affected by a faulted cable section to a target of 500 or less. The Company's goal of approaching 500 customers per segment offers the best balance between reliability and expenditure given the current system configuration.

Specifically, we are taking the following actions:

- Deploy 486 vacuum reclosers – intelligent switches that can automatically detect faults and isolate portions of feeders without operator intervention. We installed 46 units in 2013. We installed 134 units in 2014, and plan to install 208 units in 2015 and 98 units in 2016.
- Install Supervisory Control and Data Acquisition (SCADA) enabled switches for 53 circuit segments where additional vacuum reclosers cannot be added. These switches, called gang switches, are remotely controlled devices that allow operators to determine the location of a fault and isolate damaged sections from the control room, without having to dispatch a crew to the location. Having specific information on where the fault is located also

[20] A Kyle switch is a type of automatic recloser that allows for single phase isolation.

allows our operators to narrow down where on our system a repair may be needed. We installed 53 units in 2014 to complete this project.

- The Remaining 37 circuit segments have been addressed as a part of our "Improving Auto-loop Reliability" program, which is discussed on page 26 of this document.

b) Isolating Open Wire Spurs from Feeder Main Runs

Our overhead distribution system relies on a combination of main feeder lines and smaller spurs off of the main line to distribute power throughout a neighborhood. Usually the spurs – some of which have their own sub-spurs – are strung with open wire. Open wires are generally more vulnerable to damage from contact with trees and other debris than insulated wires. In some cases, damage or faults on an open wire spur can flow up to the main feeder line, potentially causing outages for many more customers down the main line. To reduce the risk that damage on spurs will affect main feeder lines, we are installing isolation devices (fuses, fuse bypass switches, and automatic sectionalizing switches) on open-wire spurs and sub-spurs that are more than two spans in length (i.e., the distance between three utility poles). These devices are designed to isolate faulted spur sections from the feeder main run.

We have identified approximately 3,500 locations where these isolation devices can be deployed. We installed 2,548 units in 2013, 637 units in 2014 and plan to install 300 units in 2015. Once the devices are installed, customers in overhead areas will be less likely to experience power outages as a result of damage to lines in other parts of their neighborhood.

c) Improving Resiliency on Targeted Supply Circuits

In 2007, Con Edison commissioned a study to examine the costs and feasibility of undergrounding our overhead facilities. The study developed an estimated cost to underground overhead feeders based on the characteristics of six typical feeders (three in Staten Island and three in Westchester) and an underground loop-type system design consisting of cable installed in a conduit and manhole system with underground vault transformers and with switching by a combination of vault-type automatic sectionalizing switches and manual single phase vacuum switches and disconnectable splices. At that time, the study estimated the cost of undergrounding our overhead facilities to be approximately $6.2 million/mile. The Company's 2013 update of the study estimated the cost to be $8.2 million/mile.[21]

In view of the high cost of undergrounding all of our facilities,[22] the Company believes that storm resiliency can be achieved more broadly and efficiently, and as effectively, by deploying a variety of measures that will a) improve circuit performance in overhead areas that have experienced relatively more storm damage and b) strengthen specific distribution facilities that supply municipal and commercial infrastructure and facilities that provide critical community needs during and following severe storms. These measures include: (1) improving auto-loop circuits, (2) installing circuit-specific measures to harden services to specific customers, and (3) selective undergrounding.

(1) Improving Auto-Loop Reliability

We are improving the reliability of our existing auto-loops – looped circuits that are fed power from both ends -- that have been susceptible to storm damage. The following measures are being implemented to improve auto-loop performance:

- Introduce additional supply feeders to allow for continued service during feeder outages
- Divide large auto-loops into several smaller loops

[21] An expenditure of $100 million would underground about 12 miles of the overhead system. Undergrounding portions of the overhead system offers several benefits including reduced storm outages, improved roadway aesthetics, reduced automobile-to-pole collisions, and reduced tree trimming costs. But undergrounding has a number of drawbacks including high cost, significant cost to residential and commercial customers to connect to the new underground service, exposure to corrosive conditions underground, longer service restoration time when outages do occur, and maintenance cost that is considerably higher than an overhead system.

[22] Con Edison's two-year Electric Rate Plan (2014-2015) reflects an expenditure of $100 million in 2015 for undergrounding portions of the electric system for purposes of storm hardening. The Phase One Report proposed the expenditure of $100 million per year in 2015 and 2016 for undergrounding.

- Upgrade wire and pole sizes to improve storm resiliency. Require poles in storm-prone areas to be 15 percent stronger and able to withstand gusts up to 110 miles per hour
- Use Hendrix Aerial Cable, which is more resilient than traditional open wire design
- Install additional vacuum closer switches to reduce circuit segment size

Auto-loops are selected for improvement based on the following criteria:

- Non-Network reliability Index (NNRI) ranking[23]
- Impact during Sandy and previous storms
- Availability of alternate supply
- Supply to critical infrastructure such as hospitals

As part of the Targeted Supply Circuit spending in 2015 and 2016, the Company plans to improve the following autoloops:

- Fleetwood Loop in Westchester
- Van Nest Loop in the Bronx
- Mt. Vernon Loop in Westchester
- Banksville Loop in Westchester
- Laurel Hill Loop in Queens
- Dyker Loop in Brooklyn
- Gravesend Loop in Brooklyn
- Marine Park Loop in Brooklyn
- Teatown Loop in Westchester
- Sing Sing Loop in Westchester
- Croton Loop in Westchester
- Yonkers Loop in Westchester

Additional auto-loops since the Phase III report that are projected for completion in 2016:

- Sleepy Hollow Loop in Westchester
- West Laconia Loop in the Bronx
- Don Bosco Loop in Westchester

[23] The Company has developed a modeling technology known as NNRI (Non Network Reliability Index) to assist our engineers in evaluating the performance of feeders supplying auto-loops. This model takes into account past performance, current circuit conditions, and projected weather patterns to forecast predicted feeder reliability. These simulations result in circuit rankings that can be compared before and after a proposed improvement.

- St Peters Loop in the Bronx
- Crowhill Loop in Westchester
- Longhill Loop in Westchester
- Elmsford Loop in Westchester
- Harbor Island Loop in Westchester
- Bowman Loop in Westchester
- Southside Loop in Westchester
- Port Chester Loop in Westchester
- Ludlow Loop in Westchester
- Warburton Loop in Westchester
- Tuckahoe Loop in Westchester
- Gun Hill Loop in the Bronx

(2) Installing Circuit-Specific Measures

Con Edison will develop circuit-specific solutions to harden services to critical customers such as hospitals, pumping stations, and community shopping centers that provide essential needs during and after a storm. These measures will include Aerial Cable systems and redundant feeds to Automatic Transfer Switch (ATS) [24] supplied Transformer Systems, and Pad-Mounted Equipment (PME) switches. [25] In addition, Kyle spurs, directional ties, and gang switches will be utilized.

An Aerial Cable System has a number of features that improve resiliency during storms. These include a durable, insulated underground-type cable that is suspended by a sturdy, non-current carrying, steel messenger cable. This cable is less likely to fault on contact with tree

[24] An ATS-supplied transformer system creates two service supplies (a preferred and a redundant alternate) that provides a back-up service for a customer if one service supply fails.

[25] PME switches provide operational flexibility to add generators or other back-up sources to maintain service in the event that distribution supply is interrupted. PME switches can support micro grid operation for further community flexibility.

limbs, less likely to be downed by tree contact, and more likely, compared to non-insulated open wire, to remain energized if dislodged.[26]

(3) Selective Undergrounding

The Company will use undergrounding of distribution equipment selectively for extended runs of overhead circuits and as a component of a location-specific approach that develops the optimal mix of measures to improve storm resiliency on specific supply circuits, as discussed above.

Examples of undergrounding extended runs of overhead circuits are the conversion/ relocation to underground of seven miles of open wire cable on feeders 33R04 and 33R06 in Staten Island during 2015. These two feeders were chosen because of their critical supply to our 4kV unit substations (Canterbury (06), Nassau (06), and Nelson (04)) and to critical customers (Staten Island University Hospital South (both 33R04 and 33R06), Tottenville High School (both 33R04 and 33R06), Seaview Hospital (33R04), and the College of Staten Island (33R06)). The feeder 33R08 project is projected to be completed in 2016 as reflected in the project list attached as Appendix Q.[27] The cost for undergrounding these circuits in 2015 is shown in the following table:

Staten Island: Install Aerial Cable and Underground Cable to Reduce Dependence on Open Wire ($ millions)	
Feeder 33R06	17.1
Feeder 33R04	7.9
Total	**25**

[26] The Company has determined that these additional auto-loops will provide a reliability/resiliency benefit comparable to selective undergrounding and without the disruption that would be required for undergrounding.
[27] The Company had reviewed other Staten Island projects with the Collaborative but will not be pursuing them at this time. The Company will continue to consider these projects in the future.

Examples of location-specific undergrounding will be the installation of underground cable sections to support ATS transformer systems providing redundant overhead and underground supplies to critical facilities such as a municipal town hall, fire station, and police station, or water works plant.[28]

The Targeted Supply Circuit Resiliency program will focus on feeders supplying areas that have experienced the highest storm damage impact and feeders supplying facilities that are critical to maintain community support following severe storms, such as police and fire stations, town halls, and pumping stations. We used a comprehensive outreach to local governments in order to determine those facilities that are most critical to maintaining the basic necessities within their respective municipalities. In addition, we have analyzed our overhead system to establish criteria to prioritize circuits and segments for hardening via the aforementioned measures.

During the Collaborative, Con Edison's Chief Engineer for Overhead System planning met with representatives of the City of New York and Westchester County to explain the increased focus on overhead feeders supplying areas that have experienced the highest storm damage and feeders supplying facilities that are critical to maintain community support during and after severe storms, such as police and fire stations, town halls, and pumping stations. As discussed in this Phase Three Report, undergrounding of distribution equipment will be available as a component of a multidisciplinary approach that develops the optimal mix of measures to improve storm resiliency on specific supply circuits and auto-loops. In the interim, while selective undergrounding will continue to be available as an option to be considered, the Company has reallocated some of the selective undergrounding funds allocated to other projects that have greater benefit, such as the aerial cable and the

[28] Various examples of selective undergrounding are shown in Appendix H.

autoloops. The list of all projects, including those not pursued, is shown in Appendix Q – Electric Overhead Prioritization.

d) Breakaway Service Connectors

We are also conducting a pilot to evaluate the functionality and benefit of break-away service connectors. If struck by falling trees or heavy branches, break-away devices on overhead service cables (cable supplying individual customer premises) are designed to break away rather than pull down and damage the customer's equipment. The break-away device is designed to fully de-energize the service conductors to maintain public safety and can be quickly reconnected to restore service to a customer. We installed 150 breakaway service connectors in 2014, installed 124 more in 2015 and we intend to continue installing in 2015 and 2016 in a pilot program area within various municipalities in southern Westchester (Greenburgh, Mamaroneck, Mt. Vernon, New Rochelle, Scarsdale, White Plains and Yonkers) where we analyzed historical outage data to identify specific areas with high concentrations of tree-related service cable outages and field verified that the targeted areas exhibit significant overhead tree exposure. The average unit cost is currently estimated to be $1,800 per device installation. Upon the completion of the pilot program, we will look to evaluate the functionality of the connectors over at least an 18 month period, weather conditions permitting -- specifically that the sacrificial component fails before damage to the associated pole or house connection can occur and that it does not fail under non-catastrophic impacts. The projected cost of this program is $0.5 million in 2015 and $0.4 in 2016.

An updated white paper describing the scope and cost for each of the four programs to storm harden the overhead electric system is provided in Appendix H – Undergrounding-Overhead Whitepapers.

3. Overhead Distribution System Storm Hardening Cost Estimates

a) Costs Reflected in Electric Rate Plan

In the rate case and in the Phase One Report, Con Edison presented plans to conduct four programs to storm harden the electric distribution overhead system from 2014 through 2016 at a total estimated cost of $242 million ($42 million without undergrounding projects), including $15 million in 2014, as follows:

1. Reduce Circuit Segment Size: $19.15 million from 2014 to 2016.
2. Isolation of Open Wire Spurs from Feeder Main Runs: $3.0 million from 2014 to 2016.
3. Improvement of Auto-loop Reliability: $19.8 million from 2014 to 2016.
4. Selective Undergrounding of Overhead Infrastructure: $200.0 million from 2015 to 2016.

The estimated costs for these projects for the period 2014 – 2016, reflected in the Electric Rate Plan and presented in the Phase One Report, are summarized in the following table:

Overhead Distribution (Rate Plan)* ($ millions)	2014	2015	2016	2014-2016 Cost (Rate Plan)
Reduce Circuit Segment Size	5.4	8.4	5.4	19.2
Isolate Open Wire Spurs	3.0	0	0	3
Improve Auto-loop Reliability	6.6	6.6	6.6	19.8
Selective Undergrounding	0	100.0	100.0	200
Total	**$15**	**$115**	**$112.0**	**$242.00**

*Rate Plan period is 2014 and 2015

b) Updated Costs

The Company's current projection of storm hardening cost for each program is as follows:

Overhead Distribution (Phase Three Report) ($ millions)	2014 Actual	2015 Current Projection	2016 Current Projection	2014-2016 Current Projection
Reduce Circuit Segment Size	10.6	17.4	12.4	40.4
Isolate Open Wire Spurs	5.7	3.0	0.0	8.7
Targeted Supply Circuit[29]	25.2	73.6	67.3	166.1
Breakaway Service Connectors	0.6	0.5	0.4	1.5
Total	42.1	94.5	80.1	216.7

The three-year decrease of $25.3 million for electric distribution reflects a re-distribution of funding to cover the increased spend associated with the Substation Resiliency Project, which was originally expected to be above the Rate Plan target by approximately that amount.

This redistribution was implemented as follows: The overhead storm hardening effort is comprised of a number of sub-programs. These include efforts to install additional fuses, sectionalizing switches, enhance automatic loop performance and selective undergrounding for municipalities that have expressed interest in it. The Company used its NNRI model to help prioritize its efforts on loops, focusing on worse performing circuits first. A similar approach was used with selective undergrounding jobs. Con Edison gave each municipal facility a priority rating – based upon the criticality of the facility – and developed a prioritized list on that basis. The project list was intended to be dynamic from the outset to account for changes in projects as more detailed designs were developed and changes in municipal interest. In other words, the

[29] This category includes Improve Auto-Loop Reliability and Selective Undergrounding.

Company intended from the outset to change the scope of work and costs as it considered implementation of these projects.

The Company then decided to transfer funds to substation storm hardening work to seek to maintain the rate plan target because of substation's higher costs (as described above) and because substations are more exposed to flooding damage and can affect larger number of customers than the overhead system. By making use of the previously established priority list for overhead projects, the Company decided to defer lower priority work originally slated for 2016 to later years. These projects will be considered for future reliability/resiliency work, subject to the Company's work prioritization process.

C. Electric Substation Storm Hardening

1. Electric Substation Storm Hardening Objectives

Prior to Sandy, flood protection of substations was based on applicable codes, standards and historical storm data. As Sandy approached, initial predictions for the storm surge appeared to be approximately at the Company's existing flood protection level. As added protection, additional temporary protection measures were installed, including water barriers and sand bags to protect critical equipment as much as three feet above the predicted storm surge level. Nonetheless, the storm surge far exceeded predictions, and the additional flood control measures were overwhelmed. Critical stations were severely impacted leading to the loss of load at key locations, which resulted in extensive customer outages followed by an extended system restoration period. [31]

[31] As a result, ten networks in lower Manhattan lost power for approximately four days until the transmission stations could be brought on line to energize the area substations. The Goethals and Fresh Kills transmission substations in Staten Island were also shut down due to flooding and wind. As a result, three area stations in Staten Island and associated load areas lost power for up to 13.5 hours.

Flooding during Sandy shut down six transmission substations and eleven area substations. In total, 11 Manhattan networks and three Staten Island load areas were shut down as the result of flooding at these substations. These substations suffered a tremendous amount of salt-water flooding that damaged an extensive amount of equipment that is critical to feeder operation including the various components of the protective relaying and dielectric systems.[32] Salt water submergence caused extensive corrosion of controls and operating mechanisms. Transmission feeders and equipment could not be restored to service until minimal amounts of these auxiliary systems were in service. Restoration of these systems entailed a laborious and time-consuming process to clean, dry, or replace relay protection and station auxiliary equipment. The East 13th Street Substation supply to lower Manhattan networks was lost during Sandy due to a combination of the failure of Transformer (TR) 13 and the loss of the remaining seven 345kV supply feeders when salt water entered relay systems and caused them to mis-operate and de-energize. [33]

Post-Sandy assessments of damage at Con Edison's substations identified additional measures needed to protect the stations from storm flooding, including reinforcing station perimeter walls, installing gates and floodwalls, and raising critical equipment. The Company developed plans to protect the following 16 substations stations against future flood conditions and storm surge:

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[32] All major components of these transmission stations (feeders, power transformers, phase angle regulators and breakers) require protective relaying systems. These relay systems detect electrical faults and remove current carrying equipment from service to minimize damage and prevent cascading trip-outs from occurring. These relay systems, which require power to operate, are comprised of low voltage wires, control cabinets, relays, and telephone lines. Many of the feeders (transmission and sub-transmission) are comprised of current carrying conductors contained within a pipe. The conductors are surrounded by pressurized oil (pressurized to approximately 200 pounds per square inch), which is the insulating medium for the conductor. The dielectric system maintains this pressurized oil. It is comprised of Public Utility Regulating Stations (PURS), pumping plants and pressurization plants, which contain many components such as pumps, valves and piping. These plants require power to operate.

[33] The transmission substations are East 13th St.138 kV, East 13th St. 345 kV, and East River in Manhattan and Goethals, Fresh Kills 345 kV, and Fresh Kills 138 kV in Staten Island. The area substations are Avenue A, Cherry, East 29th St., East 36th St., West 19th St., Leonard St. No. 1, Leonard St., No. 2, and Seaport in lower Manhattan and Woodrow, and Fresh Kills 33kV in Staten Island.

1. East 13th Street
2. East River
3. East 15th Street PURS
4. East 36th Street
5. Seaport
6. Trade Center
7. Gowanus
8. Goethals
9. Fresh Kills
10. Hellgate/Bruckner
11. Sherman Creek
12. Farragut
13. Rainey
14. Vernon
15. Leonard Street
16. Avenue A

The installation of storm hardening measures will help to maintain the operational integrity of these facilities during extreme storm events. Overall, the substation storm hardening program is focused on the following primary objectives:

- Maintain remote control and situational awareness
- Prevent de-energization of power supply equipment due to flood water intrusion;
- Maintain relay protection integrity;
- Minimize equipment damage from salt water; and
- Allow for rapid recovery.

The storm hardening program is designed to protect each station from the infiltration of flood waters that could interfere with the operation of the station. This will allow the stations to maintain their configuration while minimizing salt water damage to critical electrical equipment that will help to prevent widespread customer outages due to a complete loss of a substation.

2. **Storm Hardening Measures Installed by June** 2013

Con Edison installed by June 1, 2013, the onset of the 2013 hurricane season, many of the following flood control measures in each of the operationally affected stations to mitigate the effects of a storm similar to Sandy:

- Installed reinforced-concrete protective moats around critical equipment and secondary flood pumps that provide additional protection against seepage into the moats;
- Sealed all electrical conduits and control wiring and cable troughs that could provide a water path between the outside environment and the protected interior;
- Installed valves on storm drains to prevent backflow of water into station;
- Installed new flood doors at egress points to protect against floodwaters;
- Installed new gaskets on cabinets to protect against water infiltration;
- Installed expansive polymer foam in the conduits that enter each panel to ensure no floodwater is able to enter and damage equipment;
- Installed nitrogen-driven pumps that maintain pressure on critical feeders in the event of a loss of normal power to the pumping plants;
- Secured industrial shrinkable fabric material to protect non-operating equipment for deployment as part of coastal storm preparations (as outlined in the Corporate Costal Storm Plan) to enhance protection against moisture intrusion;
- Removed existing fencing and raised the concrete threshold level around the perimeter of some stations;
- Installed new flood panels and new, higher, reinforced baffle plates behind louvers to protect against additional surge of floodwaters;
- Installed new reinforced-concrete wall along the property line of certain stations to protect against floodwaters; and
- Installed new watertight joint material to replace all existing caulking on the joints of precast panels at certain stations.

