



U.S. Nuclear Regulatory Commission
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MARCH 8-10, 2022

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Weather-Related Loss of Offsite Power Trends and Risk Insights

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Overview

- Evaluations of recent events caused by severe weather conditions have provided important risk insights.
- Severe weather events are most likely to lead to losses of offsite power (LOOPs).
 - A review of current LOOP data and trends can be used to evaluate whether more extreme weather events affect nuclear power plants.
- Key Questions
 - Are the frequency and duration of weather-related LOOPs changing?
 - What do the results and insights from recent weather-related LOOPs tell us?



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LOOP Data and Trends



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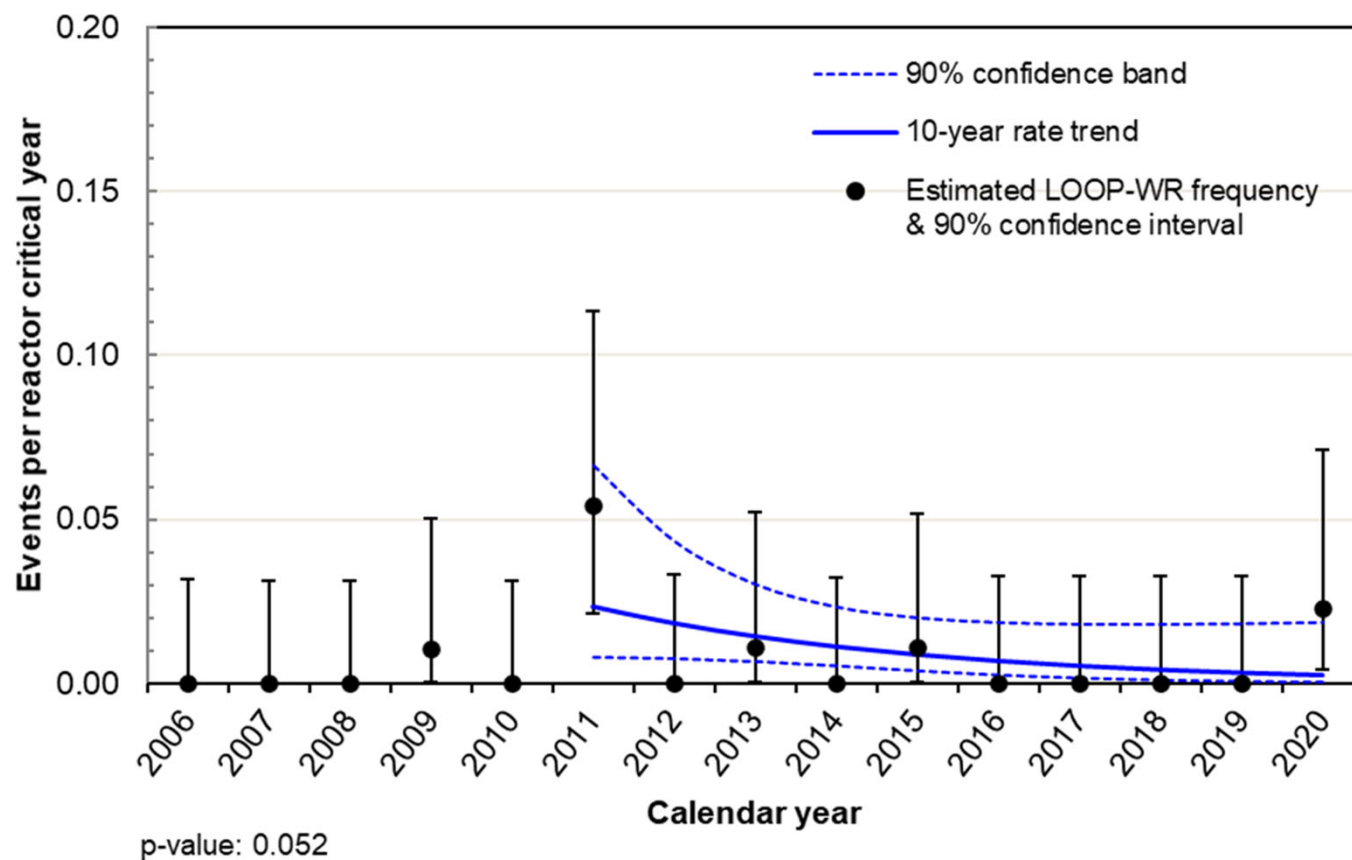
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LOOP Frequencies

