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NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Welcome

NERC Industry Workshop

Energy Reliability Assessment Task Force Industry Update and Opportunity for Industry Comments
February 16, 2022

RELIABILITY | RESILIENCE | SECURITY




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Welcome

Elsa Prince, Coordinator for the Energy Reliability Assessment Task Force
Principal Technical Advisor, PRISM
February 16, 2022

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Workshop Protocol

- If you have any technical issues, send a chat message to Levetra Pitts.
- If you have any general questions, send a chat message to Soo Jin Kim.
- Questions directed to the panelist will be managed using the Slido software.
- We will prioritize audience questions and the panelists will answer the most relevant questions during the workshop.
- All audience questions will be answered in a Q&A document and it will be posted on the Energy Reliability Assessment Task Force website within two weeks from today.

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Slido is an interaction platform that enables you to vote in polls and send questions to the speakers. Simply use your smartphone, computer, or other device and speak up.

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Workshop Agenda

- NERC Antitrust
- Introduction
- Keynote Remarks
- Panel 1: Operations/Operational Planning
- Answering Audience Questions (Slido)
- Lunch
- Panel 2: Mid to Long Term Planning
- Answering Audience Questions (Slido)
- Break
- Panel 3: R&D
- Answering Audience Questions (Slido)
- Closing Remarks

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NERC Antitrust

Levetra Pitts, Senior Program Specialist, NERC

February 16, 2022

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Introduction

Mark Lauby, Senior Vice President & Chief Engineer, NERC
Peter Brandien, Vice President, System Operations & Market Administration, ISO New England

February 16, 2022

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Keynote Remarks

Gordon van Welie, President and Chief Executive Officer,
ISO New England

February 16, 2022

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Energy Assessments Are Essential for all Regions to Successfully Navigate the Clean Energy Transition

NERC Energy Reliability Assessment Task Force

Gordon van Welie

PRESIDENT & CHIEF EXECUTIVE OFFICER

ISO New England's *Mission and Vision*

Mission: *What we do*

Through collaboration and innovation,
ISO New England plans the transmission system, administers the region's wholesale markets, and operates the power system to ensure reliable and competitively priced wholesale electricity

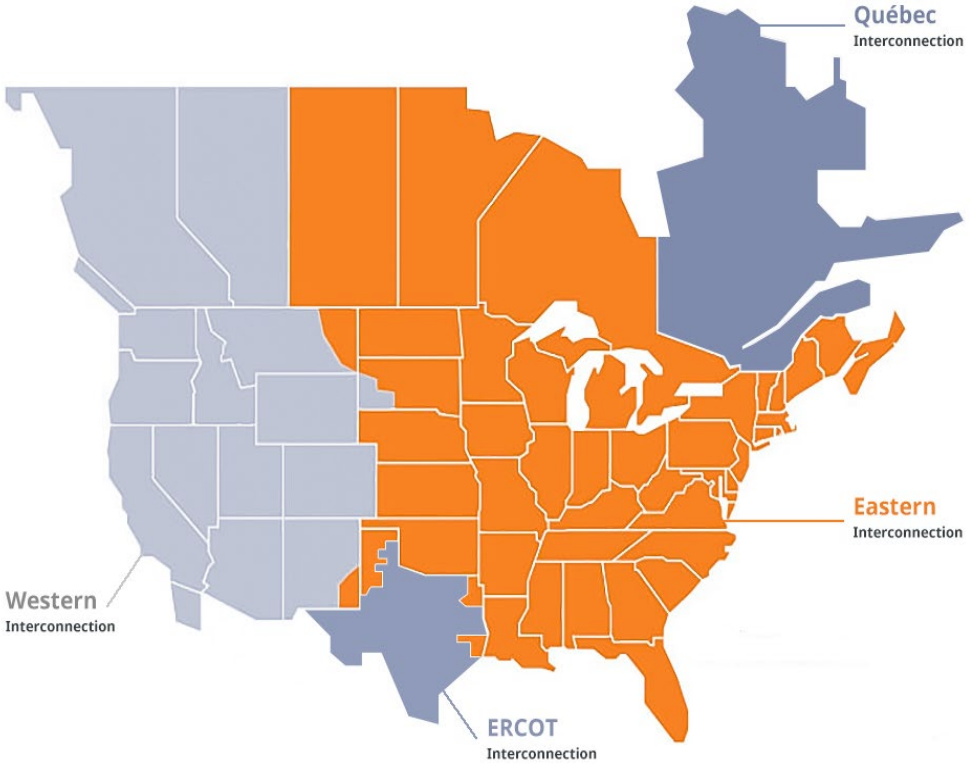
Vision: *Where we're going*

To harness the power of competition and advanced technologies to reliably plan and operate the grid as the region transitions to clean energy

