

Climate READi: Power Initiative Overview

September 2023

Resources: www.epri.com/READi

Get in touch: ClimateREADi@epri.com



EPRI: Leading Collaborative Energy R&D Around the World

EPRI advances energy technologies and informs decision-making through ~\$420M in collaborative annual research involving nearly 400 entities in ~40 countries - spanning the generation, delivery, and use of electricity.



ENGAGING

- Utilities
- Academia
- OEMs
- Regulators



LISTENING

- Financial Community
- Policy Makers
- Consumer Advocates
- Media



EPRI Climate Resilience and Adaptation Initiative (**READi**)

- **COMPREHENSIVE:** Develop a *Common Framework* addressing the entirety of the power system, planning through operations
- **CONSISTENT:** Provide an informed approach to climate risk assessment and strategic resilience planning that can be replicated
- **COLLABORATIVE:** Drive stakeholder alignment on adaptation strategies for efficient and effective investment

Workstream 1	Workstream 2	Workstream 3
Physical Climate Data & Guidance <ul style="list-style-type: none"> • Identify climate hazards and data required for different applications • Evaluate data availability, suitability, and methods for downscaling & localizing climate information • Address data gaps 	Energy System & Asset Vulnerability Assessment <ul style="list-style-type: none"> • Evaluate vulnerability at the component, system, and market levels from planning to operations • Identify mitigation options from system to customer level • Enhance criteria for planning and operations to account for event probability and uncertainty 	Resilience / Adaptation Planning & Prioritization <ul style="list-style-type: none"> • Assess power system and societal impacts: resilience metrics and value measures • Create guidance for optimal investment priorities • Develop cost-benefit analysis, risk mitigation, and adaptation strategies

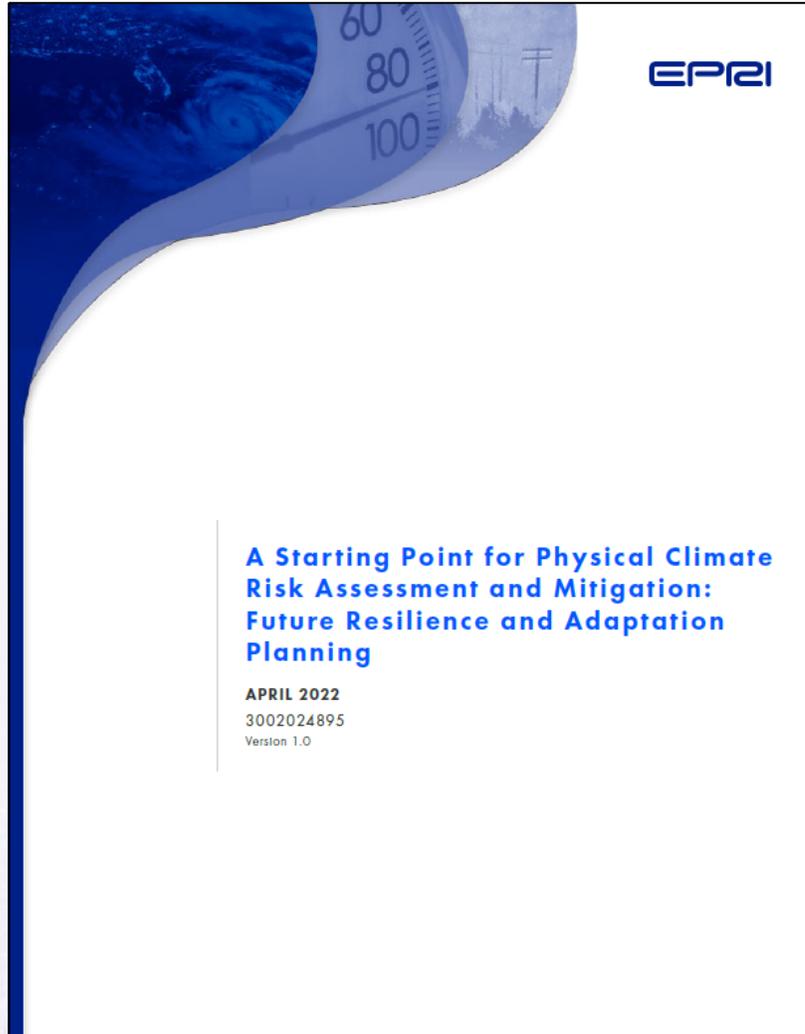


Deliverables: Common Framework “Guidebooks”

