Generation Fleet Change – Challenges and Opportunities

Reliability and Resilience

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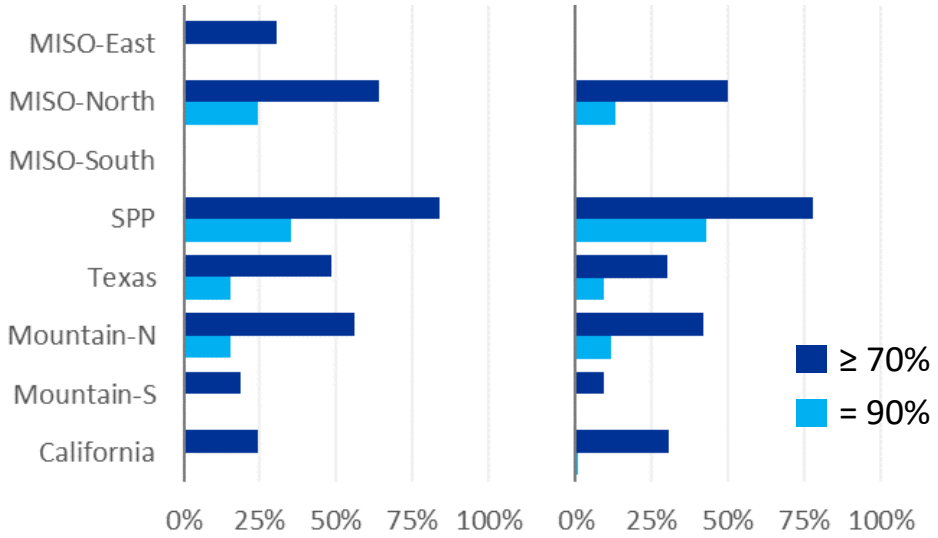
Midwest Governors Association MID GRID 2035
Little Rock, AR
Sept 28, 2023

Reliability & Resiliency Through the Transition

Enhancing Energy System Reliability and Resiliency in a Net-Zero Economy (epri.com) - 2022

