Con Edison Climate Change Vulnerability Study

September 2023

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Abbreviations

ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
BFE	Base flood elevation
CCIP	Climate Change Implementation Plan
CCRP	Climate Change Resilience Plan
CCVS	Climate Change Vulnerability Study
CDD	Cooling degree days
CERC	Corporate Emergency Response Center
CJWG	New York State Climate Justice Working Group
CMIP5/6	Coupled Model Intercomparison Project Phase 5 or 6
FEMA	Federal Emergency Management Agency
GCM	Global Climate Model
HDD	Heating degree days
HVAC	Heating, ventilation, and air conditioning
IPCC	Intergovernmental Panel on Climate Change
JU	Joint Utilities (of New York)
kV	Kilovolt
MIT	Massachusetts Institute of Technology
NESC	National Electric Safety Code
NIOSH	National Institute for Occupational Safety and Health
NRI	Network Resiliency Index
NYC or the City	New York City
NYSERDA	New York State Energy Research and Development Authority
OSHA	Occupational Safety and Health Administration
p.u.	Per unit
PSL	Public Service Law
RCP	Representative Concentration Pathway

SME	Subject matter expert
SSP	Shared Socioeconomic Pathway
TV	Temperature variable

Executive Summary

Consolidated Edison Company of New York, Inc. ("Con Edison" or "the Company") is considered a leader in climate change adaptation strategies for the energy system. For more than three decades, the Company has responded to major events such as Hurricanes Andrew, Irene, and Sandy, and more recently to extreme events such as Isaias, Ida, and numerous heat waves. In the last decade, Con Edison has invested more than $1 billion in resilience initiatives to strengthen its system. These investments have reduced weather-related customer outages (approximately 1.1 million weather-related customer outages avoided). Beginning in 2017, as a result of the Storm Hardening and Resiliency Collaborative, Con Edison took a step forward by conducting a comprehensive review of future climate change vulnerabilities across its electric, gas, and steam systems. The results were published in Con Edison's 2019 Climate Change Vulnerability Study[i] (CCVS) and 2020 Climate Change Implementation Plan[ii] (CCIP). The work was cited as a gold standard reference for climate change adaptation in the utility sector.[1] These documents were important in establishing a foundational understanding of the risks of climate change impacts out to 2080. The documents also identified initial actions taken to mitigate acknowledged risks. In the CCIP, the Company introduced a climate change governance structure to oversee the implementation of risk mitigation efforts, consisting of Senior Leadership oversight, a Climate Risk and Resilience Executive Committee, a Climate Risk and Resilience Group, and regular engagement with subject matter experts (SMEs).

[i] For the full 2019 CCVS, see https://www.coned.com/-/media/files/ConEd/documents/our-energy-future/our-energy-projects/climate-change-resiliency-plan/climate-change-vulnerability-study.pdf?la=en

[ii] For the full 2020 CCIP, see https://www.coned.com/-/media/files/coned/documents/our-energy-future/our-energy-projects/climate-change-resiliency-plan/climate-change-resilience-adaptation-2020.pdf

Since 2020, climate science has continued to evolve. This Vulnerability Study ("the Study") uses the latest climate projections and builds upon our understanding of the climate change risks that could affect our infrastructure and our customers. These projections and data have been provided by the New York State Energy Research and Development Authority (NYSERDA) in partnership with Columbia University ("Columbia"). This Study was performed by Con Edison with support from ICF's resilience team ("the Study team"). In November 2023, Con Edison will file a Climate Change Resilience Plan (CCRP) that will describe risk mitigation actions the Company plans to implement.

In summary, this Study presents:

- An understanding of the latest projected changes in climate (based on recent studies).
- An enhanced prioritization of which climate hazards may impact the electric system.
- A suite of potential adaptation strategies that will be further evaluated and considered in the forthcoming CCRP.

Short descriptions of these findings are provided below.

Climate Science

Climate change represents an existential and multifaceted threat around the world, and as such, is the subject of substantial research and studies. Climate models are regularly updated and revised to account for updated observed conditions and improved modeling techniques (see Figure 1). Con Edison is committed to basing planning decisions on the best available climate science, which means updates must be made regularly as new data become available.

Figure 1 shows the range of potential future climate impacts on a global scale from the most up-to-date simulations of representative indicators of climate change, including changes in temperature, precipitation, Arctic sea ice, and sea level.[2]

The Study leverages several data sources to develop a full understanding of how climate risks are predicted to impact the Company. Those sources include:

- New statistically downscaled global climate projections developed by Columbia University through funding from NYSERDA in 2022.[iii]
- Reconfirmed sea level rise projections from Columbia University and NYSERDA.
- Updated rainfall projections from the Cornell intensity-duration-frequency (IDF) curves.

[iii] Downscaled from the Coupled Model Intercomparison Project 6 (CMIP6) dataset.

- Prior analysis from a Massachusetts Institute of Technology (MIT) study[3] for National Grid for wind and ice projections.[iv]
- Numerous research papers and academic studies.

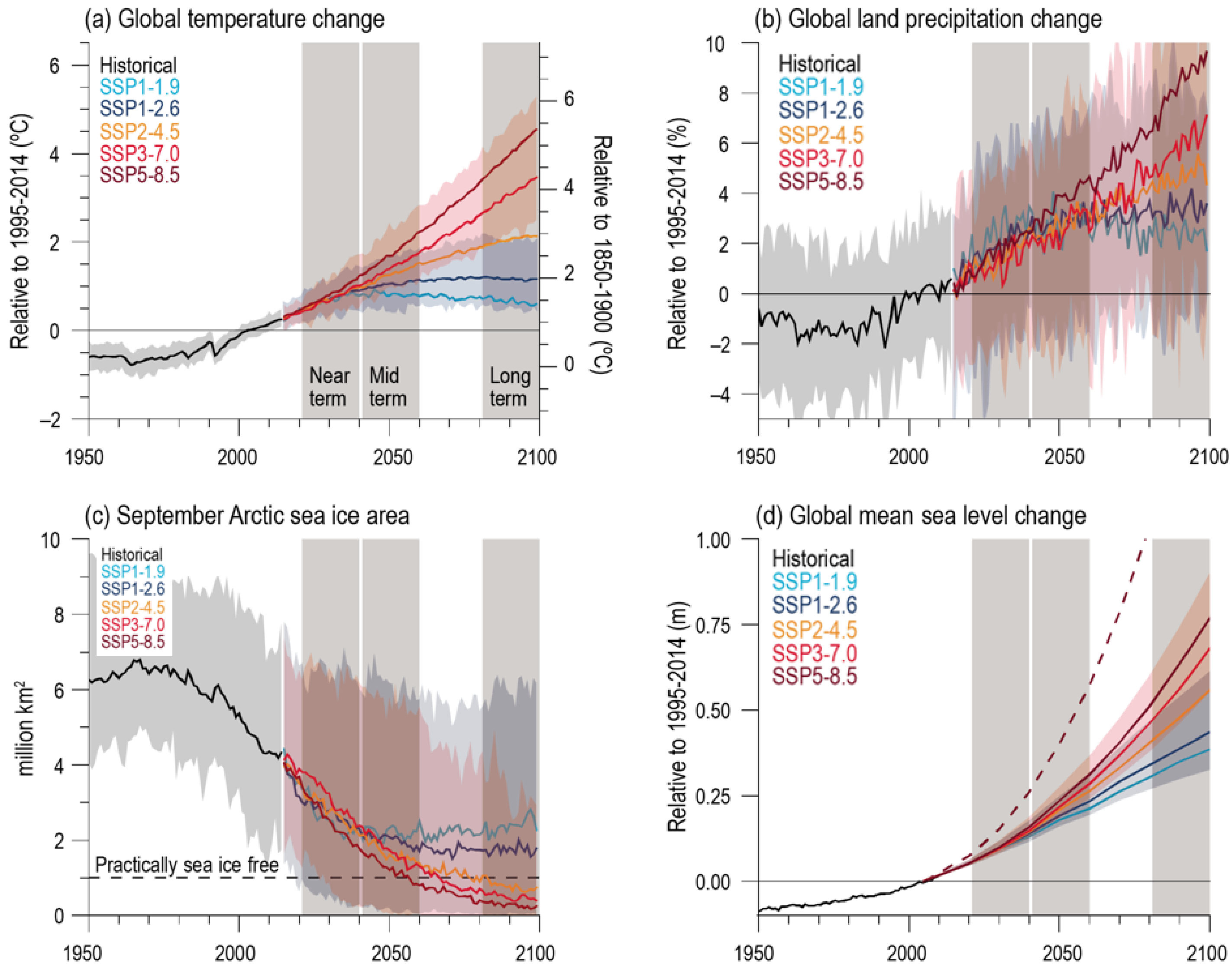


Figure 1. Climate change projections for several hazards relative to the historical average (1995-2014). (a) Change in global surface temperature. (b) Change in global land precipitation. (c) Change in September Arctic Sea ice area. (d) Change in global mean sea level. The curves show the averages of the Shared Socioeconomic Pathway (SSP) projections, the shading surrounding them shows the 5%-95% ranges for each projection, and the numbers in the upper left corner show the CMIP6 simulations. (Source: IPCC 6th Assessment Report)

[iv] The data are created by the MIT Joint Program on the Science and Policy of Global Change as described in Komurcu and Paltsev (2021), MIT Joint Program Report 352, available at: https://globalchange.mit.edu/publication/17608

The primary changes from the 2019 CCVS include:

Temperatures will increase **faster than previously projected**. For example, the temperatures previously projected for 2040 (18 days with maximum temperatures exceeding 95°F) are now projected to be closer to 2030 (17 days).

Precipitation projections show a shift relative to historical norms. This could increase deluge precipitation events—short-duration, high-intensity rainfall—that may impact municipal stormwater systems, resulting in localized flooding.

Sea level rise projections have not changed since the 2019 CCVS. Con Edison's service area is still expected to experience **16 inches of sea level rise by 2050**. While the Company's efforts and processes updates since 2019 have begun to address the risk, there is a need for continued work.

Wind, deluge rain and ice projections remain the most uncertain. A review of external scientific studies indicates that the Con Edison service area is likely to experience stronger wind gusts in the future due to **intensifying storms**, particularly during tropical cyclones. While the frequency of the most extreme wind speeds during tropical cyclones is not expected to increase in the North Atlantic basin, more frequent high wind gusts could be observed during thunderstorms, although the magnitude of this trend is uncertain. In addition, there remains the potential for more **higher-intensity radial icing** events in the winter.

Directional changes in **extreme events** have not changed since the 2019 CCVS, but new scientific research has strengthened and refined our current understanding of these risks.

- **Hurricanes** are expected to increase in intensity with a higher probability of northeast tracks due to a projected northward migration of strong hurricanes. Overall frequency of tropical cyclones in the North Atlantic basin is not expected to increase.
- **Extreme heat waves** will increase in both frequency and intensity.
- **Nor'easters and cold snaps** will decrease in frequency, but when they occur, they may be more intense.
- **Deluge precipitation** is expected in increase in both frequency and intensity.
- **Concurrent and consecutive** extreme events are expected to increase in frequency and intensity.

Physical and Operational Vulnerabilities

In this Study, the Company builds upon its prior vulnerability assessments by:

- Revisiting previously identified impacts to determine if and how they may differ (in timing or magnitude) based on the latest climate change projections.
- Advancing prior work by completing a more comprehensive rating of risks to the various components of the Company's electric system between now and 2050. This advancement entailed a review of the latest climate projections to identify the sensitivity and possibility of impacts to current designs or procedures. This was particularly useful as it helps to highlight the near-term risks, which will be the focus of the forthcoming CCRP.

Building this detailed understanding of key vulnerabilities is an important step toward identifying priority adaptation measures for the CCRP. The final prioritization of physical risks is shown below in Table 1 as primary (dark blue), secondary (turquoise) or low (light blue).

	Temperature and Temperature Variable (TV)	Flooding	Wind and Ice
Transmission Substations	Primary	Primary	Low
Area and Unit Substations	Primary	Primary	Low
Overhead Transmission	Primary	Low	Secondary
Overhead Distribution	Secondary	Low	Primary
Underground Transmission	Secondary	Secondary	Low
Underground Distribution	Primary	Secondary	Low
Key Company Facilities	Secondary	Secondary	Low

Table 1. Summary of physical vulnerabilities.

This Study also provides an update to Con Edison's understanding of operational vulnerabilities to climate change impacts. Detailed information on the physical and operational impacts of each hazard is listed below.

Temperature and Humidity

The latest climate projections show that increasing temperature and humidity remain high priority hazards for Con Edison. Data out of Columbia University suggest that temperature may increase faster than previously expected, possibly causing system impacts much sooner.

Coincident high heat and humidity is also expected to intensify rapidly over the coming decades. Con Edison combines temperature and humidity together over a three-day period as a measure of heat wave intensity in a custom climate variable called temperature variable (TV).[v]

Temperature and TV represent a high priority concern for most of Con Edison's physical assets, as shown in Table 1. Higher temperatures can cause reductions in capacity for certain equipment, accelerated degradation, as well as physical impacts, such as line sag. When high temperatures coincide with high humidity, Con Edison typically experiences a spike in demand due to customer air conditioning use. In extreme situations, reduced capacity and increased demand could lead to capacity shortfalls. Customers without access to air conditioning face an increased risk of heat-related illnesses, making hardening and recovery of electric services to critical community services like cooling centers, even more crucial.

Temperature and TV also represent a threat to Con Edison's operational processes.

- Load forecasting and load relief planning calculations are heavily influenced by temperature (since high temperature increases demand).
- Higher average temperatures can accelerate vegetation growth, increasing the risk of vegetation contact with lines.
- Higher temperatures can also pose a risk to the health and safety of Con Edison personnel who work where there may not be any climate control (i.e., air conditioning).

Many of these vulnerabilities were addressed in the 2020 CCIP; however, the accelerated rate of change in temperature likely means that additional investments will be required or will need to be applied sooner to maintain capacity, reliability, and safety standards.

Flooding

Flooding remains a high priority hazard for Con Edison, especially for unit, area and transmission substations and other on-grade or below grade assets. The Company has worked to harden the electric system in the years since Hurricane Sandy, including installing submersible equipment, and the future risk of flooding will continue to be addressed. It is anticipated that Con Edison's service area will be increasingly exposed to flooding due to sea level rise on the coast. The risk of inland flooding due to precipitation also remains high. Extreme storms such as hurricanes are likely to increase in intensity, bringing with them the possibility of higher storm surge.

[v] TV is an index that Con Edison uses to evaluate system load. It is similar to a heat index but considers the persistence of heat and humidity over several days. Electric summer TV is calculated using a weighted calculation of the rolling three-hour average of wet and dry bulb temperature for the current day (70%; D), prior day (20%; D-1), and next prior day (10%; D-2).

The latest climate science finds that a 16-inch rise in sea level by 2050 (relative to 1995-2014 sea levels[vi]) would result in 23 substations exposed to flooding in a 1% annual chance flood. This would result in equipment damage, ongoing corrosion issues, and reduced access if surrounding roads are flooded. These impacts could result in more frequent outages with longer repair times and higher costs of recovery.

An increase in flooding due to sea level rise, precipitation, or storm surge will also likely result in more frequent activations of Con Edison's emergency response procedures. The Company has an emergency preparedness and response plan, but an increase in the magnitude and number of extreme events could still impact the Company's resources and delay recovery, if not addressed.

Wind and Ice

Wind and ice have historically been difficult to model due to their highly localized nature. To inform this Study, Con Edison sought the best available information by acquiring an additional dataset from MIT, which covers the Northeast, and provides insight into future wind speeds and radial icing potential. This data and other studies demonstrate that wind speeds will likely increase, and the risk of ice accumulation on wires (radial icing) will remain. Extreme storms such as hurricanes can cause wind speeds to increase far beyond typical average speeds. Wind speeds of the most intense hurricanes are projected to increase. Freezing rain frequency and radial icing are also projected to increase, although the magnitude of the trend remains highly uncertain due to the specific atmospheric conditions required for ice storms to occur.

These potential changes in wind and ice present an especially large risk to overhead distribution equipment. Overhead distribution assets, including conductors, attachments, and cross-arms, are built to withstand defined design tolerances for combined ice and wind loading, but they are frequently adjacent to neighboring vegetation that may be downed during these events. Fallen vegetation and wind-blown debris can come into contact with lines and cause them to disconnect, fall, or even lead to pole collapse, especially older poles or those with existing damage. This can result in asset failure, leading to outages and incurring restoration costs.

Increases in the frequency and intensity of storms with high winds and ice accumulation present a risk to Con Edison's emergency response capabilities. More frequent activations could impact the Company's available personnel and spare equipment resources, if not addressed.

[vi] The historical baseline time period of 1995-2014 was used as the most recent 20-year time period for the CMIP6 sea level rise projections developed by Columbia and NYSERDA. See Appendix 1: Climate Science for more detail on historical baselines.

Extreme and Coincident Events

Climate models have difficulty resolving extreme weather events, including concurrent or consecutive extreme events, due to the small space and time scales at which these events occur and the historical rarity of the events themselves. This necessitates an evaluation of extreme events using historical analogs and projections from scientific literature. Updating the 2019 CCVS, this assessment incorporates findings from the most up-to-date scientific literature and adds additional context for hurricanes, winds, nor'easters, and cold snaps. Each extreme event illustrates differing projected future change in terms of frequency and intensity across the service territory. Hurricanes are projected to increase in maximum sustained wind speed intensity but will likely experience no change in overall frequency of formation, however, more may migrate north. Extreme heat waves are projected to increase in both frequency and intensity. Nor'easters and cold snaps are projected to decrease in frequency as temperatures warm, but the strongest storms and cold snaps could increase in intensity. Deluge precipitation, or high-intensity and short-duration precipitation events, are projected to increase in both frequency and intensity. The occurrence of multiple extreme weather events either simultaneously (compounding) or sequentially (consecutive or cascading) is projected to increase in frequency.

Extreme and coincident events amplify the damage to energy infrastructure and can hamper emergency response activities. These events are the most likely to result in prolonged outages for customers. They also strain other infrastructure systems that Con Edison relies on such as municipal stormwater drainage systems and the transportation network; these interdependencies can exacerbate the impacts to the Company's energy systems.

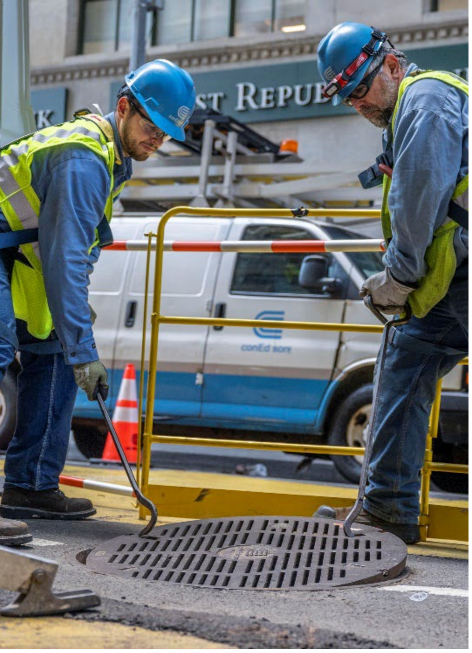
Looking Ahead

In November 2023, Con Edison plans to file a CCRP with the Public Service Commission (PSC), as required by Public Service Law §66(29). The CCRP will include an investment plan of adaptation measures to address physical and operational vulnerabilities identified in the Study using the latest climate data.

The CCRP will consider the overarching resilience framework developed as part of the 2019 CCVS. The framework encompasses investments to better withstand changes in climate, absorb impacts from outage-inducing events, recover quickly, and advance to a better state. The resilience management framework facilitates long-term adaptation that allows Con Edison's systems to achieve better functionality through time. To succeed, each component of the resilience system requires proactive planning and investments. A benefit of the framework is that it encourages *holistic* thinking about the types of measures that may help build a more resilient system. The framework encompasses investments that will help the Company:

- **Prevent** climate change impacts by hardening infrastructure.
- **Mitigate** the impacts from outage-inducing events by minimizing disruptions.
- **Respond** rapidly to disruptions to reduce recovery times and costs.

Con Edison will update this vulnerability Study every five years. Doing so will help the Company account for observed events, stay apprised of the latest advancements in climate change research and projections, and allow the Company to reassess its priority vulnerabilities as it learns from its investments in resilience.



Introduction

Consolidated Edison Company of New York, Inc. ("Con Edison" or "the Company") provides electric service that has an essential role in the daily lives of millions of customers and the functioning of the largest economy in the United States.[4] As a society, we are becoming increasingly dependent on safe, resilient, and reliable electric delivery. We live in a time defined by technological connectivity and innovation, including a transition to a greener and more electric future (e.g., electric heating, electric vehicles). At the same time, the physical impacts of climate change (rising temperatures, rising sea levels, increased flooding, and stronger storms) pose an increasing risk to proper functioning of the electric grid and exacerbate existing hazards and challenges in Con Edison's service territory. To prevent these impacts and mitigate and respond to climate events, Con Edison is continuing its long history of proactively increasing the Company's understanding of these risks, prioritizing them, and expanding on its current strategy to address them.

Background

In February 2022, New York's Governor Kathy Hochul signed a new law[5] that requires major New York State electric utilities to conduct a Climate Change Vulnerability Study (CCVS). The goal of the CCVS is to better prepare utilities for the adverse effects of climate change and severe weather events by assessing utilities' vulnerabilities to climate-driven risks through an evaluation of infrastructure, design specifications, and operational procedures. Con Edison, along with the other combination gas and electric utility companies subject to PSL §25-A[6], is required to submit a CCVS by September 22, 2023. The law requires that the Public Service Commission ("PSC") implement and administer requirements set forth by PSL §66(29) and provide submitted studies to the State.

Soon after the 2022 law was enacted, the PSC initiated Case 22-E-0222 to implement the requirements put forth by the New York State legislature. At a minimum, utilities must address their specific service territory geography and analyze the climate data associated with projected changes in temperature, wind, precipitation, sea levels, and other climate variables. This report (or "the Study") serves as the required study compliant with Case 22-E-0222 set forth by the PSC.

This is not Con Edison's first assessment of climate change risks. In 2019, the Company published a detailed vulnerability study (the 2019 CCVS). And in 2020, the Company published a Climate Change Implementation Plan (CCIP) that analyzed risks and made updates as necessary to the Company's planning, engineering, operations, and emergency response practices. The current Study builds on both the 2019 CCVS and the 2020 CCIP by using the latest climate science for New York State based on the latest generation of Global Climate Models (GCMs) and greenhouse gas concentration scenarios developed for the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment. The Climate Data Methods section provides a more detailed overview of data and methods used in this analysis.

The process for updating the assessment is summarized in Figure 2, which shows that this is an ongoing cycle and future updates will be completed every five years. The output provides guidance to develop programs and projects necessary to maintain Con Edison's resilience.

