NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

NERC Project 2023-07

Extreme Heat and Extreme Cold Temperature Events

NERC Project 2023-07 Drafting Team
July 2024

RELIABILITY | RESILIENCE | SECURITY




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NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Agenda

- FERC Order 896 Directives
- TPL-008-1 Reliability Standard
- NERC Project 2023-07 Drafting Team
- Timeline Accomplishments
- Draft 1 High-level Themes and Ballot Results
- Draft 2 Modifications
- Benchmark Events Process and Example

FERC Order 896

- FERC Issued Order No. 896 on June 15, 2023.
- Regulatory deadline of December 15, 2024.
- Summary of primary directives (25 in total):
  - Develop a new or modified Reliability Standard.
  - Develop benchmark events and planning cases based on major prior extreme heat and cold weather events and/or meteorological projections.
  - Conduct transmission system planning studies for extreme heat and cold weather events across “wide areas.”
  - Incorporate concurrent/correlated generator and transmission outages.
  - Implement a Corrective Action Plan (CAP) if performance standards are not met.

Drafting Reliability Standards

- NERC facilitates the Standards Development process.
- The Standard Drafting Team (SDT) develops specifics.
- A strong Reliability Standard:
  - Identifies responsible entity(ies) - WHO
  - Specifies objectives – WHAT
  - Specifies a periodicity – WHEN
- A strong Reliability Standard does not specify the HOW.
  - Entity facts and circumstances must be considered.
  - Entities have flexibility in meeting objectives.

Overview of TPL-008-1

- A new TPL-008-1 Standard provides a clean approach to address all directives in a single location without affecting TPL-001-5.1.
- SDT is working with climate experts with regards to statistical analysis needed to determine applicable benchmark events.
  - NERC responsible for maintaining library of benchmark events.
- New TPL-008-1 Standard will focus on the specific requirements and measures for PCs and TPs.
  - A framework process to select benchmark events, develop benchmark planning cases, and scope studies for impacted study areas drafted in Attachment 1 of TPL-008-1 standard.

NERC Project 2023-07 Drafting Team

Name	Entity
Evan Wilcox (Chair)	American Electric Power
Jared Shaw (Vice Chair)	Entergy Services
Josie Daggett	Western Area Power Administration
Michael Herman	PJM Interconnection
Tracy Judson	Florida Power & Light
Sun Wook Kang	ERCOT
Andrew Kniska	ISO New England
Dmitry Kosterev	Bonneville Power Administration
David Le	California ISO
Karl Perman	CIP CORPS
Meenakshi Saravanan	ISO New England
Hayk Zargaryan	Southern California Edison

Timeline Accomplishments

- Initial Posting:
  - March 20 – May 3, 2024 (45-day comment and ballot period)
  - Results: 18.69%
- Additional Postings:
  - July 16 – August 22, 2024 (38-day comment and ballot period)

Draft 1 High-level Themes

- High-level themes
  - Need benchmark event information
  - Why temperature focus versus weather focus
  - Double jeopardy/overlap concerns between TPL-001 and TPL-007
  - Add temperature where appropriate in TPL-008-1
  - Regional Entities should perform the study instead of PCs/TPs
  - Confusion around planning cases and system models
  - Clarity on P0 Events
  - MOD-032 data enough to complete work needed for TPL-008-1
  - Coordinated criteria
  - Instability, uncontrolled separation, or cascading boundary
  - Clarity on sensitivity analysis
  - And more….

Requirement R1 and R2

R1. Each Planning Coordinator, in conjunction with its Transmission Planner(s), shall ~~determine and~~ identify each entity's individual and joint responsibilities for ~~performing the studies needed to complete~~completing the Extreme Temperature Assessment. *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

R2. Each responsible entity, as identified in Requirement R1, shall select at least one extreme heat benchmark temperature event and at least one extreme cold benchmark temperature event, from the ~~approved~~ benchmark library, approved and maintained by the Electric Reliability Organization (ERO), for ~~performing~~completing the Extreme Temperature Assessment. *[Violation Risk Factor: High] [Time Horizon: Long-term Planning]*