During 2013, Con Edison completed the following work at nine substations and three generating stations:

- 54 new concrete moats
- 210 flood doors and barriers

- 81 submersible pumps
- 21 high capacity diesel-powered pumps (1,000 gpm) with 16 hour fuel tanks
- Approximately 3000 conduit and trough seals

3. Storm Hardening Measures to Be Installed from 2015 to 2016

During 2015 to 2016, Con Edison plans to install the following additional measures:

- Install new, lifting relay cabinets distributed throughout the substations at the location of the equipment that they protect. The new cabinets will be able to be raised on their mountings above the flood zone when a storm is expected;[34]
- Install fiber-optic-based communications equipment to eliminate or significantly reduce copper cable, which is more vulnerable to salt-water infiltration;
- For future equipment purchases, such as transformers and phase-angle regulators, define the purchase specification to ensure that new equipment comes with critical protection controls, including a tap-changer drive and control mechanism, located on the equipment housing above the flood level;
- Raise critical control cabinets in pressurization and cooling plants;
- Install new emergency diesel generators elevated above the flood-control level. Include design provisions to easily remove and reinstall the generator in case it has to be relocated during an emergency. Also, install quick-type emergency connection points that are accessible at the station; [35]
- Relocate the East 13th Street substation control room, which is located at grade level and was flooded during Sandy, to an available second floor space, which is 3.8 feet above the FEMA plus three feet design level. This shift will include the installation of new Human Machine Interface (HMI) automation equipment and relocation and installation of communication rooms. Relocation of major equipment such as the existing reactor breakers and a diesel generator is also included in the work scope at the complex;
- Install new high-capacity flood control pumps at certain stations;
- Relocate other critical station equipment above the flood-control elevation;
- Make submersible or protect critical equipment that remains in the flood zone;

[34] The distributed, elevated relay cabinets replace centralized relay houses that in flooding conditions presented a single point-of-failure exposure and long runs of copper wiring susceptible to flood damage.

[35] The electric backup generators will have dual fuel (diesel and natural gas) capability, except at two locations where the weight of dual fuel units would exceed the structural capacity of the station roof. On-site diesel fuel storage will be sufficient to operate the generators continuously under full load for approximately 24 hours. In advance of major storms, provision will be made for availability of supplemental fuel to extend generator operation. We have evaluated the cost of gas supply to these units and have included a summary of the results below.

- Install additional moat walls at other substations and raise existing walls to meet new flood-control elevations; and
- Install new sheet-pile surge walls around the perimeter of Goethals substation, and along sections of the perimeter at Fresh Kills and Gowanus stations. At Goethals, the wall will extend beyond the FEMA plus three feet flood control elevation. This wall will protect the station from flooding as well as potential infiltration of ground water.

All critical substation equipment within the FEMA plus three feet elevation will be protected from coastal flood waters. The FEMA plus three feet design adds about three to four feet to the protection level achieved by the initial storm hardening measures completed by June 2013. All work requiring elevating equipment or constructing flood barriers will be designed to the FEMA plus three feet protection level. Con Edison plans to install flood control measures at 16 substations during 2015 to 2016.

The Company also plans to replace existing electromechanical type relays with microprocessor type relays at six transmission substations in 2015 and 2016. These substations are terminations for six overhead 345kV transmission feeders located in the same transmission corridor. The existing first and second line relays for these feeders are materially degraded and cannot be maintained adequately to Original Equipment Manufacturer (OEM) specifications, and OEM parts are unavailable to replace the failed components. The existing relays for these feeders have mis-operated multiple times in the last four years taking a feeder(s) out of service, which negatively impacts the reliability of the transmission system. The existing relays are susceptible to over-tripping, which can be triggered by wind-blown debris, hail, and lightning strikes during storms or severe weather conditions.

In our day-to-day operations, Con Edison experiences approximately 85 transmission feeder trips in a year, and we implement our Rapid Restoration procedures using SCADA control from our Energy Control Center to immediately restore the feeders that tripped due to relay mis-operation. During Sandy, we experienced 72 transmission trips in approximately 18 hours, including 50 trips in just five hours. A large volume of trips in a short duration can overwhelm our capability to rapidly restore feeders using SCADA controls. This can lead to a cascading sequence of trips and loss of load because feeders that tripped due to relay mis-operations could not be restored quickly by operator action.

Because the potential for parallel mis-operation of these relays and the loss of transmission supply are enhanced during severe storm conditions, the Company will storm harden these six transmission feeders by upgrading the relays to microprocessor type relays which are not susceptible to over-tripping during severe weather conditions. The new relays will utilize Con Edison's Corporate Communications Transmission Network (CCTN), which will provide a more reliable platform for the transmission of relay signals than the current carrier platform.

Updated white papers describing the scope and cost for each substation project are provided in Appendix I – Substations Whitepapers.

4. Substation Storm Hardening Project Challenges in 2014

A significant engineering effort was completed in 2014 for some Storm Hardening projects that were originally planned to be constructed in 2014. This included planned work for 10 of the at-risk substations. After completion of the engineering effort, Con Edison believed there was sufficient time to initiate these projects and substantially complete construction in 2014, but the Company experienced two major challenges after transitioning into the construction phase: significantly higher than expected contractor bids and longer time periods to receive permits from the Department of Buildings ("DOB") to perform work.

Con Edison maintains a partnership with the Department of Buildings to properly file for and obtain all necessary permits to perform major work at Company facilities. During the first phase of the Storm Hardening efforts, the Company was able to obtain permits in less than one week's time. Upon filing for permits for the 2014 Storm Hardening work, approvals took from three months to six to seven months. This delayed starting construction on the planned 2014 projects, which in most cases were then not initiated until the beginning of 2015.

These projects were sent out to the contractor market via Request for Quote ("RFQ") to obtain competitive bids to perform the work in the field. The Company received bids for all projects that were significantly higher than expected. In addition, the margin between the bids and expected costs was not consistent, ranging from approximately 30% higher to as much as 300% higher than planned. The Company then engaged in significant negotiations and re-bid efforts to achieve contractor costs that were closer to a competitive and fair price. Con Edison was successful in lowering the prices but they were still higher than original expectations. This negotiation process caused additional delays to the start of construction of the 2014 projects.

These two major issues affected the Substations Storm Hardening program schedule. Much of the work that was intended to be constructed in 2014 was not initiated until early 2015. This has affected all of the following projects in 2015 and 2016 as well, which now have to be expedited to be completed in a smaller time window. There have also been cost impacts**.** The higher contractor bids have indicated new market conditions for which the Company did not previously account. This has increased project costs for the program, resulting in requirements for additional funding to complete the planned Storm Hardening work on schedule. This change to project cost estimates is shown in the following section.

5. Substation Storm Hardening Project Cost Estimates

a) Costs Reflected in Electric Rate Plan

In the 2013 rate case, Con Edison presented plans to install storm hardening measures at 14 substations from 2014 through 2016 at a total estimated cost of $210.0 million.

b) Updated Costs

As a result of ongoing project development work, including incorporation of the new flood protection design standard, FEMA plus three feet, in late July 2013, Con Edison has continued to refine the estimated costs of the substation storm hardening projects. As a result of adopting a new flood protection design standard in late July 2013, Con Edison identified five additional substations where flood protection measures will be installed from 2014 to 2016 and three substations where work originally planned for 2014 to 2016 will no longer be required. The five additional substations are:

1. Farragut
2. Rainey
3. Vernon
4. Leonard Street
5. Avenue A

The preliminary costs for Farragut, Rainey, and Vernon, provided in the Phase One Report, totaled $2.9 million. Preliminary costs for Leonard Street and Avenue A had not been developed.

The three substations that were removed from the 2014-2016 program are:

1. 59th Pier
2. West 49th Street
3. Academy

The Phase One Report also stated that Con Edison continued to prepare detailed designs for each project and refine the costs for each project and would adjust estimated project costs accordingly. The Company therefore provided an updated projection of storm hardening cost at each substation for the Phase Two Report.

Total projected expenditures for substation storm hardening from 2014 to 2016 increased in the Phase Two Report by $25.35 million from the rate case projection of $210 million to $235.35 million. A variety of factors contributed to the increased substation cost projections at that time.

The Company has continued to refine its estimates as it prepares detailed engineering and designs for specific components of the projects and receives bids for the performance of construction and installation work. The rate case projection, filed less than three months after Sandy, reflected preliminary development of project designs and information. Con Edison had not previously constructed storm hardening projects of this nature and consequently developed its initial estimates on the basis of roughly analogous work from other historic jobs, for example, the cost to build a platform, but without any of details regarding the specific construction characteristics and equipment outages required for the particular storm hardening project. In addition, the rate case projection did not incorporate the higher flood protection design standard, FEMA plus three feet, which the Company adopted in late July 2013. Meeting the FEMA plus three feet design standard contributed substantially to the $120.7 million cost for the East 13th Street Substation projected in the Phase One Report – an increase from the $105.1 million rate case projection.

The projected cost of the East 13th Street Substation at the time of the Phase II report was $164.3 million, an increase of $59.2 million from the original rate case projection of $105.1 million or an increase of $43.6 from the $120.7 projection in the Phase One Report. As discussed below, additional storm hardening-related costs accounted for $15 million of this $43.6 million increase, and newly required bulk power station reliability design requirements account for $28 million. The $15 million increase in storm hardening related costs result from the following:

- Upgrade and integrate the major transmission substations connected to East 13th St. in order to ensure communication among the stations and full functionality of the new East 13th Street Substation control room and automation system; also, integrate associated area substations and East River 69kV substation. In association with the relay system upgrades at East 13th Street, a substantial amount of upgrade, integration, and commissioning work will be performed at the transmission stations that are electrically tied to and fed from East 13th St. This work is essential to ensure that the new East 13th St control room, relay, and automation systems are properly integrated with these other stations and do not negatively impact the operations of the electric system. This work and the associated integration at East 13th St. will require a series of coordinated electrical system outages in order to perform the installations and upgrades while maintaining reliability. The additional projects associated with the integration of the other stations are outage-dependent and are currently projected to continue until 2020.

- Incorporate extensive subsurface interferences, located during detailed drawing and plate review, into the detailed project design, including extension and rerouting of the below grade trench and duct bank system.

- Full installation of the PASS breakers, including structural reinforcement and installation of new structures in order to effectively install the new breakers within the constraints of the existing station conditions.

The other major cost driver for the East 13th Street Substation is the revised definition of the Bulk Electric System (BES) approved by the Federal Energy Regulatory Commission (FERC) on March 20, 2014. The new definition encompasses any facilities that are operated at or above 100kV (with certain exceptions) and now captures many of Con Edison's 138kV transmission substation facilities, including the East 13th St. 138 kV substation. Compliance with this revision must commence no later than 2016, and will impact the East 13th St. storm hardening project due to the need to incorporate standard BES requirements into the 138kV components of this project. These requirements impact the station design basis, which is primarily established by the Northeast Power Coordinating Council's (NPCC) Directory No. 4: Bulk Power System Protection Criteria.

These design requirements must be incorporated into all 138kV transmission facilities on Con Edison's bulk power electric transmission system commencing when other modifications or upgrades are made to the facilities. The East 13th St. storm hardening project impacts seven 138 kV (of a total of twelve) and one 69kV (of a total of nine) feeders and bus sections from the East 13th Street 345 kV substation (already designed to be in compliance with NPCC Directory No. 4) to the East 13th street 138 kV substation and East River 69kV substation, and these storm hardening modifications and upgrades trigger implementation of the NPCC Directory No. 4 criteria. The other five 138kV bus sections and eight 69kV bus sections do not require storm hardening modifications and upgrades and will not be redesigned to NPCC Directory No. 4 criteria during the storm hardening project.

Con Edison plans to implement the equipment modifications needed to meet the NPCC Directory No. 4 design criteria at the time that it removes individual feeders from service to implement storm hardening upgrades. If the modifications are not incorporated at that time, some of the upgrades performed for storm hardening would later have to be significantly modified to meet the requirements. In addition, the overall feeder outage duration will be reduced by incorporating the design modifications with storm hardening work and avoiding a second series of lengthy feeder outages. For East 13th St., the previously planned six to eight week storm hardening outage for each of the eight feeders supplying the substation will incorporate the necessary changes to meet the NPCC Directory No. 4 criteria. If this work is not done in conjunction with the storm hardening project, an additional four-week outage for each of the eight feeders will be required. The reduction in feeder outages mitigates the impact to electric system reliability. The additional cost of work to incorporate the NPCC Directory #4 criteria is estimated to be $28 million.

With regard to the substation storm hardening projects generally, detailed engineering and design has been completed for most 2015 work and results in a more detailed cost projection for this component of the storm hardening projects. Additional engineering and design was planned to be completed to support 2015 and 2016 work, particularly for the substations that have received no upgrades to date, as well as work in 2017 and beyond in the case of East 13th Street. Engineering and design detail is still being developed for these outer years, and cost projections in this Phase Three Report reflect the previously proposed concept plans and order of magnitude estimates. For all stations except for East 13th St., cost projections will be finalized based on completed engineering details at the end of 2015 and in early 2016. East 13th St. will continue to be developed for the years 2017 and beyond and will be reflected in updated cash flow projections. The Phase Two Report appropriately identified the following risk: due to market conditions and other factors, contractor bids could be at different values than what has been estimated, and cost projections for the future years of the program may be modified on this basis as well. As described in the section above covering 2014 challenges, this had an impact on the Storm Hardening projects. The combination of these challenges and the further developed engineering and design details has resulted in updated cash flow projections for substations. Total projected expenditures for substation storm hardening from 2014 to 2016 have now increased by $67.8 million from the original rate case projection of $210 million to $277.7 million.[36]

[36] As discussed below, portions of the East 13 Street Substation work is dependent on feeder outages and will be performed at an estimated cost of $69.5 million from 2017 to 2019 as outages become available

For the three substations to receive sheet pile perimeter walls, Fresh Kills, Goethals and Gowanus, additional funding is required to complete both phases of these projects. The first phase, to install high capacity pump stations on the interior of these stations for defense in depth, was part of the 2014 set of projects that received higher contractor bids. The second phase for the sheet pile wall installation requires additional funding based on final development of the engineering and design details. In particular, the thickness and embedment of the sheet piles necessary to both withstand the FEMA + 3 feet design flood level and account for potential underseepage through the soil has resulted in higher costs than the original plan. Engineering performed an extensive analysis to minimize the structural demand on the walls while maintaining the FEMA + 3 feet design basis established by the Storm Hardening Collaborative. The design was optimized in these areas, for example for sheet pile length and thickness, but cost projections are still higher than original projections.

At Hellgate/Bruckner and Sherman Creek, a perimeter reinforced concrete wall is being used for flood projections. Original cost projections for these stations did not fully capture the necessary structural reinforcement to meet the FEMA + 3 feet design basis, which was determined in the detailed design completed earlier in 2015. In addition to this, particularly at Hellgate/Bruckner, it was expected that existing perimeter walls and structures would be used as part of the flood protection system. Due to these structural requirements, existing structures were determined to be inadequate and new reinforced concrete flood walls need to be installed. Designs at both stations also had to account for extensive subsurface interferences, which results in additional cost to install various types of foundations throughout the stations.

6. Phase Two Report Follow-ups

For the Substation Storm Hardening program, the Commission posed two questions in its order on the Phase Two Report: the possibility of expediting the schedule for the East 13th St. storm hardening project and the potential to bring natural gas to the various substation back-up diesel generators installed under the Storm Hardening program. In regard to the East 13th St. project schedule, the current plan is for project completion in 2019.[37] This is based on the various challenges described above and the outage coordination necessary to complete the project. The Commission asked Con Edison to evaluate a more aggressive schedule to complete this project earlier than the planned 2020 completion date.

The currently planned schedule for the East 13th St. storm hardening project is as follows:

- Transformers 16 & 17
  - Physical outage: Fall 2015
  - Electrical/Wiring Outage: Spring 2016
- Transformers 12 & 13
  - Outage: Fall 2016
- Transformers 14 & 15
  - Outage: Spring 2017
- Transformers 10 & 11 (Includes replacement of the transformers)
  - Outages: Fall 2017 – Spring 2018
- Transformer 9
  - Outage: Fall 2018
- Automation Completion
  - Outages: 2019

At this time, the first planned outage for this project is scheduled for fall 2015. The experience and lessons learned gained from that outage should help the Company improve processes and

[37]The Company has identified a sequence of outages that may allow the work to be completed in advance of 2020. This outage sequence needs further review to determine if it is technically viable, meets our outage scheduling criteria, can be incorporated into the overall project schedule, and adequately supports other infrastructure investment work to be carried out in this timeframe.

efficiencies for future outages. Following the fall 2015 and spring 2016 outages, Con Edison will reevaluate the project schedule.

Con Edison also evaluated the feasibility of bringing natural gas to the diesel back-up generators being installed under the Storm Hardening program. In its Phase II Order, the Commission stated it "is satisfied at this time with the Company's efforts, but the Collaborative should address these issues and the Commission directs the Company to report in the Phase Three Report on the potential to make these conversions and any issues preventing such conversions." Con Edison is currently planning to install or modify generators at East 13th St., East 36th St., East 15th St., Seaport, Gowanus, Fresh Kills, 74th Street, Ravenswood and East River. But, to retrofit these units to accept natural gas, Con Edison would need to install a high pressure gas main for each station. Only 74th Street, East River and Ravenswood already have a natural gas line available and one of the East River generators already functions as a dual fuel generator. Routing a new high pressure gas main would be the most expensive part of this effort as it includes the main installation as well as addressing various interferences in the congested streets. In addition, a dual fuel conversion kit would need to be installed for each generator and both the station and the unit would need to be outfitted to accept the high pressure gas line, which would be routed to the generator in the station, and connected to the new dual fuel kit. The combination of these efforts for all stations has been estimated to cost approximately $18 – 19 million to complete. This effort is not accounted for in the current 2014 – 2016 plan.

Con Edison believes that installing natural gas capability is unnecessary because it would be a third contingency for the generators and flood control pumps. Flood pumps at the stations have a normal light and power (L&P) feed from the standard power source in the station, which is usually fed from the network in the street. The pumps will initially operate using this feed assuming the network is operational, which should be the case given the storm hardening effort that is being completed in parallel. If the network fails, the generator will turn on to provide a backup power supply to the pumps. This is likely to occur only during a storm with significant flooding. Con Edison estimates, based on the tide cycle and anticipated duration of flooding, that there will only be a few hours of runtime necessary for the generator to power the pumps through the storm and after to remove any remaining water. Each generator includes on-site fuel sufficient for at least 12 hours of runtime, and in many cases much more than 12 hours based on how much load the generator supplements during the storm. Providing natural gas and a dual fuel kit would extend the runtime of the generators, but this is not necessary given the expected duration of the storm surge. Finally, as an alternative, Con Edison will have the ability to procure fuel trucks (in advance of the storm) with additional diesel fuel that can be staged at strategic areas throughout the territory such that if the need arose, the trucks could be quickly dispatched to the stations where it is required. Accordingly, Con Edison does not recommend adding natural gas firing capability to these back-up generators at substations.