- Climate data assessment and application guidance
- Vulnerability assessment
- Risk mitigation investment
- Recovery planning
- Hardening technologies
- Adaptation strategies
- Research priorities

The EPRI Differentiator: Power System Application

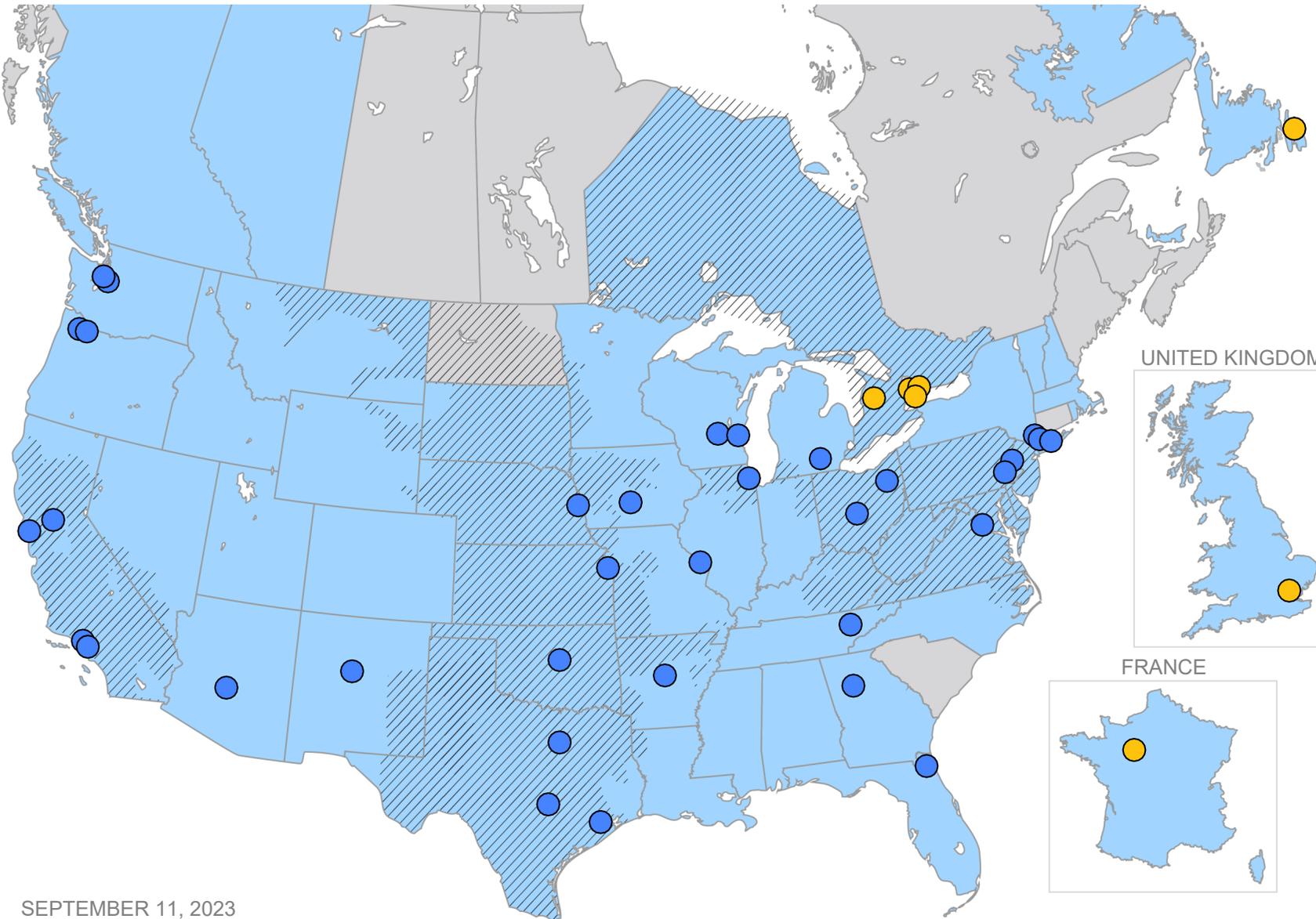
Generation Impacts



[3002024895](#)

This white paper examines the current knowledge base of potential climate-related impacts on all facets of the power sector, to serve as a foundation for a standardized and consensus-based framework to inform infrastructure investment and deployment.