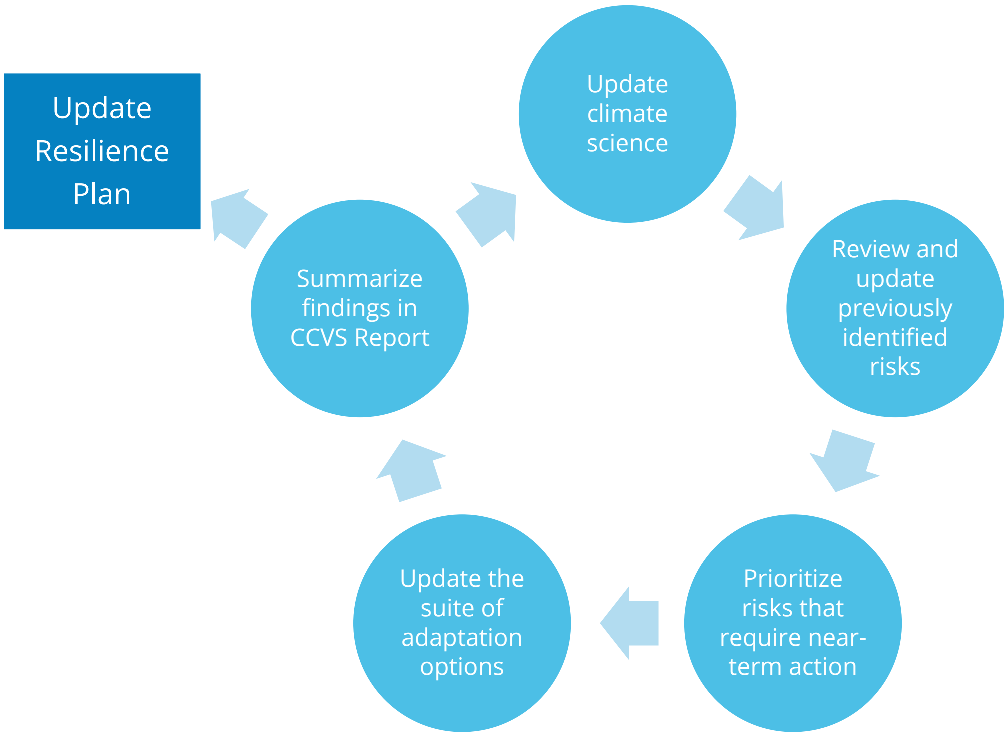


Figure 2. The assessment update cycle

This Study has three primary goals:

1. Develop a shared understanding of the updated projections for climate and extreme weather for the Con Edison service territory.
2. Summarize and prioritize the risks of climate change impacts on Con Edison's operations, planning, and physical assets, particularly within the next 20 years, to inform priorities for the Climate Change Resilience Plan (CCRP).
3. Update the Company's suite of adaptation options of operational, planning, and design measures for consideration in the forthcoming CCRP.

As required by the new law, the CCRP will be submitted 60 days after the CCVS. The CCRP will identify a holistic approach and an investment plan to address identified vulnerabilities from the Study for the next 5-, 10-, and 20-year periods.

Broad Baseline Assumptions

The Study relies upon two baseline assumptions:

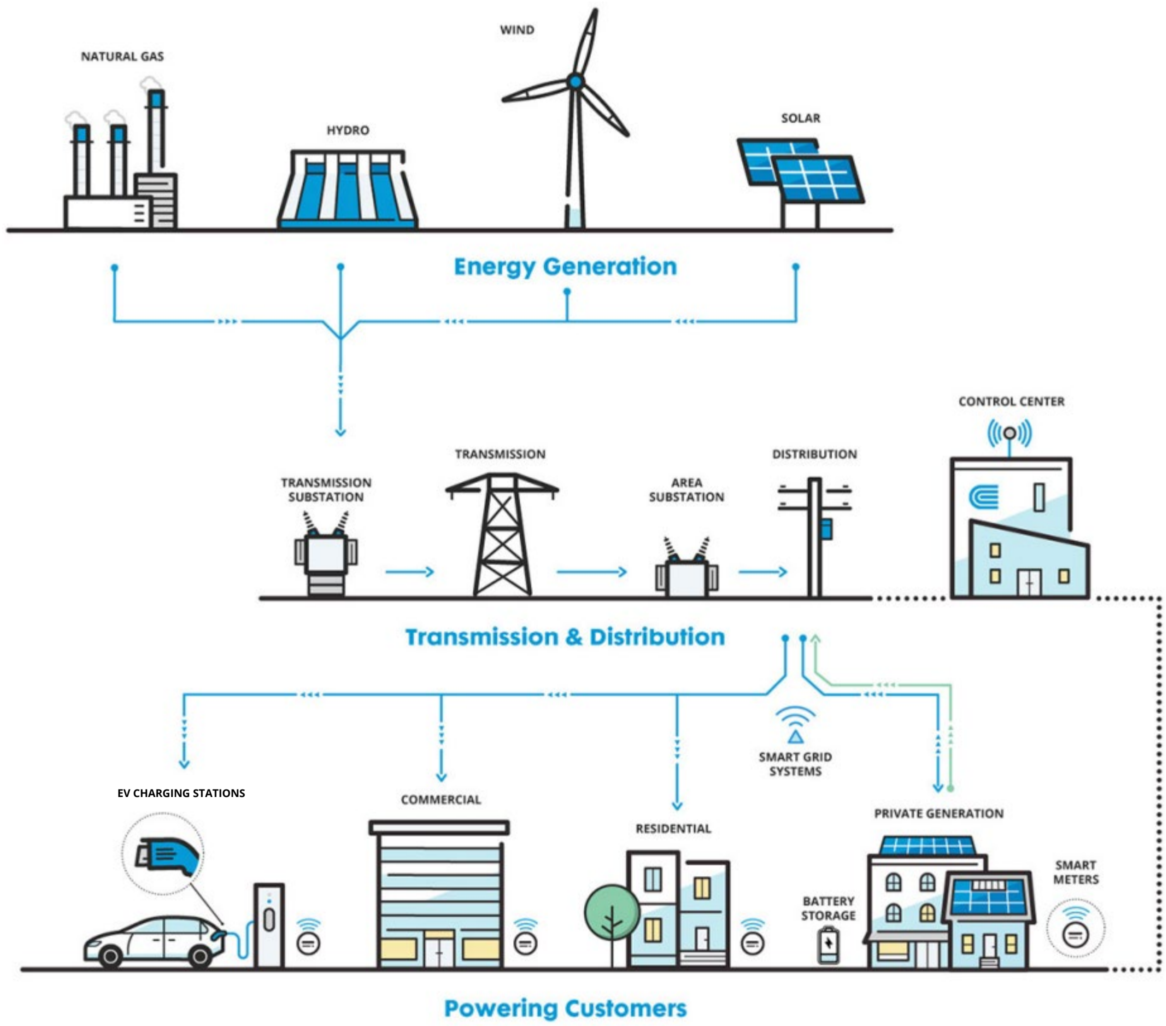
A focus on changes in climate. Over the next 20+ years, there will undoubtedly be changes in technology and policy that will alter aspects of the electric grid. Some of these changes may be relatively clear today, while others have not yet even been considered. Therefore, this Study applies current scientific data to Con Edison's existing electric system in order to provide protection in a changing environment.

An assumption of climate consistency across the service territory. Con Edison has a long-standing commitment to using the best available climate science to understand potential risks. To access the most recent climate data available for Con Edison's service region, the Study team partnered with the New York State Energy Research and Development Authority (NYSERDA) and its consultant Columbia University for a common source and methodology of climate projections for each of the six participating New York State utilities. In addition, Con Edison obtained data developed by the Massachusetts Institute of Technology (MIT) on behalf of National Grid that covers the Northeast. Additional details on these partnerships will be discussed later. Most of these data focus on providing future climate projections for New York City, featuring data from the Central Park weather station. Con Edison also incorporates data from the Dobbs Ferry weather station into its planning and design as a reference point for Westchester County. The examples in this Study focus on the Central Park station data; these data provide representative climate conditions for the largest proportion of the service territory. This station provides useful data to use in evaluating risks but does *not* capture more granular nuances that may exist within the service area. It is assumed that projections of temperature, humidity, wind, and precipitation are applicable across the entire service territory. This assumption is consistent with Con Edison's standard approach to operating—a single design standard by service class is often adopted for the whole service territory rather than varying designs based on climate differences.

Overview of Con Edison's Electric System

Con Edison's electric service territory includes both New York City and Westchester Country, covering 660 square miles and serving 3.6 million customers. Con Edison's grid is a delivery system that connects energy sources to customers.

Energy produced by generating sources is delivered via the Con Edison transmission system, which includes 430 circuit-miles of overhead transmission lines and the largest underground transmission system in the United States, with 749 circuit-miles of underground cable. The system also includes 39 transmission substations. The high-voltage transmission lines bring power from generating facilities to transmission substations, which supply substations, where the voltage is stepped down to distribution levels, as shown in the diagram below.



Con Edison has two different distribution systems—the non-network *(primarily overhead)* system and the network *(primarily underground)* system.

Summary of Priority Hazards

While climate change will impact several weather events, the scope of this report analyzes five key hazard categories: **temperature, coincident high heat and humidity (known as temperature variable or "TV"), flooding (including sea level rise and changes in precipitation), wind and ice[vii], and extreme events (including hurricanes, heat waves, Nor'easters, deluge rain, and high winds)**. The Study team selected these hazards based on the original findings from the 2019 CCVS, which identified their ability to impact the Company's assets, as well as their potential to change in magnitude and frequency due to climate change. The Study team found that while all climate hazards can impact Con Edison's assets and operations, the following hazards pose an elevated risk.

Con Edison's service territory is projected to be impacted by rising temperatures. Those impacts are expected to be amplified during intense heat waves. Increasing TV will cause load to increase, potentially challenging the capacity of the system.

Con Edison has previously experienced flooding events that have impacted its assets from major storms. Due to future climate projections, that risk is expected to expand in Con Edison's service area, and facilities like substations will be more exposed to flooding.

Con Edison's overhead distribution system has historically been the most sensitive to wind and ice, due to its susceptibility to tree contact during high wind and icing events.

Extreme events are low-likelihood, high-impact scenarios that can amplify and compound the types of impacts anticipated from changes in temperature, sea level rise, and other variables. These events pose risks to all aspects of the system and are especially impactful for emergency response planning.

Importance of Equity

Con Edison recognizes that equity must play an important role in resilience planning efforts and has been deliberate about considering equity in the planning process. Disadvantaged communities (DACs) have fewer alternatives during energy system outages and will be more impacted by climate change. Because of this, it is critical to consider how DACs may be affected by the changing climate and what Con Edison can do to provide these populations with resilient and reliable service.

To help identify and define DACs, Con Edison is employing maps developed by the State through a process that included stakeholder feedback. On March 27, 2023, the New York Climate Justice

[vii] Wind and ice are being considered together to align with the structure of energy system regulations, including National Electric Safety Code (NESC) standards, which consider wind and ice together.

Working Group (CJWG)[viii] voted to approve and adopt a comprehensive list of criteria that define DACs based on socioeconomic data (e.g., energy burden, poverty rate). The tracts are identified based off 45 indicators, some including potential pollution exposures, potential climate change risks, income, and race and ethnicity. As defined in Climate Act ECL §75-0111, DACs are identified based on public health, environmental hazard, and socioeconomic criteria, which shall include but are not limited to:

1. Areas burdened by cumulative environmental pollution and other hazards that can lead to negative public health effects;
2. Areas with concentrations of people that are of low income, high unemployment, high rent burden, low levels of home ownership, low levels of educational attainment, or members of groups that have historically experienced discrimination on the basis of race or ethnicity; and
3. Areas vulnerable to the impacts of climate change such as flooding, storm surges, urban heat island, and more intense storms.[7]

These communities make up 1,736 designated census tracts statewide. Figure 3 shows the CJWG map of DACs in Con Edison's NYC service area, color-coded by county. Due to the size of Con Edison's networks (i.e., the interconnected areas that serve as a planning unit) and the population density in the City, almost half of Con Edison's networks serve at least one DAC. This will be taken into account in the planning stage, as any potential risk mitigation measure applied to a network could benefit DACs.

[viii] The New York State Climate Justice Working Group is tasked with developing criteria to identify disadvantaged communities to help ensure that underserved communities have equal access to clean energy. https://climate.ny.gov/resources/climate-justice-working-group/

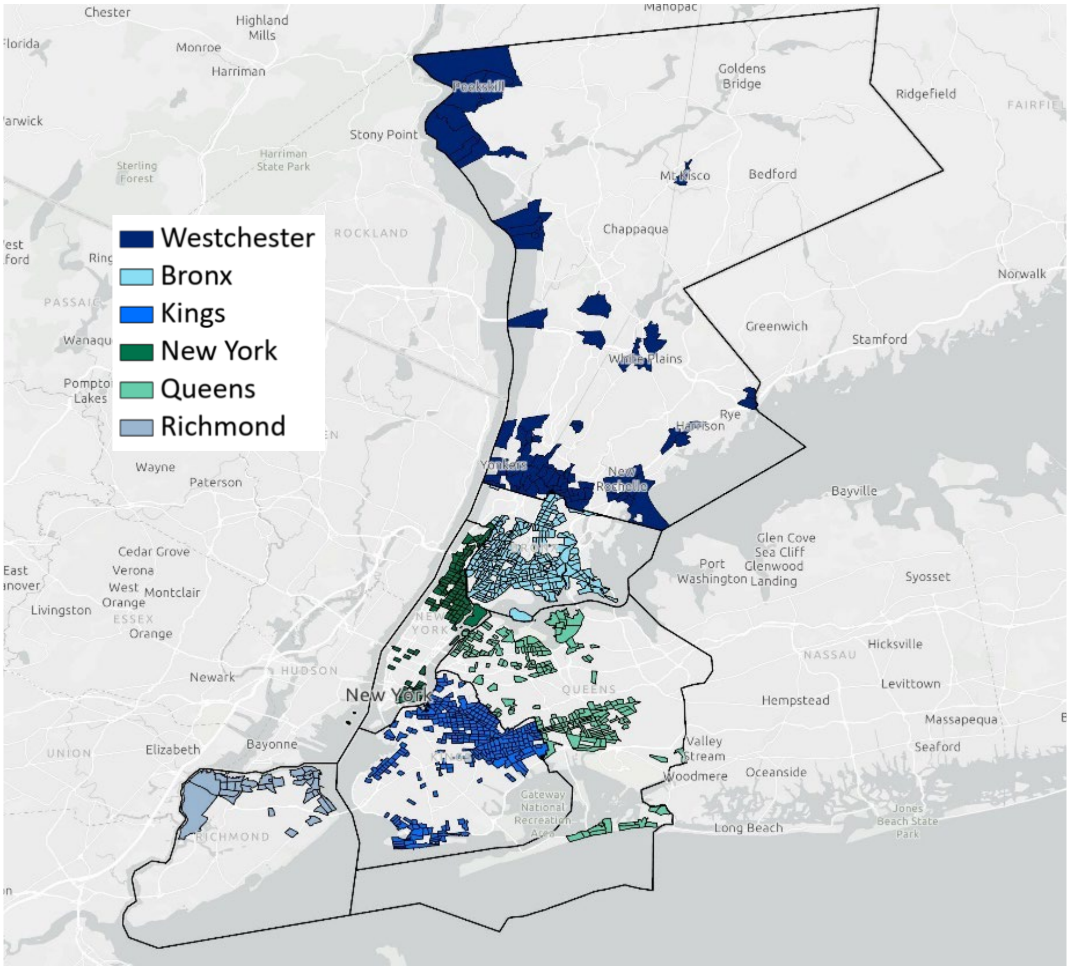


Figure 3. Map of DAC areas in the Con Edison NYC service territory (DAC areas shown in shades of blue)

The Company has formed an Environmental Justice Working Group under an executive committee, and plans to release a finalized Environmental Justice Policy Statement in 2023 to apply an equity lens to resilience-driven investments. Key components of the upcoming policy statement include:

- Operations will not disproportionately burden DACs;
- Con Edison will work to understand DAC concerns;
- Clean energy investments will benefit DACS;
- Con Edison will provide opportunities for employment in their clean energy future.

These equity considerations will help inform resilience plan investments moving forward.

Tailored Climate Data Analysis

The Study team analyzed historical and projected changes in temperature, humidity, precipitation, sea level rise, and extreme events within the service area. Climate variables were identified with the help of internal subject matter experts (SMEs) based on variables most relevant to system and operational sensitivities. Climate data are summarized for the Central Park weather station.

Applying the Science to Vulnerability Assessment: Temperature

To use temperature projections in the vulnerability assessment, the Study team selected the most relevant TV for each asset group and evaluated exposure based on that variable. For example, knowing the number of days that exceed 104°F per year is important for substations. Alternatively, average temperatures are more relevant to underground conductors.

Climate Data Methods

To support this Study, Con Edison updated the climate science datasets from its 2019 CCVS to reflect the latest science using climate change projections developed by Columbia University and NYSERDA. The updated data provide the most up-to-date climate projections tailored for New York State. This section provides an overview of the methods used to develop the climate change projections. While the Company's 2019 CCVS[8] bracketed the risk by looking at extreme upper- and lower-end climate change projections, this Study focused on the Company's previously established risk tolerance in its 2020 CCIP and associated pathways. Thus, the latest projections align with the Company's chosen pathways and will be used to inform adaptation investments (see the 2019 CCVS for more information on how the planning and design pathways were selected). By focusing on these pathways, this report provides an understanding of risk that can directly feed into the CCRP that will be filed later this year.

Data Sources

Con Edison is committed to using the best available science to understand future climate change in its service area. This Study updates the previous projections used in the 2019 CCVS with statistically downscaled[ix] climate change projections developed by Columbia University and NYSERDA in 2022.[x] These projections are being used by the six New York State electric utilities to satisfy the New York State Legislation on climate resilience and draw on an ensemble of 16 CMIP6 GCMs[xi] and two future greenhouse gas emissions trajectories based on SSPs, aligning with the latest climate science developed for the IPCC AR6[xii] (see below for more information on SSPs.) In addition, projections from the Cornell IDF curves supplement the precipitation projections and provide information on the future 4% annual chance (i.e., 25-year) 24-hour precipitation totals in the service area for the CMIP5 (an earlier set of climate models) RCP 8.5 emissions scenario.[xiii, xiv]

Projections are relative to baseline observations from 1981-2010 at the Central Park weather station (the only station in the data provided by NYSERDA within Con Edison's service area), compared to the baseline of 1976-2005 used for the projections in the 2019 CCVS for Central Park as well as LaGuardia airport and White Plains airport. Dobbs Ferry is used to represent Westchester County in this Study, but White Plains airport was used in the 2019 CCVS. Forward-looking projections are developed at decadal time horizons from the 2030s to the 2080s.

The SSPs represent scenarios of projected socioeconomic and technological changes and are used to develop emissions scenarios.[9] Climate projections provide a range of plausible climate scenarios, reflecting uncertainty in future greenhouse gas concentrations, climate sensitivity to greenhouse gas increases, natural climate variability, and other factors. The range of projections can be evaluated using percentiles[xv] that represent the low estimate (10th percentile of all model outcomes), the middle range (25th, 50th, and 75th percentiles), and the high estimate (90th

[ix] Statistical downscaling refers to methods used to reduce the spatial scale of climate model output by leveraging statistical relationships between coarser-scale climate and higher-resolution observed weather data to create high-resolution gridded climate projections.
[x] This document is not yet public. It will be published here: https://nysclimateimpacts.org/
[xi] GCMs are models that integrate climate system components to generate future projected climate conditions by dividing the globe into grid boxes and simulating the climate within those boxes; each grid box typically spans 1 to 2.5 degrees of latitude and longitude (1 degree of latitude or longitude corresponds roughly to 100 kilometers or 62 miles).
[xii] The previous 2019 CCVS projections drew on the RCPs, aligning with the IPCC AR5.
[xiii] Historical heavy rainfall is provided by the NOAA Atlas-14 for the entire United States. A point-and-click map interface with historical heavy rainfall amounts based on IDF estimates and 90% confidence intervals can be found on NOAA's website: https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=ny
[xiv] Rainfall return period projections use the ensemble mean rather than the 75th percentile because they use a different methodology than other climate projections used in this guidance and cataloged in the lifecycle tables. This information is publicly available through Cornell University: https://ny-idf-projections.nrcc.cornell.edu/
[xv] The percentiles are derived from the range of 16 models used in the climate projections developed by Columbia and NYSERDA. For example, the 90th percentile represents a higher value (warmer climate), and the 50th percentile represents the median value.

percentile)[xvi] where the 10^{th}, 50^{th}, and 90^{th} percentiles represent the low end, median, and high end of the projection range, respectively. This Study focuses on the 75^{th} percentile of the SSP5-8.5 emissions scenario (i.e., a high emissions scenario) for temperature and precipitation. This is a risk-averse scenario that aligns with other infrastructure owners and is consistent with the Company's previously selected climate change planning and design pathway (the only change is from using the older RCP scenarios to the updated and corresponding SSP scenarios).

This Study also uses sea level rise projections developed by Columbia University and NYSERDA. The sea level rise projections are specific to the Battery tide gauge[xvii] and use a combined model ensemble of SSP2-4.5 and SSP5-8.5 projections (i.e., merging a high emissions scenario with a more moderate emissions scenario). Columbia University used the 50^{th} percentile of the merged SSP2-4.5 and SSP5-8.5 sea level rise projections, drawn from an ensemble of GCMs and relative to a 1995-2014 baseline time period. This is a risk-averse scenario that remains consistent with Con Edison's climate change planning and design scenario for sea level rise.

The climate projections developed by Columbia University and NYSERDA address a range of temperature and precipitation extremes but do not address some extreme events such as tropical storms, wind gusts, and deluge rainfall due to the rarity of those types of events relative to the historical record and the limited ability of current GCMs to resolve the small space and time scales over which they occur. To address this, the Study uses a combination of literature review and supplemental dynamically downscaled[xviii] climate projections to evaluate the potential for worsening extreme weather in the service area due to climate change. These references and data are incorporated into the sections that follow. The extreme weather events literature review supplements the climate projections that illustrate expected changes and impacts. The review provides a broader understanding of complex hazards in the Con Edison service area.

Temperature

The Con Edison service area most commonly experiences extreme heat between June and August, although temperatures can exceed 90°F as early as April and as late as October. Considering historical data from 1991-2020, the warmest year on record in Central Park was 2020.[10] The 8 warmest years globally have occurred from 2015-2022[11], with the summer of 2023 being the hottest summer on record.[12] Projections show climate change could cause increases in both daily average air temperatures and extreme heat throughout the 21^{st} century (see Table 2). Notably, compared to the 2019 CCVS, changes in temperature are expected to occur sooner than previously anticipated. For example, the current Study shows the Con Edison territory

[xvi] More information on percentiles can be found at https://www.dkrz.de/en/communication/climate-simulations/cmip6-en/the-ssp-scenarios
[xvii] Data from Battery tide gauge is located in The Battery Park in New York City and is available in the NYSERDA New York State Climate Impacts Assessment (NYSCIA).
[xviii] Dynamical downscaling refers to methods used to reduce the spatial scale of climate model output by adjusting GCMs to local climate using weather forecasting models. This method preserves the climate signal of the GCM, constrains variability to local climate, and incorporates finer physical processes and properties (e.g., interactions between weather processes and local topography). This method is more computationally expensive relative to statistical downscaling and often leads to a smaller model ensemble.

experiencing high heat of 103°F occurring in 2030 which is a decade earlier than the prior projections (see Table 2).