D. Transmission System Storm Hardening

1. Transmission System Storm Hardening Objectives

Generally, overhead transmission infrastructure will not be de-energized on a preemptive basis based on wind hazards. During Sandy, Con Edison lost 3,615 MW of base load units and 728 MW of gas turbines due to flooding at these facilities. Consequently, the performance of transmission lines to supply demand and maintain system stability was crucial during this period. However, 37 of 59 345kV transmission feeders (63%) and 21 of 68 138kV transmission feeders (35%) became unavailable during Sandy. Overall, there were 45 distinct outage events on

345kV feeders and 30 distinct outage event on 138kV feeders.[38] Hence, having a robust overhead transmission system in periods of storm related high winds and rain, increases system security. Overhead feeders and towers, as demonstrated by Sandy, are vulnerable to high-velocity wind, wind-blown debris, hail, and lightning strikes during storms or severe weather conditions. The Company's transmission system storm hardening program will reduce the risk of failures on transmission feeders by reinforcing or replacing compression fittings and splices (in-line and dead end assemblies) on feeders where fittings are near end of life and by reinforcing steel-lattice towers.

2. Transmission System Storm Hardening Projects

a) Replace Compression Fittings on Feeders 99941 and 99942

This project replaces the compression fittings on the overhead 138kV feeders 99941 and 99942 on the E-Line between Dunwoodie and Sprain Brook substations. These feeders were last reinforced in 1965, and significant problems with compression fittings related to advanced age have surfaced on these feeders. Failure to replace these fittings increases the likelihood that we will experience a connector failure during severe weather conditions. Compression fitting materials were purchased in 2013, and compression fitting replacement on feeder 99941 was completed in 2013 at a cost of $1.8 million. Compression fitting replacement on feeder 99942 was completed in 2014 at an actual cost of $0.58 million.

b) Reinforce L-Line Compression Fittings

This project reinforces the in-line and dead end assemblies on feeder 398 on the L-Line between Pleasant Valley Substation and the Connecticut border. This feeder, which is about 17.8 miles in length, was constructed in 1964, and significant problems with compression fittings

[38] Of the thirty-seven 345 kV feeders that became unavailable, seven tripped twice and three tripped thrice. Of the twenty-one 138 kV feeders that became unavailable, two tripped four times each.

related to advanced age have surfaced. The reinforcement of these fitting will reduce the potential that severe weather conditions would cause a connector failure and feeder outage. Compression fittings and splice reinforcement materials were purchased in 2014, and we completed approximately 50% of the compression fitting and splice reinforcements on feeder 398 in 2014 at a cost of $1.1 million. The remainder of the compression fitting and splice reinforcements will be completed in 2015 at a projected cost of $2.9 million.

c) Upgrade Overhead 345kV Transmission Structures

This project upgrades specific 345 kV steel lattice towers that are selected based on engineering analysis. The reinforcement of these towers decreases the likelihood of tower failure during weather events and decreases the likelihood and impact of multiple failures resulting from cascading since reinforced towers are better able to withstand the loads that would result from adjacent tower failure. Priority is given to towers with the highest risk on critical transmission corridors. This is an ongoing program at a cost of approximately $2 million annually.

Updated white papers describing the scope and cost for each overhead transmission storm hardening project are provided in Appendix J – Transmission Whitepapers.

3. Transmission Structures Storm Hardening Project Cost Estimates

a) Costs Reflected in Electric Rate Plan

In the rate case, Con Edison presented plans to conduct three programs to storm harden the overhead transmission system from 2014 through 2016 at a total estimated cost of $8.9 million. The estimated costs for these programs for the period 2014 – 2016, reflected in the rate plans and presented in the Phase One Report, are summarized in the following table:

Transmission Structures (Rate Plan) ($ millions)	2014	2015	2016	2014-2016 Cost (Rate Plan)
Compression Fittings on Feeders 99941 and 99942	1.2	0	0	1.2
L-Line Compression Fittings	2.9	0	0	2.9
Overhead 345kV Transmission Structures	2.0	2.0	2.0	6.0
Total	**6.1**	**2.0**	**2.0**	**10.1**

b) Updated Costs

The Company's current projection of cost for each overhead transmission structure storm hardening project is as shown in the following table:

Transmission Structures ($ millions)	2014 Actual	2015 Current Projection	2016 Current Projection	2014-2016 Current Projection
Compression Fittings on Feeders 99941 and 99942	0.6	0.0	0.0	0.6
L-Line Compression Fittings	1.1	1.6	0.0	2.7
Lindsey Towers	1.4	0.1	0.0	1.5
Overhead 345kV Transmission Structures	0.5	1.4	2.0	3.9
Total	3.5	3.1	2.0	8.7

As shown in the chart above, the Company was able to complete these projects at slightly less than the amounts reflected in the rate plan and the Company currently estimates that the total cost of these projects will be approximately $1 million less.

E. Electric System Storm Hardening Costs

Con Edison's Electric Rate Plan reflects storm hardening expenditures for coastal network, overhead system, substation, electric generating station and transmission storm hardening. This section discusses these expenditures on a combined basis.

1. Costs Reflected in Electric Rate Plan

The table below summarizes the electric system storm hardening expenditures reflected in Con Edison's current two-year Electric Rate Plan (2014 to 2015), as well as 2016 expenditures projected in the rate case in 2016.[39]

[39] Con Edison's two-year Electric Rate Plan (2014 to 2015) established in Cases 13-E-0030, and as extended in Case 15-E-0050, reflects the Company's forecasted storm hardening expenditures subject to a net plant reconciliation mechanism designed to address the rate impacts of any difference between forecasted and actual expenditures and subject to the Commission's review of the Company's updated storm hardening plans and expenditure forecast as provided in this *Phase Three Collaborative Storm Hardening and Resiliency Report*.

Electric Rate Plan ($ Millions)	2014	2015	2016	2014-2016 Total
Coastal Networks	65	55	52.0	172.0
Submersible Transformers	12.5	11.3	11.4	35.2
Overhead Distribution	15.0	115.0	112.0	242.0
Electric Transmission	4.9	2.0	2.0	8.9
Substations	60.0	70.0	80.0	210
Electric Generation	14.0	21.0	20.5	55.5
Total*	**171.4**[40]	**274.3**[41]	**277.9**	**723.6**

* Excludes electric share of Common storm hardening capital expenditures.

2. Updated Costs

The table below summarizes the electric system storm hardening expenditures projected in this Phase Three Report:

[40] Appendix 27 of the Joint Proposal in Case 13-E-0030 indicates capital expenditures of $179.9 million during 2014 for electric system storm hardening. In addition to $171.4 million in the infrastructure expenditures for Coastal Networks, Submersible Transformers, Overhead Distribution, Electric Transmission, Substations, and Electric Generation in 2014 discussed in this Report, the sum of $179.9 million includes the electric share of Common storm hardening expenditures ($1.1 million), discussed later in this Report, and $7.5 million for two post-Superstorm Sandy programs that enhance the Company's storm outage response: Mobile Strategy ($5 million in 2014) and Outage Dashboard ($2.5 million in 2014). These programs were presented in the Company's Infrastructure and Operations Panel July, 2013 update testimony (pages 5-10) and in Exhibits __ IIP-17 and __ IIP-18 in Case 13-E-0030.

[41] Appendix 27 of the Joint Proposal in Case 13-E-0030 indicates capital expenditures of $278.3 million during 2015 for electric system storm hardening. In addition to $274.3 million in the infrastructure expenditures for Coastal Networks, Submersible Transformers, Overhead Distribution, Electric Transmission, Substations, and Electric Generation in 2015 discussed in this Report, the sum of $278.3 million includes the electric share of Common storm hardening expenditures ($2.2 million), discussed later in this Report, and $1.8 million for the Mobile Strategy program to enhance the Company's storm outage response.

Phase Two Report ($ Millions)	2014 Actual	2015 Current Projection	2016 Current Projection	2014-2016 Current Projection
Coastal Networks	31.7	36.6	38.5	106.8
Submersible Transformers	45.3	30.0	27.6	102.9
Overhead Distribution	42.1	94.5	80.1	216.7
Electric Transmission	3.5	3.1	2.0	8.7
Substations	24.0	92.8	151.5	268.3
Electric Generation	1.8	5.9	30.0	37.7
Totals	148.4	262.9	329.7	741.1

*Portions of East 13 Street Substation work is dependent on feeder outages and will be performed at an estimated cost of $57.3 million from 2017 to 2019 as outages become available.

Including work planned for 2016, overall storm hardening expenditures are projected to increase by $17.5 million above the amount projected in the rate case for the period of 2014 through 2016 ($723.6). The sections above have explained the cost drivers for the various projects.

Consistent with the provisions of the Joint Proposal as extended, Con Edison requests that the Commission approve the electric storm hardening projects presented in this Phase Three Report for 2016 the third rate year of the Electric Rate Plan and the forecasts for 2014 through 2016. To the extent that the actual expenditures for these projects result in net plant balances above those reflected in the Storm Hardening category of the Average Electric Plant In Service Balances for the Electric Rate Plan, the Joint Proposal provides that the Company may defer for later collection the carrying costs associated with such net plant exceedances upon the Commission's approval of such expenditures. [42]

Accordingly, Con Edison requests that the Commission approve the Electric Rate Plan expenditures for the electric system storm hardening projects presented in this Phase Three Report. Upon such approval, and consistent with the Joint Proposal, the Company would defer for later collection the carrying costs associated with actual expenditures above those reflected in the Company's Electric Rate Plan.

V. Gas System and Tunnel Storm Hardening

This section addresses storm hardening projects to improve the resiliency of Con Edison's gas distribution system, the Liquefied Natural Gas ("LNG") plants, and tunnels.

A. Gas System Storm Hardening

1. Gas System Storm Hardening Objectives

While Con Edison's gas system performed relatively well throughout Sandy, our post-storm assessments have identified the potential for significant damage if our region were to experience a significant coastal storm in the future. A critical threat to the gas system is the

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[42] The Joint Proposal (p. 36-37) states:

> With respect to the Storm Hardening category of the Average Steam Plant In Service Balances, the Commission's order regarding RY2 Storm Hardening programs in response to the Company's September 1, 2014 Storm Hardening report (see section D.4 below) may call for Storm Hardening capital expenditures in RY2 in an amount more or less than the amount reflected in the Storm Hardening category of the Average Electric Plant In Service Balances for RY2.
>
> If the Commission's order calls for RY2 Storm Hardening capital expenditures greater than the amount reflected in the Storm Hardening category of the Average Steam Plant In Service Balances for RY2, the net plant reconciliation mechanism will continue to apply as described herein and the Company will defer for future collection from customers the revenue requirement impact (i.e., carrying costs, including depreciation, as identified in Appendix 8) of the amount of average net plant resulting from the additional capital expenditures.
>
> These provisions were updated in the Commission's order on Con Edison's electric rate proposal to account for an extension to rate year 3.

introduction of water into gas equipment, which can damage pipes, lead to over-pressurization, or result in service interruptions. By protecting our gas system from water infiltration, we will spare our customers the long and laborious process of restoring each and every gas service, which must be done one customer at a time. We have also identified flooding vulnerabilities at our Liquefied Natural Gas (LNG) plant and at gas regulator stations and remote operated valves in flood zones.

To harden our gas system in the near term, we are:

- accelerating plans to install vent line protection devices to prevent water from entering high-pressure regulators through the regulator vents (completed in April 2015);
- replacing cast iron and bare steel pipe in flood-prone areas because these types of pipe could be more susceptible to water infiltration under flooding conditions;
- installing measures to protect critical back-up systems at our LNG plant from inundation during a storm surge; and
- hardening gas regulator stations and remote operated valves against water intrusion

2. Gas Distribution System Storm Hardening Projects

a) Installing Vent Line Protection Devices to Prevent Water Infiltration

Water infiltration into the vent-line of high-pressure regulators could result in damage due to over-pressurization of downstream customer equipment, or loss of customer pilot lights. To mitigate these risks during future flooding events, Con Edison has installed 3700 vent-line protection devices ("VLPs") also known as "float-check valves." VLPs will prevent over-pressurization of the customer's internal gas equipment due to flooding by preventing water infiltration through the vent-line, and thus maintain gas service to customers during flood events. VLPs became commercially available in late 2012 after six years of research and development by Con Edison, the industry's national Gas Technology Institute, and several equipment vendors.

Following Sandy, the Company identified approximately 9,200 existing high-pressure services within 2003 SLOSH[43] Category 1 through 4 hurricane flood zones that would benefit from this measure and projected the cost of installing vent line protectors to be $4.8 million. Based on the 2013 FEMA plus three feet standard for New York City locations and 2003 SLOSH Category 1 and 2 for Westchester County locations, approximately 3,700 high pressure services require vent-line protection devices. (Because FEMA has not published new flood maps for Westchester County, we have used 2003 SLOSH Category 1 and 2 to identify high pressure services in Westchester County). In April 2015, high pressure service vent line storm hardening was completed by installing protection devices or raising vent lines above the FEMA plus three feet standard. The total cost of the project is $3.2 million.

b) Replacing Cast Iron and Bare Steel Pipes in Flood Zones

Leaking and/or weakened low-pressure cast iron and bare steel gas pipes can result in water infiltration into the distribution system during a coastal flood. Water infiltration, in turn, can result in poor system pressure, lengthy customer outages, and potentially hazardous interruptions of service.

As a result of Sandy, Con Edison's gas system had almost 400 service outages affecting over 4,200 customers in the Bronx, Manhattan, Queens, and Westchester. Customer outages resulted from water that infiltrated into the gas mains, mainly caused by shifting ground conditions that occurred during flooding and by long-term corrosion that occurs on bare steel pipe. To reduce the potential for similar or more significant damage in future storms, the Company is conducting a targeted low-pressure cast-iron and bare-steel replacement program in

[43] SLOSH stands for sea, lake and overland surges from hurricanes.

flood-prone areas. By replacing this pipe with plastic or protected steel pipe, we will reduce the likelihood of water infiltration.[44]

Con Edison's Gas Rate Plan provides that the Company will replace at least nine miles of leak-prone pipe in the FEMA 100-year flood plains during 2014 to 2016, including two miles in 2014, three miles in 2015, and four miles in 2016 with a minimum of six miles of such pipe to be replaced in Manhattan.

The Company's program prioritizes pipe replacement to mitigate the greatest risk. In 2013, the Company evaluated pilot areas throughout flood zones to identify key factors required to develop a program including factors for quantifying risk. As a result, the program quantifies risk according to factors such as elevation, Sandy flood area, and population density. The program targets small diameter (8" or less) leak-prone pipe for replacement. These pipes exhibit the highest risk for water intrusion. Where possible, low pressure pipe will be replaced by high pressure pipe.

Con Edison currently estimates a total cost of $41.4 million to meet the commitment in the Joint Proposal to replace 9 miles of pipe over three years (2014 to 2016), including six miles in Manhattan. The actual cost for 2014 and the projected costs for 2015 and 2016 are as follows:

- Actual 2014 - $ 5.3 million for 2.36 miles of mains (1.45 mile in Manhattan)
- Projected 2015 - $16.1 million for 4.35 miles of mains (2.72 miles in Manhattan)
- Projected 2016 - $20 million for 2.37 miles of mains (1.83 miles in Manhattan)

[44] Another source of water infiltration is damage to customer equipment located in flooded basements, which then allows water infiltration into the low-pressure distribution system from the customer's side of the service. Currently, no commercially available device addresses this issue. Gas Operations is working with Con Edison's R&D Department on an initiative to develop an isolation device to prevent water infiltration into the low pressure system from flooded basements and damaged customer piping or equipment. A device has been developed and the Gas Technology Institute (GTI) is in the process of performing testing.

The Gas Rate Plan reflects $79 million for this targeted replacement program and the current forecast is $41.4 million for approximately 9 miles. Costs have been reduced because there have been opportunities to remove leak prone pipe where there was other existing facilities on the same street, requiring less capital infrastructure work. In addition, Con Edison's work in the outer boroughs has been at a lower unit cost than originally anticipated.

Remotely Operated Valve Hardening

Remotely operated valves (ROV) provide the capability to immediately isolate sections of the gas system to mitigate conditions such as over-pressurization or pipe rupture. Intrusion of water can cause the failure of ROV components including:

- Transducer and transducer cable failure resulting in loss of visibility/loss of pressure readings
- Actuator and actuator power and communication cable failure resulting in loss of control over remote operated valves
- Remote Terminal Unit (RTU) and actuator control box (located aboveground) failure resulting in loss of control and loss of visibility/pressure readings in the Gas Operations Supervisory System[45]

The Company plans to harden ROVs and associated underground vaults against flooding caused by coastal storms. The objective of this work is to allow the ROV to continue functioning during a storm event and/or minimize the restoration work that may be needed following the storm.

The scope of the project is as follows:

- Harden ROV Equipment
  - Replace wire in hollow conduit with solid cables and cable glands that are rated for wet/dry use eliminating water migration path
  - Replace analog actuators with digital actuators

[45] The Gas Operations Supervisory System monitors real-time pressure and flow information through remote terminal units located at various field locations, including interconnection points with interstate pipelines, electric and steam generating stations, and custody transfer metering stations with the National Grid gas system.

- Harden ROV manhole vault
    - Remove existing casting and install storm hardened bolt-down inner pan and casting where feasible
    - Excavate as necessary to expose all vault penetrations and interface between vault wall and ceiling, then apply waterproof coating over these elements.
    - Apply waterproof coating inside of manhole
    - Install or replace penetration seals as needed
    - Rebuild vent post system if it appears to be a major source of water infiltration
    - Remediate manhole walls if deemed to be a major source of water infiltration

The Company plans to relocate and harden one ROV location in 2015 at an estimated cost of $1.72 million. Of the 20 identified ROV sites in flood zones, one was selected for hardening in 2015, using past history of flooding, likelihood of flooding, and proximity to critical facilities (such as gate stations, generating stations or tunnels) as prioritization criteria. We also plan to harden three additional ROV sites in 2016 at a cost of $180,000 each (the cost is lower because hardening for these sites does not involve relocation). We will consider additional ROV hardening in the future.

c) Regulator Station Hardening

As gas flows through the system, regulators control the flow from higher to lower pressures. If a regulator senses that the pressure has dropped below a set point, it will open accordingly to allow more gas to flow. Conversely, when pressure rises above a set point, the regulator will close to adjust. Water intrusion in a low-pressure regulator pilot vent line can cause the regulator set point to increase and could lead to over-pressurization. Intrusion of water can also cause the failure of regulator above-ground electronics including failure of the RTU and the Smart Regulator/Transducer box.

The Company plans to harden pressure regulator stations against flooding.[46] The project will raise the level of the pilot regulator vent above the FEMA 2013 plus three feet flood elevation. If the vent is not water tight, the vent will be rebuilt before elevation. The project will also waterproof the existing regulator station manhole vault using the measures identified above for ROV manhole vaults.[47]

The Company plans to harden one low-pressure regulator station in 2016, at an estimated cost of $440,000 in 2015 and an additional transmission-pressure regulator station in 2016 at the same price. This project consists of raising electronics at an above ground regulator station above the FEMA 2013 plus 3 feet level.

3. Liquefied Natural Gas Plant Hardening

a) New Switchgear and Batteries and LNG Salt Water Pump House

The LNG plant provides peaking and contingency supply of natural gas to firm gas customers. The plant's automatic fire protection system utilizes an electric motor driven fire pump and a back-up diesel engine driven pump. The electric motor and the diesel engine and their associated fire pumps are located within a pump house that is sited alongside Luyster Creek, the salt water source for the fire pumps. The pump house also contains the electrical switchgear for the electric motor and the battery bank for the diesel engine. The transformers and high tension vaults for the 27kV feeder supply to the electric motor are adjacent to the pump house. A storm surge similar to Sandy could flood both the electrical switchgear for the electric motor, the battery bank for the diesel engine, and the high tension vaults and transformers for the electric motor, which could make the pump inoperable.

[46] Low pressure stations will be targeted first because high pressure regulators will not experience significant set point drift, even if water infiltrates pilot vent.
[47] The first measure of protection during a flood condition will be shutting down the regulator station, if possible, as there is an inherent risk to allowing a regulator station to continue to operate when it is inaccessible due to flood water.