Climate READi Members



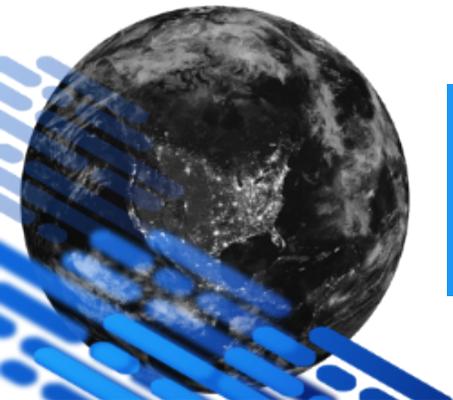
SEPTEMBER 11, 2023

Member Headquarters
 Member Operating States/Provinces
 ISO Service Territories
 (only HQ location shown for IPPs)

aes Indiana	exelon™	PG&E
aes Ohio	FirstEnergy	pjm
Alliant Energy	FORTIS INC.	PNM
Ameren	hydro one	ppl
AMERICAN ELECTRIC POWER BOUNDLESS ENERGY™	ieso Connecting Today. Powering Tomorrow.	PSE PUGET SOUND ENERGY
BERKSHIRE HATHAWAY ENERGY	JEA	Rte
BONNEVILLE POWER ADMINISTRATION	LA DWP Los Angeles Department of Water & Power	SNP
BrucePower	LIPA Long Island Power Authority	Seattle City Light
California ISO	nationalgrid	SOUTHERN CALIFORNIA EDISON™
CenterPoint Energy	NEW YORK STATE OF OPPORTUNITY NY Power Authority	Southern Company
Consumers Energy	OG&E	SPP Southwest Power Pool
conEdison	your energy partner OPPD Omaha Public Power District	TVA TENNESSEE VALLEY AUTHORITY
ercot Your Power. Our Promise.	ONTARIO POWER GENERATION	VISTRA
evergy	PGE	WEC Energy Group

Climate READi Affinity Group

The Climate READi Affinity Group (CRAG) is comprised of individuals from academia, consulting, finance and insurance institutions, non-governmental organizations, national labs, regulators and government— among others—bringing their expertise to address the critical challenge around resilience and adaptation to the energy sector.



*Embracing a 'Big-Tent'
Approach to Framework
Development*

- ▶ Accenture
- ▶ ADEX
- ▶ Alison Silverstein (Consultant)
- ▶ Andre Dessler (Consultant)
- ▶ Applied Weather Associates
- ▶ Argonne National Laboratory
- ▶ Baringa
- ▶ Battelle
- ▶ Black & Veatch
- ▶ Brookhaven National Laboratory
- ▶ CAMPUT
- ▶ Canadian Climate Institute
- ▶ CANDU Owners Group
- ▶ CarbonPlan
- ▶ CDP North America
- ▶ Center for Climate & Energy Solutions
- ▶ Chemonics
- ▶ Clark Miller (Consultant)
- ▶ Clean Air Task Force
- ▶ Climate Risk Institute
- ▶ Columbia University
- ▶ Copperleaf Technologies
- ▶ CSA Group
- ▶ Desert Research Institute
- ▶ Disaster Tech
- ▶ Eagle Rock Analytics
- ▶ Eaton
- ▶ Electricity Canada
- ▶ Energy Systems Integration Group
- ▶ Energy Networks Association
- ▶ Enline Transmission
- ▶ Exponent
- ▶ Grid Lab
- ▶ Grid2.0
- ▶ Guidehouse
- ▶ Houston Advanced Research Center
- ▶ ICF
- ▶ IEEE
- ▶ Imperial College London
- ▶ King Abdullah Petroleum Studies and Research Center
- ▶ Institute of Nuclear Power Operations
- ▶ Jacobs Engineering
- ▶ Khalifa University
- ▶ King Abdullah University of Science and Technology
- ▶ King's College London
- ▶ Lawrence Berkeley National Laboratory
- ▶ Lawrence Livermore National Laboratory
- ▶ McCormick Taylor
- ▶ Midwest Climate Collaborative
- ▶ Model World Consulting
- ▶ National Association of Regulatory Utility Commissioners
- ▶ National Association of State Energy Officials
- ▶ National Center for Atmospheric Research
- ▶ National Oceanic and Atmospheric Administration
- ▶ National Renewable Energy Laboratory
- ▶ North American Electric Reliability Corporation
- ▶ North American Transmission Forum
- ▶ Nuclear Energy Institute
- ▶ Nuclear Electric Insurance Limited
- ▶ National Renewable Energy Laboratory
- ▶ Oak Ridge National Laboratory
- ▶ Oregon State University
- ▶ Pacific Northwest National Laboratory
- ▶ Pacific Northwest Utilities Conference Committee
- ▶ Power Systems Engineering Research Center
- ▶ Quanta Services
- ▶ RAND Corporation
- ▶ Resources for the Future
- ▶ RS Poles
- ▶ RUNWITHIT Synthetics
- ▶ Sharply Focused
- ▶ SLR Consulting
- ▶ Storm Impact
- ▶ Sunairio
- ▶ Union of Concerned Scientists
- ▶ Universidad Pontificia
- ▶ University of Albany
- ▶ University of Illinois
- ▶ University of Michigan
- ▶ University of Nottingham
- ▶ University of Reading
- ▶ University of Saskatchewan
- ▶ Verdantas