Variable	Study	Baseline	2030	2040	2050	2080
Highest annual maximum daily temperature (see Figure 4a)	Current Study	97°F	103°F	104°F	106°F	112°F
	2019 CCVS	97°F	101°F	103°F	104°F	108°F
The number of days per year in which maximum temperatures exceed 95°F (see Figure 4b)	Current Study	4 days	17 days	27 days	32 days	69 days
	2019 CCVS	4 days	11 days	18 days	23 days	47 days
The number of days per year in which daily average temperatures exceed 86°F (see Figure 4c)	Current Study	3 days	16 days	22 days	31 days	68 days
	2019 CCVS	3 days	11 days	16 days	21 days	45 days

Table 2. **Projections for subset of TV used in both current and 2019 studies.**

Up to 32 days per year with maximum temperatures above 95°F by the 2050s

Multiday heat events, known as heat waves, are impactful because they drive demand for air conditioning and can strain infrastructure. Heat waves of three or more consecutive days with **maximum daily temperatures** above 90°F occurred approximately twice per year in New York City between 1981 and 2010. Recent heat waves in New York City include events in July 2022, July 2019, July 1999, and July 1993, which featured 6, 4, 10, and 11 consecutive days, respectively, with maximum daily temperatures at or above 90°F, respectively.

Projections show that the number of three-day heat waves with temperatures averaging above 90°F for each day will increase (see Figure 4d). While heat waves with daily average temperatures above 90°F provide a measure of sustained heat during the daytime and nighttime hours, heat waves with daily maximum temperatures above 95°F represent periods of prolonged daytime heat. The number of consecutive days with peak temperatures above 95°F at Central Park was up to two days on average between 1981 and 2010. By 2050, this could be seven consecutive days.

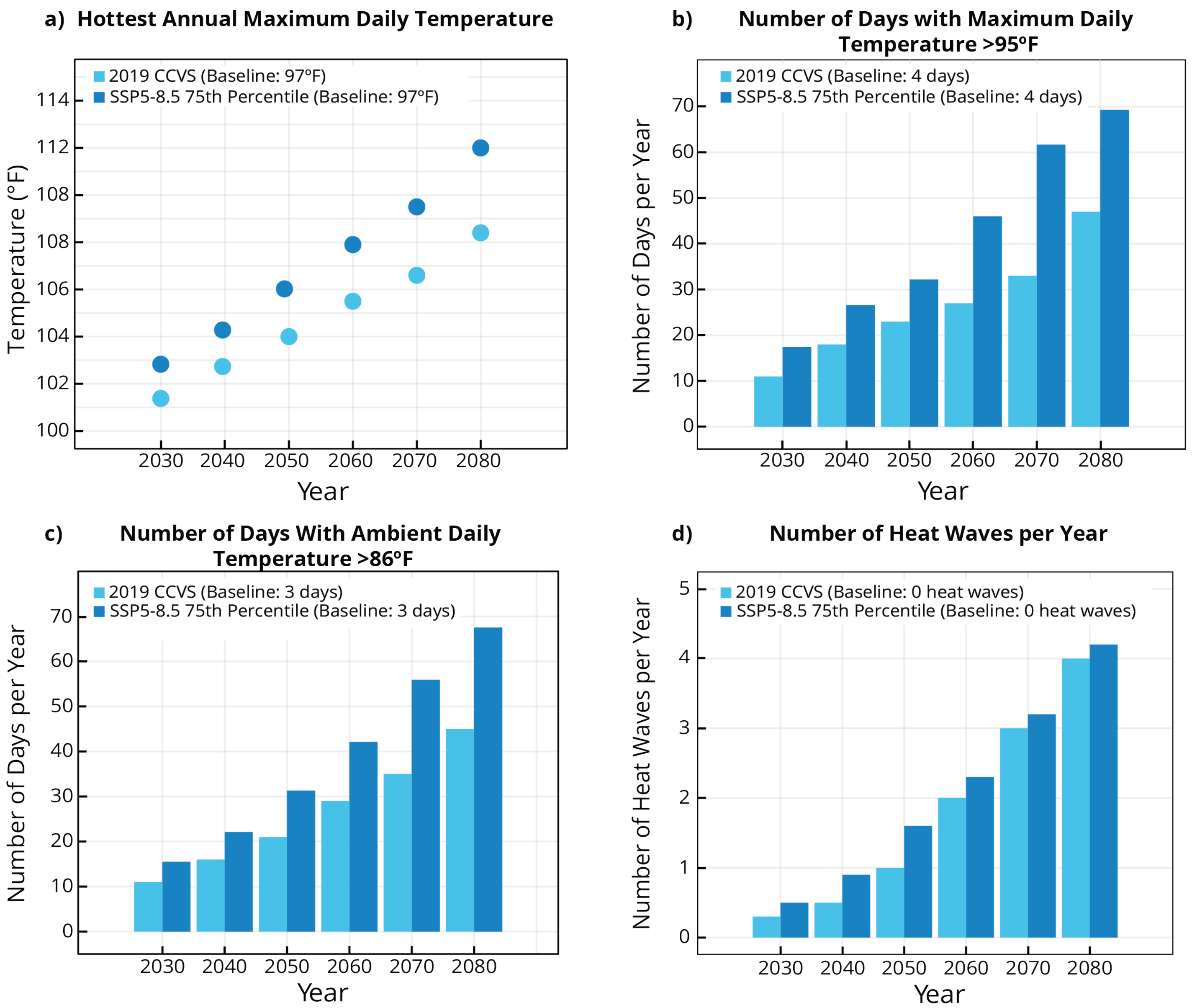


Figure 4. **Projections under SSP5-8.5 75th compared to RCP 8.5 75th percentile (2019 CCVS) in Central Park, relative to the historical observed period of 1981-2010.**
(a) Projected hottest annual maximum daily temperature under SSP5-8.5 and RCP 8.5, relative to a baseline of 97°F. (b) Projected days with maximum daily temperatures exceeding 95°F under SSP5-8.5 and RCP 8.5, relative to a baseline of 4 days. (c) Projected number of days with average daily temperature exceeding 86°F under SSP5-8.5 and RCP 8.5, relative to a baseline of 3 days. (d) Projected number of heat waves under SSP5-8.5 and RCP 8.5, defined as 3 or more consecutive days with average temperatures exceeding 90°F, relative to a baseline of zero.

New York City Micronet

Con Edison has invested in the New York City Micronet, which comprises a network of weather monitoring stations across the City's five boroughs. The Micronet monitors a range of weather variables based on location through time, including temperature, precipitation, wind, and humidity. These datasets support a range of use cases, such as tracking temperatures and temperature differentials, and in turn, potential asset impacts across the City due to factors such as the Urban Heat Island (UHI) effect.

The UHI effect causes urban areas to run warmer than surrounding areas because urban land surface characteristics retain more heat than nonurban or vegetated areas. The UHI effect typically affects nighttime and minimum temperatures the most by limiting overnight cooling. Data collected at Micronet stations from 2021 to 2022 illustrate this effect across New York City using daily minimum, or overnight, temperatures averaged across the summer months (June, July, August). Average daily minimum summer temperatures between 2021 and 2022 are the coolest at Fresh Kills site on Staten Island (68°F) due to its relatively unpopulated location and sea breeze cooling. Average daily minimum summer temperatures are warmest at the heavily urbanized Murray Hill station (72°F) over the same time period. The table below provides average daily minimum summer temperatures spanning 2021-2022 across a set of representative Micronet stations.

These data support Con Edison's monitoring and asset management efforts for historical and present-day climate conditions. For example, this information can be used to provide up-to-date information for current load forecasting and mobilization efforts, particularly related to real-time precipitation totals. This monitoring will also contribute to a more robust baseline dataset of climate normals throughout the service area that can serve as a reference point alongside future climate projections to support long-term climate adaptation efforts. However, data gaps exist, particularly in Westchester County. Looking forward, the Micronet's hyperlocal forecasts should be expanded to support these areas.

Site Name	Borough	Average Daily Minimum Summer Temperature (°F)
Fresh Kills	Staten Island	**68**
South Ozone Park	Queens	**69**
Tremont	Bronx	**70**
Navy Yard	Brooklyn	**71**
Murray Hill	Manhattan	**72**

Projections also show warmer winters in the future. Historically, the coldest winters in Central Park occurred in 1888 and 1875, and the coldest temperature recorded in Central Park was -15°F in February 1934.[13] Projections show that the coldest annual minimum daily temperatures could increase to 19°F by 2050, relative to a baseline of 7°F. However, climate change does not preclude the possibility of future severe cold snaps. Scientific literature and recent cold snaps suggest that climate change could amplify some cold weather phenomena such as polar vortex events.[14] There remains a high degree of uncertainty regarding these future scenarios, and more research is needed.

Temperature, Humidity, and Peak Load Forecasting

Coincident high heat and humidity drive temporary load increases (e.g., for air conditioning) that cannot be represented by temperature projections alone. To address this, the Company evaluates the potential for peak loads using an index referred to by Con Edison as temperature variable (TV)[xix], which incorporates considerations of both temperature and humidity. Con Edison currently forecasts system peak load at a TV value of 86°F, and in long-range forecasts, based on the 2019 CCVS, it assumes an increase in 2030 to 87°F TV and in 2040 to 88°F TV, with respective increases in peak load correlating to those TV changes.

Applying the Science to Vulnerability Assessment: Load Forecasting

To evaluate Temperature Variable (TV), the Study team looked at the number of days per year with summer daily TV exceeding 86°F.

Up to 16 days per year with maximum summer TV above 86°F by the 2050s

Consistent with the 2019 CCVS, projections show that the average number of days per year with summer daily TV exceeding 86°F at Central Park could increase by the 2030s, relative to the historical baseline time period. Furthermore, projections show that days with maximum summer TV exceeding 86°F could increase from both the baseline and the previous 2019 CCVS projections (see Table 3).

Variable	Study	Baseline	2030	2040	2050	2080
Days per year with maximum summer TV exceeding 86°F	Current Study	1 day	6 days	10 days	16 days	49 days
	2019 CCVS	1 day	6 days	10 days	15 days	35 days

Table 3. **Projections for TV used in both current and 2019 studies.**

[xix] TV is calculated using the weighted time integration of the highest daily recorded three-hour temperature and humidity over a three-day period. The historical reference TV for Con Edison is 86°F, which approximates a heat index of 105°F.

The TV projections are not large enough to warrant an update in the Company's coincident peak load forecasts above and beyond the changes made in 2020. However, the projected frequency of high TV events could affect asset performance or reliability under certain circumstances.

Sea Level Rise and Coastal Flooding

Overall, sea level rise is projected to accelerate during the 21st century, which will increase the frequency and intensity of coastal flooding in the service area, even without changes in coastal storms (e.g., hurricanes). Current literature suggests that coastal storms are likely to increase in both frequency and intensity in the future, with some studies projecting an approximately 5% increase in North Atlantic hurricanes in the future.[15,16,17] A range of underlying factors drive local sea level rise, including the rate of ice loss from glaciers and ice sheets, thermal expansion of the ocean, atmosphere and ocean dynamics, and vertical coastline adjustments.[18] The current projections are consistent with the 2019 CCVS projections, showing sea level rise could reach 16 inches by the 2050s and 36 inches by 2100 (relative to 1995-2014) within the service area, as shown in Figure 5.

Applying the Science to Vulnerability Assessment: Flooding

To evaluate vulnerability, the Study team used maps that were internally developed by Con Edison to represent future sea level rise across the service territory.

Up to 16 inches of sea level rise at the Battery by the 2050s.

Sea level rise will have profound effects on coastal flooding and storm surge. Recent literature shows that storm surge in New York City will likely increase in the future, largely due to long-term sea level rise.[19] Scientific literature also suggests that sea level rise has likely increased the severity of coastal flooding during past extreme events. For example, one study found that regional sea level rise over the past two centuries increased the severity of Hurricane Sandy's flooding in New York City by 22%.[20] Additionally, flood depths during the 1% annual chance (1-in-100-year) coastal flood in New York City are projected to increase from the baseline depth of 10.9 feet to as high as 15.8 feet in 2100 under a high climate change scenario.[xx] Rising sea levels will also increase incidence of nuisance flooding, which occurs at high tide in low-lying areas.

[xx] Flood values are above the mean lower low water (MLLW) datum at the Battery tide gauge. MLLW is measured as 2.57 feet below mean sea level at the Battery. Projections are from the NYC Flood Hazard Mapper. https://www.nyc.gov/site/planning/data-maps/flood-hazard-mapper.page

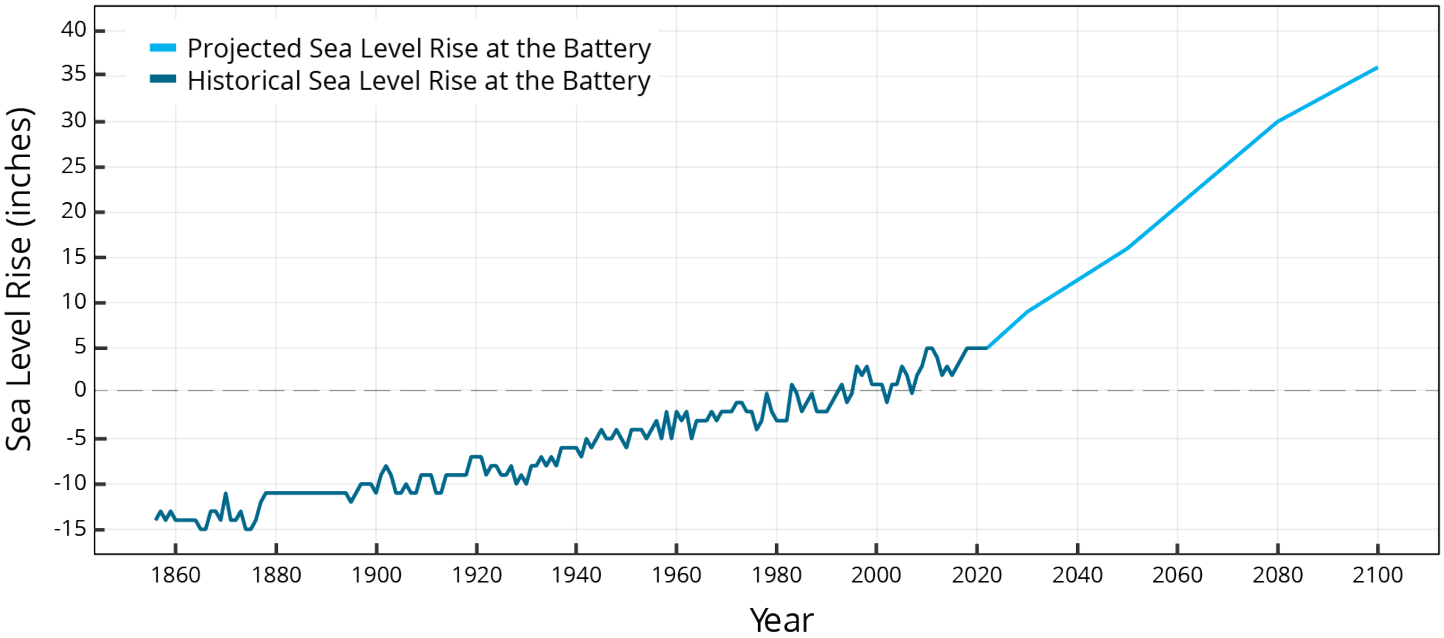


Figure 5. Historical and projected sea level rise at the Battery Tide Gauge in New York City under the combined SSP2-4.5 and SSP5-8.5 50th percentile. The dark blue line shows historical mean sea level at the Battery tide gauge (NOAA Tides & Currents).[21] The light blue line shows the 50th percentile of projected sea level rise relative to the Battery tide gauge, with a historical baseline time period of 1995-2014. Since 1992, the Battery tide gauge has experienced approximately 5 inches of sea level rise.

Precipitation and Inland Flooding

Con Edison's service area experiences a range of precipitation types, including rainfall and frozen precipitation (i.e., snow, sleet, and freezing rain). The region has experienced several tropical cyclones producing heavy precipitation over the last century. For example, in 2011, Hurricane Irene produced up to 12 inches of rain in the service area, with nearly 7 inches in Central Park. More recently, remnants of Hurricane Ida in 2021 brought over 7 inches of rain to Central Park. Alternatively, nor'easters have brought some of the heaviest snowfall on record to New York City, along with freezing rain. Recent analogs of note include the January 2021 nor'easter, which accumulated up to 2 feet of snow in New York City. Climate change is projected to drive heavier precipitation events because a warmer atmosphere holds more water vapor and provides more energy for storms, among other factors.

Looking forward, projections show climate change could drive stronger and more frequent storms in the region, bringing heavy precipitation, wind, and storm surge.[22] Tropical cyclone rainfall totals are projected to increase by approximately 10%-15% in the North Atlantic basin by the late 21st century.[23,24] In addition, extratropical cyclones[xxi] could become 5%-25% more wet in

[xxi] Extratropical cyclones, such as nor'easters, are low-pressure centers that derive their energy from strong temperature gradients (e.g., frontal boundaries), form in the midlatitudes, and are characterized by cold air in the center of the storm. In contrast, tropical cyclones are also low-pressure centers that form in tropical and midlatitudes but derive their energy from convection near the storm center rather than temperature gradients.

the future relative to present day.[25] In contrast, climate change could reduce the frequency of snowfall and other frozen precipitation in future decades.[26,27,28]

Projections show that heavy precipitation in the service area could increase throughout the century relative to the baseline (see Figure 6). Projected changes do not differ significantly from the 2019 CCVS (see Table 4).

Variable	Study	Baseline	2030	2040	2050	2080
Annual days with precipitation exceeding 2 inches	Current Study	3 days	4 days	4 days	5 days	6 days
	2019 CCVS	3 days	4 days	4 days	4 days	5 days

Table 4. **Projections for annual number of days with precipitation exceeding 2 inches used in both current and 2019 studies.**

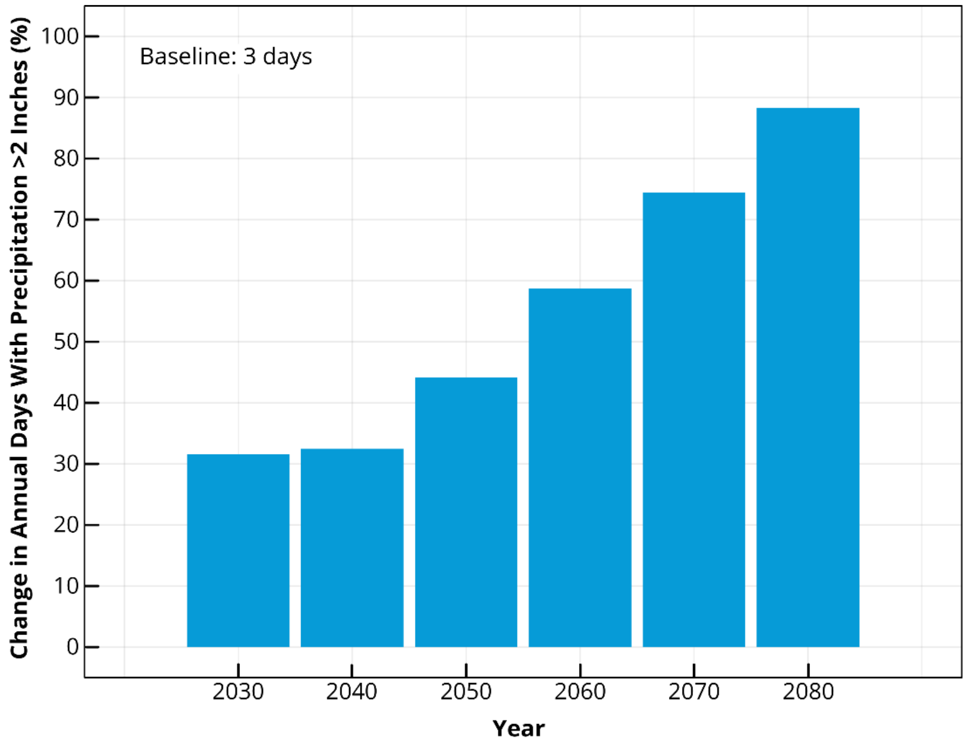


Figure 6. **Percent change in annual days with precipitation exceeding 2 inches under SSP5-8.5 75th percentile in Central Park, relative to the baseline of three days for the historical observed period of 1981-2010.**

Short duration, heavy rainfall is called deluge precipitation (or deluge rainfall) and can soften soil foundations, overwhelm drainage systems and cause urban flooding. If these events are accompanied by strong winds, the likelihood of downed trees from saturated soil increases and creates risk to overhead systems. A recent example is the downbursts of rain that occurred throughout the northeast United States in July 2023, which caused numerous trees to fall and resulted in outages.[29] Deluge rainfall can also result from hurricanes, which can produce large volumes of rain over the course of a day or more as they travel. Importantly, hurricanes can be forecast, unlike deluge rainfall events that develop with little warning and produce large volumes of rain in much shorter time periods (i.e., one hour or less). For example, in 2021, the remnants of Hurricane Ida deposited more than 7 inches of total rainfall in Central Park and caused severe flooding across the New York City metropolitan area.[30]

To better understand risks from deluge rainfall in a complex urban setting, New York City developed stormwater flood maps accounting for the compounding effect of extreme precipitation and sea level rise on the City's stormwater drainage system.[xxii] Like many property owners, Con Edison relies on the City's stormwater system to drain any excess rainfall from deluge-like events. The Company may not be able to rely on this infrastructure if system outfalls are blocked due to sea level rise and stormwater has nowhere to drain. Figure 7 shows street-level flooding that could occur under a 10% annual chance rainfall event in combination with 2.5 feet of sea level rise in 2050 due to blocked storm drains and outfalls. However, it is important to note the uncertainty associated with deluge rainfall projections and floodplain maps.