Requirement R3

R3. Each Planning Coordinator shall develop and implement a process for coordinating the development of benchmark planning cases ~~among~~, using the selected benchmark temperature events identified in Requirement R2, among adjacent impacted Planning Coordinator(s), Transmission Planner(s), and other designated study entities ~~based on the selected benchmark events as identified in Requirement R2.~~, within an Interconnection. This process shall~~:~~ include seasonal and temperature dependent adjustments for Load, generation, Transmission, and transfers to represent the selected benchmark temperature events. *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

~~**3.1.** Define the planning study area boundary based on the selected benchmark events.~~

~~**3.2.** Modify the benchmark planning cases to include seasonal and temperature dependent adjustment for Load, generation, Transmission, and transfers which represents the selected benchmark events.~~

Requirement R4

R4. Each responsible entity, as identified in Requirement R1, shall ~~develop and maintain System models within its planning area for performing the Extreme Temperature Assessment. The System models shall~~ use the coordination process developed in accordance with Requirement R3 and data consistent with that provided in accordance with the MOD-032 standard, supplemented by other sources as needed, ~~and shall represent projected System conditions based on the selected benchmark events as identified in Requirement R2.~~to develop and maintain the following:
[Violation Risk Factor: High] [Time Horizon: Long-term Planning]

4.1. ~~Each responsible entity,~~Benchmark planning cases that include seasonal and temperature dependent adjustments for Load, generation, Transmission, and transfers to represent the System conditions of the selected benchmark temperature events as identified in Requirement R2 for one of the years in the Long-Term Transmission Planning Horizon. The rationale for the year selected for evaluation shall be available as supporting information. ~~R1,~~This establishes Category P0 as the normal System condition in Table 1.

4.2. Sensitivity cases to demonstrate the impact of changes to the basic assumptions used in the benchmark planning cases. To accomplish this, the sensitivity cases shall have changes to at least one of the following conditions:

- Generation;
- Real and reactive forecasted Load; or
- Transfers.

Requirement R5 through R7

R5. Each responsible entity, as identified in Requirement R1, shall have criteria for acceptable System steady state voltage limits ~~and~~, post-Contingency voltage deviations, and applicable Facility Ratings for ~~performing~~completing the Extreme Temperature Assessment ~~in accordance with Requirement R3~~. *[Violation Risk Factor: High] [Time Horizon: Long-term Planning]*

R6. Each responsible entity, as identified in Requirement R1, shall define and document the criteria or methodology used in the Extreme Temperature Assessment analysis to identify instability, uncontrolled separation, or Cascading ~~.~~ within an Interconnection. *[Violation Risk Factor: High] [Time Horizon: Long-term Planning]*

R7. Each responsible entity, as identified in Requirement R1, shall identify ~~Contingencies used in performing the Extreme Temperature Assessment~~the planning events for each ~~of the event categories~~category in Table 1 that are expected to produce more severe System impacts ~~within~~on its ~~planning area~~portion of the Bulk Electric System. The rationale for those Contingencies selected for evaluation shall be available as supporting information. *[Violation Risk Factor: High] [Time Horizon: Long-term Planning]*

Requirement R8

R8. Each responsible entity, as identified in Requirement R1, shall complete ~~an~~steady state and transient stability analyses in its Extreme Temperature Assessment ~~of the Long-Term Transmission Planning Horizon~~ at least once every five calendar years~~,~~ using the ~~benchmark planning cases~~ Contingencies identified in Requirement R7, and ~~the System models identified in Requirement R3 and R4, and the Contingencies identified in Requirement R7 for each of the event categories in Table 1, and~~ shall document the assumptions and results of the steady state and transient stability analyses. The Extreme Temperature Assessment shall include the following~~:~~: *[Violation Risk Factor: High] [Time Horizon: Long-term Planning]*

8.1. ~~Assessment~~Analysis of the benchmark planning cases developed ~~under~~ in accordance with Requirement R4~~, for one of the years in the Long-Term Transmission Planning Horizon. The rationale for the year selected for evaluation shall be available as supporting information.~~ Part 4.1.

