Climate Change Vulnerability Study

Final Report

December 2019

In partnership with:

ICF

Lamont-Doherty Earth Observatory
Columbia University | Earth Institute

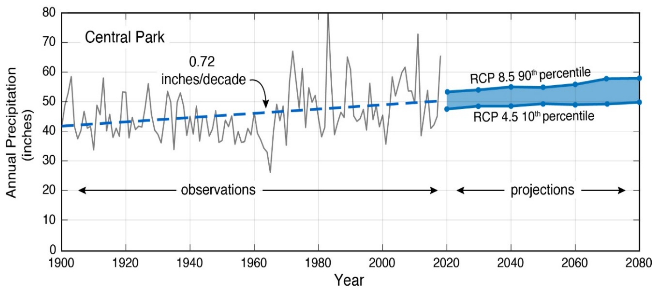
Contributions from: O'Neill Management Consulting, LLC, The Risk Research Group, Inc., and Jupiter Intelligence Inc.

conEdison

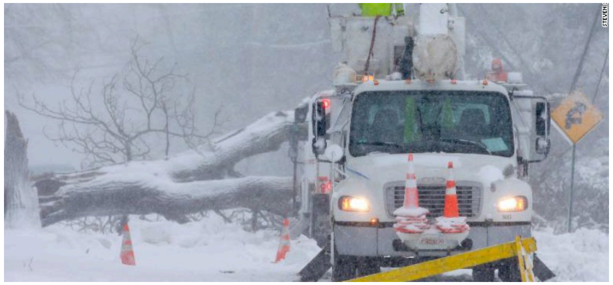
SUMMARY

Climate Change Vulnerability Study Goals

- Research and develop a shared understanding of new climate science and projected extreme weather for the service territory.



- Assess risks of potential impacts of climate change on operations, planning and physical assets.

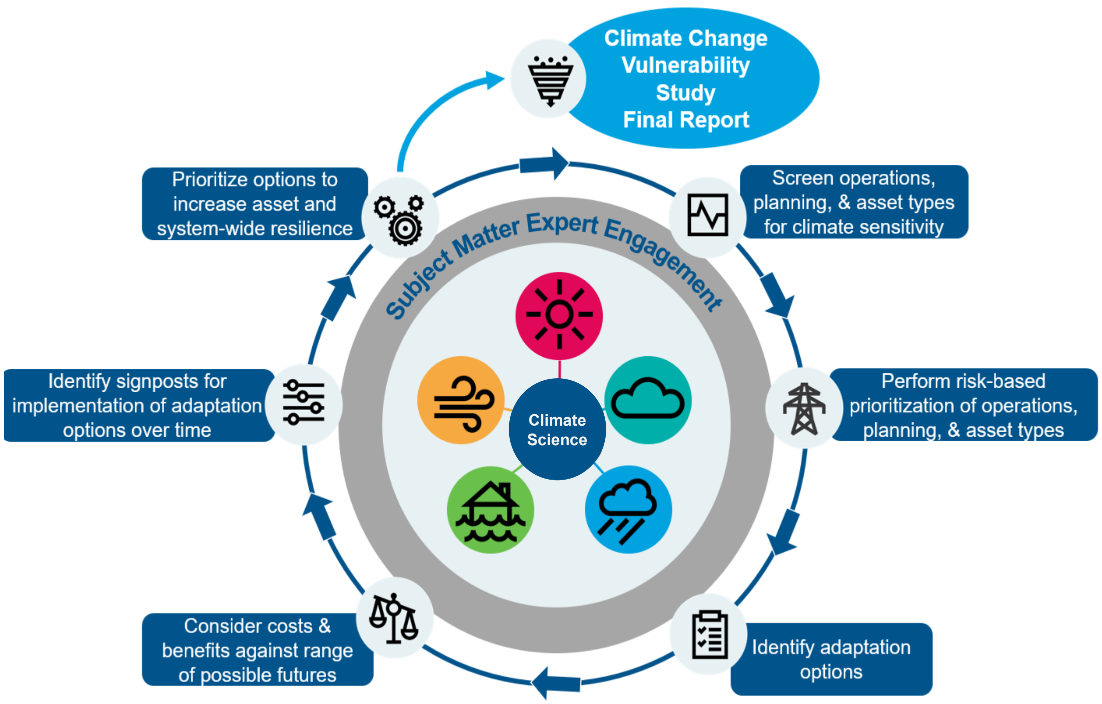


- Review a portfolio of operational, planning and design measures, considering costs and benefits, to improve resilience to climate change.

