Climate READi

EPRI's Climate Resilience and Adaptation Initiative for the Power Sector

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EPRI's Role



Guiding climate and grid strategy

Economy-wide modeling to optimize sustainability, reliability, and resiliency solutions

> A trusted source of information

Industry, lawmakers, policymakers, thought leaders, regulators, financial community

Pushing the technological frontier

Develop and evaluate solutions while engaging national labs, technical partners, and international stakeholders Enhance value to members and society

Strategic Research



Market **Transformation**/ Low-**Policy/Regulatory** Carbon **Electric System Education** Resources **Reliability/Resilience** Ħ ŝ End-Use/ **Electric System Economy-Wide Flexibility** Carbon **Reduction**



Information Needs for Analyzing the Climate Impact on The Electric Power System

- Improved understanding of risks presented by weather phenomena in the present climate to the present system
- Documented and vetted means of estimating the change in risks due to predictable changes in climate (due to the predictable component of decadal variability and to anthropogenic forcing)
- Justifiable projections of the change in risks due to the expected changes in the electrical system (due to technological change, climate change mitigation efforts, and other policies)



CLIMATE READI RESILIENCE AND ADAPTATION INITIATIVE

EPRI Climate <u>Re</u>silience and <u>Adaptation Initiative (READi)</u>

- 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



Deliverables: Common Framework "Guidebooks"

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

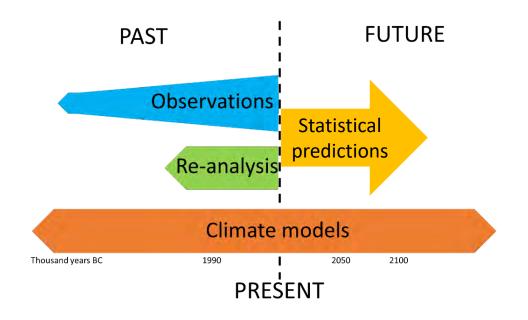
Workstream 1	Workstream 2	Workstream 3
Physical Climate Data & Guidance	Energy System & Asset Vulnerability Assessment	Resilience / Adaptation Planning & Prioritization
 Identify climate hazards and data required for different applications Evaluate data availability, suitability, and methods for downscaling & localizing climate information Address data gaps 	 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 	 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





Characterizing hazards due to climate change

- Data-based approaches
- Climate system model output
- Downscaled climate system model output
 - Statistical downscaling
 - Dynamical downscaling



Power system exposure to climate risks

em to ks	 Energy Demand Higher summer temperatures drive increasing demand for cooling energy (primarily electricity) Higher winter temperatures drive reduced demand for heating energy (including natural gas, oil, and electricity) 	 Electric Grid Winds, ice storms, and wildfires damage transmission and distribution towers/lines Extreme heat reduces power line/transformer capacity Flooding can damage substations/transformers/underground lines 	 Wind, Solar, and Biofuels Changes in wind patterns and solar resources impact generation Extreme winds damage wind and solar infrastructure Increasing temperatures reduce generat- ing capacity Extreme heat/drought reduces biofuels production 	 Hydropower Drought and reduced runoff reduce power production Earlier snowmelt shifts peak production earlier in the year Flooding increases risk of damage and disruption
	<image/>	Pipelines • Flooding damages pumping stations,	Refineries • Externe weather/flooding damage	Functional damage equipment operation and operation operation operation operati
	 drilling, fracking, and mining operations Thawing permafrost and subsidence reduce access and impact production 	 Flooding damages pumping stations, undermines/scours river crossings Loss of electricity impacts pumping operations 	refineries Reduced water availability can constrain fuel refining and processing Loss of electricity impacts refining operations 	 roads and rails and can damage bridges, river and coastal ports, and storage facilities Reduced river runoff can impede barge traffic Extreme weather, flooding, and blackouts can disrupt distribution outlets and gas stations

Power system exposure to risks

- Variables of interest for assessment of hazards to the electrical power system include:
 - *Temperature, humidity, and wind speed* near the earth's surface impact:
 - Electrical demand
 - Thermal power generation
 - Photovoltaic generation
 - Transmission
 - Downwelling solar radiation and its direct and diffuse components impact
 - PV generation
 - Electrical demand
 - Wind speeds at 50 150 m impact
 - Wind generation
 - Ice and snow accumulation impact
 - Transmission, distribution
 - Wind and solar generation
 - Lightning and vegetation dryness relate to wildfires that impact
 - Transmission & distribution
 - Precipitation and Evaporation changes impact
 - Hydrological generation and storage potential
 - Biomass production potential

Nota bene: We need hourly data!





Characterizing risks due to climate change

Resource Adequacy

- Summer warming increases peak loads
- Warming, drought reduce efficiency of thermal power plants that rely on evaporative heating
- Electrification of heating increases winter loads, may shift peak load to winter, but climate warming makes these increases smaller than they would otherwise be
- Changing diurnal profiles of load and generation
- Loss of Load
 - Ice storm/wind storm/tree fall risks to distribution lines
 - Enhancement of wildfire risk interaction of transmission lines and wildfire fuels; cutting off of remote generation from load centers



Climate Impacts & Electric System Planning – 3 Takeaways

1. Electric company system planning needs and motives to explore climate risks vary

- Motivation ranges from past experiences (e.g., Sandy) with resiliency threats to shareholder resolutions
- Much heterogeneity (e.g., regional differences, regulatory environment, market structure)
- Climate considerations can no longer be handled in "isolation" integrated resource planning is increasingly complex (e.g., evolution of end-use devices and services, power markets, DERs, clean energy policies, variable renewables, fuel supply)

• 2. Climate and climate change mitigation policies are two of several factors driving change in electric sector

- Technological changes unrelated to climate policy has its own dynamics (for example, the fall of gas prices during the fracking boom, electrification of transportation for performance and quality reasons)
- Pollution control apart from greenhouse gas emissions is driving changes in many electrical markets, with resulting climate feedbacks
- Regulatory environments and market structures have a large impact on transmission deployment and siting of various power generation infrastructure

• 3. Planning for what? Incremental/chronic change vs. acute/extreme events vs. variability

- Means vs. extremes, chronic vs. acute events, intra- vs. inter-annual variability, spatial variability
- Assessment methodologies differ deterministic vs. stochastic approaches
- Extremes matter most for adaptation planning: max (min) temp drives peak cooling (heating) demand, max storm surge drives extent of coastal protection, etc.

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