~~**8.2.** Sensitivity analysis to demonstrate the impact of changes to the basic assumptions used in the model. To accomplish this, the sensitivity analysis in the Extreme Temperature Assessment shall include, at a minimum, changes to one of the following conditions:~~

- ~~Generation;~~
- ~~Real and reactive forecasted Load; or~~
- ~~Transfers~~

Requirement R9

R9. Each responsible entity, as identified in Requirement R1, shall develop a Corrective Action Plan(s) (CAPs) when the assessment of a benchmark planning case ~~study results indicate the~~, in accordance with Requirement R8 Part 8.1, indicates its portion of the Bulk Electric System is unable to meet performance requirements for Table 1 P0 or P1 Contingencies. ~~The~~For each Corrective Action Plan, the responsible ~~entities~~entity shall ~~share~~: *[Violation Risk Factor: High] [Time Horizon: Long-term Planning]*

9.1. Make their ~~CAPs with,~~CAP available and solicit feedback from~~,~~ applicable regulatory authorities or governing bodies responsible for retail electric service issues. ~~In addition, where Load shed is allowed as an element of a CAP for the Table 1 P1 Contingency, the responsible entity shall document~~

Requirement R9 Continued

~~8.3.~~9.2. Document the alternative(s) considered~~, as mentioned in Requirement R10~~, and notify the applicable regulatory authorities or governing bodies responsible for retail electric service issues~~. Revisions to the CAP(s) are allowed in subsequent Extreme Temperature Assessments, but the planned System shall continue to meet the performance requirements. *[Violation Risk Factor: High] [Time Horizon: Long-term Planning]*~~ when Non-Consequential Load Loss is utilized as an element of a CAP for the Table 1 P1 Contingency.

9.3. Be permitted to utilize Non-Consequential Load Loss as an interim solution, which normally is not permitted in Table 1, in situations that are beyond the control of the Planning Coordinator or Transmission Planner that prevent the implementation of a Corrective Action Plan in the required timeframe. The use of Non-Consequential Load Loss as an interim solution in this situation is permitted, provided that each responsible entity documents the situation causing the problem, alternatives evaluated, and takes actions to resolve the situation.

9.4. Be allowed to have revisions to the CAP in subsequent Extreme Temperature Assessments, provided that the planned BES shall continue to meet the performance requirements of Table 1.

Requirement R10 and R11

R10. Each responsible entity, as identified in Requirement R1, shall evaluate and document possible actions for the following: *[Violation Risk Factor: Lower] [Time Horizon: Long-term Planning]*

10.1. Benchmark planning cases where possible actions are designed to mitigate the consequences and adverse impacts when the study results indicate the System could result in instability, uncontrolled separation, or Cascading for the Table 1 P2, P4, and P7 Contingencies.

10.2. Sensitivity cases where possible actions are designed to mitigate failures to meet the performance requirements in Table 1 for category P0, P1, P2, P4, and P7 Contingencies.

~~**R9.**~~**R11.** Each responsible entity, as identified in Requirement R1, shall provide its Extreme Temperature Assessment results within 60 calendar days of a request to any functional entity that has a reliability related need and submits a written request for the information. *[Violation Risk Factor: Medium] [Time Horizon: Long-term Planning]*

Table 1.1

Table 1.1: Contingencies Category See Footnote 2 for BES Level			
Category	**Initial Condition**	**Event**	**Fault type**
P0 No Contingency	Normal System	None	N/A
P1 Single Contingency	Normal System	Loss of one of the following: 1. Generator 2. Transmission Circuit 3. Transformer 4. Shunt Device[3]	3Ø
		5. Single Pole of a DC line	SLG
P2 Single Contingency	Normal System	1. Opening of a line section w/o a Fault [4]	N/A
		2. Bus Section Fault	SLG
		3. Internal Breaker Fault[5] (non-Bus-tie Breaker)	SLG
		4. Internal Breaker Fault (Bus-tie Breaker)[5]	SLG
P4 Multiple Contingency *(Fault plus stuck breaker[6])*	Normal System	Loss of multiple Elements caused by a stuck breaker[6](non-Bus-tie Breaker) attempting to clear a Fault on one of the following: 1. Generator 2. Transmission Circuit 3. Transformer 4. Shunt Device[3] 5. Bus Section	SLG

Table 1.1. Continued

Table 1.1: Contingencies Category See Footnote 2 for BES Level			
Category	**Initial Condition**	**Event**	**Fault type**
		6. Loss of multiple Elements caused by a stuck breaker[6] (Bus-tie Breaker) attempting to clear a Fault on the associated bus	
P7 Multiple Contingency *(Common Structure)*	Normal System	The loss of: 1. Any two adjacent (vertically or horizontally) circuits on common structure 2. Loss of a bipolar DC line	SLG

Table 1.2.