SUMMARY

Climate Change Vulnerability Study Approach

- Characterized historical and projected climate changes across Con Edison's service territory,
  - including increasing temperatures, heavier precipitation events, sea level rise and extreme weather.
  - Used best-available science, including downscaled climate models, recent literature and expert elicitation.
- Evaluated present-day infrastructure, design specifications, and procedures against expected climate changes to better understand Con Edison's vulnerability to climate-driven risks.



Conclusions

- Con Edison's three energy systems are all vulnerable to flooding while the electric system is additionally vulnerable to heat waves and overhead storms.
- Even under the most severe climate scenario, a combination of currently available and proposed adaptations options can effectively provide resilience for Con Edison’s energy systems.
- While many of the strategies used to build resilience after Superstorm Sandy will continue to be effective going forward, new adaptations may be needed to fully address growing climate risk.
- Much of Con Edison’s current analytical toolbox can help to assess and address climate risks, with opportunities to modify and improve (e.g., forward-looking reliability modeling and load forecasting).
- Some adaptation options can be incremented gradually (e.g., increasing system delivery capacity) while others (e.g., flood height protection) require earlier decisions and monitoring of signposts via the flexible adaptation pathway framework.

SUMMARY

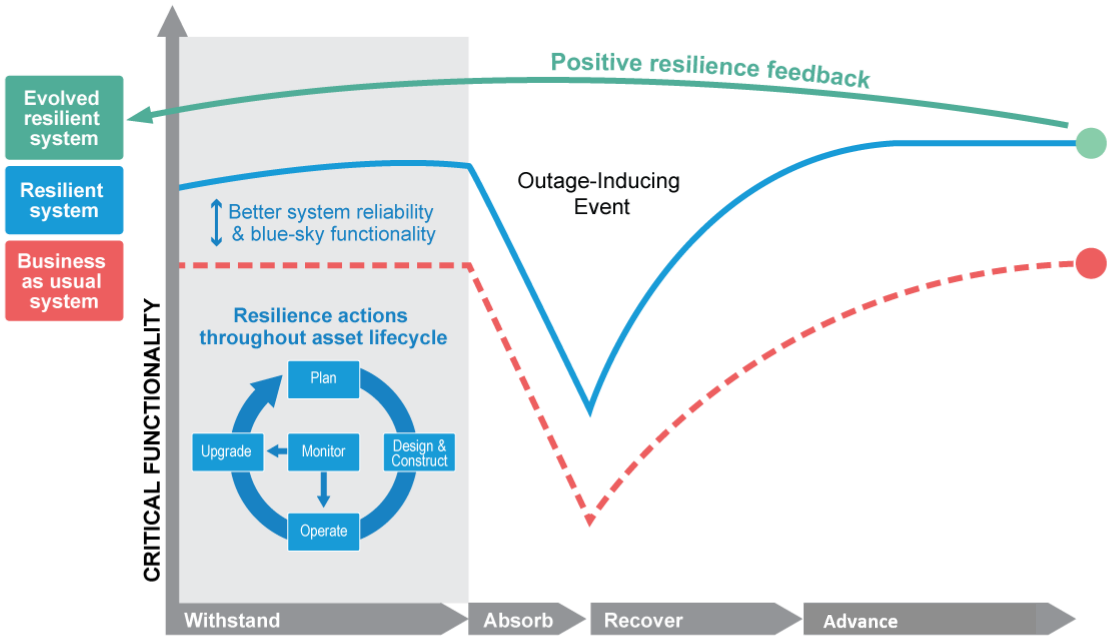
Conclusions (continued)

- This study used the best available climate science to evaluate risk and develop recommendations.
- Because climate science continues to advance, it is imperative that Con Edison keep abreast of new developments and evaluate the potential relevance of those developments to its long-term plans.
- Many of the most effective adaptation options will involve collaboration and will need to consider interdependencies with systems outside of Con Edison’s control.
- We will need to continue to manage uncertainties and will be developing appropriate responses in our implementation plan.