[xxii] The New York City stormwater flood maps can be found at https://experience.arcgis.com/experience/6f4cc60710dc433585790cd2b4b5dd0e

Moderate NYC Stormwater Flood Maps With 2050 Sea Level Rise

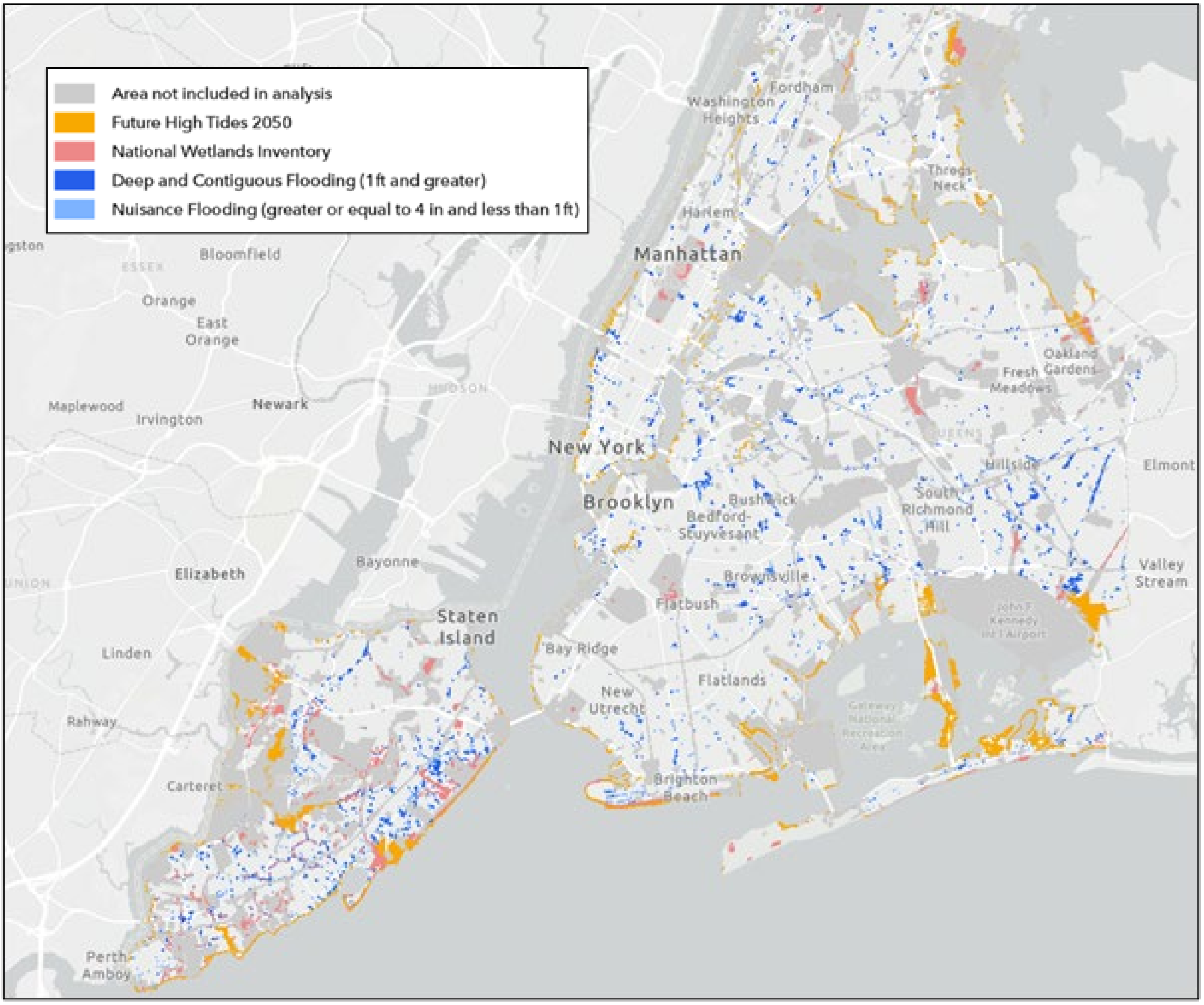


Figure 7. **Map of moderate stormwater flood with 2050 sea level rise in New York City, including future high tides in 2050, national wetlands inventory, deep and contiguous flooding (1 foot and greater), and nuisance flooding (greater than or equal to 4 inches and less than 1 foot)**

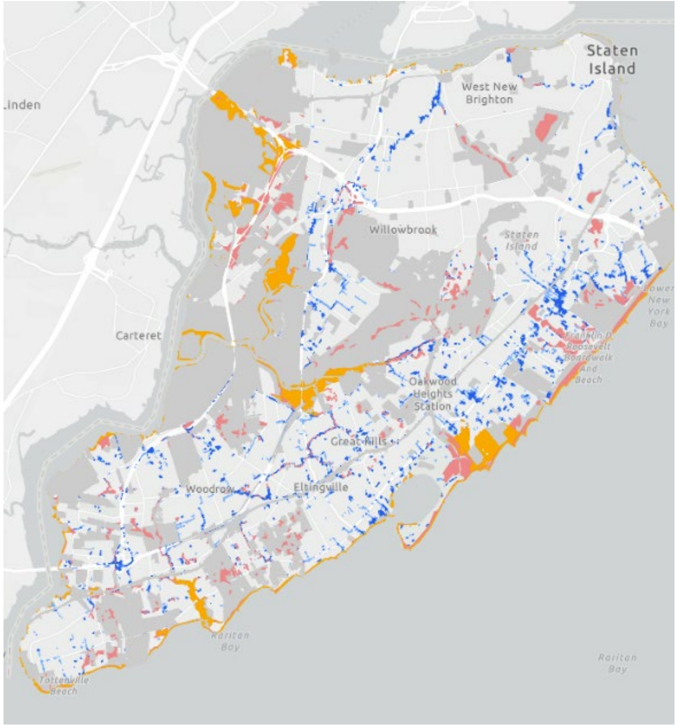


Figure 9. **2050 moderate flooding, zoomed in on Staten Island**

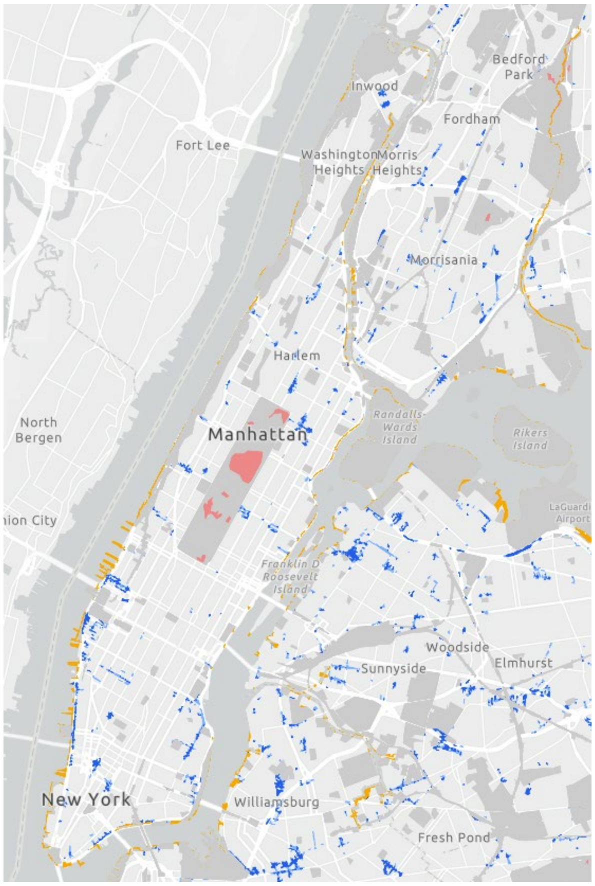


Figure 8. **2050 moderate flooding, zoomed in on Manhattan**

Extreme NYC Stormwater Flood Map With 2080 Sea Level Rise

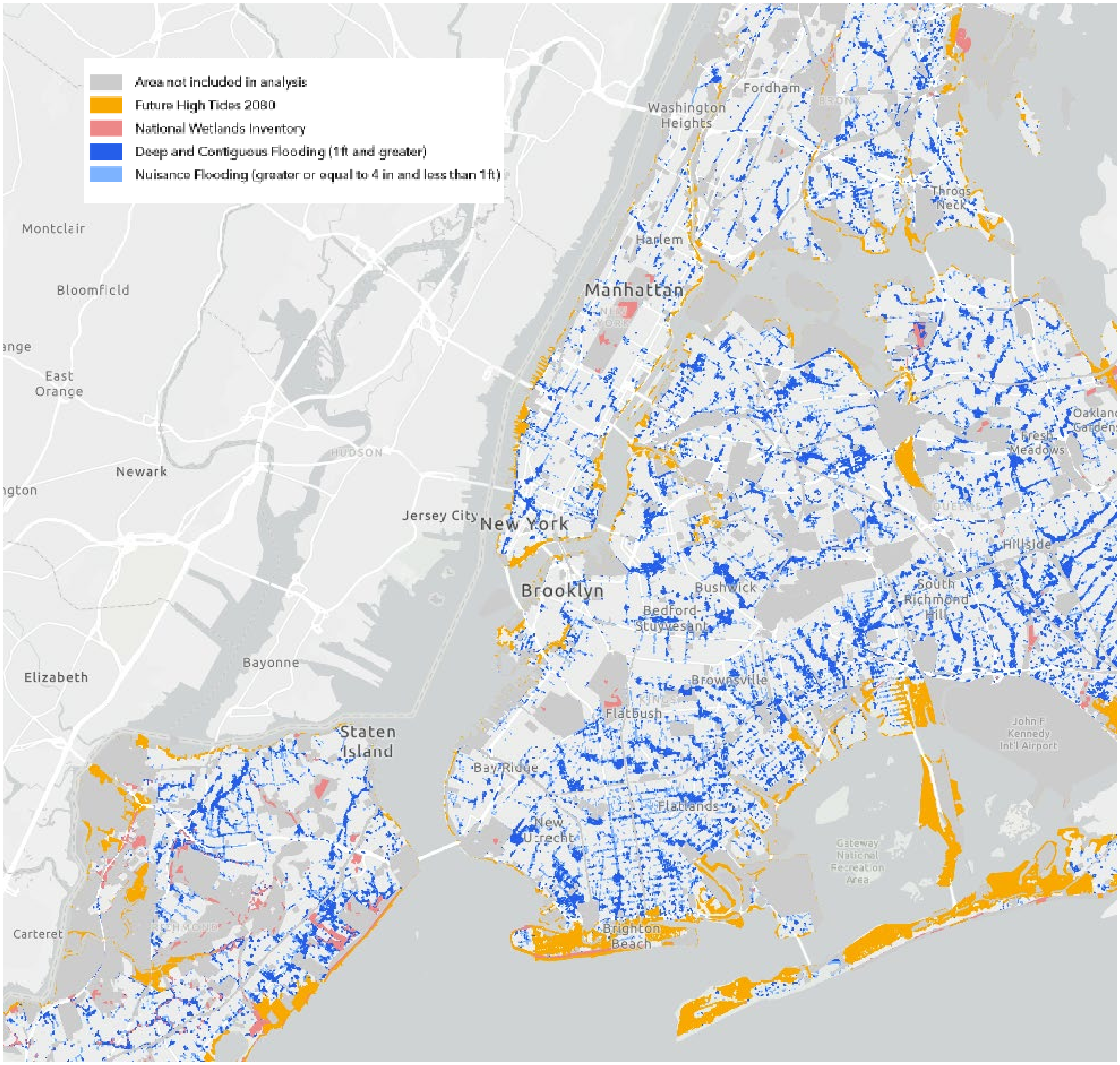


Figure 10. **Map of extreme stormwater flood with 2080 sea level rise in New York City, including future high tides in 2080, national wetlands inventory, deep and contiguous flooding (1 foot and greater), and nuisance flooding (greater than or equal to 4 inches and less than 1 foot)**

Snowfall also poses a potential risk to the service territory. Historically, nor'easters have been responsible for some of the heaviest snowfall on record in the greater New York City region. Of note are the January 23, 2016, and February 9, 2013, storms that produced up to 24 inches of snow and blizzard conditions (40-45 mph wind gusts) in the service area. Projections reveal a decrease in snowstorm frequency corresponding with a warming climate.[31] However, while the likelihood of a given storm producing snow instead of rain will decrease in the future, singular storms could produce more snow (or ice) than during the present day if atmospheric conditions are cold enough.[32]

Wind and Radial Icing

Overall, the Con Edison service area is likely to experience higher wind speeds and gusts due to intensifying tropical cyclones (hurricanes), extratropical cyclones (nor'easters), and thunderstorms in the future.[33] Furthermore, current scientific literature indicates that more frequent high wind gusts could be observed during thunderstorms in the future, although the magnitude of this trend is uncertain. Similarly, there is the potential for higher-intensity radial icing events in the winter months.

During Hurricane Sandy in October 2012, maximum sustained winds of up to 55 mph and gusts up to 80 mph were observed in New York City.

Historically, wind and extreme weather events associated with strong winds, such as hurricanes, extratropical cyclones, and thunderstorms, have posed a risk to the service area and are projected to increase in the future.[34] A recent analog of note includes Hurricane Sandy in 2012, with 30-55 mph winds and gusts up to 80 mph. See Table 17 for recent historical hurricanes and their associated wind speeds.

Like hurricanes, nor'easters have historically been responsible for high winds, although not as extreme as hurricane winds, in the New York City metropolitan region and are projected to increase in the future. See Table 18 for recent historical nor'easter analogs and their associated wind speeds in the service area. Furthermore, thunderstorms are often accompanied by severe weather such as strong winds, hail, and tornadoes, and are projected to increase in the future.

Scientific literature, including the Fourth National Climate Change Assessment and reports by the New York City Panel on Climate Change, indicates that winds are projected to become more intense and have faster wind speeds in the future largely due to more intense storms.[35,36,37] Warming atmospheric and ocean surface temperatures will likely lead to more intense tropical cyclones in the North Atlantic, characterized by an increased northward migration of strong hurricanes.[38] Models project that warming temperatures and increased moisture availability could drive more favorable conditions for severe weather during the warm season and increase the potential for thunderstorm activity and extreme wind events.[39] While there is overarching alignment in the direction of change, quantitative projections of future wind speeds have not reached a consensus due to high uncertainty in the magnitude of future trends. Examples of potential changes in wind include:

- Increases of up to 2% in the average hurricane maximum wind intensity (winds greater than 78 mph) in the near-term (2016-2035) and 4% by late-century (2081-2100).[40],[41]
- Maximum wind gusts in New York City could increase from 80 mph to 110 mph by midcentury.[42]
- The 700-year return period wind speed is projected to increase from 115 mph to 124 mph by midcentury.[43]

Applying the Science to Vulnerability Assessment: Wind and Ice

The Study team evaluated projected changes in average wind speed and ice accumulation, as well as expected changes in likelihood of extreme wind events, such as hurricanes.

- Both average and maximum low level wind speeds (at a height of approximately 33 feet) associated with moderate extratropical cyclones are projected to increase by approximately 3%-4% by the end of the century.[44]
- The number of days with conditions favorable for severe thunderstorms and corresponding high winds could double in New York City by the late 21st century under a high emissions scenario.[45]
- On average globally, severe weather events, including thunderstorms, strong winds, and tornadoes, could increase in frequency by 5%-20% per 1˚C warming.[46]

To try to further explore the science on future changes in wind, Con Edison obtained a dataset developed by MIT that covers the Northeast. MIT developed the data for National Grid and offered it to members of the Joint Utilities (JU) as supplemental material to the Columbia data. Table 5 summarizes the 2025-2041 projected and baseline observed annual maximum and average wind speeds at Central Park, JFK, and LaGuardia.

	Central Park		JFK		LaGuardia	
Wind Speed	1-min Baseline	MIT Projection	1-min Baseline	MIT Projection	1-min Baseline	MIT Projection
Annual maximum (mph)	51.0	60.2	46.1	57.5	55.0	62.4
Annual mean (mph)	14.0	17.6	18.1	19.2	20.1	18.5

Table 5. Summary of projected 2025-2041 annual maximum and annual mean wind speeds (mph) in the MIT data relative to the approximate observed baseline.

Table 6 summarizes the 2025-2041 projected 5-, 10-, and 20-year return period wind speeds at Central Park, JFK, and LaGuardia. 5-, 10-, and 20- year return period wind speeds represent maximum wind speeds that are expected to occur every 5, 10, and 20 years. Projected increases in return period wind speed magnitudes indicate an increasing likelihood of more extreme wind speeds during each return period timeframe. More frequent extreme wind speeds will increase return period wind speeds. This projection is consistent with current scientific literature, which indicates that winds are projected to become more intense in the future.

Return Period Wind Speed	Central Park	JFK	LaGuardia
1-in-5 Years	52.3	53.8	49.6
1-in-10 Years	56.7	56.1	53.8
1-in-20 Years	61.7	58.5	59.8

Table 6. **Summary of projected 2025-2041 return period wind speeds (mph) in the MIT data.**

Con Edison's design standards for wind also include considerations for ice since both add stress to overhead equipment. Current design standards for overhead distribution are 0.5 inches of radial ice and 45 mph winds. Current design standards for overhead transmission are 1 inch of uniform radial ice combined with 20 pounds per square foot of wind pressure. Freezing rain is relatively common during winter months in New York, but ice storms are rare. These events have produced total ice accumulations of up to 2 inches, lasting from a few hours to almost five days. Infrastructure impacts have ranged from a few hours to more than one week after storms pass, especially when followed by a prolonged cold spell.[47] Appendix 1: Climate Science illustrates historical analogs for ice storms impacting the service area, as well as historical ice storms in surrounding areas.

Projections for the influence of climate change on ice storms are difficult to resolve and remain highly uncertain due to the specific atmospheric conditions required for ice storms to occur relative to other high-impact hazards.[48] However, the MIT data do provide some useful insights. Annual radial icing (i.e., the sum of all icing for the year) projections from the MIT data at Central Park show high interannual variability with the potential for icing exceeding current design standards (see Table 7). Additionally, a review of the scientific literature demonstrates the potential for increased freezing rain frequency and ice accumulation in the region.[49]

Year	Total Annual Radial Icing For the Year (in.)	Number of Hours With Radial Ice Accumulation
2025	0.18	23
2026	0.06	7
2027	0.03	5
2028	0.06	10
2029	0.00	0
2030	0.59	22
2031	0.02	3
2032	0.02	3
2033	0.03	3
2034	0.03	3
2035	0.04	3
2036	0.05	2
2037	0.15	9
2038	0.10	4
2039	0.04	7
2040	0.96	46
2041	0.39	10

Table 7. **Projected annual radial icing projections at Central Park using the MIT data.**

Extreme and Coincident Events

There is high confidence that the probability of coincident extreme events will likely continue to increase in both frequency and intensity in the future. Extreme weather events, including concurrent or consecutive extreme events, present unique challenges to operations, planning, and infrastructure across the electric system. Climate models have difficulty resolving extreme weather events due to the small space and time scales at which these events occur, as well as the rarity of the events themselves, necessitating an evaluation of extreme events using historical analogs and projections from the scientific literature. The 2019 CCVS focused on hurricanes, extreme heat waves, nor'easters, and multiple extreme weather events to illustrate expected changes and impacts in extreme events in the service area. This Study expands on these events using findings from the most recent scientific literature and adds further analysis on hurricanes, winds, nor'easters, and cold snaps.

Table 8 summarizes findings from the climate projections and literature review on historical information and future projections of extreme events in the Con Edison service area.

Extreme Event	Future Frequency	Future Intensity
Hurricanes	Unchanged	Increase
Extreme heat waves*	Increase	Increase
Nor'easters and cold snaps	Decrease	Increase
Deluge precipitation	Increase	Increase
Multiple extreme weather events	Increase	Increase

*Includes the higher-impact and lower-frequency tail-end heat events.

Table 8. **Summary of future changes in frequency and intensity of extreme events in the Con Edison service territory.**

Hurricanes

Historical Information

Hurricanes, also referred to as tropical cyclones, are rapidly rotating low-pressure systems that produce extreme precipitation, high winds, and coastal storm surge. They are classified according to their intensity and wind speed, with Category 1 and Category 5 hurricanes featuring 74 mph and 157 mph sustained winds, respectively. Historically, the strength and impact of these storms depend, in part, on the hurricane track as they approach the service territory. Historically, the most damaging storms in terms of the combined impacts of rain and wind have tracked over Long Island. These storms, such as Gloria (1985) and Donna (1960), have featured sustained winds of 60 mph, gusts of over 100 mph, and rainfall totals between 3 and 5 inches. Storms that track further west generally produce more rainfall, including Irene (2011), which produced 8-12 inches of rain locally and nearly 7 inches in Central Park. Storms tracking further east generally produce higher wind speeds but lower rainfall amounts. For example, Esther (1961) produced 98 mph gusts in Central Park, but only 1-3 inches of rain. More recently, after the remnants of Hurricane Ida hit the northeast United States in 2021, an EF3 tornado hit Mullica Hill, New Jersey, and the first tornado emergency of its kind was issued in the Northeast.[50] Appendix 1: Climate Science illustrates recent historical hurricanes and their associated wind speeds.

During Hurricane Sandy in 2012, major coastal flooding and prolonged power outages impacted the service area.

Future Projections

Global climate model projections show that warming atmospheric and ocean surface temperatures will likely invigorate hurricanes in the North Atlantic to become more intense (an approximately 5% increase) and have higher rainfall amounts (an approximately 10%-15% increase) relative to historical hurricanes.[51,52,53] Increasing storm intensities imply stronger hurricane winds and, in turn, coastal storm surge. Despite projected decreases or no change in the frequency of total hurricanes in the North Atlantic, the frequency of the strongest hurricanes will likely increase in the North Atlantic.[54,55,56] Projections and recent historical trends also show a northward migration of the location of maximum hurricane intensity, increasing the likelihood that a hurricane exceeding Category 2 could make landfall in the New York metro region in the future.[57,58] At the same time, models of future hurricane activity in the North Atlantic suggest that overall hurricane frequency will most likely remain the same or decrease slightly under average 21st century climate change projections;[59,60] however, this finding has been contested by studies that show a marked increase in the frequency of tropical cyclones globally through the end of the 21st century.[61] Furthermore, recent warming of sea surface temperatures in the Atlantic Ocean, despite the limiting effects of the ongoing El Niño event, could increase the likelihood of an above-normal Atlantic hurricane season.[62] Ultimately, while the total number of hurricanes occurring in the North Atlantic may not change significantly over the next century, the percentage of very strong and destructive (i.e., Categories 4 and 5) hurricanes is projected to increase, as confirmed by the latest IPCC Assessment Report.[63]

Extreme Heat Waves

Extreme heat can manifest as heat waves or other tail-end heat events, such as heat domes, that increase demand for air conditioning and, in turn, limit the capability of efficiency reductions. Unlike hurricanes or other extreme storms, heat wave intensity and frequency are tightly linked to long-term changes in atmospheric temperature and are thus comparatively well-simulated in climate model projections. Additionally, higher temperatures associated with urbanization, a phenomenon referred to as the Urban Heat Island (UHI)[64], such as from lower surface reflectivity of built surfaces and waste heat from buildings, can exacerbate the impacts of extreme heat events. The Temperature section highlighted projections for heat waves and days with extreme heat in the service area. This section supplements the quantitative projections with historical analogs and future projections cited in current scientific literature to understand how the most extreme heat waves may change in the future.

Historical Information

In July 2019, a heat wave in New York City resulted in numerous scattered power outages.

The Con Edison service territory regularly experiences heat waves. Heat waves are intensified by events such as heat domes, which are areas of high pressure in the atmosphere that trap hot air.[65] Extreme heat occurs most commonly between June and August, although temperatures can exceed 90°F as early as April and as late as October. Between 1971 and 2000, New York City experienced an average of two heat waves per year that lasted at least four days.[66] New York City averaged 18 days per year above 90°F during this time period.[67] More recently, July 2023 has seen the hottest three-week period of global mean surface air temperatures ever recorded, along with several temperature records broken across the globe.[68] The impacts of these higher temperatures are exacerbated in urban areas, and it is estimated that 78% of the total population of New York City, including Con Edison's assets in those areas, experiences at least 8°F more heat due to the UHI.[69]

Future Projections

Model projections reveal increases in the frequency, duration, and intensity of extreme heat days by the late 21st century in the service territory.[70] Furthermore, Columbia University's climate projections show greater warming than the previous 2019 CCVS climate projections, particularly at the high end of the climate model distribution and for higher emissions scenarios. Heat domes are also expected to increase in frequency due to increased sea surface temperatures, which will act to intensify heat waves.[71] See the Temperature section for specific projections of heat waves in the service area, relative to historical values. The occurrence of heat waves could be exacerbated if weaker prevailing winds and static weather patterns become more common, ultimately increasing the likelihood of long-duration heat waves in the service territory. The ability of climate models to simulate the full range of possible changes in the frequency of static weather patterns is unknown.