Table 1.2: Steady State & Stability Performance Requirements					
	P0	P1	P2	P4	P7
Steady State Performance Requirements	• Applicable Facility Ratings shall not be exceeded. • System steady state voltages shall be within acceptable limits as defined in Requirement R5.	• Applicable Facility ratings shall not be exceeded. • System steady state voltages shall be within acceptable limits as defined in Requirement R5.	Instability, uncontrolled separation, or Cascading, as defined in Requirement R6, shall not occur.		
Stability Performance Requirements	The System shall remain stable. Instability, uncontrolled separation, or Cascading, as defined in Requirement R6, shall not occur.	Instability, uncontrolled separation, or Cascading, as defined in Requirement R6, shall not occur.	Instability, uncontrolled separation, or Cascading, as defined in Requirement R6, shall not occur.		
Requirements for Benchmark Planning Case Assessment Results					
Corrective Action Plan Required	Yes (See Requirement R9)	Yes (See Requirement R9)	No (See Requirement R10)		
Non-Consequential Load Loss Allowed	No (See Requirement R9)	Yes (See Requirement R9)	Yes		
Interruption of Firm Transmission Service Allowed	Yes	Yes	Yes		
Requirements for Sensitivity Case Assessment Results					
Corrective Action Plan Required	No (See Requirement R10)	No (See Requirement R10)	No (See Requirement R10)		

Table 1.2. Continued

Table 1.2: Steady State & Stability Performance Requirements			
Non-Consequential Load Loss Allowed	Yes	Yes	Yes
Interruption of Firm Transmission Service Allowed	Yes	Yes	Yes

Table 1.3.

Table 1.3 – Steady State & Stability Performance Footnotes
1. Unless specified otherwise, simulate Normal Clearing of faults. Single line to ground (SLG) or three-phase (3Ø) are the fault types that must be evaluated in Stability simulations for the event described. A 3Ø or a double line to ground fault study indicating the criteria are being met is sufficient evidence that a SLG condition would also meet the criteria.
2. Facility voltage level of Contingency is applicable to: a. BES level 200 kV and above (referenced Contingency voltage) b. For P7 events include Contingencies that have at least one 200kV voltage and above Facilities on common structure that has more than one mile in length. c. For non-generator step up transformer outage events, the reference voltage, as used in footnote 2a, applies to the low-side winding (excluding tertiary windings). For generator and Generator Step Up transformer outage events, the reference voltage applies to the BES connected voltage (high-side of the Generator Step Up transformer). Requirements which are applicable to transformers also apply to variable frequency transformers and phase shifting transformers.
3. Requirements which are applicable to shunt devices also apply to FACTS devices that are connected to ground.
4. Opening one end of a line section without a fault on a normally networked Transmission circuit such that the line is possibly serving Load radial from a single source point.
5. An internal breaker fault means a breaker failing internally, thus creating a System fault which must be cleared by protection on both sides of the breaker.
6. A stuck breaker means that for a gang-operated breaker, all three phases of the breaker have remained closed. For an independent pole operated (IPO) or an independent pole tripping (IPT) breaker, only one pole is assumed to remain closed. A stuck breaker results in Delayed Fault Clearing.

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Benchmark Event Process and Event Example

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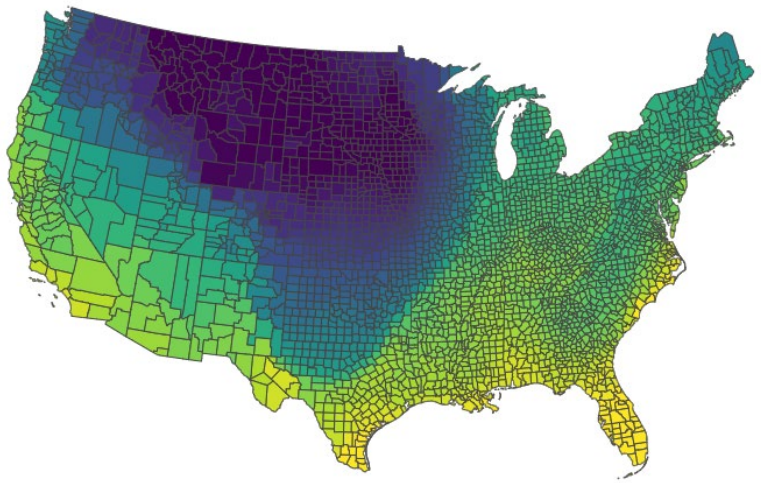
Initial Benchmark Event Development