Percentage of Annual Hours that Solar+Wind Supply >= 70% of Generation



Annual National Share Wind+Solar

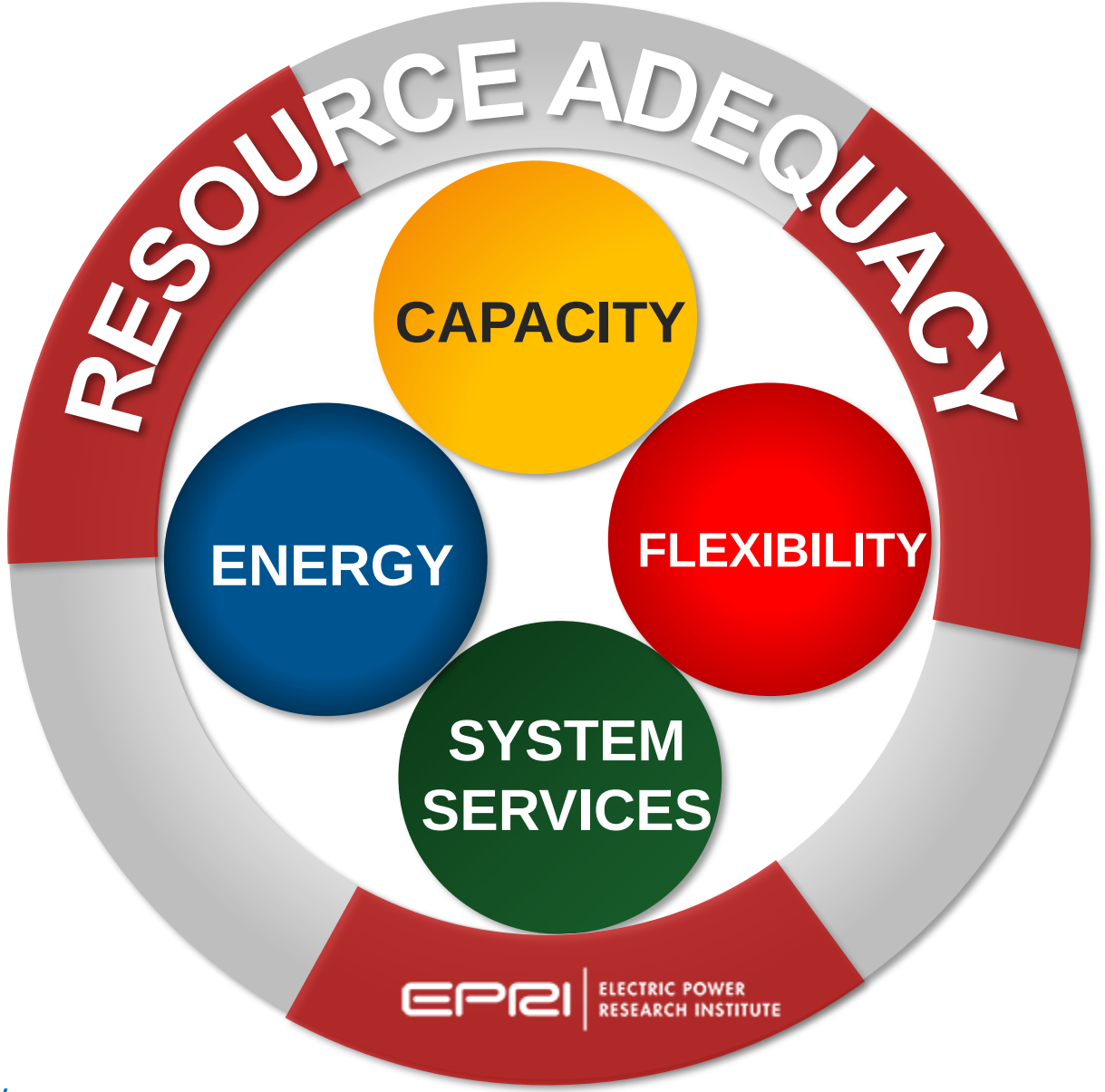
46%

32%

RESOURCE ADEQUACY	DELIVERY ADEQUACY
Additional resources to meet energy needs for resiliency to extreme future scenarios	Regional T&D capacity to integrate renewables and DER and serve increased electrification demand
BALANCING AND FLEXIBILITY	**GRID STABILITY**
Flexibility resources and operating reserves to manage variability and uncertainty	Resources and controls to maintain frequency and voltage for much faster dynamic system

A Decarbonized Grid must be more reliable and resilient as the grid becomes more dynamic, decentralized, and inverter-based in the context of changing climate and other hazards.

What does it mean to have adequate resources?



An adequate supply fleet is not just the installed MW in the ground. The capacity must have energy to sustain during critical time periods, flexibility to accommodate condition changes, and sufficient reliability services to provide when necessary

RA Mailing List

www.epri.com/resource-adequacy

Resource Adequacy Initiative

Overview - https://www.epri.com/resource-adequacy

RA Guidelines: http://gridops.epri.com/adequacy

Scope and Deliverables

RA Process

- Recommended Metrics and Criteria
- Future Scenario Database and Tool

Models and Data

- Emerging Resource & Demand Side Models
- Model Data Development Tools

Analysis Tools

- Existing RA Tool Capabilities
- New Algorithms and open-source code

Case Studies — Evaluation of existing and development of new capabilities based on 4-6 regional RA case studies covering differing RA issues and tools.

Tech Transfer — Reports and workshops to be conducted to disseminate results and to promote broad adoption in commercial tools.

25+ Participants

Southern California Edison, CPS Energy, Duke Energy, aeci, Hawaiian Electric, American Electric Power, LCRA, conEdison, Ameren, TVA, Austin Energy, New York State of Opportunity / NY Power Authority, LA DWP Los Angeles Department of Water & Power, Arkansas Electric Cooperative Corporation, Southern Company, SRP, NERC North American Electric Reliability Corporation, MISO, SPP Southwest Power Pool, aps, ISO new england, pjm, Entergy, evergy, New York ISO Independent System Operator, Manitoba Hydro, NPCC, Inc.