Nor'easters and Cold Snaps

Nor'easters, also called extratropical cyclones, are low-pressure systems driven by the convergence of cold polar air from Canada and warm air over the Atlantic Ocean. As a result, nor'easters occur most frequently during the cold season between November and April, when the temperature contrast between these air masses is greatest. Nor'easters present a range of risks to the Con Edison service area, including extremely heavy precipitation, hurricane-force winds, and coastal flooding. When an intensifying nor'easter interacts with cooler arctic air transported from Canada via the polar jet stream, snow, ice, and strong winds can occur.

Extreme cold events, often referred to as cold snaps, generally occur in New York when anomalously cold, polar air from Canada protrudes into the northeast United States due to an unstable polar vortex or from northerly atmospheric circulation (winds) in the wake of a passing winter storm. An unstable polar vortex results from sudden stratospheric warming in the Arctic, which splits or weakens the vortex, allowing polar air to extend farther south into the northeast United States.[72]

Historical information

Historically, nor'easters are responsible for some of the heaviest snowfall on record in the New York metropolitan region, as well as extreme winds, coastal storm surge, and ice. Recent historical analogs of note include the January 23, 2016, and February 9, 2013, storms that produced up to 24 inches of snow and blizzard conditions (40-45 mph wind gusts) in the service area. Finally, the December 12, 1992, nor'easter produced a storm surge of nearly 7 feet at the Battery and severe flooding along FDR Drive due to winds exceeding 75 mph in the City. Appendix 1: Climate Science illustrates recent historical nor'easter analogs and their associated wind speeds in the service area.

The April 2022 Nor'easter brought heavy rainfall and wind gusts of over 50 mph, resulting in numerous customers losing power in New York.

Extreme cold events are relatively common in New York, especially in the northern and northwestern regions. The coldest temperature recorded in Central Park was -15°F in February 1934.[73] Often accompanying the cold snaps are stronger-than-average winds, and wind chill values can drop below 0°F for large portions of the service area during an extreme event. Even if no precipitation occurs with extreme cold events, the below-average temperatures and strong wind fields can cause many issues like tree impacts, leading to loss of power during times of high energy demand.

Future Projections

Focused studies using regional downscaled climate models can help approximate the direction and magnitude of future change in nor'easters.[74] Some studies project an increase in storm track density and frequency of the most intense storms along the East Coast toward mid-to-late century, due to amplified temperature gradients between merging polar continental air and the warm Atlantic Ocean. Additionally, nor'easters along the East Coast could include 5%-25% more rain in the future relative to present day.[75] Models project that snowstorms and freezing rain are expected to decrease in frequency over the coming century in a warming climate[76,77] as the likelihood of more extreme snow and ice events shifts further north into Canada.[78,79] However, storms could produce more snow or ice than in the present day during future cold snaps if atmospheric conditions are cold enough to support frozen precipitation, despite projected future decreases in the likelihood of a given nor'easter producing snow instead of rain.[80]

Climate change is projected to warm winter temperatures and reduce the overall frequency of cold snaps. However, climate change does not preclude the occurrence of cold snaps, and some evidence shows that complex processes amplified by climate change could worsen some cold snaps, such as polar vortex events. Some studies suggest that polar vortex events over the eastern United States may occur more frequently due to reduced sea ice and snow cover in the Arctic weakening the confinement of the polar vortex.[81,82,83] One study found that extreme cold air outbreaks, possibly punctuated by widespread snow events, may paradoxically become more common as high-latitude regions warm due to resulting changes in the jet stream.[84,85] A more recent study focusing on polar vortex events back to the 1980s linked changes in the Arctic's climate to the weakening of the polar vortex, encouraging outbursts of Arctic air to mid-latitudes.[86] However, many climate scientists argue that even if cold snaps occur more frequently in the future, there is high confidence that the Arctic is warming and, therefore, the cold air outbreaks will become warmer over time as well.

It is important to underscore that the findings highlighted here are drawn from a small set of research studies, and additional research is needed to verify their results.

Deluge Precipitation

Historical Information

During Hurricane Ida in 2021, more than 7 inches of rain fell in Central Park in a single day—with more than 3 inches falling in one hour.

Deluge precipitation, also referred to as flash flooding or deluge rainfall, follows high-intensity and short-duration rainfall and is dangerous because it can overwhelm the City's local stormwater systems and cause flooding outside of FEMA floodplains[xxiii]. Deluge precipitation can occur on the backend of hurricanes and tropical cyclones, as shown in the table of historical hurricanes in Appendix 1: Climate Science. For example, when the remnants of Hurricane Ida impacted New York City in September 2021, more than 7 inches of rain fell across Central Park in a single day—with more than 3 inches falling in just one hour—causing the subway system to flood and numerous customers to lose power.[87] This event broke previous heavy rainfall records dating back to the 1800s. Additionally, it was the first flash flood emergency issued for the City.

[xxiii] FEMA floodplain maps identify the current extent and elevation of the 1% annual chance base flood using historical data. They do not account for sea level rise.

Future Projections

Precipitation projections show a moderate increase over the historical baseline, with an 88% increase in annual days with precipitation exceeding 2 inches by 2080. See the Precipitation and Inland Flooding section for projections of heavy precipitation in the service area based on the SSP5-8.5 75th percentile, relative to historical values. Additionally, NYSERDA-supported IDF curves include estimated changes in future heavy rainfall occurring over 1-, 6-, 12-, and 24-hour periods as associated with 2-, 5-, 10-, 25-, 50-, and 100-year return periods.[xxiv] Table 9 shows projected rainfall rates (inches/hour) for the recent observational period and two future time horizons (2040-2069 and 2070-2099) under RCP 8.5. Increased precipitation could increase deluge rain events that may impact the City's stormwater system, resulting in localized flooding. See Figure 7 through Figure 9 for maps of street-level flooding that could occur under a 10% annual chance rainfall event with 2050 and 2080 sea level rise projections due to blocked storm drains and outfalls.

	Observed NOAA Atlas 14 Rainfall Rates (inches/hour)			Projected 2010-2039 Rainfall Rates (inches/hour)			Projected 2040-2069 Rainfall Rates (inches/hour)			Projected 2070-2099 Rainfall Rates (inches/hour)		
Duration (hours)	5th percentile	Mean	95th percentile	10th percentile	Mean	90th percentile	10th percentile	Mean	90th percentile	10th percentile	Mean	90th percentile
1	2.04	2.82	3.88	3.34	3.87	4.31	3.51	4.14	4.97	3.57	4.42	5.49
2	1.32	1.81	2.48	2.07	2.4	2.67	2.18	2.57	3.08	2.21	2.74	3.4
3	1.02	1.4	1.91	1.56	1.81	2.02	1.64	1.94	2.33	1.67	2.07	2.57
6	0.66	0.9	1.22	0.97	1.12	1.25	1.02	1.2	1.44	1.04	1.28	1.59
12	0.43	0.58	0.78	0.6	0.7	0.77	0.63	0.74	0.9	0.64	0.8	0.99
18	0.33	0.45	0.6	0.45	0.53	0.59	0.48	0.56	0.68	0.48	0.6	0.75
24	0.27	0.37	0.5	0.37	0.43	0.48	0.39	0.46	0.56	0.4	0.49	0.61

Table 9. 100-year return period precipitation for Central Park.

Multiple Extreme Weather Events

Weather events can occur in complex combinations at any point during the year. When extreme weather events occur concurrently or sequentially to other events, efforts to respond become more difficult, and the impacts can become intensified and cascading. For example, an ice storm followed by a cold snap could prevent maintenance crews from being able to address power outages due to prolonged freezing of roads and infrastructure. Multiple extreme events can exceed resilience thresholds on a range of spatial and temporal scales.

[xxiv] This information is publicly available through Cornell University at http://ny-idf- projections.nrcc.cornell.edu/index.html.

Historical Information

In March 2018, consecutive nor'easters impacted the service area, resulting in more than 7,000 repair jobs which affected Con Edison customers.

Studies indicate that the number of compound events has increased over the past century for several major coastal U.S. cities.[88] In particular, New York City has observed an increase in compound events that may be attributable to a shift toward storm surge weather patterns that favor high precipitation. Importantly, heavy precipitation coinciding with storm surge could lead to increased flooding and possibly hinder disaster response protocols. One compounding event that impacted the service area at the local scale was the consecutive nor'easters event in March 2018, which resulted in more than 7,000 repair jobs and widespread outages.[89] In this case, multiple events hampered Con Edison's emergency response by stretching workforce capacity, limiting work time, and restricting access to nearby mutual assistance resources.

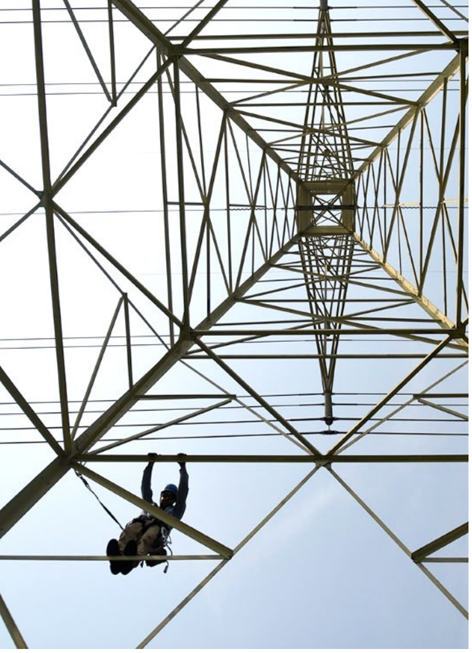
Future Projections

While extreme events are strongly controlled by natural weather conditions at a range of spatial and time scales, it is helpful to understand that natural variability is superimposed on top of climate change trends. This means that, for example, long-term increases in mean temperature incrementally raises the likelihood that the Con Edison service area will experience extreme heat waves over time. Similarly, long-term ocean temperature warming increases the likelihood of strong hurricanes, and potentially nor'easters, even if individual storms are largely dependent on short-term natural variability such as weather patterns. As a result, many climate-related extremes are projected to increase in frequency and magnitude simultaneously throughout the coming century; this will ultimately amplify the likelihood that multiple events will occur concurrently, consecutively, or in a compounded nature.

Of principal concern is that heat waves will become much more common by the late century, relative to historical conditions, which increases the likelihood that they will occur coincidently or consecutively with other extreme events such as hurricanes, humidity, or drought. The region could experience an increased risk of major hurricanes followed by extended extreme heat events[90], compounding impacts to Con Edison's system and customers if restoration times were slowed and power outages caused by the storm persisted through the heat wave. Multivariable heat and humidity events in the northeast United States could also become approximately 30 times more common by the end of the 21st century under the RCP 8.5 scenario.[91] Furthermore, another study found that compound dry-hot extremes are increasing across this region.[92] This combination of events may lead to high customer demand while critical system components are not functioning. As a result, large portions of Con Edison's customer base may lose cooling capabilities, exposing them to heat-related health and safety risks. In addition, other events like coastal flooding may damage the electric system and, if it cannot be fully repaired before a heat event, the stress of increased load may lead to additional failures.

One complication with dry-hot extremes is the potential for wildfires in more rural, wooded regions in and around Con Edison's service area. Wildfires, while less of a risk than other climate hazards, can pose a unique challenge to maintaining resilience. The projected increase in temperatures would lead to an increase in the dryness of organic material such as tree limbs (referred to as "fuel moisture") and combined with the potential for lighting strikes or human error could lead to a higher likelihood of fires. At this time, there is not enough certainty in projected trends to make actionable company investment decisions regarding wildfire (See Appendix 3: Wildfire for an expanded assessment of wildfire risk). However, the company can benchmark with other utilities, conduct drills with local government agencies, and assess current operational risks to determine the appropriate future action, if needed.

Con Edison and O&R have formed a wildfire review team, consisting of various operational, engineering, environmental and planning organizations. The team's objective is to review the historical and future impacts of wildfire risk within the Companies' service territories. Based upon the findings of these efforts, the team will develop recommendations to address the potential of wildfire risk.



Physical Vulnerability Assessment

As stated in the Introduction, this vulnerability Study builds upon Con Edison's previous climate change assessments, including the Company's 2019 CCVS and 2020 CCIP. In this Study, the Company further develops prior efforts by:

- Revisiting previously identified risks to determine if and how they may differ (in timing or magnitude) based on the updated climate change projections.
- Advancing prior work by completing a more comprehensive rating of risks to the various components of the Company's electric system between now and 2050. This advancement is particularly useful because it helps to highlight the near-term risks that will serve as a focus in the CCRP.

A detailed understanding of vulnerabilities is an important step toward identifying priority adaptation measures for the CCRP. The results of this vulnerability Study will be used to support Con Edison in its effort to develop a CCRP and increase its system resilience.

Methods

This vulnerability Study's methodology produces an understanding of the nature, extent, and priority of the vulnerabilities that Con Edison may face because of climate change. This is a refined methodology based on Con Edison's prior experience, but it draws from many established and widely adopted frameworks, including guidance from the U.S. Department of Energy.[93]

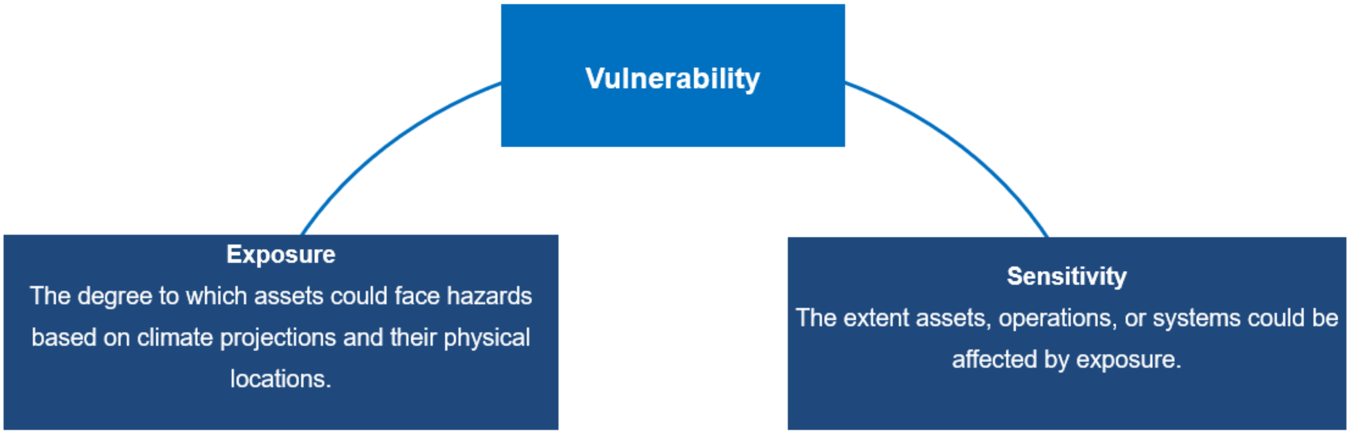


Figure 11. **Summary of vulnerability components**

To summarize, vulnerability is defined as the potential for assets or operations (and, by extension, customers) to be affected by climate change and the magnitude of potential impacts. As shown in Figure 11, vulnerability incorporates the degree to which assets may be exposed to climate hazards, as well as the potential impacts of exposure, as defined by infrastructure sensitivity.[xxv]

For each major asset group (i.e., overhead transmission, area and unit substations, underground distribution) and climate hazard (i.e., extreme heat and humidity, flooding, wind and ice) combination, vulnerability is rated and summarized as low, secondary, or primary (see Table 10 for definitions).

Asset groups incorporated in the assessment include transmission, area, and unit substations, overhead transmission and distribution equipment ("overhead T&D"), underground transmission and distribution equipment ("underground T&D"), and key company facilities. Each asset group comprises highly critical parts and subcomponents that contribute to the functionality and resilience of Con Edison's system. A non-exhaustive list of example subcomponents is shown below in Table 10.

Substations	Overhead T&D	Underground T&D	Key Company Facilities
• Transformers • Circuit breakers • Switches • Battery storage	• Conductors • Shield wires • Insulators • Wood poles • Steel towers	• Conductors • Conduits • Manholes	• Operations centers • Office buildings

Table 10. **Examples of asset subcomponents.**

[xxv] In many frameworks, consequence is another consideration in vulnerability assessments. However, the Company believes that all components of the electric system are essential for providing service to customers, so at the scale of this assessment, consequence does not provide a meaningful differentiation in overall vulnerability scores. Consequence will likely be revisited in the development of the CCRP and program implementation.

Exposure was qualitatively (literature reviews) and quantitatively (data projections) assessed using the findings from the Tailored Climate Data Analysis section. For flooding risk (e.g., sea level rise, precipitation), specific asset locations were geospatially compared to develop specific counts of exposed assets. For the other hazards (e.g., temperature, TV), that level of geographic differentiation of the risks does not exist. As such, exposure was assumed to be the same throughout the service area.

SMEs from the Study team assessed asset **sensitivity** (the degree to which assets, operations, or systems could be affected by exposure) by:

- Revisiting the prior assessments to determine if the previously identified risks were increasing, decreasing, or remaining the same.
- Reviewing electrical system equipment and processes to determine how climate change may affect their operation.

Exposure and sensitivity information for each asset-hazard combination was used to generate synthesized vulnerability ratings. **The ratings represent the potential of assets or operations to be adversely affected by projected climate hazards**. Vulnerability for each asset-hazard combination was scored as "low," "secondary," or "primary" to reflect which combinations are expected to be most impactful between now and 2050 based on the criteria identified in Table 11. Table 11 defines low, secondary, and primary vulnerability ratings and details the criteria that influence each rating.

Vulnerability	
Low	• Asset/system has low vulnerability to the given climate hazard. – There are minimal or no negative outcomes or effects associated with asset/system exposure to this climate hazard.
Secondary	• Asset/system is moderately vulnerable to the given climate hazard. • Vulnerability is influenced by one or more of the following factors: – Asset is expected to experience increased degradation over time. – Asset is moderately sensitive but expected to experience a limited increase in magnitude for the given climate hazard within the evaluated time horizon. – Asset has limited sensitivity, but the increase in magnitude for the given climate hazard is moderate.
Primary	• Asset/system is highly vulnerable to the given climate hazard. • Vulnerability is influenced by one or more of the following factors: – Asset is highly sensitive, and the increase in magnitude for the given climate hazard is high, resulting in a high risk of major individual failure or severe degradation of service. – Asset is only moderately sensitive to the given climate hazard but is expected to experience a large magnitude of change in the given climate hazard. – Asset is highly sensitive to the given hazard but will experience only moderate changes in the magnitude of the given hazard.

Table 11. **Vulnerability scoring rubric.**

Summary of Findings

Table 12 summarizes the findings of the vulnerability assessment. The table is divided into asset groups and climate hazards and represents vulnerability on a midcentury (2050) timeframe. The highest scoring asset-hazard combinations include:

- Substations and temperature/TV
- Substations and flooding
- Overhead transmission and temperature/TV
- Overhead distribution and wind and ice
- Underground distribution and temperature/TV

	Temperature and Temperature Variable (TV)	Flooding	Wind and Ice
Area and Unit Substations	Primary	Primary	Low
Transmission Substations	Primary	Primary	Low
Overhead Transmission	Primary	Low	Secondary
Overhead Distribution	Secondary	Low	Primary
Underground Transmission	Secondary	Secondary	Low
Underground Distribution	Primary	Secondary	Low
Key Company Facilities	Secondary	Secondary	Low

Table 12. Summary of vulnerabilities.

The following sections are organized by climate hazard and begin by identifying the sensitivities of electric assets as they relate to projected changes in heat and humidity, flooding, and wind and ice. These explanations are followed by more detailed, asset-specific descriptions for primary and secondary vulnerabilities. Additional information and in-depth explanations related to the expected impacts for each asset-hazard combination can be found in Appendix 2: Physical Vulnerabilities.

Temperature and Humidity

Increasing temperature and humidity are a risk to Con Edison's electric system. As noted in the Temperature discussion in the Tailored Climate Data Analysis section, updated climate projections indicate that electric assets will be exposed to higher temperatures sooner than previously projected. It is important to note that because there is one primary location with forward-looking projections within Con Edison's service territory, *all* assets are assumed to have the same exposure to future changes in temperature and TV.

In general, temperature increases are expected to occur about a decade earlier than previously anticipated; the temperatures previously projected for 2040 are now projected to be experienced closer to 2030. Current projections estimate that by 2050, there will be 32 days per year in which the daily average temperature exceeds 86°F, compared to 3 days in the historical baseline and 26 days estimated in the 2019 CCVS (a 23% increase). Additionally, heat waves have the potential to amplify the impacts of increasing average temperatures on infrastructure due to their length and intensity. Across Con Edison's service area, approximately 9 heat waves are projected to occur in 2050 compared to a baseline of 2 heat waves per year.

Overall, these projections indicate that heat-related resilience projects, such as primary feeder and non-network resilience projects, may need to be accelerated and implemented a decade sooner than previously understood.

The key sensitivities of electric assets to the projected changes in temperature and TV are:

- **Decreased asset capacity:** An asset's internal temperature is the result of (1) the amount of power flowing through it and (2) the temperature of the environment in which it operates. Operating at ambient temperatures above a design reference can decrease the operational rating of an asset. In turn, derating the system (reducing the output of power as a protective measure) due to increasing temperatures decreases the resilience capability of the system by decreasing capacity. When the capacity of the system is decreased, Con Edison will seek approval to make investments to replace lost capacity.
- **Accelerated asset degradation:** Assets are designed to operate within a particular environment. When temperatures exceed design assumptions, components (e.g., insulation) age at an accelerated rate.
- **Increased system load:** During periods of coincident high temperature and humidity (as represented by high TV values), customer cooling demand increases. Con Edison's system has historically experienced a spike in load during such conditions, primarily due to air conditioner use. These projected high-load situations could exceed system capacity.

Considering both exposure and sensitivity, the overall vulnerability of Con Edison's electric assets to changes in temperature and TV within the next 20 years is summarized below.

Area, unit, and transmission substations – primary vulnerabilities. Higher average temperatures, as well as periods of extreme high heat, increase the aging rate of substation subcomponents and the station's risk of premature or unexpected failure, which can consequently lead to outages.

Within a substation, transformers are more likely to be affected by chronic heat due to differences in design standards. Transformers are designed for a daily average temperature of 86°F with a maximum temperature of 104°F, while other equipment is designed to operate up to 104°F continuously. Additionally, higher ambient temperatures have the potential to lower the effective capacity of substation transformers.

Underground distribution – primary vulnerability. Exposure to heat waves can stress the internal components of underground distribution assets as well as cause higher peak electricity demand (further exacerbating internal conductor temperatures). Paper-insulated, lead-covered cables are particularly sensitive to extreme heat and exposure may lead to potential failure and, thus, customer outages.

Con Edison's Network Resiliency (formerly "Reliability") Index (NRI) models the consistency of the Company's underground distribution networks to better understand the potential scale and impact of heat on the system. Con Edison has a long-established NRI value of 1 per unit (p.u.) as the threshold over which network failure risk is considered unacceptable. Con Edison SMEs found that projected increases in TV may cause between 11 and 28 networks to exceed Con Edison's 1 p.u. standard of resilience by 2030.

Network Resiliency Index (NRI)

NRI is Con Edison's primary tool to predict the risk of failure by network. It models the relative strength of each network by calculating the probability of failure of multiple associated feeders within a network over time, as caused by individual component failures. It accounts for several climate variables including heat waves and TV.