- To be developed by NERC with subject matter experts
- Sample of event to be provided July 2024
- The method and criteria applied will be publicly posted October 2024
- Remainder of initial events completed in Q4 2024



ERO Benchmark Library

- A public facing library (site) to be created by Q4 2024
- Library will be maintained by NERC
- Process for ongoing maintenance of library and development of future benchmark events
  - Leverage industry forums and weather experts
  - Move to meteorological projections (future looking)
  - Changes to criteria will be publicly workshopped
  - Changes will be filed with FERC
  - Will be a repeating 5-year process

NERC Benchmark Event Process Overview

- Benchmark Events Library LIVE – December 2024
- YEAR 1 – (2025):
  - Benchmark event library tutorial
  - Training and guidance for planning case development
- YEAR 2 – (2026):
  - NERC review and modify benchmark event criteria with industry
  - Informational session on updated criteria for benchmark events

NERC Benchmark Event Process Overview

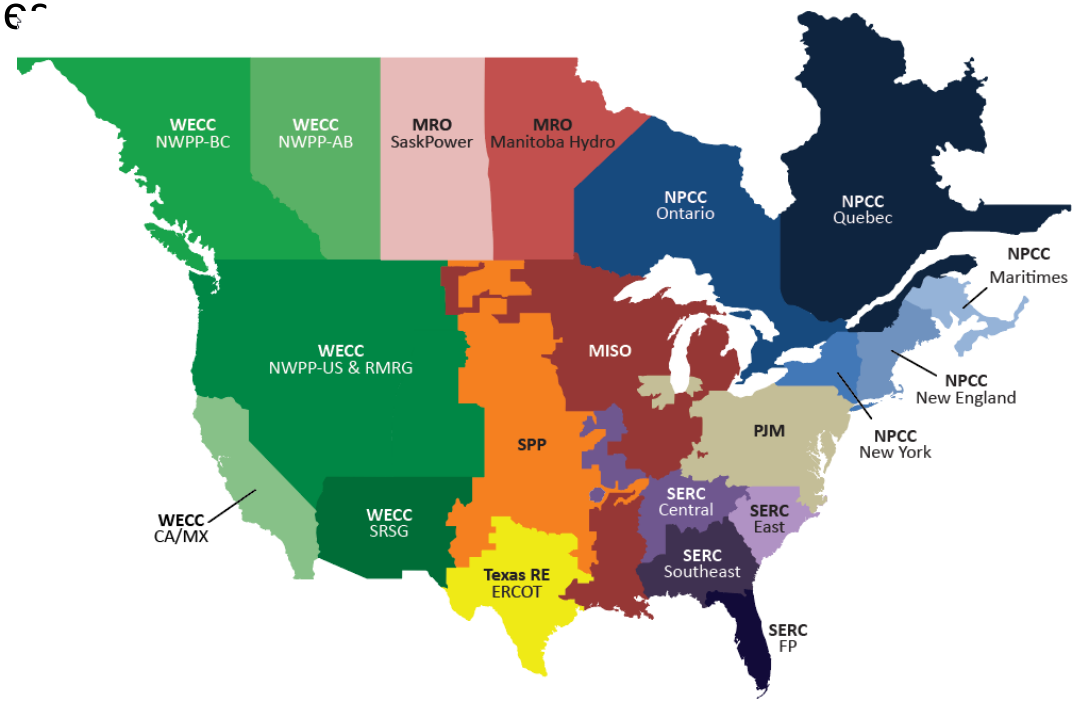
- YEAR 3 – (2027):
  - Update library with new/removed benchmark events
  - (optional) Planning Coordinator due date to submit benchmark events based on different criteria for ERO approval
- YEAR 4 – (2028):
  - (optional) Planning Coordinator due date to submit benchmark events based on different criteria for ERO approval
  - Updated benchmark event tutorial and other training