SUMMARY

Climate Change Adaptation Strategies

While Con Edison already uses a range of measures to build resilience to weather events, the vulnerabilities identified in the CCVS informed the development of a suite of additional recommended adaptation strategies.

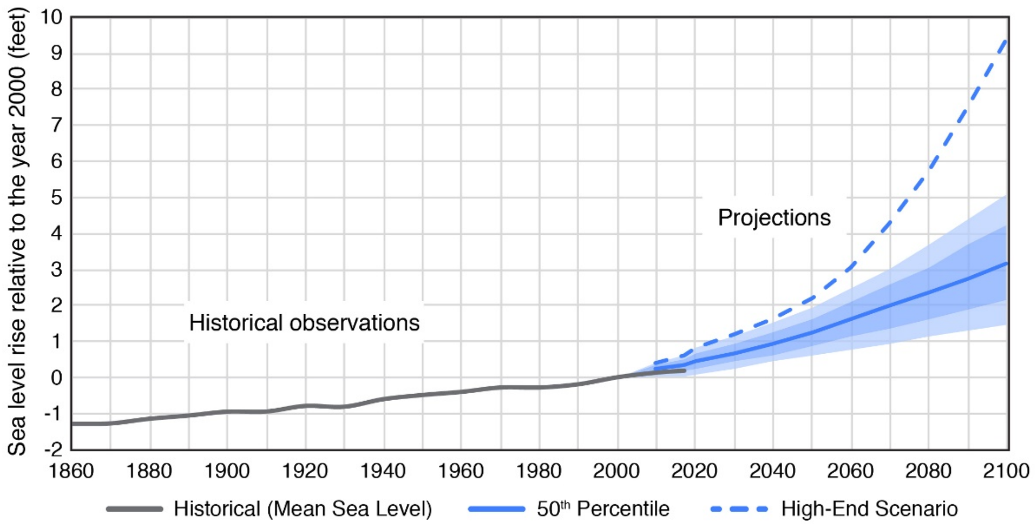


- The Study established an overarching resilience management framework that can strengthen Con Edison's resilience over time.
- While many adaptation strategies focus on withstanding (i.e., avoiding) impacts, comprehensive resilience requires a system to also be able to absorb (i.e., reduce), recover and advance further from impacts, particularly following outage-inducing events.

Withstand: Monitor

Monitoring lays the foundation for determining when additional resilience investments or changes in operational procedures are needed. Some of the monitoring strategies that Con Edison might consider include:

- Tracking updates in climate science
- Monitoring local changes in climate and differences in climate across the service territory
- Tracking weather-related expenditures and impacts
- Expanding system monitoring capabilities to preemptively identify increasing risks



Source: Columbia University

KEY RECOMMENDATIONS

Withstand: Plan

Incorporating climate change projections into Con Edison's planning processes will help identify needed investments. Some of the planning processes and tools that may benefit from consideration of climate change include:

- Load and volume forecasting for all commodities
- Load relief planning for the electric system, which should include reduced system capacity and higher load due to warmer temperatures
- Network reliability modeling and planning reflecting more frequent and severe heat waves
- Long range planning for all commodities
- Working with utilities in other environments to understand how they plan and design their system for the climate Con Edison will experience in the future

KEY RECOMMENDATIONS

Withstand: Design

The key to designing resilient infrastructure is to update design standards, specifications and ratings to account for likely changes in climate over the lifecycle of the infrastructure.

- While there is uncertainty as to the exact changes in climate an asset will experience, selecting an initial climate projection design pathway allows engineers to design infrastructure in line with Con Edison's risk tolerance.
- The Study team recommends an *initial* climate projection design pathway using 50^{th} percentile merged RCP 4.5 and 8.5 projections for sea level rise and high-end 90^{th} percentile merged RCP 4.5 and 8.5 projections for heat and precipitation. This approach follows the conservative precedent set by the City.