Partners

TELOS ENERGY

ASTRAPÉ CONSULTING innovation in electric system planning

GE

MOMENT ENERGY INSIGHTS

Blue Marble Analytics

ENELYTIX® powered by PSO

External Advisory — NARUC, NREL, ESIG, GridPath, RROs, DOE, ISOs/RTOs, G-PST, Consultants, Universities, etc.)

Metrics and Criteria

Different metrics expose different levels of risk

LOLE is a frequency metric and typically evaluated on average

Metrics that include magnitude and duration expose additional risk

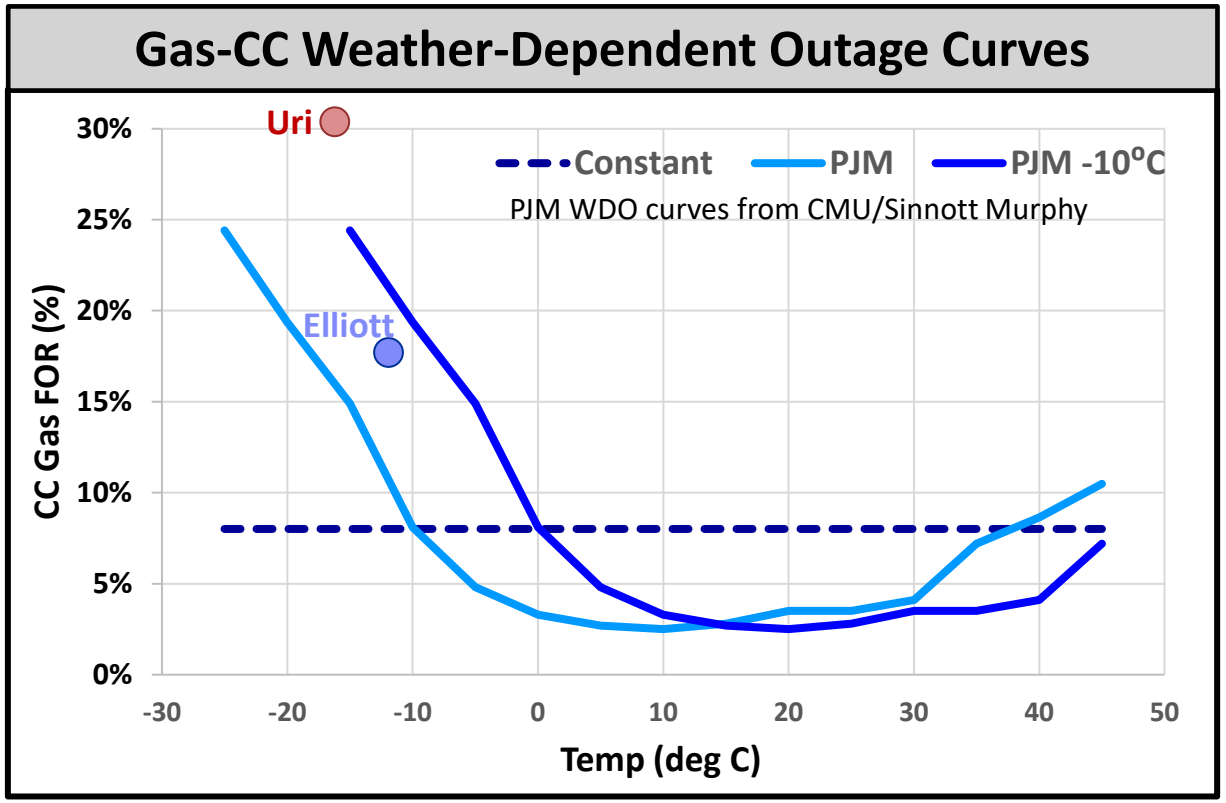
Potential for very different customer impacts for same LOLE level

NPCC Case Study: Risk conveyed by metrics			
Region	**Daily LOLE**	**Hourly LOLE**	**EUE-norm.**
A	0.10	0.15	0.37
B	0.10	0.34	0.99
C	0.10	0.39	3.37
D	0.10	0.25	1.00
E	0.10	0.48	2.54
F	0.10	0.28	0.34
Metric Scope	Frequency	+ Duration	+ Magnitude
Relative Risk	**Same**	**3X**	**10X**