This project will harden the pump house fire equipment by elevating equipment to a FEMA 2013 plus 5 feet level, higher than the FEMA plus 3 minimum level, in order to make the pump accessible to Con Edison employees. The plan includes:

- Elevating the electric fire pump motor located in the west section of the pump house;
- Installing the existing transformers and new outdoor electrical switch gear, electrical panels, batteries and fire pump controller on a new elevated interior platform on the south side of the pump house;
- Reconstructing the east section of the pump house to accommodate a new elevated interior platform where the diesel engine and its electrical panel and fuel day tank will be installed; and
- Relocating the diesel fuel supply for the diesel engine in a new elevated interior platform.

The project currently has an estimated cost to design of $350,000. The current order of magnitude estimate is $13.4 million and we have completed 50% of the detailed engineering design. The detailed engineering design identified additional requirements associated with compliance with FDNY code and Con Edison's High Tension Vault Substation (HTVS) requirements. Incorporation of these additional requirements accounts for the increased order of magnitude estimate.

b) Elevate Diesel Blackstart Generator

The LNG plant's blackstart, diesel-driven generator provides back-up power to maintain 100% operational capability during an electric contingency upon the loss of the three 27 kV feeders supplying light and power to the plant. The blackstart generator is currently installed at an elevation that leaves it vulnerable to a high storm surge.

This project raises the generator to the FEMA plus 3.5 feet flood elevation level (it is the same height as the control room) by elevating the unit on a newly installed steel corrosion resistant platform**.** The project was originally designed in 2014 and had an estimated cost of $610,000. The current project order of magnitude estimate is $810,000 and the increase in cost is the result of a more detailed engineering design based on final drawings. The currently estimated completion date is December 2015.

c) Install Dockside Auxiliary Fire Pumps

The LNG plant’s automatic fire protection system utilizes an electric motor driven fire pump. The back-up fire pump is a diesel engine driven pump. The FDNY Bureau of Fire Protection issues a permit to operate the plant predicated on the continuous availability of both of these fire pumps. To meet this requirement during the year-long construction phase for elevating the electrical and mechanical systems for the primary and back-up pumps, an auxiliary set of permitted pumps will be installed to serve as primary pumps. Thereafter, the auxiliary pumps will be maintained on site and placed in service when either the primary or back-up pump is out of service for maintenance.

This project installs two new standby auxiliary pumps with piping to tie into the existing fire protection loop. The project engineering design will be completed in 2015 at an estimated cost of $60,000, and construction will commence in 2015 and be completed in 2016. The current estimate is $1.7 million.

Updated white papers describing the scope and cost for each of the gas system storm hardening projects are provided in Appendix K – Gas Operations Whitepapers.

4. Gas System Storm Hardening Costs

a) Costs Reflected in Gas Rate Plan

In the rate case and in the Phase One Report, Con Edison presented plans for storm hardening the gas distribution system as follows:

- Complete installation of vent line protection valves to prevent water infiltration on high pressure services in 2014 at a cost of $4.8 million and
- Replace cast iron and bare steel in flood zones in 2015 and in 2016 at a total cost of $33.3 million.

The Company stated at that time that it was studying the need for storm hardening at the LNG plant, but proposals and costs had not yet been developed.

Con Edison's three-year Gas Rate Plan (2014 to 2016) established in Case 13-G-0031 reflects the forecasted expenditures shown in the following table:

Gas System Projects (Rate Plan) ($ millions)	2014	2015	2016	2014-2016 Cost (Rate Plan)
Main Replacement in Flood Zones*	18.0	26.0	35.0	79.0
Vent Line Protector Installation	4.8	0	0	4.8
Regulator Stations and ROVs Hardening	0	0	0	0
LNG Hardening	0	0	0	0
Total**	22.8[48]	26[49]	35[50]	83.8

* Main Replacement in Flood Zones program reflects cost established in the Joint Proposal, Appendix 23.
** Excludes gas share of Common storm hardening capital expenditures.

During the Phase One Collaborative meetings and in the Phase One Report, Con Edison presented plans to storm harden critical back-up facilities at the LNG plant in 2014 at an estimated cost of $2 million.[51] In addition, the City of New York urged Con Edison during the Phase One meetings to establish plans for storm hardening regulator stations and ROVs.

[48] Appendix 27 of the Joint Proposal in Case 13-E-0031 indicates capital expenditures of $5 million during 2014 for gas system storm hardening. The amount of $5 million in the "Delivery – Storm Hardening" category for Gas Rate Year 1 in Appendix 27 reflects $4.8 million for the storm hardening program "Install HP Regulator Vent Float Check Valves" and $0.2 million for the gas share of Common storm hardening expenditures.
The "Delivery – Storm Hardening" category for Rate Year 1 in Appendix 27 does not reflect the projected expenditure of $18 million in 2014 for "Additional Flood Prone Main Replacement," a storm hardening program that was agreed to in the Joint Proposal for $18 million in RY1, $26 million in RY2, and $35 million in RY3 (see Joint Proposal, page 46 and Appendix 23). The $18 million for this storm hardening program in Rate Year 1 is included in the Rate Year 1 total of $358,992 for "Delivery – All Other" shown in Appendix 27.
Accordingly, the Gas Rate Plan reflects a total of $23 million for storm hardening programs in 2014 ($4.8 million for HP Regulator Vent Float Check Valves, $18 million for Flood Prone Main Replacement, and $0.2 million for Common). Of the $23 million, $5 million is in the Delivery – Storm Hardening" category for Rate Year 1 in Appendix 27, and $18 million is in the Delivery – All Other" category for Rate Year 1 in Appendix 27.
[49] As discussed in more detail in footnote 56, *infra*, of the $26 million, $16.6 million is reflected in the Delivery – Storm Hardening" category for Rate Year 2 in Appendix 27, and $9.4 million is reflected in the Delivery – All Other" category for Rate Year 2 in Appendix 27.
[50] As discussed in more detail in footnote 57, *infra*, of the $35 million, $16.5 million is reflected in the Delivery – Storm Hardening" category for Rate Year 3 in Appendix 27, and $18.5 million is reflected in the Delivery – All Other" category for Rate Year 3 in Appendix 27.
[51] Phase One Report, pp. 158-160.

Following discussions with the City and Staff, the Company developed its plan for storm hardening these facilities and presented it to the parties during Phase Two of the Collaborative.

b) Updated Costs

Con Edison's current actual expenditures for 2014 and projected expenditures for gas system storm hardening projects during 2015, and 2016 is $66.5 million, itemized by project, are as shown in the following table:

Gas System Projects (Phase Three Report) ($ millions)	2014 Actual	2015 Current Projection	2016 Current Projection	2014-2016 Current Projection
Main Replacement in Flood Zones	5.3	16.1	20.0	41.4
Vent Line Protector Installation	2.2	1.0	0.0	3.2
Regulator Stations and ROVs	0.0	1.7	1.4	3.1
LNG Hardening (Black Start, Auxiliary Pumps and Salt Water	0.5	2.3	13.6	16.4
Total	8.0	21.1	35.0	64.1

Projected expenditures for gas system storm hardening have decreased by $19.7 million from the level reflected in the Gas Rate Plan. This decrease results primarily from the decrease in cost for main replacement offset by the costs for the projects that were not established at the time of the rate plan.

B. Tunnel Storm Hardening

1. Tunnel Storm Hardening Objectives

During Sandy, water entered the First Avenue, Ravenswood, Astoria, Hudson Avenue, Flushing, and 11th Street tunnels. These tunnels contain steam mains, gas mains, and/or high voltage electric feeders that may need to be de-energized for safety if the tunnels are significantly flooded.

With the exception of the First Avenue Tunnel, all of our tunnels have “head-house” entrances that are in close proximity to bodies of water.[52] Currently, these head houses are either sheet metal or masonry structures that are not designed to withstand coastal flooding.[53] The objective of this project is to harden these head house structures to protect against flooding and wind damage; to protect their equipment from salt water damage, flotation, and destruction due to wave action and flood hydraulic head pressure; and to provide alternate access in an emergency. Storm-hardening projects for Astoria, Ravenswood, Hudson Ave, 11th Street, and Flushing Tunnels are projected to be completed in 2016. The current schedule is to complete the detailed engineering for all five tunnels in 2015 and complete construction in 2016.[54] The design basis for all storm hardening work will meet the FEMA plus three feet flood elevation and applicable New York City Building Code requirements for wind.

As part of the entrance-hardening plans, certain head houses will be rebuilt to acceptable standards, while others will be reinforced and hardened with flood walls, flood doors and

[52] During Sandy, significant flooding and a power outage forced the First Avenue Tunnel out of service. The entrances to this tunnel consist of street-level vent gratings that allowed water to enter the tunnel. Tunnel de-watering pumps could not be operated due to the power outage; as a result, the tunnel was flooded by over 500,000 gallons of water. The resulting damage required a lengthy restoration process of pumping out the water, replacing steam pipe insulation, as well as other repairs, and restoring service.
To prevent future flooding of the First Avenue Tunnel, Con Edison designed and fabricated at a cost of $366,000 in 2013 vent cover plates that can be installed prior to a storm. These plates will prevent floodwater from entering the tunnel through the open street-level vent gratings and damaging electrical circuits, controls, piping and tunnel structures. The design incorporates a vent stack to bleed ambient heat and steam from the tunnel, and a new closure plate at the 36-inch steam-main point of entry. These measures also allow faster restoration of steam service and may allow the steam main to remain in service, depending on the nature of the weather event. Backup power generation, which will keep the pumps operational during a power outage, is in the regulatory permitting process. The permitting process is taking longer than anticipated. Our goal is to complete the installation of the generator by the end of 2015 at an estimated cost of $600,000. This amount is included in the gas cost forecast.
[53] Pictures of these head houses are provided in Appendix C.
[54] The engineering vendor originally awarded the contract for Hudson Avenue and 11th Street was not performing to our expectations and as a result the purchase order was rebid. The new purchase order was awarded April 14, 2015. A schedule has been developed that meets the 2016 target for completion. The Astoria and Ravenswood purchase order for the detailed engineering was awarded on July 9, 2015.

floodgates, and the louvers and roofing structures will be reinforced to weather rain and wind events associated with anticipated high magnitude storms. Other control measures to prevent water from infiltrating the tunnels will include the construction of barrier walls and the sealing of cracks and other penetrations in the interior tunnel walls. The project includes, where necessary, raising above flood levels the equipment in the yards surrounding the head houses, protecting equipment such as oil-water separators by raising it above the design flood elevation, anchoring, or constructing flood-barrier walls, and providing emergency back-up power. Cameras and lighting for remote monitoring will be installed.

2. Tunnel Hardening Projects

a) 2015 Projects

Con Edison plans to complete the detailed engineering design for the five tunnel storm hardening projects in 2015.

b) 2016 Projects

Con Edison plans to implement and complete construction of five tunnel storm hardening projects in 2016 –the Hudson Avenue Tunnel, the 11th Street Conduit, the Flushing Tunnel, the Astoria Tunnel and the Ravenswood Tunnel. Current construction estimates are order of magnitude estimates based on conceptual designs and are subject to variation pending the detailed engineering design, which is currently underway.

(1) Hudson Avenue Tunnel

The following measures will be implemented for the head house on the Brooklyn side of the tunnel:

- reinforce existing walls
- new roof membrane and hatches
- new wind resistant louvers
- emergency egress

- secure oil water separator

The following measures will be implemented for the head house on the Manhattan side of the tunnel:

- replace existing structure
- install flood proof hatch doors
- investigate integrity of seawall and tunnel shaft cover

(2) 11th Street Conduit

The following measures will be implemented for the head house on the Queens side of the tunnel:

- protect entry door from flooding
- new roof membrane
- new wind resistant louvers
- new coil air heater
- emergency roof egress

The following measures will be implemented for the head house on the Brooklyn side of the tunnel:

- reinforce existing structure
- new roof membrane
- new wind resistant louvers
- install bulkhead doors
- install new natural gas emergency generator
- install flood proof hatch door
- emergency roof egress
- harden and secure oil water separator with flood walls

(3) Flushing Tunnel

The following measures will be implemented for the head house on the College Point side of the tunnel:

- build new structure
- install new natural gas emergency generator
- new vent fans and louvers
- raise existing shaft
- relocate electrical panels and cabinets to interior or above DFE

The following measures will be implemented for the head house on the Corona side of the tunnel:

- build new structure
- install wind resistant louvers

(4) Astoria Tunnel

The following measures will be implemented for the head house on the Queens side of the tunnel:

- reinforce existing perimeter walls of structure
- install flood barrier doors
- install new roof
- raise vent fans above the designed flood elevation
- install flood wall around oil water separator/coke filter

The following measures will be implemented for the head house on the Bronx side of the tunnel:

- install floodwall around existing structure
- new flood gates
- new roof membrane
- new louvers

(5) Ravenswood Tunnel

The following measures will be implemented for the head house on the Queens side of the tunnel:

- replace existing structure

- install new vent fan and louvers
- relocate electrical to interior of building
- install flood wall and flood gates around oil water separator

The following measures will be implemented for the head house on the Manhattan side of the tunnel:

- strengthen supports for louvers
- protect base louver from flooding
- install new flood door
- emergency egress

Updated white papers describing the scope and cost for the tunnel storm hardening projects are provided in Appendix L – Gas Tunnels Whitepapers.

3. Tunnel Storm Hardening Costs

a) Costs Reflected in Gas Rate Plan

Con Edison's three-year Gas Rate Plan (2014 to 2016) established in Case 13-G-0031 reflects the forecasted expenditures for tunnel hardening projects shown in the following table:

Tunnel Hardening Projects (Rate Plan) ($ millions)	2014	2015	2016	2014-2016 Cost (Rate Plan)
Tunnel Hardening	0	19.5	40.0	59.5
Total	**0**	**19.5**	**40.0**	**59.5**

b) Updated Costs

Con Edison's current projected expenditures for tunnel storm hardening projects during 2014, 2015, and 2016 is $53.4 million as shown in the following table:

Tunnel Hardening Projects (Phase Three Report) ($ millions)	2014 Actual Spend	2015 Current Projection	2016 Current Projection	2014-2016 Current Projection
Tunnels Hardening	0.3	2.0	51.4	53.7
Total	0.3	2.0	51.4	53.7

Projected expenditures for tunnel storm hardening projects have decreased by $6.2 million from the level reflected in the Gas Rate Plan. This decrease results from cost estimates resulting from more refined conceptual studies for the projects. This amount is higher, however, than in the Phase II Report. The Company incorporated a 30% contingency to the Phase II Report forecast for 2016 in order to reflect the uncertainty in final design details, which are still in development, and in the market for contractors that can perform steel and concrete work for storm hardening projects, as has already been demonstrated by responses to the bid packages in other areas such as substations.

C. Gas System and Tunnel Projects Storm Hardening Costs

Con Edison's Gas Rate Plan reflects storm hardening expenditures for both the gas system and the tunnels. This section discusses these expenditures on a combined basis.

1. Costs Reflected in Gas Rate Plan

In the rate case and in the Phase One Report, Con Edison presented the following storm hardening plans:

- Complete installation of vent line protection valves to prevent water infiltration on high pressure services in 2014 at a cost of $4.8 million

- Replace cast iron and bare steel in flood zones in 2015 and in 2016 at a total cost of $33.3 million, and
- Storm harden tunnels in 2015 and in 2016 at a total cost of $59.5 million.

Con Edison's three-year Gas Rate Plan (2014 to 2016) established in Case 13-G-0031 reflects the following forecasted expenditures for the gas system and the tunnels:[55]

Gas Project (Rate Plan) ($ millions)	**2014**	**2015**	**2016**	**2014-2016**
Main Replacement in Flood Zones	18.0	26.0	35.0	79.0
Vent Line Protector Installation	4.8	0	0	4.8
LNG Hardening	0	0	0	0
Regulator Stations and ROVs	0	0	0	0
Tunnel Hardening	0	19.5	40.0	59.5

[55] Con Edison's Gas Rate Plan reflects the Company's storm hardening expenditures forecast in its initial rate case filing, as adjusted for the cost of the Main Replacement in Flood Zones program in the Joint Proposal (see Joint Proposal, Page 46 and Appendix 23), subject to a storm hardening net plant reconciliation mechanism designed to address the rate impacts of any difference between forecasted and actual expenditures and subject to the Commission's review of the Company's updated storm hardening plans and expenditure forecast as provided in this Phase Three Report.

Total ($000)*	22.8[56]	45.5[57]	75.0[58]	143.3

* Excludes gas share of Common storm hardening capital expenditures.

The forecasted expenditures for the Vent Line Protector Project and the Tunnel Projects are reflected in the "Storm Hardening" net plant category. The forecasted expenditures for the Main Replacement in Flood Zones project are reflected partially in the "Storm Hardening" net plant category ($33.1 million) and partially in the "Delivery" net plant category ($45.9).

2. Updated Gas System and Tunnel Hardening Costs

Con Edison's current projected expenditures for Gas System and Tunnel storm hardening projects during 2014, 2015, and 2016 is 129.3 million, itemized by project as follows:[59]

[56] See footnote 47.

[57] Appendix 27 of the Joint Proposal in Case 13-E-0031 indicates capital expenditures of $36.5 million during 2015 for gas system storm hardening. The amount of $36.5 million in the "Delivery – Storm Hardening" category for Gas Rate Year 2 in Appendix 27 reflects the following:

- $16.6 million for pipe replacement in flood prone areas.
- $19.5 million for storm hardening Tunnel Head Houses.
- $0.4 million for the gas share of Common storm hardening expenditures.

The "Delivery – Storm Hardening" category for Gas Rate Year 2 in Appendix 27 does not reflect the projected expenditure of an additional $9.4 million in 2015 for "Additional Flood Prone Main Replacement," a storm hardening program that was agreed to in the Joint Proposal for $18 million in RY1, $26 million in RY2, and $35 million in RY3 (see Joint Proposal, page 46 and Appendix 23). The additional $9.4 million for this storm hardening program in Rate Year 2 is included in the Rate Year 2 total of $376,363 for "Delivery – All Other" shown in Appendix 27.

Accordingly, the Gas Rate Plan reflects a total of $45.9 million for storm hardening programs in 2015 ($26 million for Flood Prone Main Replacement, $19.5 for Tunnel Head Houses, and, $0.4 million for Common). Of the $45.9 million, $36.5 million is in the Delivery – Storm Hardening" category for Rate Year 2 in Appendix 27, and $9.4 million is in the Delivery – All Other" category for Rate Year 2 in Appendix 27.

[58] Appendix 27 of the Joint Proposal in Case 13-E-0030 indicates capital expenditures of $56.9 million during 2016 for gas system storm hardening. The amount of $56.9 million in the "Delivery – Storm Hardening" category for Rate Year 3 in Appendix 27 reflects the following:

- $16.5 million for pipe replacement in flood prone areas.
- $40 million for storm hardening Tunnel Head Houses.
- $0.4 million for the gas share of Common storm hardening expenditures.

The "Delivery – Storm Hardening" category for Gas Rate Year 3 in Appendix 27 does not reflect the projected expenditure of an additional $18.5 million in 2016 for "Additional Flood Prone Main Replacement," a storm hardening program that was agreed to in the Joint Proposal for $18 million in RY1, $26 million in RY2, and $35 million in RY3 (see Joint Proposal, page 46 and Appendix 23). The additional $18.5 million for this storm hardening program in rate year 3 is included in the Rate Year 3 total of $418,522 for "Delivery – All Other" shown in Appendix 27.

Accordingly, the Gas Rate Plan reflects a total of $75.4 million for storm hardening programs in 2016 ($35 million for Flood Prone Main Replacement, $40 for Tunnel Head Houses, and, $0.4 million for Common). Of the $75.4 million, $56.9 million is in the Delivery – Storm Hardening" category for Rate Year 3 in Appendix 27, and $18.5 million is in the Delivery – All Other" category for Rate Year 3 in Appendix 27.