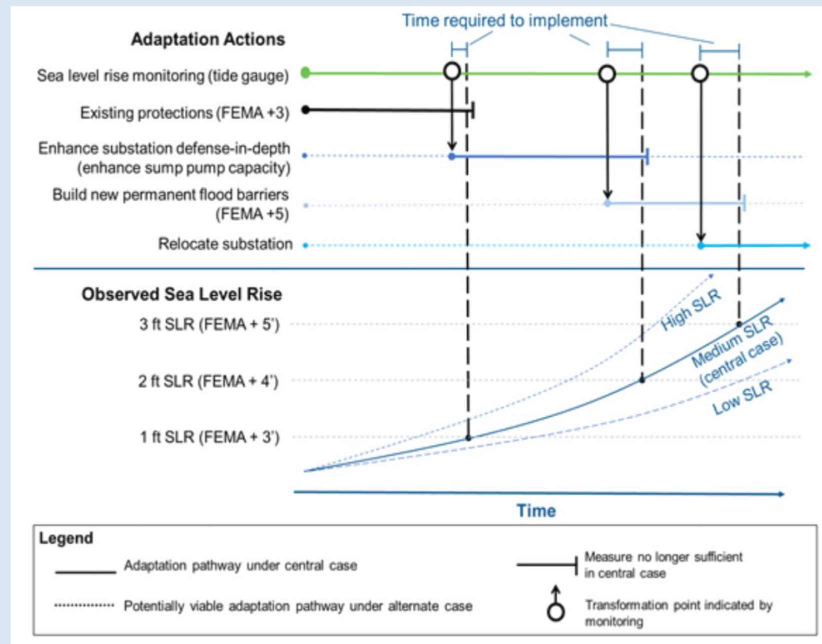
- The flexible adaptation pathways approach insures that selecting a climate pathway to plan to does not constrain the ability to revise adaptations in the future.
- Design standard should also reflect the useful life of assets as appropriate.

KEY RECOMMENDATIONS

Withstand: Upgrade

Upgrading existing assets is a critical tool to address vulnerabilities.

- Continue upgrading the capability of selected assets to withstand climate change (e.g.; selective undergrounding, stronger overhead poles).
- Changing design standards will influence the construction of new assets but does not address the vulnerability of existing assets.
- A flexible and adaptive approach to managing and upgrading assets will allow Con Edison to:
  - Manage risks from climate change at acceptable levels, despite uncertainties about future conditions.
  - Adjust adaptation strategies as more information about climate change and external conditions that may affect Con Edison's operations is learned over time.



Illustrative flexible adaptation pathway for a hypothetical Con Edison substation in a current FEMA + 3' floodplain

KEY RECOMMENDATIONS

Absorb and Recover

Absorb

- Incorporating low-probability events into long-term plans.
- Investing in energy storage, on-site generation and energy efficiency programs.
- Using smart meters to implement targeted load shedding to limit the impact to fewer customers during extreme events by limiting the likelihood of large-scale outages.

Recover

- Planning for resilient and efficient supply chains.
- Coordinating extreme event preparedness plans with external stakeholders.
- Expanding extreme heat worker safety protocols.
- Supporting the creation of resilience hubs (spaces that support residents and coordinate resources before, during and after extreme weather events and have continued access to energy service).