Overhead transmission system– primary vulnerability. Overhead transmission lines are sensitive to high temperatures and can experience line sag and loss of material strength, especially when high temperatures coincide with high demand. Line sagging reduces the clearance between overhead assets and surrounding vegetation, which can increase the potential of contact with vegetation. Vegetation contact can cause arcing, asset failure, and safety risks. Derating lines helps mitigate the risk of line sag but could necessitate adding capacity to meet demand.

Overhead distribution system – secondary vulnerability. High temperatures can cause overhead distribution lines to experience sagging and loss of material strength. Line sagging reduces the clearance between overhead assets and surrounding vegetation, which can increase the potential for contact with vegetation, leading to asset failure and safety risks.

Key company facilities – secondary vulnerability. Exposure to increased temperature and humidity decreases the ability of key facility's cooling systems to sufficiently reduce the temperature of a space. This sensitivity could impact key facilities' heating, ventilation, and air conditioning (HVAC) systems and cooling towers that are used to cool components of the transmission system.

Flooding

Flooding due to sea level rise and coastal storm surge is a high priority vulnerability for Con Edison's electric system, and flooding from changes in precipitation is a secondary priority. As noted in the Climate Data Methods discussion in the Tailored Climate Data Analysis section, the latest climate data indicates that sea level rise projections have not changed from the 2019 CCVS (i.e., 16 inches by 2050 and 36 inches by 2100, relative to 1995-2014). However, there has been a small increase in projected heavy precipitation events. Specifically, projections show that annual days with precipitation exceeding 2 inches, relative to a baseline of three days, could reach five days in 2050 (the 2019 CCVS projection was four days). Days with more than 2 inches of rain per 24-hour period could cause flash flooding that could overwhelm drainage systems, which in turn could cause localized flooding onto Company property.

Based on sea level rise projections and findings from the 2019 CCVS, Con Edison updated its design standards to account for the projected amounts of sea level rise over an asset's useful life. More specifically, assets designed to be in place past 2050 will be designed to the elevation of the FEMA 1% annual chance flood (also known as the base flood elevation, or BFE) plus 5 feet (to account for projected 3 feet of sea level rise and 2 feet of freeboard). This requires redesign of assets currently designed with FEMA BFE plus 3 feet protections and new assets with a lifespan past 2050.

The primary sensitivities of electric assets to projected changes in flooding are:

- **Equipment damage:** Floodwaters damage electric equipment and decrease the life expectancy of assets. Equipment damage costs Con Edison both capital (needed for repairs) and time (which results in longer outages and can be exacerbated if spare parts are limited). Saltwater spray can also cause arcing and failure of components. In addition, continued exposure to water can rot wooden assets such as poles.
- **Equipment corrosion:** Sea level rise and coastal storms pose a particular threat to coastal assets due to the corrosive properties of salt water, which can damage electronic components. These impacts may not be immediately evident but can present issues over time that may result in asset failures and outages.
- **Soil weakening:** Exposure to water can weaken or undermine the foundation of equipment in instances of prolonged inundation or erosion, increasing the overall risk

of equipment damage. Increases in the projected flow and magnitude of floodwaters near riverbanks and the coast have the potential to alter and intensify how erosion occurs and may require intervention to avoid assets becoming destabilized or failing.[94]

- **Limited accessibility:** Flooding presents issues of access. If assets are flooded or surrounded by water at high tide or during storms, it becomes more difficult to access the locations for maintenance and repair.

The overall vulnerability of Con Edison's electric assets to changes in flooding within the next 20 years is summarized below.

Area, unit, and transmission substations – primary vulnerabilities. Substations contain equipment that is highly sensitive to flooding. The exposure assessment found that a 16-inch rise in sea level (2050 projection) would cause 23 substations to be inundated during a 1% annual chance flood. All of these locations could experience equipment damage, corrosion, soil weakening, and accessibility issues. Seven of these locations do not currently have flood protection in place, while 16 have existing flood protection that would need to be modified or replaced to provide sufficient protection against future flood levels.

Underground transmission and distribution systems – secondary vulnerabilities. In the event of a flood, the underground transmission and distribution systems could experience corrosion and limitations to access. This vulnerability is partially mitigated because all underground cables and splices operate while submerged in water. Additionally, all underground distribution equipment installed in current flood zones (and all new installations) are submersible. However, there is equipment in the expanded future floodplain that is not yet submersible, and deluge rainfall events that overwhelm the local stormwater systems can result in flooding outside of FEMA floodplains. In cases of incomplete sealing or existing damage, even submersible sub assets could be subject to damage.

Flooding also limits the ability of Con Edison staff to access underground equipment for maintenance or repairs. This is especially relevant for underground assets that could be inundated by sea level rise, as associated tidal flooding could happen more frequently.

Key company facilities – secondary vulnerabilities. Based on a geospatial analysis, 11 key company facilities could be exposed to a 1% annual chance flood by 2050 (and one facility would be inundated by tidal flooding on a daily basis). Some facilities, such as control centers, contain equipment that is sensitive to water and could be damaged if exposed. Additionally, flooding from any source represents an access issue. If a facility is flooded or surrounded by water at high tide, it becomes more difficult to access for daily use, maintenance, or repair.

Wind and Ice

The 2019 CCVS identified extreme wind and ice (as captured in the Wind and Radial Icing section) as a high vulnerability for Con Edison's electric system. The current assessment confirms these priorities for the overhead distribution system and adds nuance for other components of the electric system. As discussed in the Tailored Climate Data Analysis section, there is uncertainty about specific changes in these hazards. However, the scientific community is moving toward consensus that Con Edison's service area is likely to experience higher wind gusts in the future, and there remains the potential for severe radial icing events.

The primary sensitivities of electric assets to the projected changes in wind and ice are:

- **Line impacts:** Con Edison's electric system is built to withstand defined design tolerances for combined ice and wind loading, consistent with the National Electric Safety Code (NESC) Rule 250B. Wind or ice loading that exceeds these standards can result in asset failure, resulting in outages.
- **Vegetation impacts:** Strong winds and ice accumulation can cause trees and tree limbs to fall on overhead lines and other equipment, causing customers to lose service.

The overall vulnerability of Con Edison's electric assets to wind and ice within the next 20 years is summarized below.

Overhead distribution system – primary vulnerability. Overhead distribution assets, including conductors, attachments, and cross-arms, are built to withstand defined design tolerances for combined ice and wind loading. Wind and ice events that exceed those tolerances can cause asset failure. The overhead system is also sensitive to the indirect impacts of nearby vegetation falling onto overhead components. Tree contact can cause lines to disconnect and fall and can even lead to pole collapse, especially older poles or those with existing damage.

Overhead transmission system – secondary vulnerability. Ice accumulation on transmission towers and lines can result in unbalanced structural loading and subsequent transmission line failure. This is especially a concern when ice accumulation is accompanied by heavy winds. However, vegetation clearances for the overhead transmission system tend to be greater than for the distribution system, which somewhat mitigates the vulnerability.

Extreme and Coincident Events

This section summarizes low likelihood extreme weather event narratives that could lead to outsized impacts in the service area by midcentury. The narratives are based on historical analog events and climate projections summarized in the Tailored Climate Data Analysis section to generate near worst-case scenarios that are extreme and highly unlikely but portray potential high-impact weather events under projected climate change. These narratives explore event scenarios that could motivate an expanded set of resilience measures beyond system hardening alone and can help identify where a broader set of potential resilience investments may be needed. All of these events would amplify the vulnerabilities discussed in the prior subsections.

Hurricanes and Wind

A plausible extreme event **worst-case scenario** for mid-to-late century is for a Category 4 hurricane to track toward Long Island and stall or migrate west, immediately south of New York City, due to a blocking high pressure system. In this scenario, the hurricane would directly impact the Con Edison service area for more than 24 hours. A storm of this magnitude could present the following representative risks and upper-limit exposure to the service area:

- Initial sustained winds could be as high as 130-155 mph at the storm's center (i.e., only within the hurricane eyewall). These winds would likely quickly dissipate as the storm approaches the service area and interacts with land, undergoes shear, or weakens due to cold ocean water upwelling.
- Wind gusts could reach 100 mph across the service area and remain highest near the coast. Inland locations toward Westchester County could experience lower wind gusts (approximately 80 mph).
- Flooding depths due to storm surge could exceed 20 feet at the coast relative to mean lower low water (MLLW) (based on Category 4 NOAA Sea, Lake, and Overland Surges from Hurricanes (SLOSH) modeling) for large segments of the service area, including lower/mid-Manhattan, Harlem, and southeast-facing coastal sections of Staten Island, Brooklyn, Queens, the Bronx, and Westchester County.
- Projected sea level rise could exacerbate flooding extent and depth along the coast.
- Storm surge could extend through multiple tidal cycles due to the slow-moving storm. As a result, storm surge could amplify water depths at high tide (as reflected in NOAA SLOSH model simulations), and low tides could remain higher than normal due to ocean water buildup.
- Total rainfall amounts could exceed 10 inches across wide swaths of the service area over the duration of the storm. Flooding could be exacerbated at the convergence of runoff and storm surge, particularly due to base-level increases within the Hudson River backwater.

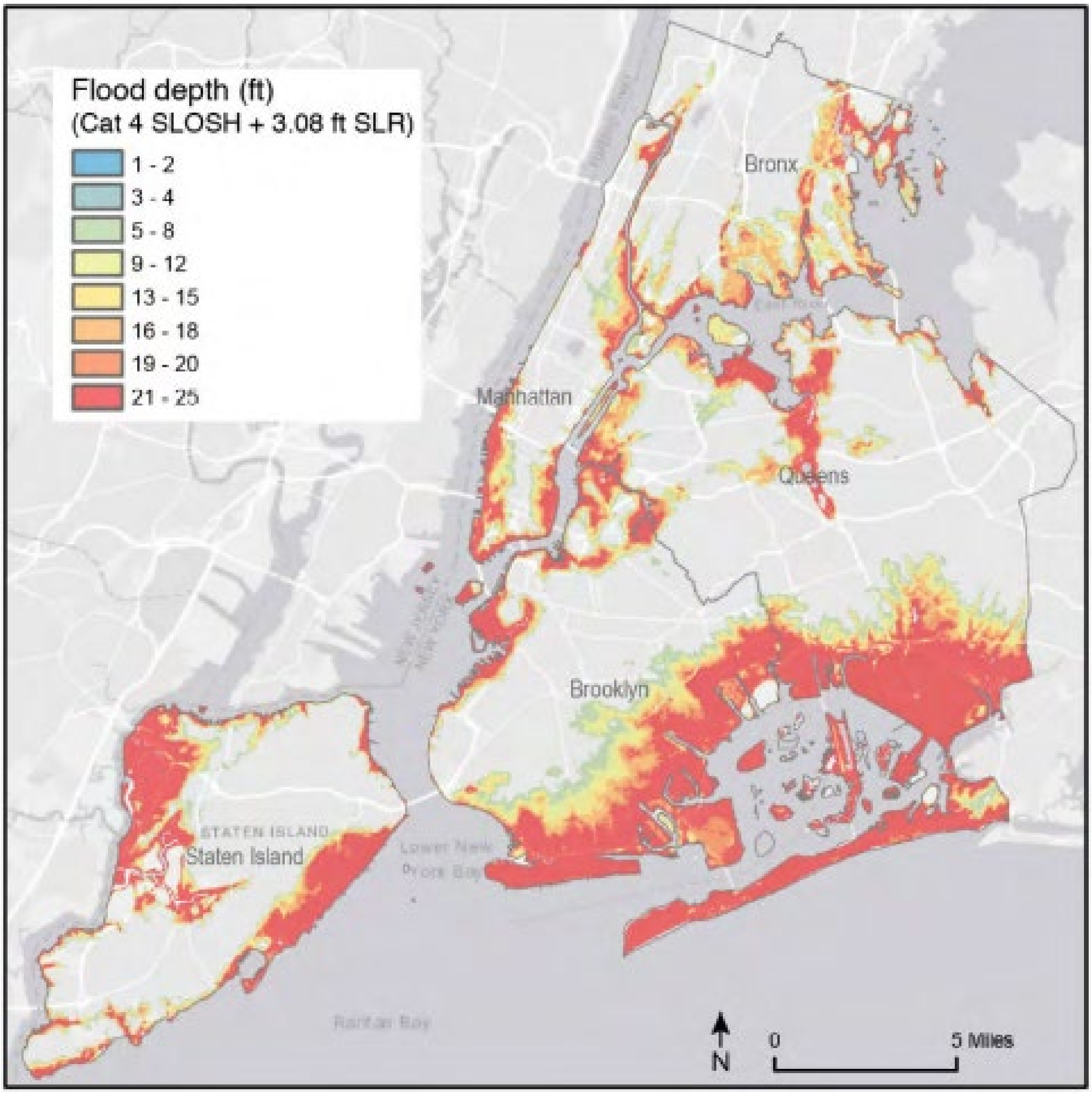


Figure 12. Coastal flood extent associated with a Category 4 hurricane storm surge, modeled using NOAA SLOSH output and assuming maximum storm surge during high tide. Storm surge depths (measured as water depth above-ground relative to the NAVD88 vertical datum) are evaluated by linearly adding 3.08 feet of sea level rise (corresponding to the 83rd percentile sea level rise in 2080 assuming RCP 8.5) to the SLOSH model output to represent estimated flood depths, if a Category 4 hurricane was to threaten the service area in the late 21st century.

Extreme Heat Waves

A plausible worst-case extreme event scenario for mid-to-late century is a 27-day heat wave with daily maximum temperatures exceeding 90°F each day. An event of this magnitude could present the following representative risks and upper-limit exposure to the service area:

- Maximum daily temperatures could exceed 95°F for significant stretches within the prolonged heat wave (i.e., more than five consecutive days).

- Temperatures could exceed 100°F within the prolonged heat wave.
- Nighttime temperatures could experience commensurate increases, meaning that daily mean temperatures could remain above 86°F for portions of the heat wave (i.e., for at least 20 days during the heat wave).
- The effects of UHI could lead to heterogeneous heat exposure across the service area, with hot spots having, on average, daily maximum temperatures about 5°F warmer than surrounding areas.

Nor'easters and Cold Snaps

A plausible extreme event worst-case scenario for mid-to-late century is for the Con Edison service area to be inundated by a historically unprecedented nor'easter tracking immediately east of New York City, with regional impacts persisting for 24 hours. An event of this magnitude could present the following representative risks and upper-limit exposure to the service territory:

- Storm track allows all precipitation to remain frozen, resulting in 30 inches of snow accumulation in New York City (Central Park) and higher amounts (up to 40 inches) in Westchester County.
- Incursion of warm air aloft could cause widespread ice accumulation of up to 0.5 inches before the snow event.
- Wind gusts could reach between 50 mph and 80 mph across the service area.
- Storm surge could exceed 10 feet at the Battery relative to MLLW, based on historical precedent (i.e., the nor'easter of December 1992, detailed in Table 18).
- Storm surge could extend through multiple high tides and be amplified due to the long-lasting nature of a slow-moving storm.
- Bitterly cold, subzero temperatures could last several days following the storm, as northwest winds draw cold polar air into the region from Canada.
- Cold snap could be broken by several days of temperatures well above freezing, causing rapid snowmelt and salt runoff into the underground system.

Multiple Extreme Weather Events

Con Edison recognizes that multiple extreme events can occur concurrently or consecutively, combining to create compounded conditions and impacts within the service area. There is high confidence that the probability of compound events has increased in the past due to human-induced climate change and will continue to increase with further global warming.[95] Compound events often form a cascade effect whereby individual events increase the likelihood of one another. Considering the interconnected nature between climate hazards and their associated impacts across time and space can provide a more complete assessment of risks than considering only one hazard at a time.

Con Edison SMEs have identified the relative magnitude of consequences associated with theoretical combinations of events, as shown in Table 13. Some combinations of events are more likely than others, though this was not factored into the impact intensity rating. Darker boxes represent higher relative impacts, while lighter boxes represent lower relative impacts.

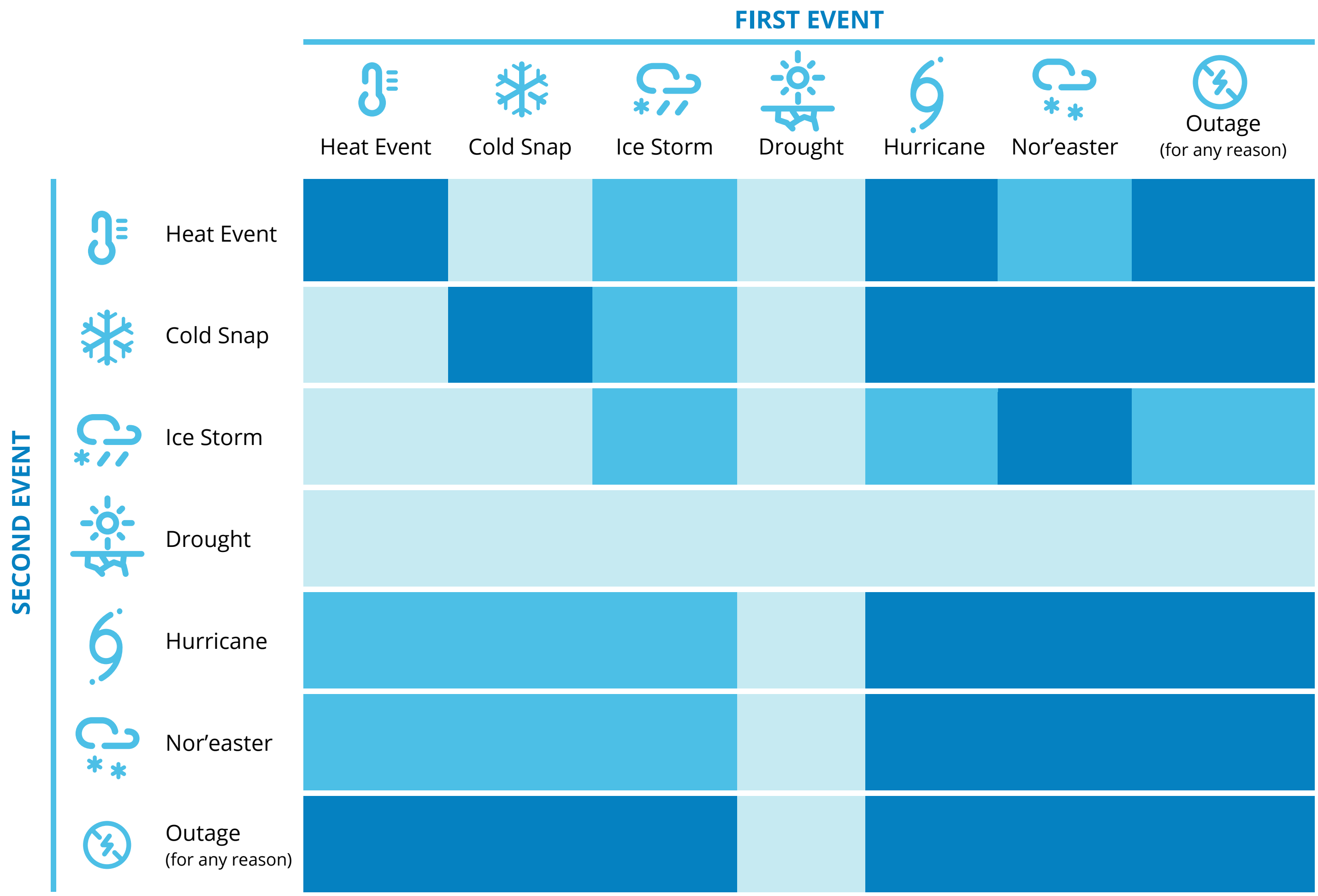


Table 13. **Relative impact to Con Edison from multiple, compounded events. Dark blue squares represent comparatively larger potential impacts. Impact scoring is informed in part by input from Con Edison SMEs.**

The driving events detailed in Table 13 manifest impacts through specific subdrivers. For example, hurricanes involve storm surge, high winds, and heavy rains. While storm surge and heavy rains may contribute to flooding and asset inundation, high winds may cause pole blowovers or power line damage from falling trees. When followed by another event, these subdrivers have unique compounding consequences. For example, consecutive nor'easters could initially present storm surge and wind followed by snowfall, which may limit repair efforts for fallen poles and power lines. At the same time, consecutive nor'easters may cause inundated assets to freeze, further impairing these components of Con Edison's electric system. Unique compounding subdriver impacts occur throughout all event combinations and motivate specific restoration and resilience strategies.

Additionally, if any of the individual events listed in Table 13 are preceded or followed by any outage, the consequences of the event could be amplified. Resilience or redundancy to absorb the event could be compromised and the event could cascade further on the system or be harder to resolve and restore.

Operational Vulnerability Assessment

Resilience to climate change cannot be achieved solely through hardening of physical infrastructure. In addition to assessing Con Edison's physical and infrastructural vulnerabilities to climate hazards, this Study provides an evaluation of potential climate risks to the Company's operations and planning processes. The operations and planning functions reviewed include:

- Worker Safety
- Load Forecasting
- Load Relief Planning
- Reliability Planning
- Asset Management
- Facility Energy System Planning
- Emergency Response

In 2020, Con Edison published their CCIP, which contained descriptions of how climate change could impact the processes listed above and proposed adaptive solutions. The following sections summarize potential impacts and how Con Edison's understanding of those impacts has changed given the updated climate science.

Figure 13. **Operations and planning functions that are vulnerable to climate hazards and were reviewed as part of this Study.**

Worker Safety

Current Practices: Con Edison maintains specifications and procedures to protect workers' safety and health, as well as the environments in which they work. These range from overarching corporate environmental procedures to general health and safety instructions, along with many others. For example, as a standard safety protocol, the Company provides and requires employees to wear fire-retardant clothing when working in areas with a potential for flame or electric arc.

Once at a work location, workers review site-specific safety, environment, and health protocols. The requirements include weather-related worker safety protocols, including measures to avoid heat stress and exhaustion. Con Edison's heat stress and overheating protections are based on recommendations from the National Institute for Occupational Safety and Health (NIOSH).

Con Edison conducts annual heat stress trainings that are based on NIOSH guidelines and industry standard practices. Internal and external stakeholders receive heat stress advisory communications periodically and prior to forecasted heat waves. The Company focuses on job planning and execution to put effective controls in place to keep Con Edison workers safe. The Company continuously monitors internal safety metrics, employee observations, field presence, and other indicators to determine how it can improve worker safety.

Future Impacts: Con Edison employees work to provide reliable energy to customers in virtually all types of weather conditions, including heat. The Heat Index quantifies the combined effect of air temperature and relative humidity and reflects the human-perceived, rather than the actual, temperature. The Company uses this index to assess health risks for employees working in the heat. Although temperature is a key indicator, humidity affects how workers feel and how easily the human body can cool. The Occupational Safety and Health Administration (OSHA) defines the threshold for high heat stress risk at 103°F. Climate projections show a potential increase in high heat stress risk levels of up to approximately 18 days per year by 2050. This may necessitate efforts to protect worker safety in the future, such as programs utilizing protective equipment, tents to work in shade and portable air conditioning units. In extreme cases, delays to projects could occur and consequently lead to further reliability disruptions.