EPRI Initiative provides Metric Viewer tool and guidance to select metrics that expose true risk

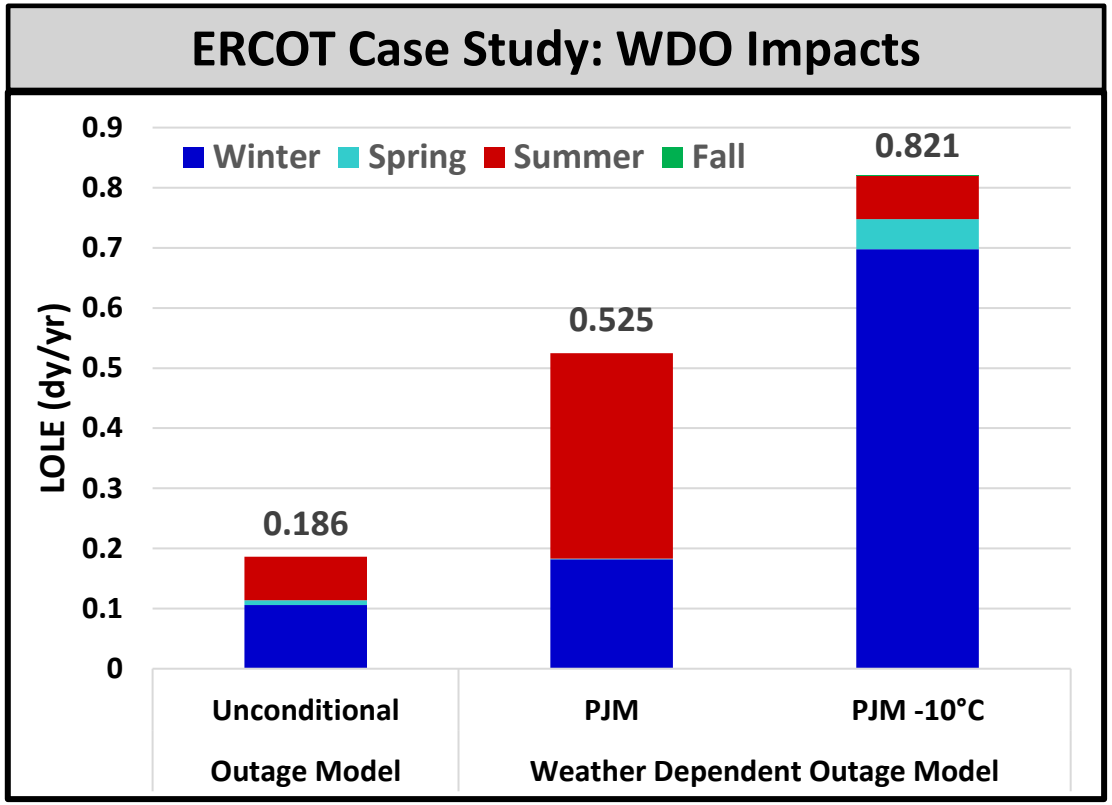
Resource Models: Weather Dependent Outages (WDO)