Advance

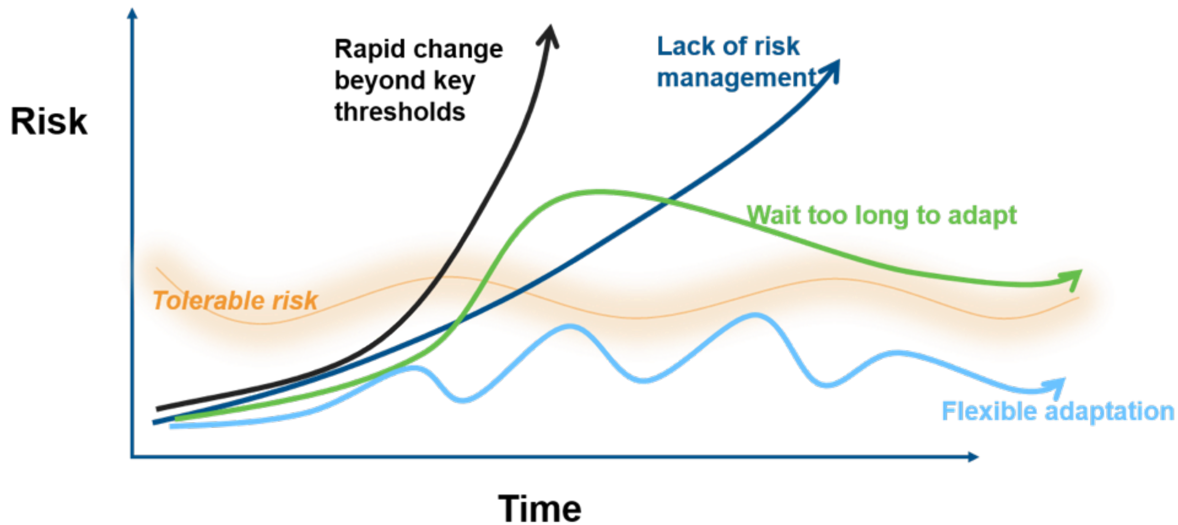
Advance

- Conduct pre-planning for post-event reconstruction to ensure restoration to a better adapted, more resilient state.
- Even with proactive resilience investments, extreme events can reveal system or asset vulnerabilities.
- Where assets need to be replaced during recovery, having a plan already in place for selection and procurement of assets designed to be more resilient in the future can help to ensure Con Edison is adapting to future extremes in a continuously changing risk environment.
- Measure the performance of adaptation investments during and after extreme events to inform additional actions.

Moving Toward Implementation

In 2020, Con Edison will develop an implementation plan that details priority actions needed in the next 5, 10 and 20 years.

- Con Edison is now equipped with a better understanding of future climate change risks.
- This information strengthens Con Edison's ability to more proactively address those risks.



Flexible adaptation over time facilitates helps keep risk within tolerable range

Figure adapted from Rosenzweig and Solecki, 2014.

NEXT STEPS

Implementation Plan

By December 31, 2020, Con Edison will develop and file with the PSC a detailed plan for implementation of the recommendations from the CCVS.

Con Edison will engage a stakeholder group for input on scope and to update on progress on a quarterly basis.

Key areas to be addressed in the plan are:

- Climate Projections and Development of Climate Projection Design Pathways
- Load Forecasting
- Load Relief
- Reliability Planning for the Sub-Transmission and Distribution Systems
- Asset Management
- Facility Energy System Planning (HVAC and Cooling towers)
- Emergency Response Activations
- Examination of Worker Safety Protocols
- Climate Risk Governance

Appendix

Energy System Vulnerability Screen

	Ambient Temperature	Temperature Variable	Precipitation	Sea Level Rise	Extreme Events
Electric	High Sensitivity	High Sensitivity	Medium Sensitivity	High Sensitivity	High Sensitivity
Gas	Low Sensitivity	Low Sensitivity	High Sensitivity	High Sensitivity	High Sensitivity
Steam	Low Sensitivity	Low Sensitivity	High Sensitivity	High Sensitivity	High Sensitivity

Low Sensitivity ● Medium Sensitivity ● High Sensitivity ●

Key Takeaways for Chapter 1

Current System	• Exceeding key reference points (86°F ambient summer temperature) can reduce equipment capacity (rating) and lifespan
Adaptation Options	• Consider climate change in long-term load relief planning • Install equipment capable of collecting ambient data; make ground temperature data more accessible and track increases over time • Track overhead lines with sag/clearance issue • Routinely review asset ratings in light of observed temperatures • Track weather-related costs and impact thresholds over time • Continue to invest in grid modernization to increase resilience • Review and centralize reference temperatures for asset ratings
Costs	• The potential maximum capital costs to add area substation and overhead transmission capacity is $510 million
Adaptation Indicators	• Number of days over specified reference temperature • Rate of change in key temperature climate variables • Estimated reduction in system capacity due to increases in temperature • Average change in asset service life from extreme temperatures