Gas Project (Phase Three Report) ($ millions)	2014 Actual	2015 Current Projection	2016 Current Projection	2014-2016 Current Projection
Main Replacement in Flood Zones	5.3	16.1	20.0	41.4
Vent Line Protector Installation	2.2	1.0	0.0	3.2
LNG Hardening (Black Start, Auxiliary Pumps and Salt Water Pump House)	0.5	2.3	13.6	16.4
Regulator Stations and ROVs	0.0	1.7	1.4	3.1
Tunnels Hardening	0.3	2.0	51.4	53.7
Total	8.3	23.1	86.4	117.8

Projected total expenditures ($117.8 million) for gas system and tunnel storm hardening have decreased from the level reflected in the Gas Rate Plan. The current projected amount for total gas system and tunnel storm hardening expenditures is uncertain given that many of these projects are still in the design phase and actual total expenditures at the end of the Gas Rate Plan may still be as high as originally authorized. Given the collective desire of the parties to the collaborative for Con Edison to have a robust storm hardening program, and since customers will receive credits if actual expenditures result in average net plant lower than the level reflected in rates, the Commission's order on this Report should not call for gas storm hardening expenditures less than the amount reflected in the Storm Hardening category.

VI. Steam System Storm Hardening

This section addresses storm hardening projects that improve the resiliency of Con Edison's steam system. These include projects related to the operation of the Company's steam

[59] As noted in the discussion of these expenditures in the sections above, the Company's Phase One Report updated some of the costs reflected in the Gas Rate Plan.

and electric generating stations (collectively "generating stations") and the steam distribution system.[60]

A. Generating Stations Storm Hardening

1. Generating Stations Storm Hardening Objectives

Prior to Sandy, generating station storm hardening objectives were based on the impact of previous storms and were designed to withstand a storm surge corresponding to a peak tidal water level of 12.1 feet at the Battery. During Sandy, flooding from the unprecedented storm tide levels exceeding 14 feet at the Battery overcame restraint barriers protecting critical generating station equipment. The storm surge levels resulted in station shut-downs and steam service impacts as follows:

- Preemptive shutdown of the East River Generating Station to protect the station's steam distribution outlet mains from contact with flood water;
- Shut down of 59th and 74th Street Steam Generating Stations (nearly 90% of total steam generating capacity being unavailable);
- Shut down of the First Avenue Tunnel;
- Operation of the steam system at pressures lower than normal due to shut-down of steam generating stations; and
- Isolation of steam service to 53 large commercial customers due to forecasted loads in excess of available steam generation capacity.

The East River, 59th Street, and 74th Street Complex generating facilities incurred significant damage during the storm.

Post-Sandy assessments of damage at Con Edison's generating stations identified additional measures needed to protect the stations from storm flooding, including reinforcing station perimeter walls, installing gates and floodwalls, and raising critical equipment. Con

[60] Con Edison's several steam generating stations and its one electric generating station at East River are operated by the Steam Operations department within the Company's Central Operations organization. The East River Generating Station produces both electricity and steam.

Edison is conducting storm hardening projects to protect the following five generating stations against future flood conditions and storm surge:

- East River Generating Station and South Steam Station
- 59th Street
- 74th Street
- 60th Street
- Ravenswood A House

Overall, the storm hardening program is focused on the following primary objectives:

- Minimize equipment damage from salt water
- Mitigate major water entry into steam stations
- Maintain continuous operation during a coastal storm event
- Allow for rapid recovery

2. Generating Stations Storm Hardening Measures Installed by June 2013

The first-phase, immediate storm hardening projects listed below were completed as of June 2013 in advance of the hurricane season. The measures were designed to prevent damage to critical equipment from a storm similar to Sandy that would otherwise significantly delay the start-up of the station. The objective of the following measures was to mitigate the infiltration of water in the generating stations from three primary sources: tunnels, the station perimeter (including doorways and roll-up doors), and pipes and conduits entering the station from the exterior:

- Install new reinforced concrete flood walls to isolate tunnel openings from other areas of the station;
- Install new reinforced concrete flood walls and moats around critical station equipment to protect the equipment against floodwaters that enter the station;
- Install new floodgates and doors in new walls and moats to access isolation zones;
- Install new flood pumps on mobile skids to remove any excess water that enters new isolation zones and moats;

- Seal selected tunnel openings in the station with new plates;
- Install new sealed plate covers with gaskets for manhole covers that link the tunnels and the station floor;
- Intercept all known open drain-piping connections entering the station from the exterior by installing new isolation valves inside the station boundary;
- Install new expansive RTV foam seals at any trench and conduit penetrations into the critical areas of the station to minimize the infiltration of water. These new seals were installed at all conduits and trenches to ensure that the enclosed critical areas of the station are watertight;
- Install new expansive RTV foam seals in conduits entering all critical panels and cabinets. The expansive foam seals were installed in all conduits entering the piece of equipment in order to ensure the cabinet or panel is watertight and protected against floodwaters;
- Secure industrial shrinkable fabric material to protect selected non-operating equipment within the postulated flood plain. This protective fabric will be deployed during the Company's 120-hour Corporate Costal Storm Plan to enhance protection from water damage;
- Install new sliding or hinged steel flood control gates, doors and barriers at all station openings, including doorways and roll-up doors; and
- Construct new barriers and walls to close all non-required openings, such as doors, roll-up doors, or windows, that are no longer in service.

3. Generating Stations Storm Hardening Measures to Be Installed from 2015 to 2016

In addition to the immediate measures described above, the Company has developed a longer-term storm hardening plan for these five generating stations. The following summarizes the installation work to be performed at the generating stations under this longer-term hardening plan:

- Install sluice gates, reinforced concrete walls or other measures in the intake and discharge tunnels to control the inundation of floodwaters from those routes (this will require de-silting of some tunnels);
- Relocate critical mechanical and electrical equipment above the defined flood-control elevation;
- Install submersible equipment within the flood-control elevation;
- Reinforce station perimeter walls to withstand higher flood levels;

- Install pressure resistant/submarine type doors to protect deep basements or structures;
- Install permanent, high-capacity flood-control pumps in additional areas of the stations;
- Install new emergency generators to power flood pumps and to provide additional support to the stations during an emergency; and
- Raise existing moats and walls to meet the flood-control elevation.

All critical equipment within generating stations located within the FEMA plus three feet flood zone will be protected to at least the FEMA plus three feet elevation. The FEMA plus three feet design adds about three to four feet to the protection level achieved by the initial storm hardening measures completed by June 2013.

The primary sources of water intrusion into the stations are flood water ingress through perimeter openings and river water ingress through the station water intake and discharge tunnels. Water entering the station from the perimeter will be addressed by flood doors, barriers, isolation valves, sealants, and gaskets installed to the FEMA plus three feet elevation. If necessary, station perimeter walls will be reinforced to withstand hydraulic pressure based on the FEMA plus three feet elevation. Sluice gates and other barriers will be installed at the 59th Street, 74th Street, and East River Generating Stations to prevent tunnel water ingress into the stations. The installation of sluice gates will prevent the ingress of tunnel water at any storm surge height, including FEMA plus three feet and above. These measures provide the primary protection against flooding to the FEMA plus three feet elevation.

Secondary measures are being established to address any water that may enter the stations from the perimeter or the river despite these primary measures. High-capacity pumps, supported by emergency generators, will remove water from station interiors. Moats and compartmentalizing walls protect critical station equipment from any pooling water before it is pumped out. Compartmentalizing wall and moats are backup measures to the primary perimeter and sluice gate barriers and the secondary flood pumps.

Flood-control measures at the generating stations are designed to maintain four of our five steam stations online throughout a storm surge. These measures will significantly reduce the number of steam customers affected by a storm and will reduce the number of days that service must be restricted while the full system is restored. The fifth steam plant, the East River Station, will be preemptively shut down ahead of large coastal storms to protect the heated steam distribution pipes exiting the station from contact with cool floodwater, but with the measures listed above, the station will return to service faster following a flood event.

Con Edison plans to install flood control measures at five generating stations during 2015 to 2016. Updated white papers describing the scope and cost for each generating station project are provided in Appendix M – Generation Stations Whitepapers.

4. Generating Stations Storm Hardening Project Cost Estimates (2014 to 2016)

a) Costs Reflected in Steam and Electric Rate Plans

In the rate case, Con Edison presented plans to install storm hardening measures at the five generating stations from 2014 through 2016 at a total estimated cost of $147.5 million, including $40.5 million in 2014. The Company estimated $55.5 million for electric generation facilities and $92.0 million for steam generation facilities. The estimated costs for these projects for the period 2014 – 2016, reflected in the Steam Rate Plan, are summarized in the following table.[61]

[61] In the Phase One Report, Con Edison reported an increase in projected 2014 expenditures for the East River steam plant from $2.5 million to $4.8 million, a decrease in projected 2016 expenditures for the 59th Street steam station from $14 million to $11.9 million, and a decrease in the projected expenditures for the 74th Street steam station from $14 million to $12.9 million.

Generating Station Rate Plan ($ millions)	2014	2015	2016	2014-2016 Cost (Rate Plan)
East River EP	14.0	21.0	20.5	55.5
East River SP	2.5	4.5	7.0	14.0
59th Street	10.0	12.0	14.0	36.0
74th Street	10.0	12.0	14.0	36.0
60th Street	2.0	1.0	0.0	3.0
Ravenswood A House	2.0	1.0	0.0	3.0
All Steam Stations	**26.5**	**30.5**	**35.0**	**92.0**
All Generating Stations	**40.5**	**51.5**	**55.5**	**147.5**

b) Updated Costs

As a result of ongoing project development work, including incorporation of the new flood protection design standard, FEMA plus three feet, in late July 2013, Con Edison has refined the estimated costs of the generating station storm hardening projects. In addition, as was presented during the Phase Two collaborative and discussed below, $10.4 million is being reallocated from steam generating station funding to the steam distribution system due to the benefits that can be realized by hardening distribution infrastructure. The steam generating station storm hardening projects for 2014 also faced similar challenges as substations, including delays in obtaining permits to start work from DOB and higher than expected contractor bids that required extended negotiations and re-bids to resolve.

The Company’s current projection of storm hardening cost at each generating station is as follows:

Generating Station (Phase Three Report) ($ millions)	2014 Actual	2015 Current Projection	2016 Current Projection	2014-2016 Current Projection
East River EP	1.8	5.9	30.0	37.7
East River SP	0.3	3.4	9.4	13.1
59th Street	3.2	9.4	12.1	24.7
74th Street	3.3	9.8	12.0	25.1
60th Street	1.1	1.4	0.5	3.0
Ravenswood A House	0.2	1.4	1.0	2.6
All Steam Stations	8.1	25.4	35.0	68.5
All Generating Stations	9.9	31.3	65.0	106.2

Projected generating station storm hardening expenditures have decreased by $41.3 million. Following the development of a new scope of work, which provides an equivalent level of protection up to the FEMA + 3 design standard, Con Edison was able to revise downward the forecasted costs for all of the projects. [62]

With regard to the generating station storm hardening projects generally, detailed engineering and design has been completed for most 2015 work, and results in a more detailed cost projection for this component of the storm hardening projects. Additional engineering and design will be completed to support 2016 work. Some engineering and design is still in development for 2016, and cost projections in this Phase Three Report reflect the previously

[62] The decrease for East River specifically resulted from changes in three major projects for which the Company identified a more cost effective solution after further review of the original proposed design that will continue to protect the East River Station to the FEMA 100-year flood level + 3 feet design basis : (1) the sluice gate project, which has been modified to make use of a simpler Kevlar barrier as opposed to large steel sluice gates; (2) the project to replace and elevate diesel generator #3, which is no longer being replaced because it was repaired and tested functional after Sandy and will have an interior barrier and trash pump to protect its location inside the station; and (3) the project to elevate breakers in the 69kV yard, which would have required expensive modification to the congested equipment and electrical bus work inside the station and is instead being addressed by placing an interior barrier around the critical breaker that will maintain light and power feeds.

proposed concept plans and order of magnitude estimates that include the 30% contingency based upon the level of detail.

B. Steam Distribution System Storm Hardening

The Phase One Report noted that Con Edison is developing several projects to improve steam distribution system resiliency and proposed that the Phase Two Collaborative "examine Con Edison's storm hardening project plans under development for initiation in 2015, including … steam distribution projects."[63] Con Edison presented to the Phase Two Collaborative five steam distribution storm hardening projects that the Company is implementing to comply with the FEMA plus three feet flood design elevation. This Phase Three Report describes these projects, as well as the Company's implementation plan for each.

1. Steam Distribution System Storm Hardening Objectives

After Con Edison adopted the FEMA plus three feet flood standard in July 2013, Con Edison's Steam Operations organization applied that standard in planning protective measures to mitigate the impacts of flooding on Con Edison's steam system.

Con Edison's Corporate Coastal Storm Plan establishes protective measures to mitigate the impacts of flooding on Con Edison's steam system. The Coastal Storm Plan calls for preemptive shut down of flood-prone areas of the steam distribution system in case of a severe storm. Isolation and de-energization of steam main and services are necessary to prevent damage to the mains from contact with flood water and the creation of condensation conditions that could lead to water hammer.

[63] Phase One Report, pp. 9, 23, 83

The FEMA plus three feet floodtide boundary encompasses approximately 14 miles of steam mains and steam services to about 216 customers in lower Manhattan.[64] Con Edison will pre-emptively isolate these steam mains and services when warranted by forecasted storm conditions. The steam distribution system storm hardening projects discussed below are being implemented to efficiently implement Con Edison's plan for preemptively isolating customers in flood areas and restoring their steam service without delay when flood water recedes..

2. Steam Distribution System Storm Hardening Projects

a) Install tie between the 15th Street Distribution Main and the 1st Avenue Transmission Main

Portions of three major steam mains lying within the FEMA plus three feet flood zone supply lower Manhattan, the Avenue D main, the 7th Avenue main, and the First Avenue main. These mains will be isolated depending on the severity of flood conditions. When these three mains are isolated from the system, approximately 13 miles of steam mains and 137 customers in lower Manhattan outside of the FEMA plus three feet flood zone will be isolated as well. The installation of a tie between the 15th Street distribution main and the 1st Avenue transmission main will re-route steam from the 15th Street main to the First Avenue main in order to maintain steam supply through the First Avenue transmission main south of 10th Street to Trinity Place north of Cedar Street, which are portions of the First Avenue main that are not in the flood zone. The tie, which includes a 24" diameter 120 foot cross tie main and an isolation valve, will help to provide continued steam supply for approximately 110 of these 137 customers in lower Manhattan, which include three hospitals, one university, one high school, Police Headquarters, and City Hall. This project commenced in 2014 and will be completed in 2015 at a total projected cost of $2.3 million.

[64] The steam distribution system contains 105 miles of steam pipe supplying service to approximately 1,700 customers.

b) Install additional isolation valves outside of flood zone

This project will extend steam service to the remaining 27 customers who would otherwise lose steam service when the Avenue D main, the 7th Avenue main, and the 1st Avenue main are shut down as described above. These customers include the New York Stock Exchange/Amex Equities (former American Stock Exchange), Trinity Church, New York Bank of Mellon, Deutsche Bank, and Chase Manhattan Bank. This project will install isolation valves at Reactor Street west of Trinity Place, Cedar Street west of Trinity Place, and W15th Street west of Eighth Avenue. This project will be completed in 2015 at a total projected cost of $1.1 million.

c) Install remote operated valves to facilitate isolation of mains in lower Manhattan flood zone

The Avenue D Main, the First Avenue Main, and the Seventh Avenue Main supply steam to Lower Manhattan will be isolated depending of the severity of flooding. The Avenue D Main is located in the flood zone, and this main will be preemptively isolated prior to anticipated flooding conditions. The First Avenue Main is supplied from the East River Generating Station, which is in the flood zone. All steam mains emanating from the East River Generating Station will be shut down to preclude flood water from contacting live steam mains. However, as discussed in project "1" above, steam will be rerouted to the First Avenue Main via a tie from the 15th Street Main so that steam supply in Lower Manhattan can be maintained.

Portions of the Seventh Avenue Main in the lower Manhattan area are in the flood zone. During flooding conditions, this main will be kept in service as long as possible along with other mains outside of the FEMA plus three feet flood area in lower Manhattan.

Steam Distribution will convert the existing control valve on the First Avenue main south of 10th Street to a control/isolation valve, and change the manual valve on the Seventh Avenue main south of 12th street to a control/isolation valve. These installations will provide capability to keep the mains and adjoining customers in lower Manhattan in service as long as possible during a severe storm and will avoid shutting down the entire steam system if supply to lower Manhattan must be isolated.

When steam is supplied through the First Avenue main to lower Manhattan via the tie from the 15th Street main, the Company must be able to control the steam flow and completely isolate it if necessary depending on the extent of flooding in lower Manhattan. For this purpose, Con Edison will convert the existing control valve (CV3) on the First Avenue main south of 10th Street to a control/isolation valve. CV3 currently provides remote operation to divert flow between upper and lower Manhattan. This control valve has a hole in its rotating disc maintains flow through the valve. It has a "stop" installed to prevent full closure of the valve, and no seat is present in the valve to allow for completely sealing. In addition, the electronics do not allow precise control that would be required for isolation use. Therefore, the existing valve and its controls will be replaced to provide remote throttling and a tight shut-off for isolation.

On Seventh Avenue south of 12th Street, the existing valve is a manually operated valve that is used only for isolation purposes. This valve will be replaced with a new control/isolation valve which can be remotely throttled to control the flow, and remotely operated.

With these two remotely operated valves, the steam dispatcher will be able to remotely sectionalize the steam system to isolate lower Manhattan if warranted by flood conditions while maintaining steam service to the remainder of the steam system. The remote operated valves will avoid shutting down the entire system due to lower Manhattan flooding and will maintain steam service for approximately 1,424 customers that are outside of lower Manhattan. As flood levels rise during a storm, steam dispatchers will use these remotely operated valves to supply steam to lower Manhattan. If flooding becomes severe and threatens lower Manhattan mains and customer services, or upon sudden loss of an electric network in lower Manhattan, steam dispatchers will be able to remotely operate these two control/isolation valves to immediately isolate lower Manhattan without risking the safety of the employees in the field for manual valve operation during severe storm conditions. Immediate isolation will also minimize the risk of a water hammer event, which can endanger the public.

This project commenced in 2014 and will be completed in 2015 at a total projected cost of $1.7 million.

d) Improve debris capture and removal in the York Steam Main located on Hudson Avenue Property

This project will reconfigure the main and drip pot arrangement located immediately downstream of main valve YMS-1 on Marshall Street in the Hudson Avenue Property to facilitate draining of condensate in the York steam main from Brooklyn Navy Yard Cogeneration Partners (BNYCP) and purging of the pipe to prevent transport of debris to the steam traps further downstream in the system.

Currently, BNYCP will preemptively isolate in anticipation of a coastal storm. This includes preemptive isolation of the adjoining York steam main, which is below grade in the FEMA plus three feet flood zone and is usually submerged during storm conditions. Although the York main and the mains in BNYCP will be preemptively isolated, flood water inundation rapidly cools the mains causing the protective magnetite layer on the inside wall of the pipe to scale off. After start up and when flow conditions create enough velocity, the scales are transported in the flow. The reconfiguration of the pipe and drip pot arrangement would be on the above-ground section of the York main and would provide a suitable flow condition and a mechanism to capture the transported debris. The new arrangement utilizes a tee fitting in place of an elbow, provides a horizontal run of several feet of straight pipe beyond a vertical riser and relocates the drip pot to facilitate the transport of pipe scales/debris to the drip pot for capture and removal before it goes further downstream into the steam system. This project also helps to expedite the restoration of the main. The cost of this project is included in the Tie-Main project.

e) Storm Hardened Remote Monitoring System (RMS)

The RMS provides information regarding the operation of steam facilities at particular locations on the steam system. This information includes the presence of water in steam manholes. This project will waterproof approximately 300 underground Remote Telemetry Unit (RTU) boxes within the FEMA plus three feet flood zone to avoid RTU failures due to flooding. In addition, this project will install the RMS at approximately 45 new locations that have been identified to provide system status information during storm tide conditions. The information from these RTUs will assist Steam Operations in determining the need and scope of steam main isolation during flooding conditions. This project commenced in 2014 and will be completed in 2015 at a total projected cost of $3.3 million.