*The ISO's new **Vision** for the future represents our long-term intent and guides the formulation of our Strategic Goals*

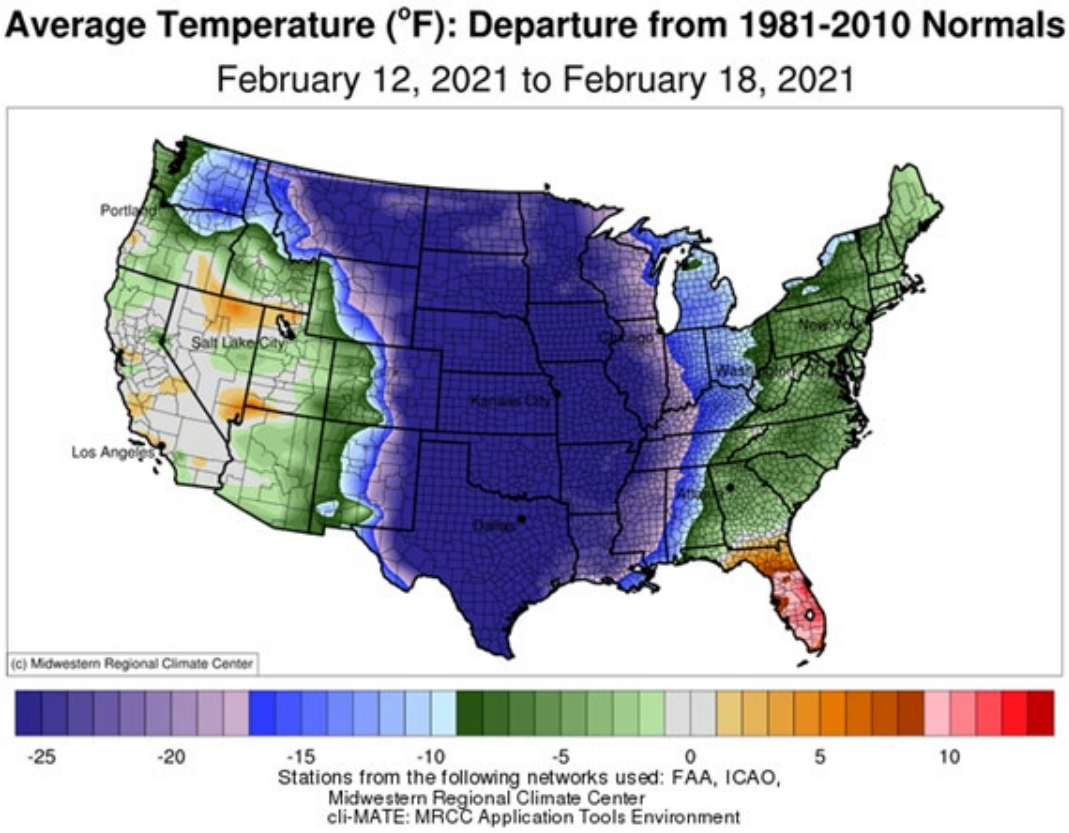
Performing Regional Assessments Is Essential in a Large, Highly Interconnected Power System

- We are tied to one another by physical **infrastructure** and a shared interest in a **reliable** power system
- Wide-area monitoring and mandatory reliability standards came about to **address risks** revealed by the 2003 blackout
- The rapidly changing resource mix poses new risks and requires **new tools** to enhance our situational awareness
- The trajectory toward full **decarbonization** of the industry makes this essential



New England Is Not Texas, but Risks Remain

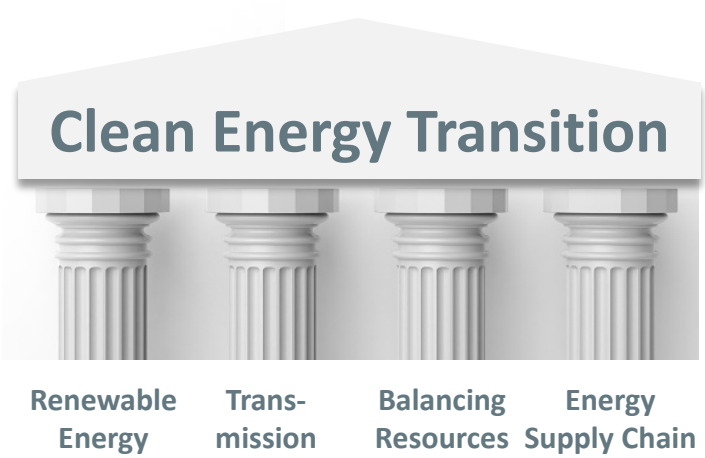
- New England generators and transmission lines are **better winterized**, but this region remains vulnerable during *extreme* and *extended* cold weather
- **Transmission** to neighboring power systems is beneficial; however, a *large-scale weather event* is likely to impact New York and Canada, limiting their ability to export excess power to New England