In addition, air quality is another risk to workforce safety that was not directly studied in this analysis. Recent events in Northeastern U.S. have shown that climate change has implications for regional air quality due to wildfires in other parts of the region and the world. Con Edison must therefore be prepared to respond to air quality events that may become more frequent and severe.

Ongoing Efforts: Currently, Con Edison is monitoring changes in climate for impacts to worker safety as described above. As climate projections are updated, Con Edison will continue to assess the need for additional heat stress protocols or investments in new technology for climate change adaptation. Con Edison will also continue to monitor new technological advancements and new worker safety guidelines and benchmark with peer utilities to address operational excellence.

Load Forecasting

Current Practices: Con Edison is continuously investing in its systems to meet the current and evolving needs of its customers. During this period of energy transition and increased uncertainty, Con Edison is committed to continuously improving its forecasting methods, tools, and applications. These activities are founded on electric system load forecasting. Each year, the Company produces 20-year electric peak demand forecasts to help plan investments that meet projected growth in demand. Con Edison's demand forecasts consider recent weather and drivers of demand, such as new construction and economic activity; electrification of transportation, heating, and cooling and negative load modifiers such as energy efficiency, demand response, voltage optimization, photovoltaic/solar technologies, distributed generation, and battery storage.

Future Impacts: Temperature is the main climate-related variable that factors into load forecasts. Con Edison has developed its own customized temperature and humidity indicator—temperature variable, or TV— for peak forecasting purposes. TV is correlated with demand for power and uses cooling degree days (CDD) to evaluate volumetric forecasts. Con Edison's electric peak demand forecasts were previously calculated based on historical data and applied a fixed design TV of 86°F degrees in NYC and 85°F degrees in Westchester County. A rise in design TV will indicate higher peak demand and potential greater investment needs to meet it.

Ongoing Efforts: In 2020, Con Edison committed to updating the design TV values in their 20-year peak load forecasting process to account for climate change. This has already been estimated and incorporated into the process as a design TV of 87°F in 2030 and 88°F in 2040.

The Con Edison Commodity Forecasting Department has evaluated the service area's climate data and determined that the planned increases to design TV (as described above) are sufficient. CDD and HDD data were also adjusted for climate impacts as well as the volumetric forecast.

Load Relief Planning

Current Practices: Con Edison evaluates the growth in electric peak demand annually to identify areas where load could exceed system capacity. The Company then designs solutions to meet this growth and maintain equipment ratings within design parameters. This process, conducted uniquely for the electric system, is called load relief planning. Con Edison performs annual load relief planning at the distribution level. This planning cycle begins in the fall and is based on temperature-adjusted, actual peak loading from the summer, which is currently when load peaks (due to air conditioning).

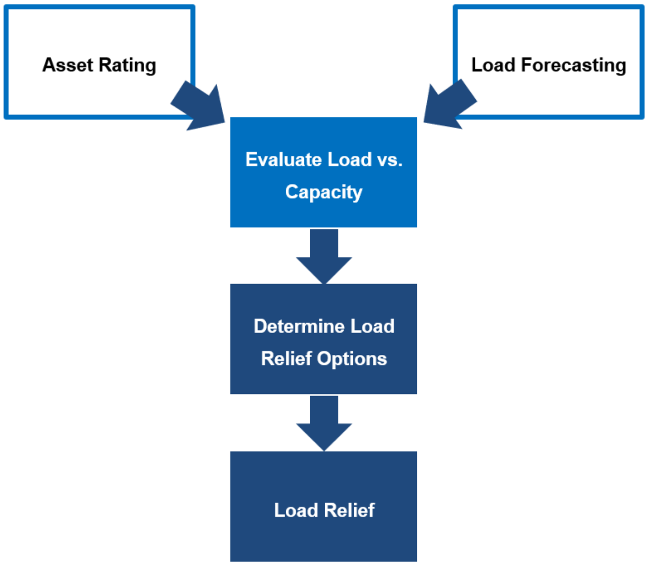


Figure 14. Load relief planning process

Future Impacts: Con Edison's selected temperature pathway indicates an increase in temperature and TV due to climate change. As a result, future load relief planning will need to account for the impacts of climate change on increased loads (driven by air conditioning use) and reduced electrical equipment capacity.

The Company assessed the implications of increasing temperature in its 2020 CCIP and found that about 1% of distribution network transformers could require action by 2040 as forecasted load exceeds transformer ratings (which may need to be lowered due to ambient temperature projections beyond 2040).

Ongoing Efforts: Higher projected temperature and TV values will likely increase load and decrease equipment capacity, which could necessitate additional load relief investments. The Company has updated its process for planning load relief measures to consider climate-driven changes in system load and asset capacity.

Reliability Planning

Current Practices: Con Edison is committed to improving electric system safety, reliability, and resilience. Each year, the Company conducts maintenance and investment activities in support of this commitment. Underpinning the Company's activities is a comprehensive reliability planning process for the electric subtransmission and distribution systems. The process considers performance at the asset, circuit, and system levels to identify electric system needs, solutions, and priorities. This planning process culminates in the development of reliability plans.

Reliability planning seeks to enhance the reliability of the electric system under all *operating* conditions, including heat, rain, wind, snow, ice, and other weather conditions. It also includes *system* conditions such as customer demand.

Future Impacts: Increased temperatures intensify customers' need for air conditioning and, in turn, places more demand on Con Edison's electric delivery system. Distribution equipment failure rates could rise with demand, particularly at the beginning of the summer. Therefore, future heat conditions are an important consideration in reliability planning processes.

In addition, storms and high wind events (particularly those that cause tree contact with power lines) drive equipment failures within Con Edison's overhead distribution system. As described in the Wind and Radial Icing section, scientific literature, including the Fourth National Climate Change Assessment, reports by the New York City Panel on Climate Change, and the MIT data, shows that winds are projected to become more intense, with faster wind speeds in the future (largely due to more intense storms). Future storms are thus an additional consideration in reliability planning for the overhead distribution system.

Ongoing Efforts: In the 2020 CCIP, Con Edison stated that it would use forward-looking climate change adjusted load forecasts and projected increases in TV in its resilience modeling. While these changes have been implemented, the latest climate projections suggest there may be a need for continued investment to maintain resilience in a more rapidly changing environment.

Asset Management

Current Practices: Con Edison's asset management program consists of processes, procedures, specifications, and protocols for the operation, maintenance, and replacement of equipment across the electric system. This includes 39 transmission substations, 62 area substations, 237 unit substations, 135,000 miles of cable, and 95,000 transformers, among other equipment. Asset management supports preventive maintenance and investments in reliability and includes processes for evaluating the condition and performance of assets.

Future Impacts and Ongoing Efforts: Con Edison's climate change pathways indicate future increases in temperature, TV, sea level, and wind and ice. Increases in temperature and sea level will directly affect the Company's asset management program.

- **Flooding:** Sea level rise and coastal storms pose risks to the electric system, as discussed in the Flooding section. Coastal flooding is projected to increase (meaning more frequent and severe flooding of equipment) in the 1% annual chance floodplain. However, Con Edison has already updated its design standards to account for projected changes in sea level. All new assets will be protected against flooding throughout their useful life. Updating existing equipment to meet this new standard, as discussed above, may require additional investment.
- **Temperature:** Electric equipment ratings are sensitive to increases in temperature. For example, asset ratings for transformers, cables, busbars, and connections on the sub transmission and distribution systems are all sensitive to temperature. As average temperatures increase, an asset's ability to dissipate heat decreases. To maintain an asset's useful life, Con Edison may need to lower (i.e., derate) the normal and emergency ratings.
- **Wind and Ice:** High winds and ice storms could increase the risk of vegetation and wind-blown debris coming into contact with lines. Contact with trees and/or debris can lead to an increase in damaged poles and lines.

Facility Energy System Planning

Current Practices: Con Edison operates buildings that use HVAC systems for indoor temperature and climate control. These systems require periodic evaluation of operating performance and replacement as they reach the end of their useful lives. Con Edison's facility energy systems are designed to maintain indoor climate within acceptable limits under a range of outdoor temperatures. In accordance with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards,[xxvi] Con Edison's HVAC equipment is designed for the top percentile temperature experienced in a year.

Future Impacts: In 2020, the Company found that, all else being equal, the size of the cooling equipment in Con Edison's facilities in New York City may require an increase of up to 40% by 2040.[96] The updated climate data indicate that this may become a concern sooner than was calculated in 2020.

Ongoing Efforts: Con Edison has updated its designs to provide more flexibility for modifications during HVAC system replacement. In addition, the Clean Energy Commitment by 2030 for facilities is evaluating the potential to electrify HVAC systems utilizing geothermal and heat pump technology.

[xxvi] ASHRAE is a nonprofit professional association that publishes technical standards, among other activities. Relevant standards include ASHRAE Standard 169-2021, Climatic Data for Building Design Standards.

Emergency Response

Current Practices: Con Edison's emergency preparedness group helps other Company departments prepare for and respond to storms and other emergencies. The Company maintains an Electric Emergency Response Plan for wind, rain, snow, heat, and other weather events. Con Edison also has a Corporate Coastal Storm Plan covering all Company departments for severe flooding events. The Company reviews and updates these plans regularly based on lessons learned from prior events. Finally, the Company regularly conducts drills and exercises to practice and prepare for real-life events.

Many of the Company's emergency response plans have triggers for storm preparation and staffing requirements based on the weather forecast and, for storms impacting the electric system, customer outage forecasts. For example, predicted coastal storms trigger companywide conference calls, beginning five days before the storm arrives, to plan mobilization and response. For overhead events, weather and impact forecasts provide lead time to electric operations departments to plan staffing and reach out to mutual assistance workers. For all extreme events, the Company can activate its Corporate Emergency Response Center (CERC) for companywide coordination and preparedness or response measures in anticipation of any impactful weather (e.g., prolonged heat waves, major coastal storms, nor'easters, etc.). The Company's Emergency Preparedness group serves as the liaison with all federal, state, city, and local municipal agencies to help coordinate assistance efforts following any impactful event.

Con Edison also employs meteorologists who monitor the weather, provide daily weather and system impact forecasts (e.g., expected number of outage jobs), and participate in all Company pre-storm mobilization meetings to provide the latest expected weather projections.

Future Impacts: As discussed in the Tailored Climate Data Analysis section, climate projections indicate that Con Edison's service area will likely experience more hot weather days, coastal flooding, and extreme storms. All of these hazards could result in more frequent activations of emergency response procedures. While Con Edison's existing emergency response system is flexible and well-prepared, a large increase in the number of activations could strain the system's capacity and resources.

Ongoing Efforts: Con Edison continuously updates its drills and exercises to reflect the types of extreme events anticipated under a changing climate. The Company plans to improve and better incorporate climate projections into its weather and impact forecast model it uses for emergency response preparation. The Company is also looking into leveraging various technologies (both software and hardware) that can assist with a variety of emergency response functions.

Potential Adaptation Measures

In light of the climate vulnerabilities described above, Con Edison will file a CCRP in November 2023. The plan will include a suite of adaptation measures to reduce risk to the system. These measures will be selected using Con Edison's resilience framework developed as part of the 2019 CCVS. One benefit of the framework is that it encourages *holistic* thinking about the types of measures that may help to build a more resilient system.

The framework encompasses investments to:

- **Prevent** climate change impacts by hardening infrastructure.
- **Mitigate** the impacts from outage-inducing events by minimizing disruptions.
- **Respond** rapidly to disruptions by reducing recovery times and costs.

The "prevent" component of this framework considers both gradual and extreme climate risks by proposing and evaluating resilience actions that consider the lifecycle of assets. As such, many adaptation strategies fall under this category. Investments to increase the resilience of the system to withstand climate events also provide benefits such as enhanced blue-sky functionality and reliability of Con Edison's systems.

In support of the resilience framework, a toolbox of potential adaptation measures has been identified that could help address the identified vulnerabilities (Table 14).

Hazard	Adaptation Measure
Temperature	Install equipment capable of collecting, tracking, and organizing temperature data at substations to allow for location-specific ratings and operations
Temperature	Increase capabilities to provide flexible, dynamic, and real-time line ratings for overhead transmission lines
Temperature	Make ground temperature data more accessible and track increases over time
Temperature	Routinely review asset ratings in light of observed temperatures
Temperature	Standardize ambient reference temperatures across all assets for developing ratings
Temperature	Continue to invest in grid modernization to increase resilience to climate change through new technology and increased data acquisition
Heat waves	Complete paper-insulated lead-covered (PILC) cable replacements
Heat waves	Implement load relief strategies to maintain NRI. Options include use of feeder extensions and sectionalization, replacement of poor performing circuits, installation of interrupters, and/or reconfiguration of networks with a combination of these options.
Heat waves	Incorporate climate change projections into NRI modeling
Heat waves	Improve fault monitoring capabilities
Heat waves	Maintain non-network resilience in higher temperatures by implementing autoloop sectionalization and increased feeder diversity
TV	Integrate climate projections into long-term load forecasts for temperature variable (e.g., 10- and 20-year projections)
TV	Develop a load relief plan that integrates future changes in temperature and TV into asset capacity and load projections
TV	Integrate considerations of climate change into the long-range transmission plan
TV	Continue tracking changes in the 1-in-3 peak producing TV event and update infrastructure design to match the observed changes
TV	Routinely update voltage reduction and hands-off thresholds in correlation to the changing TV ratings for electrical equipment due to the increasing temperature projections
Precipitation	Update precipitation design standards to reference NOAA Atlas 14 for up-to-date precipitation data [xxvii]
Precipitation	Update the design storm from the 25-year precipitation event to the 50-year event to account for future increases in heavy rain events

[xxvii] The record length for NOAA Atlas 14 precipitation data is characterized by the number of years for which annual maxima can be extracted rather than the entire period of record. A minimum of 30 data years is required for stations recording daily durations and a minimum of 20 data years is required for stations recording at sub-daily durations, with a few exceptions.

Hazard	Adaptation Measure
Precipitation; Extreme events	Harden electric substations from increased incidence of heavy rain events by raising the height of transformer moats, installing additional oil-water separator capacity, and increasing “trash pumps” behind flood walls to pump water out of substations
Precipitation	Underground critical transmission and distribution lines
Precipitation	Retrofit ventilated equipment with submersible equipment to eliminate the risk of damage from water intrusion
Precipitation	Reduce the incidence of manhole events due to increased precipitation and salting by (1) expanding Con Edison’s underground secondary reliability program; (2) accelerating deployment of vented manhole covers and latches to lessen the severity of manhole events; and (3) replacing underground cable with dual-layered and insulated cable, which is more resistant to damage.
Precipitation	Expand monitoring and targeting of high-risk vegetation areas
Sea level rise	Revise design guidelines to consider sea level rise projections and facility useful life
Extreme events – heat waves	After the annual NRI reviews, proactively install high reliability components and remove/replace high-failure equipment as needed (e.g., removal before failure strategy)
Extreme events – heat waves	Continue to actively engage forward-looking technologies to further reduce the impact of extreme heat on distribution systems by (1) using automated splicing systems to reduce feeder processing times and (2) integrating demand-response technologies that more efficiently regulate load
Temperature; Extreme events – heat waves	Replace limiting wire sections with higher rated wire to reduce overhead transmission line sag during extreme heat wave events. Alternatively, remove obstacles or raise towers to reduce line sag issues.
Extreme events – heat waves	Continue employing other measures to mitigate line sag risks, such as clearing out vegetation and contouring terrain
Extreme events – heat waves	Continue to track line sag and areas of vegetation change via LiDAR flyovers to identify new segments that may require adaptation
Extreme events – heat waves	Explore incorporating higher temperature-rated conductors
Extreme events – heat waves	Undertake measures that contribute to load relief and represent the lowest cost options, such as energy efficiency, demand response, and adding capacitor banks or upgrading limiting components such as circuit breakers, disconnect switches, and buses
Extreme events – heat waves	Gradually install transformer cooling or replace existing limiting transformers within substations
Extreme events – heat waves	Expand technologies to address the health of transformers in the face of extreme heat, including health monitoring and trend analyses
Extreme events – hurricanes	Continue to expand existing programs to reinforce transmission structures; address problems with known components

Hazard	Adaptation Measure
Extreme events – hurricanes	Invest in retrofits for open-wire design with aerial cable and stronger poles
Extreme events – hurricanes	Underground critical sections of the overhead distribution system to address resilience against hurricane force winds and storm surge
Extreme events – hurricanes; Precipitation	Continue to explore and expand operational measures to increase resiliency of the overhead distribution system by (1) increasing tree trimming efforts to limit tree-on-line events and (2) increasing spare pole inventories to replace critical lines that are compromised during extreme weather events
Extreme events – hurricanes	Complement the existing meteorological model used to predict work crews required to service weather-driven outages with an updated model that better resolves (1) extreme weather events and (2) extreme weather impacts to customers in the service area
Extreme events – nor'easters	Continue to expand programs to reinforce transmission and distribution structures and expand the number of compression fittings used to address weak points in transmission lines
Extreme events	Stagger demand response consecutive event days across different customer groups
Extreme events	Help demand response program participants understand the purpose and cause of the program
Extreme events	During load relief planning, consider if extreme events could reduce the effectiveness of the demand response program
Extreme events	Use Advanced Metering Infrastructure (AMI) to rapidly shed load on a targeted network to help manage demand so it does not exceed supply
Extreme events	Consider additional deployment of hybrid energy generation and storage systems at critical community locations and resilience hubs
Extreme events	Continue installation of energy storage strategies, including onsite generation at substations or mobile storage on demand/TESS units and CNG tank stations
Extreme events	Consider increasing the percentage of solar or other distributed generation projects to allow for islanding
Extreme events	Encourage onsite generation for individual businesses and residential buildings
Extreme events	Increase use of LiDAR and drones to assess damage and reduce manual labor
Multiple	Remote sensing and near-real-time monitoring (e.g., to aid storm recovery such as flood and system damage monitoring and assessment)
Multiple	Expand vegetation management practices to incorporate greater use of technology (e.g., GIS modeling, drones, LiDAR) and improve ability to assess potential impacts (e.g., combat line sag and wind-blown debris impact)
Multiple	Using Micronet and in situ observation, expand observations in Westchester County and Con Edison service area to understand UHI and other phenomena

Hazard	Adaptation Measure
Multiple	Using Micronet and in situ observations, standardize observations across stations

Table 14. **Ongoing list of adaptation measures.**

Conclusion and Next Steps

This Study analyzed climate data from Columbia University, MIT, and climate literature to develop an updated understanding of Con Edison's physical and operational vulnerabilities to climate change hazards over the next 20 years. The results are largely consistent with findings from Con Edison's 2019 CCVS, with accelerated projections for high temperatures being the most notable change. Flooding remains a concern, especially for exposed substations. A summary of the vulnerability findings is shown in Table 15.

	Temperature and Temperature Variable (TV)	Flooding	Wind and Ice
Transmission Substations	Primary	Primary	Low
Area and Unit Substations	Primary	Primary	Low
Overhead Transmission	Primary	Low	Secondary
Overhead Distribution	Primary	Secondary	Primary
Underground Transmission	Secondary	Secondary	Low
Underground Distribution	Primary	Secondary	Low
Key Company Facilities	Secondary	Secondary	Low

Table 15. **Summary of Vulnerabilities**

In Con Edison's 2020 CCIP, the Company committed to taking action to reduce many of the operational vulnerabilities by updating design standards and planning practices. However, updated climate change projections will mean that additional investments may be required to meet the standards set by the Company (e.g., for load relief planning, reliability planning). High temperatures and extreme events remain the largest drivers of operational vulnerability.

Adaptation measures will be developed for each primary vulnerability, using the list in the Potential Adaptation Measures section as a starting point. Adaptation measures will be identified for 5-, 10-, and 20-year time scales. Asset-hazard combinations considered to be secondary vulnerabilities may also be selected to have adaptation options developed, if deemed prudent by system engineers and climate change experts. These measures will be described in the forthcoming CCRP. Con Edison has begun development of the CCRP and will file it with the PSC in November 2023.

Climate science is a rapidly evolving field, with new models and studies being developed continuously. Therefore, Con Edison has committed to performing updates to this vulnerability Study using the best available science every five years.[97]

Appendix 1: Climate Science

MIT Projections

To try to further resolve future changes in wind, Con Edison obtained a dataset developed by MIT and previously used by National Grid. The MIT data contain projections for several hazards that were not available in the Columbia data, such as wind and icing. The MIT data provide complementary insights to the literature review, with dynamically downscaled projections on wind speed, wind direction, and radial ice accumulation with hourly time resolution in the Con Edison service territory. MIT projections provide a snapshot of climate change in the near future to help understand potential risks. The dataset was cited in the most recent IPCC report for its potential for local-scale risk analysis.

Limitations of the MIT data include:

- Future projections are available for only one near-term time horizon (2025-2041)
- The analysis uses a single GCM rather than a larger ensemble of models due to the high computational cost of dynamic downscaling relative to statistical downscaling (e.g., projections by Columbia for NYSERDA)
- The emissions scenario used is the older CMIP5 RCP 8.5 emissions scenario
- The projections do not resolve all storm event types, such as tropical cyclones, and may not be fully calibrated for all extreme variables (e.g., deluge precipitation)
- The data obtained do not include baseline model runs, so the Study team created an approximate observed baseline wind dataset based on locally observed one-minute wind speeds. This is an imperfect comparison because of constraints and differences between the datasets. However, it is intended to provide a first-order, directional understanding of how projected winds in the MIT data compare to historical observed conditions.

Historical Analogs

The following tables illustrate historical analogs for ice storms, hurricanes and tropical cyclones, and nor'easters that have impacted the region and surrounding areas.

Date	Radial Ice Accumulation	Impacts and Notes
February 12, 2017	Up to 0.2 inches in Central Park	Winter storm warnings were issued across much of the Northeast, including a blizzard warning for parts of Long Island. More than 2,400 flights were cancelled, and slick roads caused bus crashes in Manhattan.
December 17, 2016	Up to 0.08 inches in NYC	Traces of freezing rain impacted LaGuardia and JFK.
February 2, 2015	Up to 0.15 inches in NYC and 0.11 inches in Central Park	Snowfall and freezing rain impacted New York City, along with strong winds and blizzard conditions.
January 31-February 3, 2011	Up to 1.0 inch in northern New Jersey and NYC	Many areas of the northeast United States saw up to 1 inch of ice accumulation. Power outages, flight cancellations, airport closures, roof collapses, and more affected the area.
December 11-12, 2008	Up to 0.9 inches in Schenectady and Albany counties, NY	Widespread tree and power line damage. More than 350,000 customers lost power in New York and New England, with power outages lasting for several days after the storm ended. With hourly ice accumulation rates of 0.5-0.33 inches per hour recorded, this event is considered a benchmark for impacts to trees and power infrastructure from 0.5-1.25 inches of icing.
January 14-15, 2007	Up to 1.0 inch in Saratoga County	Widespread power outages (more than 100,000 customers) primarily impacted Capital Region and North Hudson Valley. Winds in the wake of the storm caused additional power outages, and arctic air drawn into region dropped temperatures into the single digits to below zero.
March 3-4, 1991	1-2 inches in most affected areas	This event produced over 17 hours of freezing rain and snow and caused power outages due to downed power lines and trees. Eighteen counties had disaster declarations in New York, and there were impacts in Rochester and Watertown. Nearly 325,000 customers were without electricity.
December 4-5, 1964	Up to 1.5 inches in east central New York	Widespread power loss occurred for up to two weeks, and it took more than a week for ice to thaw, leading to additional outages from snapped wires one week after event. The icing extended from Buffalo to Boston.