In order to protect the steam distribution system to the FEMA plus three feet flood protection standard as rapidly as possible, the Company expects to complete the projects no later than 2015. An updated white paper describing the scope and cost for each project is provided in Appendix N – Steam Distribution Whitepapers.

Reinforce the Steam System in Flood Zones.

The Company will further harden the steam distribution system within the FEMA plus 3 feet flood zone to align with its plan for strategic isolation of smaller portions of the system based on the elevation of the steam system area. This project will further subdivide the FEMA plus 3 feet flood zone into various levels of isolation and develop Company operational measures to allow for preemptive isolation of such sublevels when warranted by forecasted flood levels.

Inside the FEMA plus 3 feet flood zone, Company will reinforce the system to provide flexibility to isolate the steam mains and customers in the affected area even if the forecasted flood level is less severe than the FEMA plus 3 feet standard, but there is flooding that affects the steam distribution system. These reinforcements are:

- Storm harden the manholes that house the isolation valves;
- Storm harden anchors adjacent to isolation valves with more corrosion resistant and higher mechanical strength material;
- Storm harden the priority structures in the flood sublevels to minimize water accumulation and flooding;
- Install additional isolation valves where electric networks extend to reach certain customers; and
- Waterproof the remote monitoring boxes in the flood sublevels.

The objective is to reinforce the system to reduce the footprint of the outage area, minimize customer outages and to aim for a faster restoration time in an efficient manner after the storm.

f) Storm Hardening of the First Avenue Steam Main

As discussed above, the new FEMA+3 feet flood boundary covers approximately 14 miles of steam mains and about 216 customers that will be pre-emptively isolated when warranted by forecasted storm conditions. The mains are isolated using the main valves immediately outside of the FEMA + 3 feet flood boundary. Included among the 14 miles of mains are the 2.22 miles of the First Avenue steam main located between E20th and E38th

Streets. Although a portion of the main between E24th and E33rd Streets (approximately 0.54 miles) is located outside of the FEMA+3 feet flood zone, it will be pre-emptively isolated because of its geographical location sandwiched between the two aforementioned flood areas. Approximately 50 customers will be affected, including three major hospitals, essential healthcare facilities, psychiatric services for the homeless, public health laboratories, and numerous residential buildings.

The Company would accordingly segregate the section of the First Avenue steam main between E20th and E38th Streets to minimize the outage footprint and to reduce impact to the customers located outside of the FEMA+3 feet flood zone. The Company has developed the following proposed plan to storm harden the First Avenue main:

- Install an 8” diameter cross-tie between the E26th Street and E27th Street radial mains across Second Avenue. The length of the cross tie is approximately 900 feet and it includes a new isolation valve;
- Relocate an existing main valve from north of E23rd Street to north of E24th Street;
- Install and waterproof approximately 500 feet of 8” service to VA Hospital; and
- Waterproof remote monitoring boxes at the isolation valves

This project would enhance reliability of the section of main feeding the hospitals, health care facilities, other commercial and residential buildings that would otherwise be preemptively isolated with areas inside the FEMA plus three feet flood zone even though this section of main is outside the flood zone. The Company is currently developing conceptual plans that are expected to be completed in 2016. The order of magnitude estimate for this project is approximately $8 million, but this amount is not funded in the current steam storm hardening program. The Company is not currently planning to proceed with this project and will likely consider it later. If, however, there are steam storm hardening funds available for this project during 2016, then the Company may decide to proceed with this project during that year.

3. Steam Distribution System Storm Hardening Project Costs

The projected costs of the steam distribution storm hardening projects are as shown in the following table:

Steam Distribution Project (Phase Three Report) ($ millions)	**2014 Actual costs**	**2015 Current Projection**	**2016 Current Projection**	**2014 – 2016 Current Projection**
Tie Main	0.8	1.3	0.0	2.1
Isolations Valves	0.1	1.1	0.0	1.2
Remote Operated Valves	0.5	1.2	0.0	1.7
Hardening REMS	3.3	0.0	0.0	3.3
Reinforce System in Flood Zones	0.0	2.1	0.0	2.1
Total	4.7	5.7	0.0	10.4

C. Steam System Storm Hardening Costs

1. Costs Reflected in Steam Rate Plan

The Steam Rate Plan reflects $92.0 million for storm hardening expenditures at the steam generating stations and no expenditures for storm hardening of the steam distribution system as shown in the following table:

Steam Generating Stations Rate Plan ($ millions)	2014	2015	2016	2014-2016 Cost (Rate Plan)
All Steam Stations	26.5	30.5	35.0	92.0
Steam Distribution System	0	0	0	0
Total	**26.5**	**30.5**	**35.0**	**92.0**

In the steam rate case, Con Edison did not propose steam distribution storm hardening projects to meet the FEMA plus three feet flood design standard because that standard is based on FEMA flood maps that were issued after the Company filed its steam rate case on January 25, 2013. The Company adopted the FEMA plus three feet standard in July 2013. Accordingly, the Company's three-year Steam Rate Plan does not reflect the projected expenditure of $10.4 million for the steam distribution storm hardening projects that were examined during the Phase Three Collaborative and are proposed in this Phase Three Report.

2. Updated Costs

Con Edison's current projected expenditures for Steam Generating Stations and Steam Distribution System storm hardening projects during 2014, 2015, and 2016 is $78.9 million, shown as follows:

Steam Generating Stations Phase Two Report ($ millions)	2014 Actual	2015 Current Projection	2016 Current Projection	2014 – 2016 Current Projection
All Steam Stations	8.1	25.4	35.0	68.5
Steam Distribution System	4.7	5.7	0.0	10.4
Total	12.8	31.1	35.0	78.9

The Company now forecasts that its total expenditures for steam plant storm hardening ($78.9 million) is a decrease from the amount ($92.0 million) reflected in the Company's Steam Rate Plan. The current projected amount for total steam system and tunnel storm hardening expenditures is uncertain given that many of these projects are still in the design phase and actual total expenditures at the end of the Steam Rate Plan may still be as high as originally authorized. Given the collective desire of the parties to the collaborative for Con Edison to have a robust storm hardening program, and since customers will receive credits if actual expenditures result in average net plant lower than the level reflected in rates, the Commission's order on this Report should not call for steam storm hardening expenditures less than the amount reflected in the Storm Hardening category.

VII. Facilities Storm Hardening

This section addresses storm hardening projects that are conducted and funded by Con Edison's Facilities organization and for which capital costs are allocated among the Company's Electric and Gas Departments and reflected accordingly in Con Edison's Electric and Gas Rate Plans.[65] These projects support the storm and flood integrity of buildings and yards used in common for electric, gas, and steam operations.

A. Facilities Storm Hardening Objectives

Con Edison's Facilities organization is responsible for the day-to-day operation and maintenance of the Company's buildings and yards (generally service centers). In the wake of Sandy, a number of Con Edison's buildings and service centers were flooded resulting in substantial damage and creating significant disruption to electric, gas and steam operations that the properties support. For example, the two main buildings at the 16th Street Service Center

[65] Interdepartmental rent is charged to the Steam Department for these facilities.

near the East River were flooded to depths of four (at Building 750) and five to six feet (at Building 700) and incurred significant damage to key operational equipment. The Facilities organization has developed a storm hardening plan that seeks to minimize flood and wind damage to building structures, minimize damage to critical building equipment, and mitigate interruption to operations. The overall program incorporates a combination of three different types of measures – permanent, deployable and administrative – depending on the circumstances presented by each location. Permanent or passive measures involve physical modification to a building or site with the intent of making it a permanent feature of the facility. A primary example is structural strengthening of building/room enclosures to sustain high hydrostatic forces and prevent storm surge water from damaging critical building infrastructure necessary to keep the facilities habitable and functional, *e.g.* chillers, boilers, sewage pumps, emergency generators, air compressors, electrical equipment. Deployable measures are implemented immediately in advance of a potential flood condition to provide protection for the duration of the storm event and are then removed. Administrative measures provide for the temporary relocation of equipment and supplies from flood prone locations to minimize damage and allow faster deployment.

B. Facilities Storm Hardening Projects

Facilities' storm hardening plan includes a capital program to storm harden service centers and other buildings that are most vulnerable to flooding. In conjunction with a consultant's hardening study, which provided evaluation and recommendations for the properties within the FEMA plus three feet flood zone, Facilities has identified 14 vulnerable service centers and buildings. Facilities plans to harden the six most vulnerable of these sites during 2015 and 2016, at a cost of $5 million per year, as follows[66]:

- 2015 Projects
  - 16th St. and 28th St. Service Centers and portions of The Learning Center
- 2016 Projects
  - 110th St., College Point and Neptune Ave Service Centers

For each of the above projects, Facilities issued a request for proposal (RFP) to generate detailed design packages based on concept study design criteria specified in the RFP. Detailed design engineering for the 16th St and 28th St. Service Centers and The Learning Center is complete and the Company has bid the projects. The plan is for construction at these properties to be completed in 2015. The design packages for 110th St., College Point and Neptune Ave Service Centers sites are being prepared and should be completed in 2015 for construction in 2016.

The design for each project will incorporate various measures to prevent water from entering the building that provide protection for key locations and equipment within the building. The various hardening measures consist of the following:

- Harden and seal existing interior and exterior walls surrounding equipment rooms
- Replace existing doors
- Replace or remove existing windows
- Replace elevator sensors and switches with submersible cable and equipment
- Provide for emergency power to critical equipment
- Provide submersible sump pumps/leak detection

[66] In 2017, Facilities plans to harden Eastview Service Center, which was not heavily damaged by Sandy but is prone to flooding from the adjacent Saw Mill River; and the remaining interior portions of The Learning Center as part of a separate effort to be funded by the Company's Common Capital Budget (i.e., Facilities Flood Mitigation Program). The most vulnerable areas of The Learning Center will be protected by hardening the facilities' perimeter and preventing storm surges from entering the building's lower level, as part of the 2015 program described above.

- Relocate vents/louvers
- Seal electrical penetrations
- Seal concrete slabs
- Deploy drain plugs
- Install storm sewer backflow valves
- Install sanitary sewer backflow prevention devices
- Protect lobby entrances and loading bays - flood defense blocks

An updated white paper describing the scope and cost for the 2015 to 2017 Facilities storm hardening projects is provided in Appendix O – Facilities Whitepapers.

C. Facilities Storm Hardening Project Costs

1. Costs Reflected in Electric, Gas, and Steam Rate Plans

In the 2013 rate case, Con Edison presented preliminary plans to establish projects to storm harden its Facilities properties that sustained flood damage during Sandy and estimated the cost at $5 million per year in 2015 and 2016 as shown in the table:

Facilities Projects (Rate Plan ($ millions)	2014	2015	2016	2014-2016 Cost (Rate Plan)
Facilities	0	5.0	5.0	10.0

2. Updated Costs

Following the consultant's hardening study, conceptual design and detailed design work for the 2015 projects, the Company continues to project expenditure of $5 million annually in 2015 and 2016 consistent with the expenditures reflected in the Company's Electric, Gas, and Steam Rate Plans.

Facilities Projects (Phase Two Report) ($ millions)	2014 Actual	2015 Current Projection	2016 Current Projection	2014-2016 Current Projection
Facilities	0	5.0	5.0	10.0

VIII. Telecommunications System Storm Hardening

A. Telecommunications System Storm Hardening Objectives

Con Edison owns and operates a private communications network called the Corporate Communications Transmission Network (CCTN). This network provides secure communications circuits for SCADANet, voice, video, protection, and the computing and storage environment. The CCTN supports consolidation of computing resources and reduces public carrier costs. Communications rooms, communications huts, and enclosures at over 100 Company locations host CCTN equipment, and over 400 miles of fiber optic cable in underground structures and on utility poles and electric transmission towers provide CCTN communications services. The CCTN provides multiple radio systems that support voice-to-field crews, such as from control centers to field crews, and machine-to-machine smart grid applications, such as the distribution automation system. These systems share an infrastructure of antenna sites throughout the service territory that enable wireless communication to occur on the CCTN.

Con Edison has established three projects to address the impacts of Sandy. The first initiative is to harden radio sites by improving backup generator power and reinforcing antennas and radio frequency cables at radio sites. The second is to extend the CCTN fiber optic network to critical transmission substations in lower Manhattan. The third is to mitigate the impact of flooding on communications infrastructure.

B. Telecommunications System Storm Hardening Projects

1. Harden Radio Sites

During Sandy, high winds detached antennas and cable at two of our 35 radio facilities, and several radio sites experienced prolonged power outages that interrupted radio service in pockets of Westchester County. The unavailability of these radio facilities had an adverse effect on the overhead distribution restoration efforts in the areas served by the affected radio sites. Typically, radio sites have 8 to 16 hours of battery backup time compared to the several days it took to restore utility power. To harden these sites, our Antennae Hardening Project inspects, evaluates, redesigns, reinforces and replaces antenna and line systems at all radio sites and dispatch centers – more than 50 locations. The project reinforces supports, fastenings and anchoring systems used to secure various antennas, including pole, panel and dish antennas and radio frequency cabling and waveguides. The projected cost of this project is $200,000.

To date, inspections have been completed at 55 facilities with antennas and RF waveguides. Minor reinforcement and repair work was completed at 26 facilities and major remediation work at 13 facilities. This aspect part of the storm hardening initiative is complete.

We will also deploy a backup generator at the Buchanan complex radio hut, increase generator gas tank capacity at the Graymoor radio site, and install a gas-fired generator at the North Castle 1 radio site. These enhancements to the backup power facilities will maintain wireless communications during an extended power outage in Westchester County. The projected cost of this project is $350,000.

Generator work was completed at Graymoor and North Castle radio sites and the generator installation at Buchanan radio site is currently in progress and is expected to be completed in late 2015.

The two radio systems initiatives are projected to cost approximately $550,000 over three years from 2014 to 2016.

2. Extension of CCTN in Lower Manhattan

During Sandy, the local exchange public carriers sustained (i) severe damage to their telecommunications facilities, which included central offices and copper outside plant directly affected by the flood waters, and (ii) power outages that resulted in prolonged service outages to their customers. These outages adversely affected voice and data services and feeder protection circuits at lower Manhattan substations. Therefore, to provide carrier diversity for critical communication circuits, Con Edison is extending the CCTN fiber optic network to the Leonard Street, World Trade Center, and Seaport substations in lower Manhattan.

CCTN will provide these substations with a high-speed, redundant and diverse complement to public carriers. The work entails installing CCTN telecommunications facilities at each substation and building underground fiber spans linking 4 Irving Place, Leonard Street, World Trade Center, Seaport, and Cherry Street Substations in a self-healing ring topology. The new telecommunications equipment will be housed in pre-fabricated huts and existing communications rooms and will possess diverse points of entry to the substations and redundant electronic components, including power sources, to eliminate any single point of failure and provide redundancy and diversity. The estimated cost for this project is approximately $5 million. The projected completion date is December 2016.

Work on the CCTN extension in lower Manhattan is underway. The fiber has been installed between Cherry St and Seaport (SEA) substations and is proceeding onto World Trade (WTC) substation in 2015. Work is also in progress at the telecommunications room at WTC and is expected to begin at SEA in 2015. Both rooms will be completed in 2015. The planning and design for the fiber optic routes from WTC to Leonard (LEO) St. Substations and from LEO to 4 Irving Place has also commenced in 2015.

3. Elevation of Communication Huts

Telecommunications equipment is housed in communications rooms and pre-fabricated huts located at generator stations, substations, and other operations and office facilities. During Sandy, CCTN circuits remained operational at all locations except the telecom room at East 13th Street substation and the communications hut at Goethals substation, which were severely impacted by flood waters. Con Edison installed replacement equipment at Goethals higher on the equipment rack. The planned construction of flood walls around the Goethals substation will further protect the equipment to the FEMA plus three feet flood elevation, and the Company is evaluating elevating the equipment above that elevation as a defense-in-depth measure. A communications room will be established in the new control center at the East 13th Street substation, which will be above the FEMA plus three feet elevation.

All new huts in flood-prone areas will be installed on a concrete pad at least three feet above the FEMA 100-year flood elevation. The Company is currently evaluating solutions that range from enhanced sealing techniques to prevent water ingress to hut replacements at existing flood-prone locations. The communications huts at Fresh Kills substation and 1 Davis Avenue in Staten Island are in flood prone areas. The planned construction of flood walls around the Fresh Kills substation will protect the communication equipment to the FEMA plus three feet flood elevation, and the Company is evaluating elevating the equipment above that elevation as a defense-in-depth measure. In 2016, the hut at 1 Davis Avenue will be elevated to at least the FEMA plus three feet level. The estimated cost for this program during 2015 and 2016 is approximately $1.0 million.

The work to relocate all active electronic components from the Fresh Kills communications building to the control room building is in progress and will be completed in 2015. Similarly, we are evaluating relocating the equipment from the communications building at Davis Avenue to a 2nd floor room in the main building. The evaluation will be completed in 2016.

An updated white paper describing the scope and cost for the Telecommunications System storm hardening projects is provided in Appendix P – Telecommunications Whitepapers.

C. Telecommunications System Storm Hardening Project Costs

1. Costs Reflected in Electric, Gas, and Steam Rate Plans

In the rate case, Con Edison presented the CCTN storm hardening projects described above and estimated expenditures $1.3 million in 2014, $2.7 million in 2015, and $2.6 million in 2016 as follows: [67]

Telecommunications System Projects (Rate Plan) ($ millions)	2014	2015	2016	2014-2016 Cost (Rate Plan)
Total	**1.3**	**2.7**	**2.6**	**6.6**

2. Updated Costs

The Company continues to project expenditure of these sums in 2015 and 2016, as follows:

[67] The Phase One Report also identified this cost. See, Phase One Report, pp. 10, 25, and 83. These expenditures are allocated among the Company's Electric and Gas Departments, and the Steam Department is charged interdepartmental rent for use of the CCTN. The project costs are reflected accordingly in the Company's Electric, Gas, and Steam Rate Plans.

Telecommunications System Projects (Phase Three Report ($ millions)	2014 Actual	2015 Current Projection	2016 Current Projection	2014-2016 Current Projection
Radio Site Hardening	0.06	0.06	0.10	0.22
Generators	0.06	0.16	0.05	0.27
CCTN Extension	1.2	2.2	1.7	5.1
Communication Huts	0.0	0.25	0.75	1.0
Total	1.3	2.7	2.6	6.6

IX. Risk Assessment and Cost Benefit Modeling

A. Background

Con Edison's portfolio of storm hardening projects is designed to mitigate the impact of severe weather events on Con Edison's customers and systems. Con Edison, in conjunction with the Collaborative parties, was tasked with developing analytical tools for assessing the merits of the Company's storm hardening projects. There are two related deliverables: (1) risk assessment and prioritization, and (2) economic cost value analysis.

1. Risk Assessment and Prioritization Model

During the Phase One Collaborative, Con Edison and the Collaborative parties developed a risk assessment and prioritization model to gauge, in terms of risk reduction to customers and critical infrastructure, both the collective impact of Con Edison's programs and their relative merits across different components of the Company's system. The output of this model quantifies and ranks the reduction in risk associated with each of the storm hardening projects related to the Company's transmission, substation, coastal network, and overhead distribution systems.