Key Takeaways for Chapter 2

Current System	• Increased frequency and intensity of heat waves will impact network reliability • Annual energy demand profile will shift towards cooling degree days and away from heating degree days

Adaptation Options	• Peak load forecasting
	  • Integrate climate projections into long-term forecasts of peak load
	  • Consult utilities in cities with higher temperatures to refine the load forecast equation for high TV numbers
	  • Consider changes in winter TV in long range planning processes
	• Load relief planning
	  • Develop a load relief plan that integrates future changes in climate

Costs	• The cost to adapt in 2050 could be $1.1 to $3 billion (RCP 4.5 or 8.5)
Adaptation Indicators	• Network Reliability Index (NRI) • Heat index • Cooling and heating degree days

Key Takeaways for Chapter 3

Current System	• Precipitation and flooding can pose a risk of steam main rupture, interruption of gas service and damage to underground equipment • Substation spill containment is sensitive to precipitation levels • Radial ice can lead to transmission and distribution line failures • Salt spread can result in manhole events
Adaptation Options	• Expand and accelerate hardening investments and operational programs (e.g., vegetation management, rain event day patrols) • Expand monitoring capabilities (e.g., remote monitoring of electric, steam and gas systems, crowd-sourcing leak detection) • Improve collaboration with the City of New York on stormwater design, maintenance, and hardening to address the coupling of systems
Benefits	• Economical, incremental adaptation • Positive company exposure and new community partnerships with the City
Adaptation Indicators	• Key existing precipitation thresholds • Updates to non-storm and storm precipitation projections

Key Takeaways for Chapter 4

Current System	• Post-Sandy investments resulted in infrastructure that will withstand one foot of sea level rise • 65-70% probability that one foot of sea level rise will be exceeded in the 2050s
Adaptation Options	• Continue to build to higher of FEMA + 3' or Category 2 storm • Upgrade design guidelines to integrate SLR & facility useful life • Leverage and adjust existing risk management tools • Consider/monitor how changes in the frequency of smaller flooding events impact assets • Leverage new innovations and advancements in flood protections • Perform coastal monitoring of SLR for adaptation timing
Costs	• The cost ($2018) to harden assets to FEMA + 5' could exceed $679 million
Adaptation Indicators	• Sea levels • Updates to design guidelines from NYC • Flooding events at existing assets • Community-scale flood protection strategies

Key Takeaways for Chapter 5

Current System	• **Hurricanes:** flooding may cause asset inundation and failure; high winds and heavy precipitation may damage or destroy overhead assets • **Nor'easters:** snow and ice loading may disrupt or stress overhead assets; street salt may corrode underground assets, causing damage and potential failures • **Heat waves:** heat-driven load increases may cause cables and splices to overheat, transformers to overheat, and distribution and transmission lines to sag
Adaptation Options	• **Harden:** Reinforce or retrofit equipment to harden against extreme conditions • **Absorb:** Increase the ability to shed non-critical load to ensure continued service of critical loads • **Recover:** Develop and prioritize creative strategies that align with and promote customer and community resilience/coping, such as resilience hubs and energy storage • **Recover:** Increase recovery efficiency through continued improvements to workforce sourcing, supply chains, communications, and coordination on City-dependencies • **Adapt:** Re-assess and update designs after extreme weather events as appropriate
Benefits	• Economical and flexible adaptation strategies • Improved customer safety during extreme weather • Proactively planning for and adapting to extreme weather events builds resilience into Con Edison's system, providing important co-benefits, such as better blue-sky functionality
Adaptation Indicators	• Frequency and characteristics of events, damages incurred, costs of these damages • Number, spatial extent, and duration of outages caused by extreme weather • Number of customer complaints received relative to extreme events