Recent Deliverables

READi Insights: Extreme Heat Events and Impacts to the Electric System

Evaluates severity of recent extreme heat events in the context of historical records and climate change and potential future implications of extreme heat for the power system ([300202552](#))

Costs & Benefits of Proactive Climate Adaptation in the Electric Sector

Outlines how proactively implementing adaptation strategies is expected to result in a more resilient power system, avoided damages, and reduced societal impacts ([3002025872](#))

Workstream 2 Asset Literature Review Series

Five volumes of literature reviews that characterize asset vulnerability to climate change for nuclear, non-nuclear, cross-cutting topics, and transmission and distribution assets. ([3002025313](#), [3002026314](#), [3002026315](#), [3002 026316](#))

Climate-Informed Planning & Adaptation for Power Sector Resilience

Compilation of literature from researchers and industry stakeholders on climate risk, power system impacts, and current practices to address power system resilience against climate hazards ([3002026317](#))

Physical Climate Data 101

Over 250 comments from 19 EPRI members and 10 CRAG organizations during review period for the first training in the Climate 101 series ([3002026223](#), [3002026297](#), [3002026298](#), [3002026296](#))

READi Insights: Extreme Winter Weather Challenges for the Power System

Evaluates severity of recent extreme winter events in the context of historical records and climate change and potential future implications of extreme heat for the power system ([3002027393](#))

Climate READi: Power Year One Annual Report

Year One Annual Report

Overview from the first year of activity, summarizing current progress and the plan ahead for the remaining two years. ([3002027401](#))

ONE 2023 Highlight per Work Stream

WS1 - Climate Data & Guidance

Climate Data Guidance Document & Phase 1 Inventory

Climate READi WS1 2023 Deliverables

- Progress to date:
- Developing Zero Order Draft for member review and comment (End of Q1)
 - Consolidating prior feedback for inputs

- Opportunities for engagement:
- Review of Zero Order Draft (Prior to May Workshop)
 - Suggestion of topics to include in climate data guidance deliverable

01
Climate Data Assessment and Inventory

Assessment of data available to meet industry-defined information requirements; Gap analysis

02
Guidance for applying climate data

Guidance for selecting and utilizing climate data in diverse power system applications