The model establishes the value of each of Con Edison's storm hardening initiatives in terms of the magnitude of the reduction in risk at each targeted asset. This metric helps to demonstrate a cost causality linkage between capital funding allocated for storm hardening and the reduction in risk obtained via that investment. Key components of the model are:

- Location-specific information regarding high-rise residential buildings and municipal critical infrastructure, *e.g.*, hospitals and water treatment facilities;
- Location-based flood probabilities provided through proprietary New York City inundation models;
- Wind damage probabilities derived from historical wind gust frequency distributions;
- Costs to storm harden Con Edison's facilities; and
- Projected outage durations in absence of and after implementation of effective storm mitigation.

The Phase One Report provided a detailed explanation of the development and function of the risk assessment and prioritization model, including inputs and outputs.[68]

The model prioritizes risk reduction under the assumption that all of the proposed storm hardening programs will be undertaken. The risk reduction ranking illustrates that the proposed capital funding for the storm hardening programs are being appropriately allocated to maximize risk reduction to the most critical assets. The model is not intended, however, to establish a threshold below which particular projects would be deemed as not viable and eliminated from consideration. In other words, the risk prioritization ranking is not a standalone litmus test of project value. If overall funding for storm hardening were to be reduced, the Company would not necessarily eliminate the programs displaying the lowest degree of risk reduction. The Company would apply engineering judgment reflecting system design and operating

[68] See Phase One Report, Section VI B, pp. 66-73.

characteristics and experience in the selection of eliminated programs while considering the prioritization ranking.

2. Phase II Refinement of Risk Assessment and Prioritization

The Risk Assessment and Prioritization model developed and vetted during Phase One of the Collaborative provides the fundamental data assemblage structure carried forward into the Phase II risk modeling effort. Maintained in the Phase I to Phase II evolution are the asset specific targeting, 20 year asset life horizon, pre and post hardening base year and asset life probabilities, pre and post hardening outage durations, asset specific populations, asset specific infrastructure counts, and the computational methodologies detailed in the Phase One Report.[69]

Where necessary, the Phase I risk model was augmented via enhancements to the targeted scope of work for existing resiliency programs and direct additions to the targeted list of assets reflecting a maturation of the resiliency planning process. The cost of resiliency projects has been updated. Additionally, using the company's Network Reliability Index (NRI) model, reliability based programs for the eight highest risk networks have been blended into the model to capture the impact of heat and the offsetting effects of heat related risk mitigation strategies on those networks.

The updated risk model now includes preliminary heat wave related events in the mix of current system impacts (wind and flood). This inclusion links the company's NRI model and the resiliency initiatives and allows for a simultaneous assessment of network capital expenditures on both a reliability and storm resiliency basis. Traditionally, heat waves and resulting high system loads have been addressed through targeted reliability programs and have not been viewed from the perspective of storm resiliency. As evidenced by consistent improvements in

[69] Phase One Report, Appendix Q.

network system summer performance over the past years, these reliability enhancement programs provide a viable means of strengthening the networks against high heat conditions.

Visual summaries of the Phase II Risk Assessment and Prioritization model analogous to Charts I through IV contained within Section VI of the Phase One Report were provided as part of the model package supplied to the Collaborative. As evident from the numerical model results and graphical depictions, the results of the Phase II risk analysis continue to support the consistent prioritized allocation of capital funding for risk reduction across assets both with and without the presence of the original five major "too big to fail" assets. These visual summaries appear in Phase II Risk Assessment and Prioritization Model Simulation provided in Appendix R to the Phase II Report.

Additionally, enhancements to the Phase II Risk Assessment and Prioritization model incorporating dynamic probability simulations of flood, wind damage, and durations in place of the fixed estimates of those parameters have been completed and are also reflected in Appendix R to the Phase II Report.

Through the application of established Monte Carlo methods to empirical probability distributions of flood potential, wind damage, and storm durations, a simulated quantification of risk reduction within stated percentile levels was obtained. These percentiles allow for a broader perspective of the risk reduction coverage provided by each of the asset specific storm resiliency initiatives.

In all cases, the risk reduction levels for area and transmission substation level assets satisfied the 90th percentile tier. This effectively indicates that the storm resiliency measures taken for these assets cover up to 90% of the anticipated flood likelihoods. In similar fashion, the majority of risk reduction levels realized for distribution underground (coastal networks) and overhead assets fell within the 70th to 80th percentile levels thereby establishing an upper level of resiliency coverage against flooding and wind damage, respectively.

It should be noted that in gauging the significance of these results the limitations inherent in any simulation of long horizon, *i.e.*, 20 year, weather effects must be acknowledged. The risk reduction levels indicated are derived and restricted to currently available sources. These sources include flood probabilities provided through the extensive NYC inundation modeling, historical Con Edison regional wind gust and derivative damage probability distributions, and historical Con Edison storm duration distributions. As more refined local climate studies become available, these simulations can be updated as needed using any revised weather information as the foundation.

Of particular note, Con Edison did not carry out simulations of the risk reduction percentiles associated with heat events due to the uncertainty regarding an acceptable characterization of a "warmer summer period" and the lack of required viable temperature distributions. Essentially, an overall increase in summer temperature can take a myriad of definable but not easily predictable forms. Temperature rise could be uniform but moderate. It could represent an increase in the number of heat waves, an increase in their individual severity, *i.e.*, higher daily temperatures, or an increase in their individual durations. Ultimately, any combination of these four potential temperature pattern changes could manifest themselves as an increase in summer temperatures. Because the impact of each of these conditions on system reliability differs greatly in the absence of specific knowledge regarding the likelihood of each form of temperature increase, any simulation of weather effects becomes problematic.

3. Cost/Benefit Analysis Model

The Con Edison Cost/Benefit model has been developed within the overarching analytic structure established previously through the Phase I Risk Assessment and Prioritization model ("risk model") and refined via the current Phase II evolution of that effort. The risk model provides an effective and convenient starting point from which the Cost/Benefit analysis can evolve.

Due to the innovative nature of the Cost/Benefit model as a potential utility planning tool, the Company engaged the expertise of an industry recognized Economic/Engineering consultant, "O'Neill Management Consulting, LLC", to lend broader support and direction to the computation of the outage cost estimates. They assembled and provided a primer on factors and specific values that affect the monetary value of avoiding a power outage. Outage cost information referenced in this primer was used in the development of the Cost/Benefit analysis. An extrapolation of those values and associated outage cost estimates was incorporated into the initial cost/benefit model and are discussed in more detail below.

In the primer provided to Con Edison by O'Neill Management Consulting, a study published by The Ernest Orlando Lawrence Berkeley National Laboratory, June 2009, titled "Estimated Value of Service Reliability for Electric Utility Customers in the United States" and authored by Freeman, Sullivan & Co.[70] provided what is considered to be the most comprehensive and analytically supportable meta-data base of the cost of various outage durations by customer class.

The information appearing there allows for the conversion of an electric commodity measure (kWh or kW) into a related outage cost. The derivative cost is provided as a function of five distinct outage durations and three major customer class groupings (Residential, Small Commercial, and Large Commercial). Con Edison used these commodity conversion factors as representative of its service territory to determine outage costs by commodity measure within

[70] http://certs.lbl.gov/pdf/lbnl-2132e.pdf

customer class groupings to capture the wider range of outage durations manifest in the Phase II risk model parameters used. For the purposes of the Cost/Benefit model, annual kWh by customer class was selected as the constructive variable to which the cost conversion factors described above were applied. Annual kWh is a commodity measure directly available on the Company's billing system and common to all three customer types. Annual kWh data was assembled by asset by customer type and converted via the associated commodity conversion factors into estimates of outage costs based upon the pre and post outage durations and pre and post asset life event probabilities appearing in the risk model. The direct impact of critical assets above and beyond their kWh captured within their parent asset was accomplished through a conversion of asset counts into equivalent annual kWh.

The final component of outages costs were provided by again applying the commodity conversion factors by customer type to these estimated kWh based on pre and post outage durations and pre and post asset life event probabilities. These costs were combined on an asset by asset basis with the customer type outage costs computed previously to yield a total asset level estimate of pre and post hardening outage costs. Computing the simple difference on an asset by asset basis between the pre and post resiliency monetary impact costs results in an estimate of the monetary impact reduction that can be expected from the storm hardening initiative.

Similar to the dynamic simulation enhancements being reflected in the Phase II Risk Assessment and Prioritization Model Simulation, the Cost-Benefit analytic effort was expanded to more adequately capture the uncertainty surrounding the parameters driving asset storm impacts and the associated efforts toward the reduction of those risks. Paralleling the use of a Monte Carlo approach to the empirical probability distributions of flood potential, wind damage, and storm durations carried out in the risk assessment simulation, monetary impact reductions within stated percentile levels were developed and provided comparable interpretations.

Area and transmission substation level assets again satisfied the 90th percentile tier for monetary impact reduction indicating that the storm resiliency measures taken for these assets again cover up to 90% of the anticipated flood likelihoods. The majority of monetary impact reduction levels realized for distribution underground assets are within the 70th to 80th percentile levels against flooding events. For distribution overhead assets about two-thirds of the monetary impact reductions are within the 70th to 80th percentile groups while the remaining third fell within the 80th to 90th percentile level for wind damage events.

Regarding the interpretation of these simulated monetary impact levels, the same caveat as stated for the risk reduction simulations applies. As the results of more refined local climate studies become available, their inclusion in these simulations can be easily carried out.

B. Comparative Economic Impact Analysis for the Phase III Report

In its Order on the Phase II Report, the Commission directed Con Edison to conduct an analysis comparing the economic impact estimation methodology used in its cost-benefit model and the economic impact estimation methodology used by the New York City Mayor's Office of Sustainability and the Office of Recovery and Resiliency. Specifically, the Commission stated:

> Consolidated Edison Company of New York, Inc. shall include in its Phase Three Report to the Commission a detailed discussion regarding whether its risk assessment model should incorporate the economic impact methodology used by the City of New York, including the extent to which the two competing methodologies may overstate or understate actual societal impacts.[71]

[71] While the Order used the word "actual," both models are *estimates* of the potential societal impact.

In addition the Commission stated that any analysis done should be "coordinated with the cost-benefit work expected to take place in the REV proceeding." The following subsections of the Phase III report will address the Commission's concerns by:

- Briefly describing the City of New York's Risk Assessment and Economic Impact Models, including the economic impact methodology used;
- Describing the structure of the comparative analysis between the City's and Con Edison's economic impact estimation methodologies;
- Presenting the results of and conclusion from the comparative analysis of the City's and Con Edison's methodologies; and
- Discussing the potential use of Con Edison's cost-benefit model methodology in future initiatives.

1. Summary of the City of New York's Risk Assessment and Economic Loss Model

The City of New York's risk assessment model estimated the likelihood of substation inundation via storm surges. The model, for each of Con Edison's transmission and area substations around New York City, calculated inundation probability exceedance curves that take into account the elevation of each substation's critical equipment. These curves were built off of background data on storm surge tide estimates from FEMA's Flood Rate Insurance Maps (FIRMs), the New York City Panel on Climate Change's (NPCC) sea level rise projections between 2020 and 2050, and the University of North Carolina's Advanced Circulation (ADCIRC) model.

Based on the results of the City of New York's risk assessment model, economic loss estimates were then calculated for the customers supplied from each of the substations within New York City limits. The City used gross domestic product (GDP) lost to estimate the financial impact of asset loss due to storm damage. The GDP lost from a given substation outage in New York City was estimated by McKinsey & Company (McKinsey). McKinsey estimated the GDP loss for the specific area fed by a substation, using the income approach of estimating GDP, by aggregating IRS tax data by zip code and then prorating county-level GDP data. This zip code-level data was then superimposed on top of Con Edison's electrical networks to provide estimates of the GDP loss associated with different substations being out of service.

2. Structure of the Comparative Economic Model Analysis

One of the risk models, on which the economic impact estimation methodologies – $/kWh loss or GDP loss – can be applied, should be chosen to conduct the comparative analysis. Con Edison's risk assessment and prioritization model captured all potential storm damage possibilities (i.e., wind damage, flooding, and heat) across every electric system asset type (i.e., substations, overhead load areas, and underground networks). The City of New York's risk assessment model, however, only captures the flooding potential across substation assets. In addition, the City of New York's substation inundation risk model was already incorporated into Con Edison's risk assessment model. The Commission noted this in its statement on the Phase II report:

> [I]t is important to clarify that the [Con Edison] risk assessment model contained in the Phase Two Report… incorporated the City's probabilistic assessment of the likelihood that future storms will affect specific facilities.

The "probabilistic assessment" mentioned refers to the pre- and post-storm hardening project inundation probabilities from the City's models that were included in the damage probability section of Con Edison's Risk Assessment model. Con Edison included the City's modelling results through a collaborative effort, because it produced the most robust risk model possible.

Therefore, Con Edison chose its model as the base risk model on which to apply both economic estimation methodologies for comparison.

Using the Con Edison risk assessment model, Con Edison quantified the differences yielded in asset/project prioritization – in terms of economic loss reduction and the associated spend to achieve that reduction – between Con Edison's $/kWh methodology[72] and New York City's GDP methodology. In other words, the analysis was structured to answer the question, "How much different would the prioritization of projects – and the spend addressing those projects – have looked had the Collaborative used the GDP loss metric instead of the $/kWh metric?" The analysis only quantified the differences in economic loss model estimates across assets within New York City, because the McKinsey study only created GDP estimates for areas within New York City limits. In all, we included 86 assets across the three asset classes of substations, underground networks, and overhead networks in the comparative analysis.

3. Comparative Analysis Results and Conclusion

Analysis Results – Comparison of Modeled Economic Impact Reductions

We initially examined the magnitude of the dollar differences between the estimates of both economic loss methodologies. As shown by the position of the two curves in Chart One of Appendix R – Cost-benefit Analysis Comparison, Con Edison's $/kWh economic impact reduction methodology consistently produced larger economic loss reductions than did the City of New York's GDP methodology. Across all 86 assets within New York City limits, the Con Edison model estimated $5.1B in impact reduction while the New York City model estimated $3.4B in impact reduction due to storm hardening projects.[73] The Con Edison model had a 50% higher impact reduction than did the City of New York model The impact reductions are

[72] All Con Edison data used in the analysis was taken from the risk assessment and cost-benefit model files submitted with the Phase II report.
[73] Table One, Appendix R.

higher in the Con Edison model because the pre-storm hardening project impact estimate is higher in the Con Edison model than it is in the City of New York model. The same applies to the post-storm hardening project impact estimates. We then conducted a follow-up analysis to determine why Con Edison's economic impact methodology was estimating higher baseline, pre-storm hardening financial risk than New York City's economic impact methodology.

The Company determined that the main driver for higher pre- and post-storm hardening project estimates in Con Edison's model was the inclusion of estimates of the societal benefit gained from keeping critical infrastructure – such as hospitals, public safety, and mass transit – in service during storms. The inclusion of the critical infrastructure equivalents[74] – the societal benefit associated with keeping critical infrastructure in service, converted to an equivalent kWh metric – was an important component of Con Edison's risk assessment model that reflected the criticality of these customers to the quality of life of all customers within the Company's service territory.[75] The GDP methodology proposed by the City of New York only considers economic loss due to outages. As shown by Chart Two in Appendix R, Con Edison's impact reduction estimates, excluding the critical infrastructure equivalents, are consistently more conservative than those produced by the City of New York's model. As stated earlier, the City's model estimates a $3.4B impact reduction from the storm hardening projects across the 86 assets within the New York City limits. The Con Edison model without critical infrastructure estimates a $2.3B impact reduction, representing a 32% decrease from the City's estimate.[76] Additionally, the sum of pre- and post-storm hardening impacts are higher in the City's model than in the Con

[74] The inclusion of the critical infrastructure equivalents was vetted in the earlier stages of the Collaborative so that higher weights could be given to assets serving critical customers that provide societal benefit.
[75] Details on the critical infrastructure equivalents can be found in Appendix Q of the Phase II report.
[76] Appendix R, Table Two.

Edison model excluding critical infrastructure, again explaining the reason for the higher impact reduction estimate in the City's model.

Analysis Results – Asset/Project Prioritization Comparisons

We next focused on analyzing how the prioritization of assets changed between the two models. As the scatter point chart (Chart Three in Appendix R) shows, there is an extremely high correlation[77] between the impact reduction estimates of each model for each asset. As described in the previous subsection, there are dollar differences between the impact reduction estimates of the two models. But, this chart demonstrates that, had the Collaborative adopted the City of New York's GDP methodology, there would not have been a material change in the prioritization of assets for storm hardening projects.

Moreover, to gain additional confidence in this conclusion, the Company reviewed the targeted financial risk reduction yielded from both models from a different perspective. This was done with two other model comparisons: one analyzing prioritized financial risk reduction groupings and one analyzing spend groupings associated with that prioritized financial risk reduction. To accomplish this, the Company constructed three-tiered economic benefit charts, much like the ones used in the Phase I and II reports, to show prioritized risk reduction groups and prioritized spend groups for each model while smoothing out the variability from individual assets changing rankings between the two models.

Charts Four and Five in Appendix R show that the relative percentage of benefits within each risk group are nearly identical, with risk group one accounting for 91% of the benefit, risk group two accounting for 8% of the benefit, and risk group three accounting for 1% of the benefit in the City's model (versus Con Edison's model showing 90%, 9%, and 1% of the benefit in risk groups one, two, and three, respectively). We also produced similar prioritized risk

[77] 98.5% correlation (square root of .9719)

reduction group charts displaying the percentage of capital spend that would have been allocated to each risk group, across both methodologies – shown in Charts Six and Seven of Appendix R.[78] Comparing the City of New York's prioritization to the same chart using Con Edison's prioritization, the similarities are apparent. 63% of the spend is attributed to projects in risk group one of both models, with 29% of the spend attributed to risk group two using the City's model (versus 27% in Con Edison's model) and 8% attributed to risk group three (versus 10% in Con Edison's model). This evidence also demonstrates that had the City's prioritization model been used, asset targeting decisions would not have been substantially changed.[79]

Conclusion

After the Company conducted its analysis, the results were presented at the Collaborative presentations held at the Con Edison offices on June 17, 2015. The Company is also continuing to hold meetings with the City to discuss the results of the analysis and of the Con Edison model. While both parties realized that their respective economic impact methodologies viewed outage costs in slightly different lights, they both also saw the significance of the analysis results and understood the main conclusion drawn from the data – that regardless of economic impact methodology used, both methods would lead to a similar prioritization of assets/projects for storm hardening purposes.[80] In addition, because Con Edison already had $/kWh metrics that could be applied to all its assets – while the GDP metrics computed by McKinsey were only applicable to assets within New York City limits and not within Westchester County – the use of

[78] The capital spend on projects is the same for both Con Edison's model and the City of New York's models, as the project cost estimates are developed only by Con Edison.
[79] As shown by Table Three in Appendix R summarizing the differences in risk reduction percentages and capital spend percentages for each risk reduction group between the two models. The similarities are clear in model outputs, in the areas of both prioritized impact reduction and spend to achieve that prioritized impact reduction.
[80] The City has requested that Con Edison use a societal cost calculation based on its service territory and not the results from the Berkeley survey, which did not include the Northeast. Con Edison agrees that a more locally oriented societal cost calculation would be more accurate, and will continue to discuss how to address this concern with the City. How and when Con Edison will conduct and complete such a study will depend upon various factors, including whether there is sufficient funding to conduct the study.

Con Edison's methodology made more sense. Given the consensus reached between the parties, they agreed, for the purposes of the Storm Hardening Collaborative, to move forward with Con Edison's economic impact methodology. Con Edison plans to continue using its model.

4. Use of Con Edison's Economic Impact Methodology in Future Initiatives

The PSC stated that any cost-benefit work done in the Storm Hardening Collaborative should be coordinated with similar work done in the REV (Reforming the Energy Vision) proceeding. As required by the recent Staff White Paper in the REV proceeding on cost-benefit analysis, the Company plans to use its model to inform what it may include in the handbook proposed for the REV proceeding for outage costs, to the extent applicable.