- The overall frequency of all LOOPs is decreasing over the past 15 years (2006–2020).
- There is no statistically significant trend for weather-related LOOPs during the past decade (2011–2020).





Weather-Related LOOPs (2006–2020)

Event Date	Plant	Cause	Power Ops/ Shutdown	Duration (hours)
8/10/2020	Duane Arnold	Hurricane	Power Ops	25.3
8/3/2020	Brunswick 1	Hurricane	Power Ops	14.0
3/13/2018	Pilgrim	Snow and Wind	Shutdown	12.0
10/8/2016	Shearon Harris	Hurricane	Shutdown	7.4
1/27/2015	Pilgrim	Snow and Wind	Power Ops	0.03
2/8/2013	Pilgrim	Snow and Wind	Power Ops	21.0
10/29/2012	Oyster Creek	High Winds	Shutdown	14.4
4/27/2011	Browns Ferry 1	Tornado	Power Ops	0.03
4/27/2011	Browns Ferry 2	Tornado	Power Ops	0.03
4/27/2011	Browns Ferry 3	Tornado	Power Ops	0.03
4/16/2011	Surry 1	Tornado	Power Ops	5.1
4/16/2011	Surry 2	Tornado	Power Ops	5.1
8/19/2009	Wolf Creek	Lightning	Power Ops	2.2
2/24/2007	Duane Arnold	Ice	Shutdown	17.5



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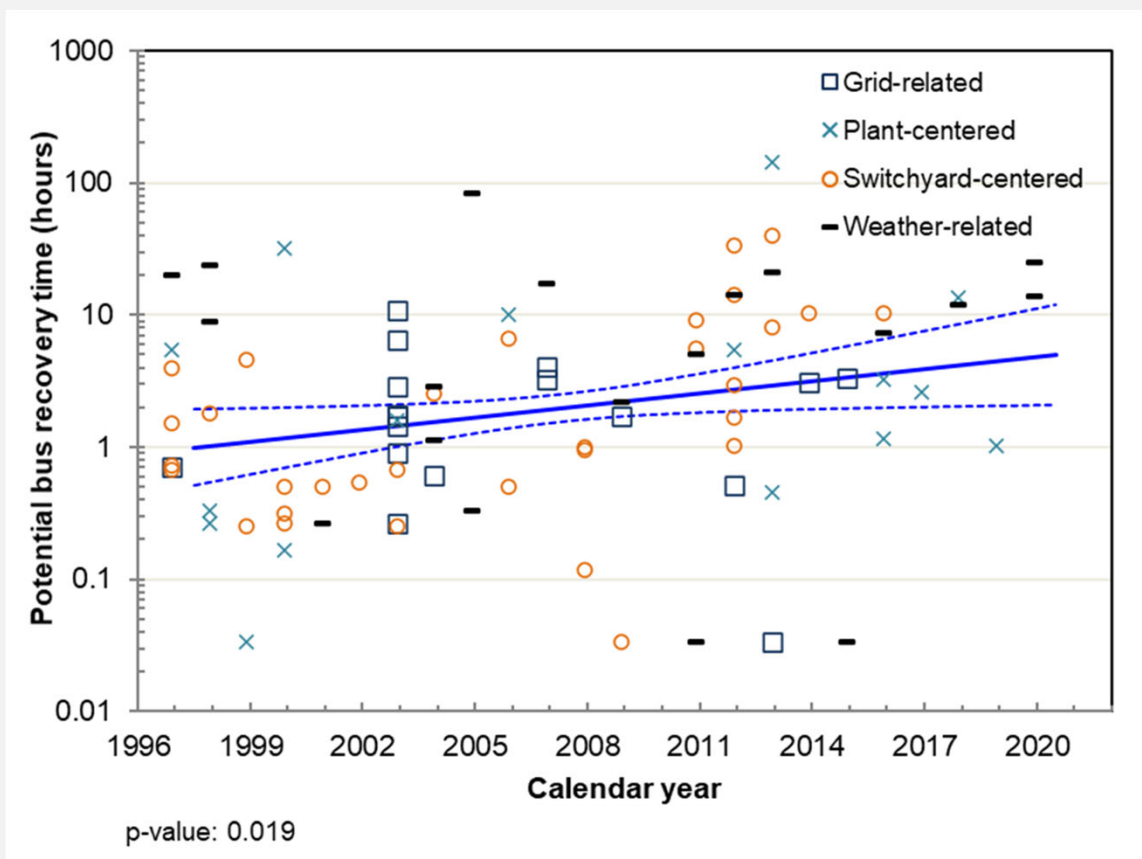
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LOOP Duration