Note: Ice data are the range of observations from the three main reporting stations in the service territory. Data is from NOAA.

Table 16. Historical analogs for ice storms impacting the Con Edison service area and surrounding areas.[98]

Name	Date	Winds	Rainfall	Impacts
Hurricane Ida (remnants)	September 1, 2021	An EF3 tornado (136-165 mph winds) impacted Mullica Hill, New Jersey	~6.06 to 7.13 inches	A tornado watch was issued for the area; the storm forced most of the subway system to close with flooded stations; NYC was put under a flash flood emergency for the first time
Hurricane Henri	August 22, 2021	72 mph wind gusts at Great Gull Island	~2.30 to 4.45 inches	Set a daily rainfall record in Central Park of 1.94 inches in one hour, later broken by Hurricane Ida
Tropical Cyclone Isaias	August 4, 2020	70 mph peak gusts at JFK, sustained winds of 39 mph in NYC	~0.45 to 0.72 inches	Flash Flood Emergency Plan was activated; tornado watch was issued; more than 579,000 customers lost power in New York
Hurricane Sandy	October 29, 2012	30-55 mph, gusts to 80 mph	~0.5 to 1 inch	Major coastal flooding and power outages in the service territory; record maximum water level at the Battery
Hurricane Irene	August 28, 2011	32-46 mph, gusts to 59 mph	~5 to 6 inches	Center of storm passed directly over New York City; inland flooding (upwards of 12 inches of rain northwest of the service area)
Hurricane Floyd	September 19, 1999	25-40 mph, gusts to 46 mph	~5 inches	Major inland flooding (10-12 inches of rain) in areas just to the west of the service territory
Hurricane Bob	August 19, 1991	Gusts to 50 mph	~2.5 to 3 inches	Strongest impacts just to the east of the service area; winds approached approximately 100 mph and two tornadoes struck Long Island
Hurricane Gloria	September 27, 1985	Gusts to 51 mph in Central Park	~2.75 to 4 inches	Storm hit at low tide, but still caused flooding with 3.48 inches of rainfall in Central Park. The worst impacts were in Long Island, with strong winds of approximately 90 mph and heavy rainfall (~6 to 8 inches).
Hurricane Agnes	June 22, 1972	Gusts to 65 mph on Long Beach	~1 to 2 inches	Slow-moving storm caused rainfall flooding just to the west of the service territory. Locations in Pennsylvania saw approximately 10 inches of rain.
Hurricane Esther	September 18, 1961	Sustained winds of 40 mph and gusts up to 60 mph in Putnam and Rockland counties. Wind gusts up to 108 mph in Long Island.	~1 to 3 inches	Coastal flooding and winds of nearly 100 mph led to severe crop losses and more than 300,000 power outages.
Hurricane Donna	September 12, 1960	Gusts to 75 mph	~1 to 3 inches	Coastal flooding in lower Manhattan. Strongest wind gusts of ~100 mph over New Jersey.

Note: Wind and precipitation data are the observations from the main reporting station in the service area. Data are from NOAA.

Table 17. Recent historical hurricane and tropical cyclone analogs and associated wind speeds on the Atlantic Coast.

Date	Winds	Impacts
April 18-20, 2022	50 mph wind gusts along Long Island	Up to 18 inches of snow in New York caused delays, power outages, and other damages
January 31-February 2, 2021	Up to 50 mph winds at JFK*	More than $100 million in damages across the northeast United States
December 14-19, 2020	62 mph wind gusts in Mantoloking	Snowfall eclipsed the entire snowfall total from the previous winter season (surpassing 4.8 inches) and killed at least seven people
March 2, 2018	40-50 mph winds, gusts to 65 mph	Multiple tide cycles with coastal flooding; strong winds caused tree and wire damage
January 23-24, 2016	30-40 mph winds, gusts to 45 mph	Largest snowstorm on record in New York City (Central Park); blizzard conditions observed across the service territory
December 26-27, 2010	25-40 mph, gusts to 60 mph	Heaviest snowfall from the New York City metro area into the lower Hudson Valley; blizzard conditions observed across the service territory
March 13, 2010	40-60 mph winds*	Wind and coastal flooding event; heaviest rainfall from New York City, south and east
February 25-26, 2010	20-35 mph winds*	Temperatures near freezing caused a heavy, wet snowfall with greatest amounts in the lower Hudson Valley. Tree and power line damage was reported across the service territory.
February 16-17, 2003	25-50 mph winds*	Cold temperatures (in the teens) combined with very heavy snowfall and strong wind gusts
January 7-8, 1996	30-50 mph winds, gusts to 55 mph	Multiday event with widespread heavy snowfall; days after the storm, temperatures rose quickly, bringing rain and flooding
March 13, 1993	Gusts of 60-70 mph	Snow changed to rain, then back to snow. Extreme wind gusts caused power outages, and coastal flooding was also reported.
December 11, 1992	Gusts of 65-75 mph	Flooding in the New York City region; power outages impacted transportation systems; snow fell the next day (~6 inches)

Note: Wind data are the observations from Central Park, unless otherwise specified. Data are from NOAA.
*Indicates that these are the peak wind speeds.

Table 18. Recent historical nor'easter analogs and their associated winds in the service area.

Appendix 2: Physical Vulnerabilities

Temperature and Humidity

Considering both exposure and sensitivity, the overall vulnerability of Con Edison's electric assets to changes in temperature and TV within the next 20 years is summarized below.

Area, unit, and transmission substations – primary vulnerabilities. The combination of high exposure to increasing temperatures, potential for accelerated aging, and the need to decrease capacity of critical components justifies the primary vulnerability rating. Higher average temperatures, as well as periods of extreme high heat, increase the aging rate of transformers' insulation. Accelerated aging of critical components results in decreased asset life and increases the risk of premature or unexpected failure, leading to outages.

Within a substation, transformers are more likely to be affected by chronic heat because their design reference daily average temperatures tend to be lower (i.e., 86°F) than that of other assets. Circuit breakers, disconnect switches, GIS, and switchgear begin to experience degradation at temperatures above 104°F, which is projected to occur approximately five days per year in 2050, compared to a baseline of zero.

Additionally, higher average temperatures have the potential to lower the effective capacity of substation transformers up to 0.7% per 1-degree Celsius increase in temperature above 40°C (104°F).[99]

Underground distribution – primary vulnerability. Underground distribution conductors are highly vulnerable to increasing temperatures. Exposure to heat waves can stress internal components of these assets. Additionally, increased heat typically leads to higher peak electricity demand, further exacerbating internal conductor temperatures. PILC cables are particularly sensitive to extreme heat and exposure may lead to potential failure and, thus, customer outages.

Con Edison's NRI models the strength of the Company's underground distribution networks to better understand the potential scale and impact of heat on the system. Con Edison has long established an NRI value of 1 p.u. as the threshold over which network failure risk is considered unacceptable. During the 2019 CCVS process, Con Edison found that projected increases in TV may cause between 11 and 28 networks to exceed Con Edison's 1 p.u. standard of resilience by 2030. Currently, there are no networks that exceed this standard. Since 2019, Con Edison has continued to address projected deficiencies by making network investments in infrastructure hardening and added redundancy, diversity, and flexibility in power delivery. NRI is evaluated annually, adding recent system conditions and the latest climate projections to anticipate weaknesses in the system and identify investments to reduce the associated risk per the 1 p.u. standard.

Overhead transmission system – primary vulnerability. Overhead transmission lines are sensitive to high temperatures and can experience line sag and loss of material strength, especially when high temperatures correspond with high demand. Line sagging can reduce the clearance between overhead assets and surrounding vegetation, which can increase the potential for vegetation to come in contact with lines, leading to asset failure and safety risks. Derating lines helps mitigate the risk of line sag but could necessitate load relief measures (demand reduction calls, voltage reduction, or, at worst, localized outages) if other system capacity is unavailable. Comprehensive LiDAR and digital mapping of the transmission line right of way could help to better predict line sag issues in the future.

Additionally, in an environment of continued high heat and high load, transformer fuses may be triggered, resulting in transformer failure.

Overhead distribution system – secondary vulnerability. High temperatures can cause overhead distribution lines to experience line sag and loss of material strength. Line sagging can reduce the clearance between overhead assets and surrounding vegetation, which can increase the potential for vegetation to come in contact with lines, leading to asset failure and safety risks.

Key company facilities – secondary vulnerabilities. Exposure to increased temperature and humidity decreases the ability of key facilities' cooling systems to sufficiently reduce the temperature of a space. This sensitivity could impact both key facilities' HVAC systems and cooling towers used to cool components of the transmission system. In this situation, cooling systems would not fail, but rather would not be able to cool to specified temperatures. Although this is a concern over the next 20 years for both worker safety and critical system functioning, cooling systems generally have a short useful life (about 15-25 years), so it is likely that they can be upgraded at their next scheduled replacement to a larger size, if needed. For more information on this risk, see the Facility Energy System Planning section.

Flooding

The overall vulnerability of Con Edison's electric assets to changes in flooding within the next 20 years is summarized below.

Area, unit, and transmission substations – primary vulnerabilities. The exposure assessment found that a 16-inch rise in sea level by 2050 (relative to 1995-2014 sea levels) would impact 23 substations in 2050 by a 1% annual chance flood. All these locations could experience equipment damage, corrosion, soil weakening, and accessibility issues. Seven of these locations do not currently have flood protection in place, and 16 have existing flood protection that would need to be modified or replaced to provide sufficient protection against future flood levels.

Substations contain equipment that is highly sensitive to flooding. Specifically, the following components are unable to tolerate inundation without disruption or failure:

- Substation transformers
- Protection and control devices
- Circuit breakers
- Instrument transformers[xxviii]

In addition, substations might experience an overflow of water from transformer spill moats in a severe enough rainstorm that coincides with another source of flooding. However, the risk of such a coincidence is very low. Transformer spill moats are built to contain several sources of flooding at the same time.

Underground transmission and distribution systems – secondary vulnerabilities. Con Edison's underground electric systems are exposed to all surface-level flood events (via infiltration into manholes) and could be exposed sooner than surface-level assets if water can back up through conduits. This exposure is partially mitigated because all underground cables and splices operate while submerged in water. Additionally, all underground distribution equipment installed in current flood zones (and all new installations) are submersible. However, there is equipment in the expanded future floodplain that is not yet submersible, and deluge rainfall events that overwhelm the local stormwater systems can result in flooding outside of FEMA floodplains.

The primary sensitivities for this asset-hazard combination include corrosion and limited access. In cases of incomplete sealing or existing damage, even submersible conductors could be subject to corrosion. Salt water, either from storm surge or sea level rise, can infiltrate the underground distribution system, causing arcing and failure of components.

Chronic flooding events may also affect pad mount transformers and switchgear that are located on the surface and serving underground cables. Most pad mount transformers and switchgear are not designed to be submersible and cannot operate while flooded. Flooding also limits the ability of Con Edison staff to access underground equipment for maintenance or repairs. This is especially relevant for underground assets that could be inundated by sea level rise, as associated tidal flooding could happen more frequently.

Key company facilities – secondary vulnerabilities. Eleven key company facilities could be exposed to a 1% annual chance flood by 2050 (and one facility would be inundated by tidal flooding on a daily basis). Some facilities may contain equipment that is sensitive to water and could be damaged if exposed. Additionally, flooding from any source represents an access issue.

[xxviii] This category includes potential transformers, coupling capacitor voltage transformers, and current transformers.

If a facility is flooded or surrounded by water at high tide, it becomes more difficult to access for daily use, maintenance, or repair.

Overhead distribution system – low vulnerability. The exposure assessment projects that 12.4%, or just under 30,000, of Con Edison's distribution poles will be within the 1% annual chance coastal floodplain by 2050 (only 384 or 0.2% will be impacted by permanent inundation at this time).

In a worst-case scenario, exposure to flood events can result in structural damage and/or limit access to poles for maintenance or repairs. In more typical circumstances, distribution poles can tolerate temporary or even permanent flooding without meaningful impacts.

Overhead distribution system – low vulnerability. Overhead transmission assets have low sensitivity to flooding due to robust tower design. In extreme cases, the footing around tower foundations could become unstable.

Wind and Ice

The overall vulnerability of Con Edison's electric assets to wind and ice within the next 20 years is summarized below.

Overhead distribution system – primary vulnerability. Overhead distribution assets, including conductors, attachments, and cross-arms, are built to withstand defined design tolerances for combined ice and wind loading. The overhead system is sensitive to both the direct impacts of wind and the indirect impacts of nearby vegetation falling onto overhead components. Both of these scenarios can result in asset failure, leading to outages and restoration costs. Tree contact can cause lines to disconnect and fall, and can even lead to pole collapse, especially older poles or those with existing damage. Clearances between distribution lines and trees tend to be smaller than those for transmission lines, accentuating the risk for overhead distribution assets.

Overhead transmission system – secondary vulnerability. Ice accumulation on transmission towers and lines can result in unbalanced structural loading and subsequent transmission line failure. This is especially a concern when ice accumulation is accompanied by heavy winds. However, as stated above, vegetation clearances for the overhead transmission systems are greater than for the distribution system, which justifies the secondary rating.

Area, unit, and transmission substations – low vulnerability. Substation assets are typically designed with high wind loading thresholds and/or are located in cabinets or buildings that limit their exposure to wind and ice events.

Underground transmission and distribution systems – low vulnerability. Underground assets do not experience wind and ice hazards due to their location underground.

Key Company facilities – low vulnerability. Key facilities are not typically sensitive to average wind speeds. Although unlikely, some damage may occur from extreme wind events. Exposure to ice does not pose a significant risk to facilities. Con Edison's company facilities adhere to the NYC Building Code and are in accordance with the wind load requirements.[100]

First Event	Second Event	Key Concerns
Hurricanes		
Downpour	Heavy Winds	Overhead: Damage to overhead distribution lines and utility poles from being undermined.
Storm Surge	Heat Event	Substations: Equipment failure during a period of high loads.
Heavy Winds	Downpour	Switchgear, Insulators: Water intrusion, causing flashover.
Hurricane	Nor'easter	Health and Safety: Major system disruption; recovery efforts limited by loss of service.
Heat Waves		
Heat Event	Heat Event	Electrical Underground: Multiple locations without contingencies for redundancy.
Drought	Heat Event	Electrical Underground: Reduced cooling for transmission feeders.
Nor'easters		
Ice Storm	Cold Snap	Electrical Underground: Salt flow into manholes from snowmelt.
Snowfall	Cold Snap	Manholes: Salt flow into manholes; manhole explosions. Above Ground: Electric shocks; cable failures.
	Downpour	Electrical Underground: Salt impacts.
	Snowfall	Electrical Underground: Salt impacts.
	Ice Storm	Switchgear, Insulators: Contaminated insulators from deicing salts' flashovers.
	Heavy Winds	Overhead: Damage from heavy, wet snow.
	Thunderstorm	Manholes: Flooding.
	Nor'easter	Overhead: Electric failures; damaged equipment; high demand.
Nor'easter	Heavy Winds	Overhead Electric: Damaged overhead equipment from heavy, wet snow.

Table 19. **Multiple extreme event combinations, including primary extreme events (e.g., hurricanes) and subdrivers (e.g., downpours and heavy winds).**

Appendix 3: Wildfire

Summary

For the Con Edison service area, the **overall risk from wildfire remains relatively low**, particularly relative to the risks associated with other extreme weather events. The Study team reviewed the most recent studies on wildfire risk, which suggest there may be a potential increase in the occurrence of wildfires in highly forested areas. However, these studies have a high degree of uncertainty and vary based on local factors (e.g., population, urbanization, wildfire response). The projected increases in temperatures would lead to an increase in the dryness of organic material (referred to as "fuel moisture") and, when combined with the potential for lightning strikes or human error (the most common causes of wildfires), could lead to a higher likelihood of wildfires. However, mitigation measures and investments in wildfire control measures, such as fuel reduction measures taken by local government agencies, reduce the degree to which climate change increases the risk. Therefore, model projections that only consider the influence of climate change could overstate the amount that wildfire risk could increase in the future in the Con Edison service area.

Background

Wildfires, also called forest fires, are large, unplanned or unwanted fires that burn vegetation, often in arid, or dry, landscapes. Large wildfires require a substantial, relatively unfragmented supply of fuel, or flammable vegetation such as brush or forests, across a landscape. Wildfires may occur naturally from lightning, but human activity is the predominant cause of wildfires.[101] Fuel moisture refers to the amount of water within organic material; it is controlled by seasonal, daily, and immediate weather changes. Fuel moisture content limits fire propagation. When fuel moisture content is high, fires are difficult to ignite and burn poorly, if at all. When fuel moisture is low, fires start easily, and wind and other driving forces may cause rapid and intense fire spread.[102]

Review of Wildfire Risk

The frequency and intensity of wildfires across the globe has increased in recent years; studies have linked this to climate change through increasing temperatures and drying patterns.[103,104] Some studies suggest that lightning and thunderstorms could increase in the northeast United States as global mean temperatures continue to warm, and, therefore, the risk of wildfires sparked by lightning could also increase. Additionally, projected increases in drought in the service territory could further amplify wildfire risk. Studies have linked the co-occurrence of forest fires and drought and how plants' responses to drought may affect forest flammability, specifically increased forest flammability with decreased fuel moisture and an increased ratio of dead-to-live fuels.[105]

Models project fuel moisture decreases in the northeast United States due to future temperature increases. Future projections of fuel moisture potentially precondition the future service territory to wildfires (Figure 15).[xxix] Greater decreases are seen for the 2040-2069 period (Figure 15, bottom image) than for the 2010-2039 period (Figure 15, top image), reaching a -0.6% change in some areas, as shown by the darker red shading.

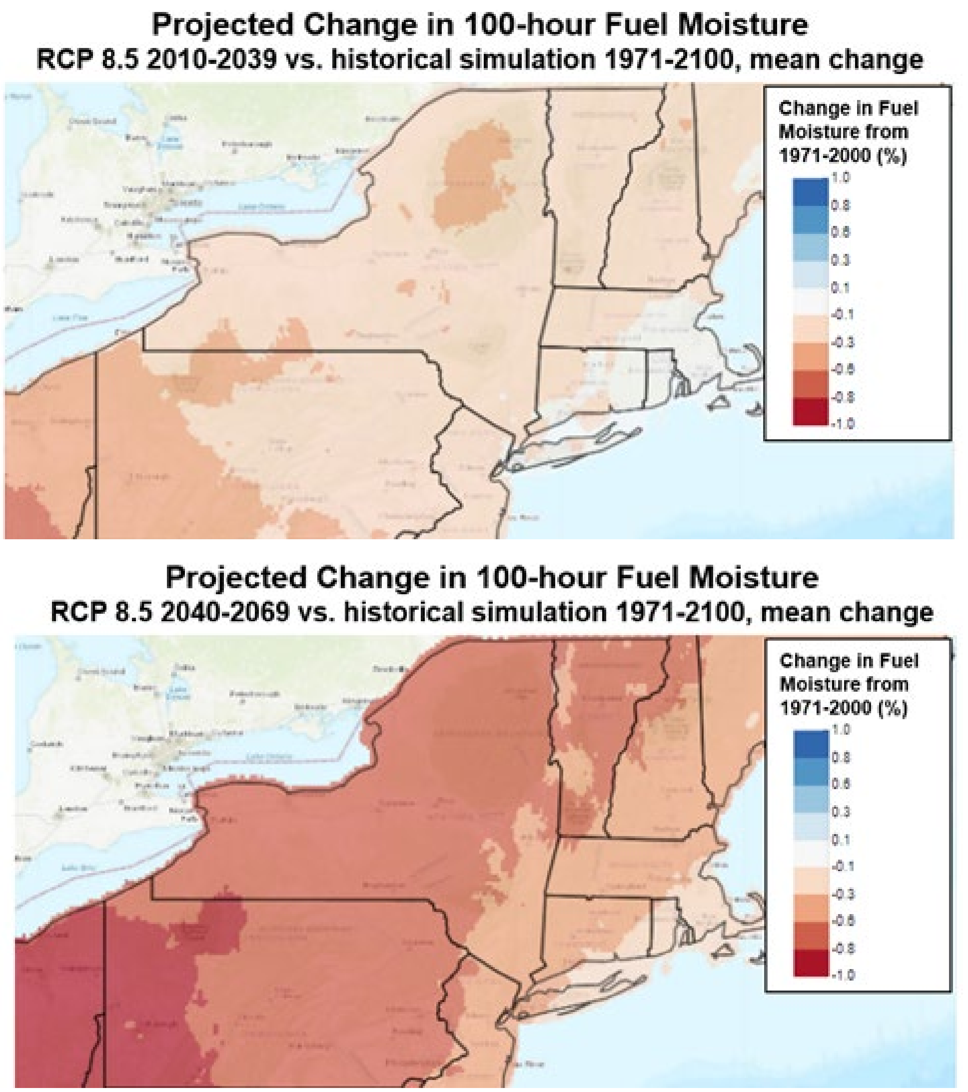


Figure 15. Projected change in 100-hour fuel moisture for summer months (i.e., June, July, August) under RCP 8.5 between 2040-2069 and 1971-2000 and between 2010-2039 and 1971-2000 using a multi-model mean derived from 18 downscaled CMIP5 models (https://climatetoolbox.org/tool/Climate-Mapper)

[xxix] Projections are from 20 Global Climate Models under RCP 4.5 and 8.5, which were downscaled to a ~4km resolution over the contiguous United States using the Multivariate Adaptive Constructed Analogs version 2 (MACAv2) statistical method with the gridMET training dataset from the University of California, Merced.

Furthermore, one study used an ensemble of statistically downscaled GCMs combined with the Physical Chemistry Fire Frequency Model (PC2FM) to project changing potential fire probabilities in the conterminous United States for the RCP 4.5 and RCP 8.5 scenarios. They found that regions not currently associated with frequent wildfires, such as New England, are projected to experience a doubling of occurrence probabilities by 2100 under RCP 8.5.[106]

Finally, changes in population, land use, and vegetation could play a role in reducing or enhancing wildfire risk during the 21st century. Population growth and urbanization, changes in the wildland-urban interface, and long-term changes in vegetation types could have impacts on ignition patterns and fuel combustibility, which will influence fire size and likelihood. In addition, climate change historically has less influence on fire activity in non-forested regions.[107] The enhanced drying effect of warming temperatures is most impactful to wildfires if shrub-covered or forested landscape is present to propagate fires. Importantly, these types of landscapes are limited across Con Edison's service area.

Ultimately, studies suggest that the occurrence of wildfires in the region could increase in the future due to climate change in forested areas, but these projections are characterized by a high degree of uncertainty. Projected increases in temperatures, decreases in fuel moisture, and increases in the occurrence of lightning strikes could act to increase the likelihood of wildfires in the northeast United States in the future. However, mitigation measures and investments in wildfire control measures, such as fuel reduction measures taken by the New Jersey Forest Fire Service, reduce the degree to which climate change increases risk.[108] Therefore, model projections that only consider the influence of climate change could overstate the amount that wildfire risk could increase in the future. Despite the potential for projected increases in wildfires, the overall risk in the service area remains relatively low, particularly relative to the risks associated with other extreme event hazards.

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