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Transmission System Reliability in the Face of Climate Change

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Motivation

- Utilities are faced with the need to better understand their vulnerability to climate change and how to mitigate the resulting risks. With respect to transmission systems, it is anticipated that climate change will be accompanied not only by higher temperatures and humidity, resulting in higher peak system loads, but also by more frequent periods of relatively high load.
- This would render the transmission system potentially more vulnerable to reliability challenges.
- To better understand the risks posed by climate change, we used existing reliability models to predict whether longer periods of high load and worse weather would affect transmission system reliability.
- To accomplish this, we projected future values of temperature and humidity for the years 2030, 2050 and 2080, assuming a conservative climate change pathway (the 90th percentile prediction for Representative Concentration Pathway (RCP 8.5): this analysis therefore represents a stress test.

Method/Approach

- Sets of predicted temperature and humidity data were developed from Global Climate Model predictions, bias-corrected and downscaled as described.
- Specifically, the high- end projection (90th) were developed for Representative Concentration Pathway2(RCP) RCP 8.5 in the near, intermediate and long terms. Specifically, we used Predictions for 2024, a 90th percentile case for RCP 8.5 in the years 2030, 2050 and 2028.

Predictions

- The frequencies of severe heat waves; the percentage of days where the value of the Temperature Variable (TV) is or exceeds 86oF (30ºC); and the percentage of hours in which transmission system load exceeds 80 % of peak load are presented for the cases modeled in Figure 2.
- The predicted frequencies of load drop and challenges to the reliability of transmission system in summer for the cases modeled and expressed relative to the base-case predictions made for 2024 are presented in Figure 3.

Model and Data

- The model employed is a 2024 reliability model for Con Edison's transmission system.
- This system comprises 438 miles of overhead circuits operating at 138, 230, 345 and 500 kilovolts, 727 miles of underground circuits operating at 69, 138 and 345 kilovolts, 38 transmission substations and 63 area substations.
- All these are modeled together with ~ 10,000 pieces of equipment.
- The model is embedded in a sequential Monte Carlo simulation, the failure of equipment and its restoration to service being followed over time.
- As the failure rates prevailing at any time are determined for each piece of equipment by the prevailing weather and prior events, the simulation will ascertain if a particular vulnerability to climate change has a significant effect on system reliability.

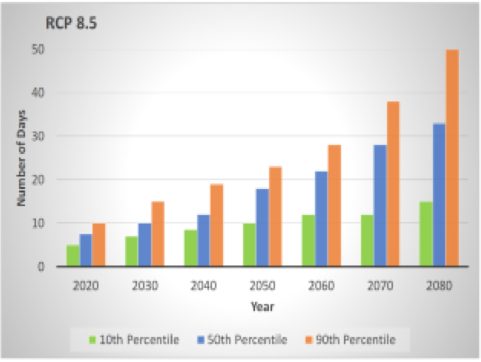

Figure 1 : Projection of The Average Number of Days per Year with Maximum Summer Air Temperatures Exceeding 95°F in Central Park, NY [3]