- The duration of all LOOPs showed an increasing trend during the 1997–2020 period.
- There is no statistically significant trend for the duration of weather-related LOOPs during this same period.





Durations by LOOP Type

Parameter	Plant	Switchyard	Grid	Weather
LOOP event count	16	32	17	19
Mu (μ)	0.70	0.44	0.35	1.37
Standard error of μ	0.53	0.29	0.33	0.51
Sigma (σ)	2.13	1.66	1.36	2.24
Standard error of σ	0.38	0.21	0.23	0.36
Fitted median, hour	2.00	1.56	1.41	3.94
Fitted mean, hour	19.17	6.21	3.55	48.23
Fitted 95 th percentile, hour	66.10	24.03	13.19	156.51
Error factor	32.97	15.42	9.33	39.70



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Recent Events



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Brunswick LOOP during Hurricane Isaias

- Storm-generated debris resulted in a LOOP to Unit 1 in August 2020.
- The LOOP lasted approximately 14 hours.
- The mean conditional core damage probability (CCDP) was 2×10^{-5} .
 - LOOP transient scenarios dominated risk; station blackout (SBO) risk was minimal.



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Duane Arnold LOOP during Derecho

- Severe winds (100–130 miles per hour) during a derecho resulted in a LOOP in August 2020.
 - The storm caused severe damage to nonsafety-related cooling towers and minor damage to a few buildings.
 - The high winds also resulted in increased debris loading to the essential service water system and resulted in a clogged strainer.
- The LOOP lasted approximately 25 hours.
- The mean CCDP was 8×10^{-4} .
 - SBO scenarios were the dominant risk contributors.



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Waterford LOOP during Hurricane Ida

- The high winds, heavy rain, and localized flooding resulted in damage to both sources of offsite power.
- The supplemental diesel generator experienced a failed battery due to rapid discharge after the LOOP occurred.
- The LOOP lasted approximately 53 hours.
- The preliminary analysis indicates a mean CCDP from mid 1×10^{-4} to low 1×10^{-3} .
 - SBO scenarios were the dominant risk contributors.



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General Risk Insights

- SBO risk is dominant for two emergency diesel generator (EDG) plants for long-duration LOOPs.
 - Multiunit sites with shared EDGs typically have much lower risk.
 - Having an EDG not included in the same common-cause component group as the other safety-related EDGs can be a significant benefit.
 - Modeling of common-cause failures across the units introduces significant uncertainties because the data do not support this modeling.
- LOOP duration has significant impact on plants that have dominant SBO risk.
- FLEX credit can have significant impact on the results.