Gas-CC Weather-Dependent Outage Curves



Extreme temperature impacts generator forced outage rates

ERCOT Case Study: WDO Impacts



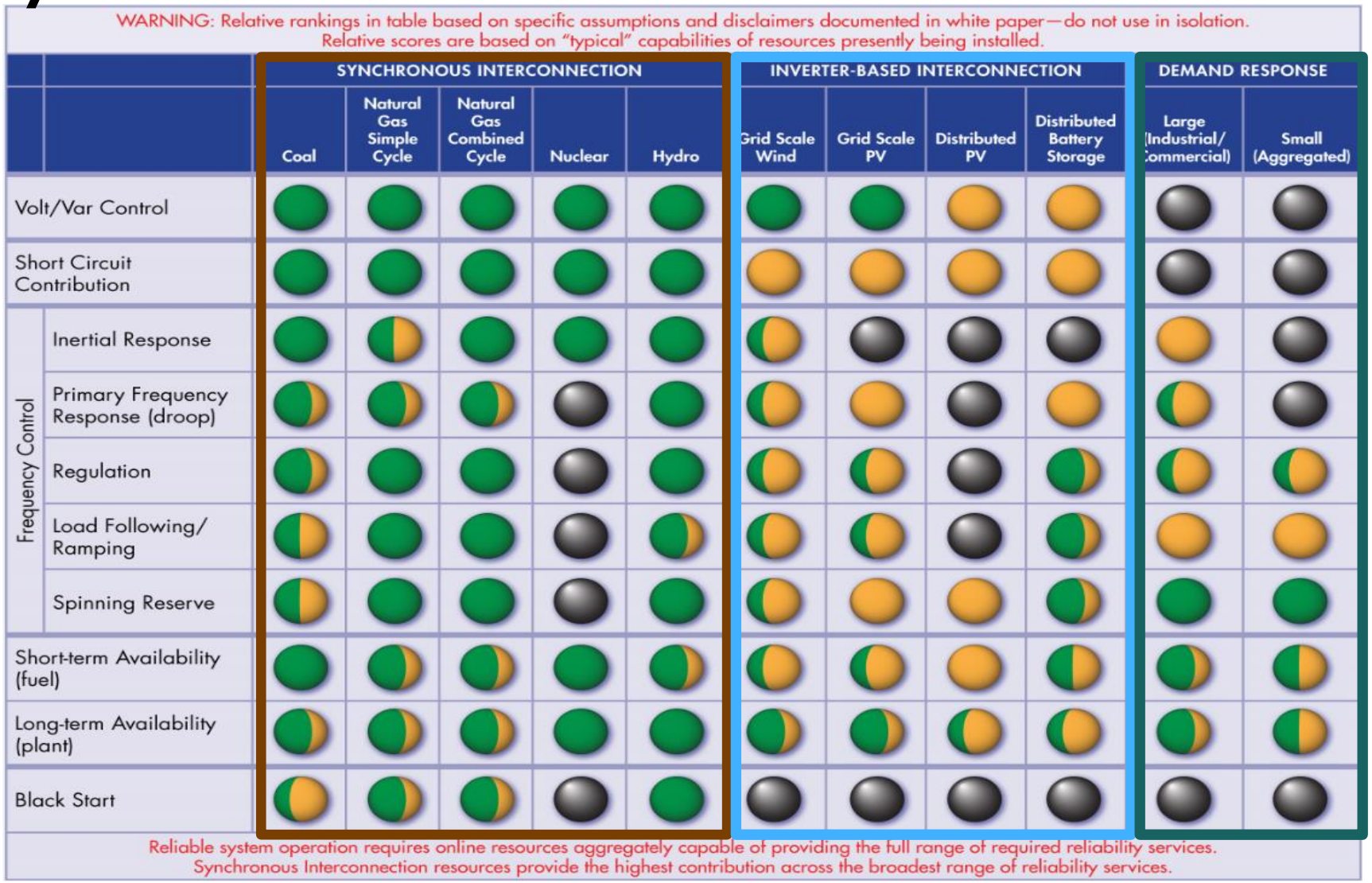
Including WDO in RA risk assessment exposes additional risk

EPRI RAI provides methodology for creating generation WDO curves, modeling guidance (renewables, storage, and, transmission, et. al.), and guidance on data and application in tools

Relative Reliability Contributions for Various Resources

- Must ensure reliability when considering new resource mix
- Not all resources are equal in “Reliability Capability”
- Synchronous resources broader & deeper ability to support reliability
- Reliability is not only consideration: Sustainability, Diversity, Economics, Emissions, among others
- Currently updating (2023 Q4)

EPRI whitepaper (2015): Contributions of Supply & Demand Resources to Required System Reliability Services (3002006400)



Relative score for currently installed technologies:

EPRI Climate Resilience and Adaptation Initiative (READi)

CLIMATE READi
RESILIENCE AND ADAPTATION INITIATIVE

- **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	**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 asset design and operation	• 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