NERC Benchmark Event Process Overview

- YEAR 5 – (2029):
  - Informational filing to FERC for any change to criteria and modifications to benchmark events library
  - Review process and revise based on lessons learned and industry feedback
  - Updated benchmark event tutorial and other training

Benchmark Events

- Screening for Extreme Heat and Extreme Cold Temperature Events
  - Multi-day Weather Events
  - Wide-area Assessment
  - Wide-area Boundaries



Benchmark Events

- Extreme Cold Events

Rank of events by average three-day average min temperature, 1980-2022

Event Type	Year	Month	WECC NW	CA / MX	WECC SW	ERCOT	SPP	MISO	SERC	FRCC	PJM	NYISO	ISONE	LOWEST RANK	TOP 5 COUNT	SHORTLIST	PRIORITY EVENTS
Cold Event	1981	1							12	4	9	2	1	1	3	1	
Cold Event	1983	12	3			3	2	4	2	3	3			2	7	1	Widespread cold, worst case
Cold Event	1984	1	13			14	13	3	16		2	3		2	3	1	
Cold Event	1985	1				11	10	10	1	1	4			1	3	1	Widespread cold
Cold Event	1989	2	2	2			12			13				2	2	1	
Cold Event	1989	12				1	1	5	3	2	5			1	6	1	
Cold Event	1990	12	1	1	1		16							1	3	1	Western Cold
Cold Event	1994	1						2	7		1	1	3	1	4	1	Eastern Cold
Cold Event	1996	2	11			5	3	1	5		7	16		1	4	1	
Cold Event	2004	1	8									8	2	2	1	1	
Cold Event	2011	2			2	4	11	13						2	2	1	2011 Southwestern Event
Cold Event	2021	2				2	4	14						2	2	1	Winter Storm Uri
Cold Event	2022	12				8	9		6	11				6	0	1	Winter Storm Elliott
Total Cold Events Selected			6	2	2	8	10	8	8	6	7	5	3			13	

Numbers represent rank of event relative to a region's 43-year history. Lower numbers represent more extreme for that region.