X. Climate Change Vulnerability Study

A. Climate Change and Impact on Infrastructure

Con Edison's equipment and systems are exposed to various weather conditions including storm surge, wind, rain, snow, ice, temperature variations, humidity, and heat waves. These conditions are used in our system design and equipment procurement standards to continually deliver reliable energy to our customers. A key element of the Company's approach to improving resiliency going forward is to understand how weather and climate may be changing and how those changes will impact the Company's infrastructure.

In the rate cases, Con Edison, New York City, and other interested parties agreed on a flood protection design standard for projects that Con Edison commenced in 2014, and the Company has adopted that standard for future flood protection projects and will review this standard at least every five years. A number of other key system and equipment design standards (as reflected in the table below) will be analyzed related to the effects of climate change.

	Prior Con Edison design	**Current Con Edison design**

	standard	standard
Flood	• FEMA 2007 100-yr floodplain plus two feet	• FEMA 2013 100-yr floodplain plus three feet
Wind	• 98 mph wind • 45 mph plus 0.5 inch of ice	• (Under review)
Temperature & Temperature Variable	• 86°F	• (Under review)
Heat waves	• Two per year • Four days long	• (Under review)

An understanding of these key climate and weather factors, as well as those applicable to flooding, is an essential building block in determining the system and equipment design standards and consequent infrastructure investments necessary to improve system resilience to the effects of future climate change

Five of Con Edison's top-10 storms from a customer outage perspective have occurred in the three years from 2010 to 2012. All were coastal type storms.

Historical Storm Comparison		
Date	**Type of Storm**	**Customers Interrupted**
29-Oct-12	Superstorm Sandy	1,115,028
28-Aug-11	Tropical Storm Irene	203,821
13-Mar-10	Nor'easter	174,800
29-Oct-11	Nor'easter	135,913
9-Sep-85	Hurricane Gloria	110,515
2-Sep-06	Tropical Storm Ernesto	78,300
25-Feb-10	Snow	65,200
18-Jan-06	Wind / Rain	61,486
31-Mar-97	Nor'easter	45,180
19-Oct-96	Nor'easter	41,830

In summer 2013, a seven day heat wave gripped our service area with 90°F and greater temperatures from July 14 to 20. A seven-day heat wave is rare and has occurred only seven times since 1869.

Temperature and precipitation data shows that the climate of our region is changing. The Phase One Report examined weather trends in New York City based upon recorded weather history since 1869 and concluded that the general trends for various temperature and precipitation related metrics show an increase above climatological normals.

The science of forecasting future climate conditions is based on both climate model-based percentile outcomes, and qualitative projections of peer-reviewed scientific literature. The Phase One Report synthesized a sample of authoritative climate reports and found that the reports are aligned on the direction and magnitude of their quantitative projections.[81] Specifically, for our region, those directions appear to be:

- Increased average surface air temperatures by 2050;
- Increasing number of extreme heat days (including consecutive days);
- Decreasing number days below freezing;
- Increasing precipitation; and
- Increasing sea level rise.

These trends may manifest themselves as greater electric demand on the distribution system, larger storm surges impacting and damaging coastal infrastructure, and soil more commonly saturated – resulting in increased damage from wind/rain events.

B. Goals of Climate Change Vulnerability Study

The New York City Panel on Climate Change ("NPCC") climate projections released in June 2013 project that our climate will continue to change to one that by mid-century will

[81] The Phase One Report summarized climate projections in the following reports:

- The New York City Panel on Climate Change: Climate Risk Information 2013: Observations, Climate Change Projections, and Maps. The City of New York,
- The U.S. Department of Energy: U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather, July, 2013,
- U.S. National Oceanographic and Atmospheric Administration: 2013 Regional Climate Trends and Scenarios for the U.S. National Climate Assessment, and
- Working Group 1 to the International Panel on Climate Change: Summary for Policymakers, September 27, 2013.

include higher temperatures, increased precipitation, and higher sea levels. In addition, extreme weather events such as heat waves, heavy downpour, and coastal flooding will be more frequent and severe. However, neither the NPCC report, nor reports or forecasts on climate change issued by other agencies, including the US Department of Energy, National Oceanic and Atmospheric Administration, and Federal Emergency Management Agency, address all the key weather and climate inputs that are required for Con Edison to review its design standards, such as:

- Daily and Hourly Temperatures - NPCC has published temperature projections as changes in average yearly temperature for the 2020s and 2050s; however, Con Edison's design standards require a more detailed understanding of summer temperature and humidity projections, both of which are currently not addressed.
- Wind – NPCC does not include projections of wind speed and duration.
- Precipitation – NPCC does not include forecasts of types of precipitation (*e.g.*, rain, snow, and ice) and the frequency of such events.

Con Edison is committed to understanding the impact of climate change and has undertaken a Climate Change Vulnerability Study (Study) with the following goals:

- Develop a shared understanding on the impact of climate change on Con Edison's infrastructure;
- Quantify climate change risks and uncertainties;
- Consider revisions to system and equipment design standards; and
- Develop a risk mitigation plan.

The Study will synthesize current scientifically credible views on predicted climate change, the output of the most up-to-date climate model, and input from Collaborative participants.

C. Progress Report on Climate Change Vulnerability Study

Con Edison appointed two persons to be project managers for the Study. One person has represented the company on climate-adaptation matters for the past 8 years, including the New York City Climate Adaptation Task Force and Governor Paterson's Climate Action Plan and has undergraduate and post-graduate degrees in earth science, environmental science, and Public Administration. The other person is a degreed meteorologist with over 10 years of experience and is a Certified Consulting Meteorologist through American Meteorological Society.

The Project Managers met with representatives of the Columbia Center for Climate Law (CCCL) and the Office of the New York Attorney General (NYOAG) – two Collaborative Parties that have been primary proponents of the Study -- to prepare the following three-phase action plan to guide the work of the Study:

1. Climate Change Vulnerability Study Action Plan

<u>Step 1</u>. Utilize outside expertise to develop a shared understanding of climate science gaps.

a. Identify climate factors and associated parameters that are relevant to our utility territory and impact infrastructure design specifications.
b. Work with a reputable party or institution to develop projected climate data from existing climate models, identify projected climate data that cannot be projected from current modelling and research ("gap analysis data"), and establish parameters for longer term modelling and research necessary to develop gap analysis data.
c. CCCL representative and NYOAG representative to assist with personal and institutional expertise.
d. Present gap analysis data to Collaborative in late 2014, with options for continuation of research and collaboration with national climate experts into 2015 and beyond.

<u>Step 2</u>. Work with Company and New York City engineering teams to develop future design considerations

a. Work with Con Edison electrical and civil engineering organizations to evaluate weather-sensitive components of current equipment (*e.g.*, wind specs, margins for overloading), and develop design and asset utilization solutions to adapt to future climate conditions:

i. Consider effect of New York City initiatives pursuant to A Stronger, More Resilient New York Plan.
ii. For climate variables important to existing design specifications, but for which there currently is inadequate information, assess opportunities for additional research and evaluate alternative decision-making models.

b. Develop shared understanding of design impacts with the Collaborative.

Step 3. Develop Options for future design considerations

a. Assign value propositions and costs to design options for climate change risk mitigation.
   i. Incorporate technology advances and customer perspective into solutions (*e.g.* distributed energy resources).
b. Utilize cost/benefit model as available for analysis.
c. Identify solutions; propose recommendations.

2. Action Plan Implementation Activities

The Commission's Phase II order provides[82] as follows:

> While the Commission recognizes that the science of climate change is developing and the Climate Change and Vulnerability Study is a substantial undertaking for the Company, it must be available for the Commission's use by March 2019 (five years after the issuance of the 2014 Rate Order). That means that the study must be completed well prior to that date so that the Collaborative may make use of it and the Commission can act on it, as needed. Therefore, Con Edison is directed to file, within 60 days of issuance of this Order, a timeline for completion of the Climate Change and Vulnerability Study. Staff and the parties to the Collaborative should review this filing and discuss it with Con Edison in a collaborative manner and the Company shall report in its Phase Three Report the results of those discussions and the proposed timeline for completion of the study.

Con Edison filed the update timeline with the Commission on April 6, 2015 (Filing attached hereto as Appendix S – Climate Change Study Timeline). The timeline proposed, which was subsequently reviewed with the Collaborative, projects completion of the entire study during the 4th Quarter 2018. But the Company will be releasing chapters as they are completed to aid in the Company's ongoing review of climate change vulnerability. For example, the Company is currently projecting that the first chapter on heat and humidity will be released in the 3rd Quarter 2016. While the Company intends to meet that date, the Company emphasizes that

[82] Phase Two Order at 22-23.

the timeline is approximate and not precise. After it completes Chapter 1, the Company expects that each following chapter will be delivered every two to three quarters (there will be five chapters in total). As directed by the Commission, Con Edison reviewed this timeline with the Collaborative.

The Company is currently working with the Center for Climate Systems Research, at Columbia University's Earth Institute ("CUCCSR") in order to gain a more comprehensive understanding of climate change by specifically determining the probability of occurrence for extreme temperatures. The Company and CUCCSR are currently working under contract towards the development of the scientific analysis necessary for the first two chapters of the report and are in discussions for continued engagement for later chapters. The Company expects CUCCSR's research and analysis for Chapter 1 to be completed by the fall of 2015.[83]

The parties determined that CUCCSR can perform an analysis to determine probability of occurrence for temperature extremes with existing data. However, other climate factors Con Edison requires are either not available for long-term projection or in a format that is not useful for analysis by Con Edison engineering teams. This will require the research team to examine the climate models and data outputs in novel ways to fit Con Edison specifications.[84] As such, the project team determined that it should focus on temperature extremes and heat events in the short term (2014-2015), and revisit the scientific underpinning of extreme non-temperature related events in later years (2016-2018).

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[83] Moreover, Con Edison is continuing to expand its internal workforce through the use of both full-time staff and contractors. Specifically, the Company expects contractors to add specialized experience for purposes of engineering and risk analysis with the expectation that there will be overlapping deliverables between those two disciplines

[84] CUCCSR informed the Con Edison managers that other climate change impacts, such as changes in wind speed, return frequency and intensity of coastal storms, and extreme inland precipitation events were not readily available for analysis. However, these topics continue to be of interest within the scientific community, and there is a growing body of research that may be available within the next 1-2 years to evaluate in the context of Con Edison's storm hardening.

In June 2014, CUCCSR provided a project proposal that the Company accepted that is focused on developing projections for extreme temperatures. This deliverable will utilize existing results from various global climate models to project long-term temperature extremes in the New York City area.

The Company expects that the engineering analysis will be complex and extend into 2016. Engineering teams will consider design and value-based asset utilization solutions to adapt to future climate conditions. Solutions will consider dynamic effects of governmental initiatives, such as the City of New York's adaptation planning. Future research and additional evaluation of alternative decision-making models may be required for uncertain climate variables; however, we anticipate this to be of greater importance in future years when studies to evaluate wind, storm surge, and precipitation variables are looked at more specifically.

D. Costs of Climate Change Vulnerability Study

The parties to the Joint Proposal recommended that the Commission permit the Company to recover costs associated with storm hardening initiatives approved by the Commission, though not reflected in rates, as follows:[85]

> In addition to further evaluation of the Company's current forecasted expenditures to storm harden its electric, gas and steam systems in RY1, RY2 and RY3 as described above, the Signatory Parties recognize that the Company may undertake other projects and programs that may be presented to the Commission as a result of ongoing collaborative discussions by Working Groups 1 through 4 of the Storm Hardening and Resiliency Collaborative. Since the electric, gas and steam delivery rates recommended by this Proposal do not (and could not reasonably) reflect any incremental costs associated with new or additional initiatives that the Commission may encourage or otherwise direct, the Signatory Parties recommend that the Commission authorize the Company to recover the incremental costs associated with any such initiative(s), whether by

[85] Joint Proposal, p. 52.

surcharge, deferral, and/or such other means as the Commission may determine.

Con Edison does not have sufficient information at this time to estimate the cost of the Study. At such time as the Company can estimate such costs, the Company will, consistent with the Phase II Report Order, propose to the Commission the means for the Company to recover these costs. The Company has an RFP pending and expects to be able to estimate the costs by the end of the year.

XI. Methane Emissions Reduction Collaborative Project

The methane emissions reduction collaborative is engaged in a project to investigate technologies for quantifying methane emissions from Type 3 (non-hazardous) leaks on Con Edison's gas distribution system and develop a program to further reduce the backlog of such leaks ("methane emission project" or "the project"). The 2014 Rate Order stated:[86]

> [T]he Collaborative should continue the work reflected in the Joint Proposal on reducing natural gas leaks and therefore methane emissions, by investigating technologies for quantifying emissions and proposing a program to further reduce the backlog of Type 3 (non-hazardous) leaks.
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> * * *
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> [W]e anticipate recommendations or progress reports on these Collaborative efforts as part of Con Edison's September 1, 2014 filing concerning RY2 storm hardening projects and programs.

The methane emissions reduction collaborative parties have met in a series of meetings from March to August 2014 to establish and commence action on a work plan for the methane emissions project. Additional meetings/conference calls were held on January 6, January 13, February 5, March 30, and June 1, 2015. The parties have adopted a "Scope of Work for Project to Quantify and Reduce Type 3 Leak Methane Emissions" ("Scope of Work") establishing a

86 2014 Rate Order, pp. 70-71.

governance structure and a project framework for the methane emissions project. The Scope of Work is provided in Appendix T - Scope of Work for the Methane Leak Project.

The governance structure charges the collaborative parties with identifying the project strategy, monitoring project implementation, and developing project modification, if necessary. Major project decisions will be discussed by the parties. Individual parties at their own expense may offer scientific advice of outside experts for consideration by the collaborative parties.[87]

The Scope of Work sets out five work phases for the project. Con Edison has retained the services of NYSEARCH, a product research and development organization, that has begun implementation of the project. NYSEARCH, an organization within the Northeast Gas Association, has conducted research and product development and demonstration projects on behalf of the natural gas industry since the mid-1980s focused mainly on the needs of local distribution companies. NYSEARCH has been active in the leak detection area since the early 1990s and has investigated many approaches for leak survey and leak pinpointing. NYSEARCH Staff have performed real time sensing technology scans for leak detection, damage prevention, pipeline inspection and chemical sensing for constituents that may also be part of the pipeline gas.[88]

[87] The Environmental Defense Fund ("EDF") has been an active participant in the methane emissions reduction collaborative. Drawing upon its experience in an ongoing series of research projects designed to better understand from where and how much methane is lost across U.S. natural gas supply chain today, EDF has provided to the collaborative its experience with some of the sophisticated scientific techniques that are being deployed in these projects and insights born of its experience in these research projects.

[88] The NYSEARCH R&D managers assigned to the methane emissions project have over 25 years of natural gas industry experience both within the R&D arena as well as with gas company utility operations and engineering. NYSEARCH Staff are experienced in methane survey and detection, having conducted projects concerning handheld tools, mobile platforms and work evaluating possible technologies in aerial leak detection. NYSEARCH Staff has knowledge and experience in the practical application of technology to LDCs, programmatic knowledge of technology assessments, and extensive and experience in R&D project development, including a myriad of controlled and live field test program developments. NYSEARCH's most well-known success in the area of leak detection is the design, development and testing of the Remote Methane Leak Detector, which is sold in over 40 states and 30 countries worldwide by Heath Consultants, Inc. More information about the NYSEARCH program is available at www.nysearch.org.

NYSEARCH has completed Phase I of the Scope of Work, which has been a search for and assessment of current technologies that could be applied for quantifying methane emissions rates for non-hazardous Type 3 leaks that are part of an urban environment in CECONY's service territory. In October 2014, NYSEARCH completed Phase II of the Scope of Work, which was the preparation and issuance of a request for proposal soliciting owners of those technologies found potentially suitable in the Phase I assessment to participate in technology field testing and potential adaptation to LDC operational requirements. NYSEARCH received eleven proposals. The Collaborative selected three technology providers to participate in Phase III of the Scope of Work. Working with the collaborative, NYSEARCH developed field testing protocols in February 2015 and completed the controlled release portion of Phase III of the Scope of Work, consistent with Scope of Work guidelines.[89] In Phase IV, NYSEARCH will analyze and summarize test results, recommend technology best suited for the project goal, and identify work required for commercial development of equipment utilizing the technology.

NYSEARCH's design of the main study and technology intercomparison field testing protocols was based on consensus recommendations of the collaborative parties with Con Edison retaining the option for directing NYSEARCH's activities in the absence of or upon its disagreement with such recommendations. NYSEARCH has participated in collaborative meetings to provide updates on its activities and consult with collaborative parties. As of this report, $24,905 has been paid to NYSEARCH representing the CECONY commitment to the NYSEARCH collaborative of twelve (12) LDCs participating in this project. CECONY has a

[89] Con Edison modified the Phase III Scope of Work to include a field test on known Type 3 leaks in the Company's service territory with unknown emissions to determine suitability of the technology to daily operations. This portion of Phase III is anticipated to begin October 1, 2015.

commitment of $21,165 to the NYSEARCH collaborative that has yet to be invoiced.[90] The Scope of Work recognizes that the methane emissions project is in all aspects subject to the Commission's oversight, and to that end, the Department of Public Service Staff has been an active participant in all collaborative discussions.

XII. Conclusion

Sandy was the most harmful and destructive storm our region has ever seen. Over 8.5 million customers in eight states, including 1.15 million of Con Edison's customers, lost power as a result of the storm. The National Hurricane Center estimates that the storm caused over $50 billion in damage to homes and businesses up and down the eastern seaboard.

Con Edison continues to strive to keep the power flowing and our vibrant region energized in all circumstances. Con Edison has developed a comprehensive resiliency plan to storm harden its energy system infrastructure to better enable the Company to provide safe, reliable, reasonably-priced energy services to our customers in an era of changing weather patterns and more frequent and increasingly destructive storms. To fortify our Electric, Gas, and Steam systems against future storms, we are strengthening our infrastructure so it can better withstand harsher conditions, particularly coastal flooding and high winds. In Sandy's aftermath, this involved installing measures in advance of the 2013 hurricane season so that substations and generating stations that were operationally affected by Sandy could withstand a storm similar to Sandy. Longer term, we are preparing for more intense storms, which involves measures such as further increasing the height and strength of perimeter and interior walls and barriers, installing emergency generators to keep critical equipment online, relocating a major substation control room to a higher elevation, hardening overhead networks to withstand stronger

[90] The cost for NYSEARCH's work in implementing the methane emissions projects is being funded within Con Edison's gas research and development program. The Company does not at this time contemplate seeking deferral of the costs of the project.

winds and contact with tree branches, replacing cast-iron and bare steel pipe in flood zones, and segmenting our steam system to maintain the highest possible number of customers in service during coastal floods. Moreover, the Company is not just preparing for the next Sandy, it is implementing measures to improve resiliency for a range of storms and events.

Con Edison presented its resiliency plans in its 2013 electric, gas and steam rate cases and has reviewed these plans with the parties during Phases One Two and Three of the Storm Hardening and Resiliency Collaborative. The Company continues to look for ways to improve its resiliency initiatives through input from our customers, stakeholders and regulators. The Collaborative has provided Con Edison a valuable forum for obtaining such input and examining an array of solutions to better protect our region and to prepare for our future.

Con Edison is presenting this Phase Three Report to the Commission to summarize the work of the Phase Three Collaborative and to present for the Commission's consideration Con Edison's updated plans for resiliency work during 2015 and 2016. This is the final report. The Company anticipates that going forward it will incorporate resiliency planning into its regular operations and will seek approval for such expenditures as part of its overall rate case filings.

Dated: September 1, 2015

Consolidated Edison Company of New York, Inc.