03
Climate 101, Part II

Focus on topics related to energy system assets vulnerability assessment

WS2 - Exposure & Vulnerability

Climate Asset Matrix Development

Climate-Asset Matrix

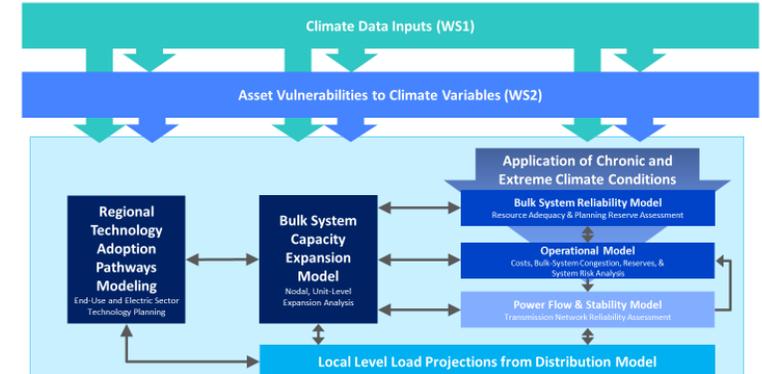
Impact ID	Application	System/Facility Type	Climate Variable Category	Impact	Specific Impact measure (e.g., threshold, dose, response function)	Liberal/conservative	Severity
1a	Operations	Run-of-river	Drought	Upstream flows are too low to sustain power output levels - leading to a draw down of the upstream reservoir. This draw down initially leads to reduced power output as the head (of the dam) decreases but eventually leads to "deadpool" where upstream flows are too low to sustain power output levels - leading to a draw down of the upstream reservoir. This draw down initially leads to reduced power output as the head (of the dam) decreases but eventually leads to "deadpool" where	Minimum stream flow to safely generate electricity		
1b	Operations	Run-of-river	Stream flow	Upstream flows are too low to sustain power output levels - leading to a draw down of the upstream reservoir. This draw down initially leads to reduced power output as the head (of the dam) decreases but eventually leads to "deadpool" where	Minimum stream flow to safely generate electricity		
2a	Operations	Reservoir/Pumped Storage	Drought	Upstream flows are too low to sustain power output levels - leading to a draw down of the upstream reservoir. This draw down initially leads to reduced power output as the head (of the dam) decreases but eventually leads to "deadpool" where	Correlation between reservoir surface elevation and power output; critical reservoir surface elevation where generation stops		
2b	Operations	Reservoir/Pumped Storage	Reservoir in-flows	Upstream flows are too low to sustain power output levels - leading to a draw down of the upstream reservoir. This draw down initially leads to reduced power output as the head (of the dam) decreases but eventually leads to "deadpool" where	Correlation between reservoir surface elevation and power output; critical reservoir surface elevation where generation stops		
3a	Multi-Service	Reservoir/Pumped Storage	Drought	Upstream flows are too low to meet downstream flow and reservoir level obligations (e.g., downstream environmental flows and flows required for operation of thermal facilities, secondary uses of reservoir), protected species may occupy exposed portions of reservoir during extended draw downs.	Minimum downstream flow (based on reservoir levels) and reservoir level		