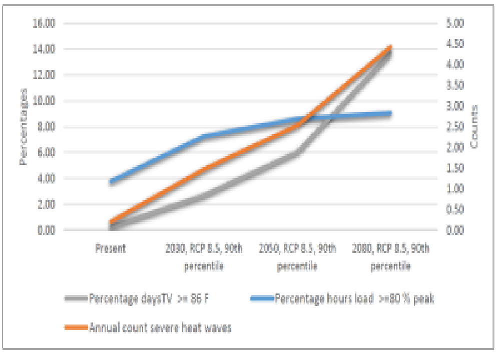

Figure 2 : Heat Waves and Loads, 2024-2080

Transmission System Reliability in the Face of Climate Change

continued

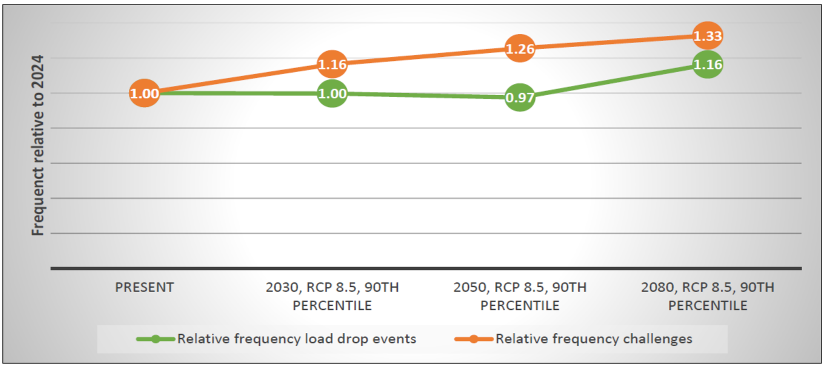

Figure 3 : Predicted Relative Frequency of Load Drops and Challenges, 2024-2080

Predictions (Contd.)

- The types of equipment associated with the predicted causes of load drop in the various cases are presented in Table 1. It appears that, ignoring asset degradation associated with increased temperatures and weather effects, no statistically significant change in the causes of load drop occurs results from of increases in load and heat wave in climate change.

Table 1

Types of Equipment Associated with the Causes of Load Drop

Equipment	Present	2030, RCP 8.5, 90th percentile	2050, RCP 8.5, 90th percentile	2080, RCP 8.5, 90th percentile
Breaker	6	4	5	4
Bus	4	4	4	3
Circuit switcher	4	5	5	4
Disconnect switch	2	1	2	2
Generator	0	1	2	2
Lines	46	43	46	44
Transformer fails	37	41	36	40

Table 2

Load Drop Frequencies for 2080, RCP 8.5, 90th Percentile Case with Asset Degradation

Case	Relative frequency summer load drop events
Base case: no accelerated degradation	1.16
Accelerated degradation	1.54
Accelerated degradation with the pro-active replacement of transformers with high hazard rates	1.48
Accelerated degradation with the pro-active replacement of transformers older than 30 years or with high hazard rates	1.07

Table 3

Load Drop Frequencies for 2080, RCP 8.5, 90th Percentile Case, with Worse Weather

Case	Relative frequency summer load drop events	Events to which lightning contributes (%)	Events to which rain contributes (%)
Base case: no accelerated degradation	1.16	6.38	0.13
Worse weather	1.22	8.44	0.25

Conclusion

• The increase in the load drop frequency will be small in the near- and intermediate term. By 2080, however, we predict a 16 % increase in the summer load drop frequency if the worst-case climate change scenario is assumed and if no action is taken. We expect, however, this potential for increased load drop frequency can be dealt with using the same measures now used to address transmission system reliability.

• If left unchecked, the accelerated aging of transformers might pose reliability problems, but the pro-active replacement of transformers will mitigate this.

• The load drop frequency would increase if peak loads are higher than are designed for. For example, we predict an additional 13 % increase in load drop frequency if loads are 10 % higher than those anticipated or unanticipated temperatures require a 10 % derating of equipment.

• The load drop frequency would increase with more severe summer weather but not markedly, but this analysis does not include hurricane events. Susceptible transmission and distribution substations have been reinforced to guard against storm surge damage.

Transmission System Reliability in the Face of Climate Change continued

Conclusion (Contd.)

These conclusions suggest that no immediate action is required and that the anticipated adverse effect of climate change can be mitigated readily. That said, we will continue to monitor the impacts of climate change, obtaining new climate data periodically and using the best available science to review our models. We will also explore how the adoption of new and improved technologies such as energy storage, advanced power-flow control devices, high-power delivery systems, advanced sensors and advanced protection systems and the incorporation of distributed energy resources can enhance reliability. Finally, we note that with the development of our climate change implementation plan, we have now made designing for climate change impacts part of our engineering process.