Benchmark Events

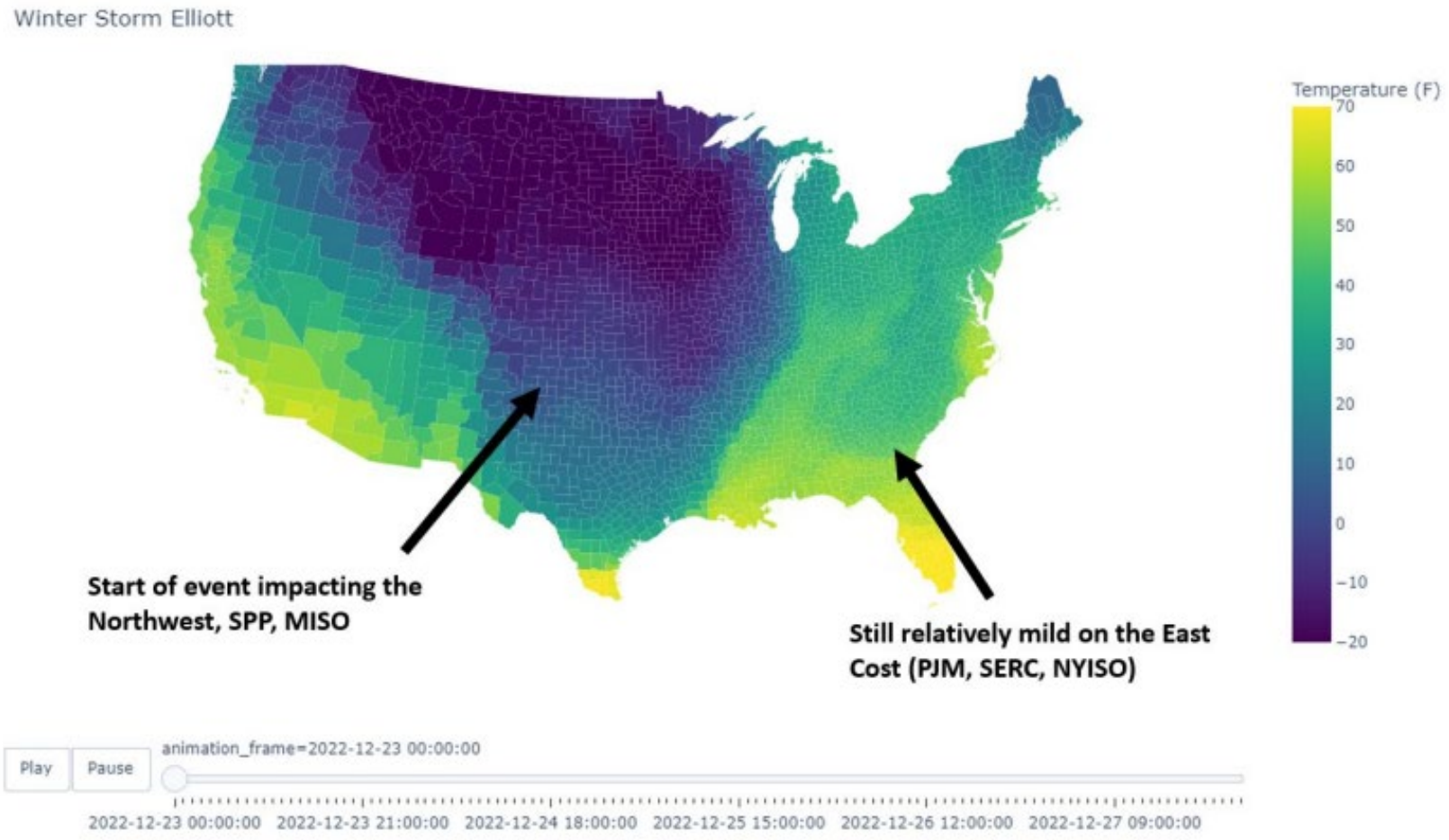
- Extreme Heat Events

Rank of events by average three-day average max temperature, 1980-2022

Event Type	Year	Month	WECC NW	CA / MX	WECC SW	ERCOT	SPP	MISO	SERC	FRCC	PJM	NYISO	ISONE	LOWEST RANK	TOP 5 COUNT	SHORTLIST	PRIORITY EVENTS
Heat Event	1980	6				2								2	1	1	
Heat Event	1981	6								3				3	1	1	
Heat Event	1988	8						1	15		4	7	16	1	2	1	
Heat Event	1991	7									12	9	1	1	1	1	
Heat Event	1995	7			1	8		9			3	8	13	1	2	1	Worst case Southwest
Heat Event	1998	6								1				1	1	1	
Heat Event	1998	7				12				2				2	1	1	
Heat Event	1999	7						4	6		2	1	6	1	3	1	
Heat Event	2000	9				1								1	1	1	
Heat Event	2002	7	7								15	13	2	2	1	1	
Heat Event	2006	7	2	3			3	7						2	3	1	
Heat Event	2006	8					12	3			5	4	4	3	4	1	Northeast Heatwave
Heat Event	2007	8							2					2	1	1	
Heat Event	2011	7					8	11	14		6	2	3	2	2	1	Eastern Interconnect Heatwave
Heat Event	2011	8				4	2		5					2	3	1	Central Plains
Heat Event	2012	7					4	2	1		1			1	4	1	Widespread heat event
Heat Event	2012	8					1	6						1	1	1	
Heat Event	2017	6			2									2	1	1	
Heat Event	2020	8	1	5	13									1	2	1	Western Heat Dome 2020
Heat Event	2020	9		1										1	1	1	
Heat Event	2022	9	10	2										2	1	1	Western Heat Dome 2022
Total Heat Events Selected			4	4	3	5	6	8	6	3	8	7	7			21	

Numbers represent rank of event relative to a region's 43-year history. Lower numbers represent more extreme for that region.

Benchmark Events



Timeline Next Steps

- Additional Postings:
  - October 2024
- Final Ballot period:
  - November
- NERC Board Adoption:
  - December 13, 2024
- File with Regulatory Authorities:
  - December 2024 (Regulatory Deadline – FERC Order 896)

Questions and Answers