Identifying specific impact measures informs adaptation options

WS3 - Planning & Prioritization

Texas A&M Synthetic T&D Model Case Study

Draft WS3 Power System Resilience and Investment Framework

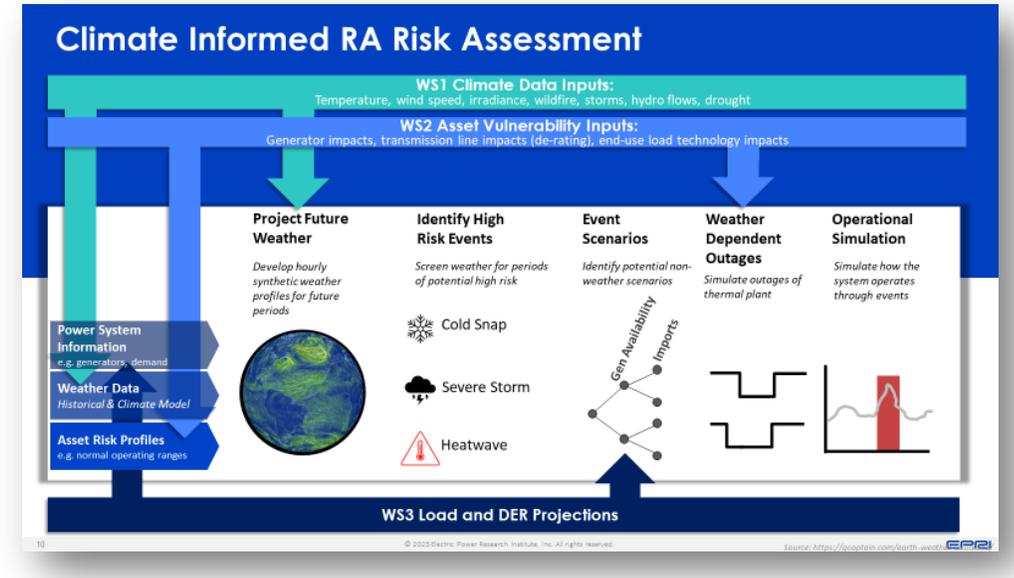


Several Workshop Opportunities to Engage!

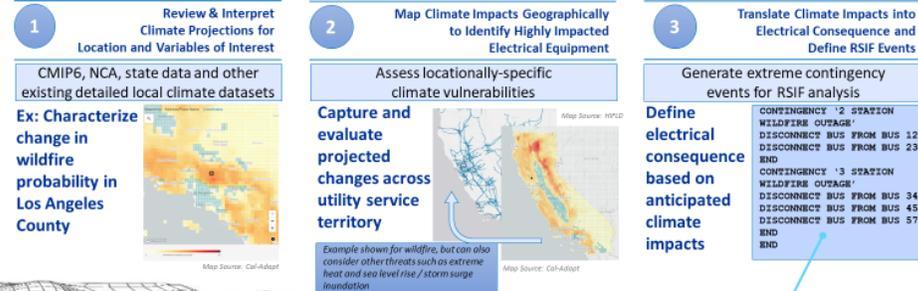
Addressing Extreme Weather Challenges

- READi working at developing a comprehensive framework that leverages existing tools and processes
- Framework can be implemented based on need and structure of the planning entity

Risk screening for resource adequacy and transmission planning assessments



Moving beyond exposure assessment to explicitly integrate climate impacts into quantitative assessment of transmission resilience



Climate Data Informs HILF Event Definition for Transmission Resilience Analysis

Can capture impacts on initial conditions and acute destructive events

Addressing Extreme Weather Challenges

- Addresses challenges in the short-term as well as the long-term impacts of climate change
- FERC Order 896 is an example of where READi learning can be leveraged in the short-term

Public EPRI webcast broke down the impacts of the order

Transmission System Planning Performance Requirements for Extreme Weather: Final Rule

Docket No. RM22-10-000, Order No. 896

Ruling issued June 23, 2023

Looks at required planning actions for the next 6-10 years and establishes an update of the NERC TPL-001-5.1. Requires NERC to consider three primary aspects with respect to extreme heat and extreme cold

1

Development of benchmark cases for extreme heat and extreme cold events

2

Planning for extreme weather using steady-state and transient stability analysis for scenarios that include the expected resource mix's availability

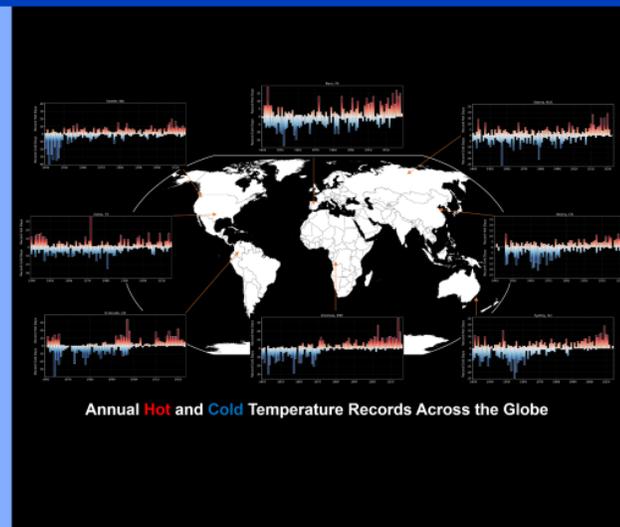
3

Develop corrective action plans that mitigate the impacts of extreme weather

Historical and Projected Changes in Extreme Weather

Extreme heat has increased in frequency and intensity in recent decades and is projected to continue going forward

Extreme cold has decreased in frequency and intensity in recent decades and is projected to continue going forward



Understanding weather and impacts on the power system is critical



Together...Shaping the Future of Energy®