Source: Midwest Regional Climate Center

There Are Four Pillars Necessary to Support a Successful Clean Energy Transition

1. Ensuring sufficient **renewable energy** to achieve decarbonization goals
2. Developing sufficient **transmission**, through a competitive process, to integrate the renewables and transmit and distribute the clean energy
3. Maintaining and attracting a robust fleet of **balancing resources** through a competitive wholesale market structure (or through traditional cost-of service mechanisms for regions/states that are vertically integrated)
4. Ensuring a robust **energy supply chain** for the balancing resources, with sufficient access to stored energy to withstand long-duration severe weather events that may include multiple contingencies

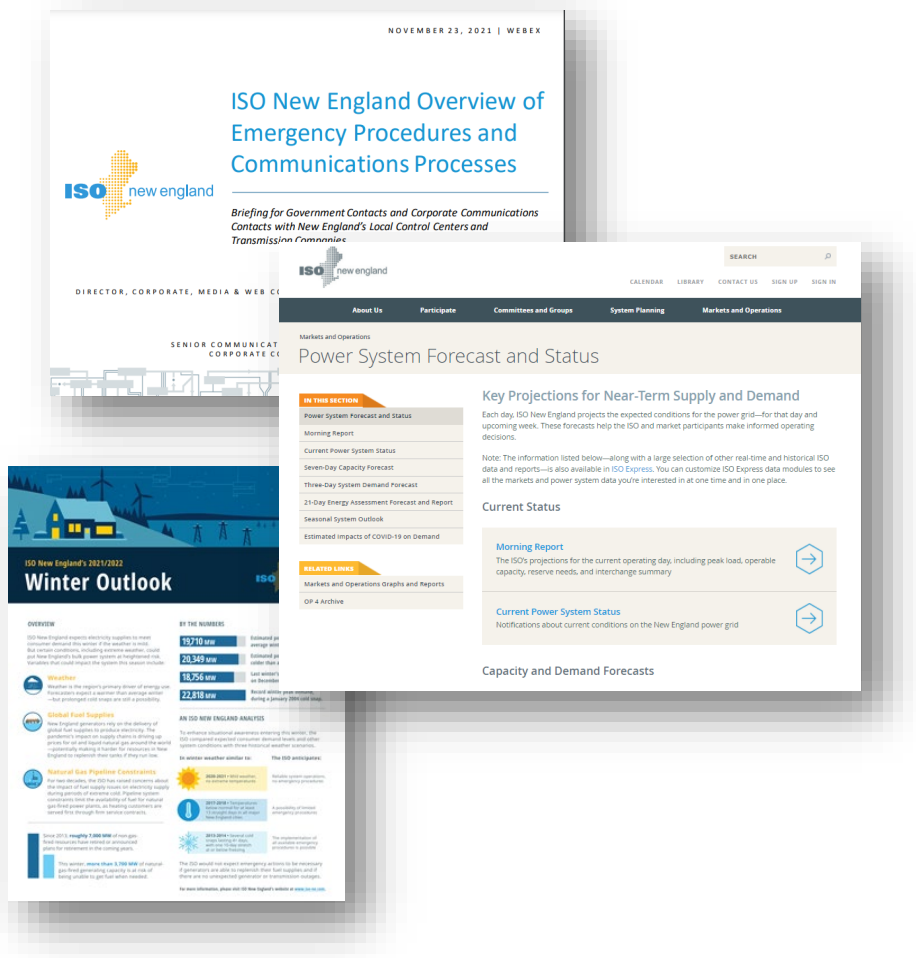


Conclusion

- To navigate this energy transition successfully, we need to understand our **energy adequacy** situation in different timeframes (operations and planning)
  - *A NERC standard would require assessments, but not dictate solutions*
    - ISO-NE built a 21-day energy forecast to enhance our situational awareness and, looking ahead, we are exploring ways to value resource capacity contributions toward resource adequacy in a more effective way
    - We have also initiated a regional discussion about the need for a regional energy reserve to be able to withstand long-duration adverse weather events in combination with significant contingencies
- This is *not* just a cold weather problem affecting certain regions
  - The emerging resource base is becoming increasingly energy-constrained by fuel availability, weather, and limitations of the energy supply chain
- This is *not* just a problem affecting a few "at risk" units
  - Large amounts of resources can be impacted at the same time
  - Neighboring regions may not be able to cover each others' energy shortfalls if we are all facing similar challenges simultaneously
  - Transmission solutions would need to extend to areas beyond those affected by a widespread extreme-weather event
- **Energy assessments can help us identify these problems and each region can formulate risk mitigation solutions**

How ISO-NE Communicates Power System Information to State Officials and the Public

- Operational and emergency procedures
  - 21-Day Energy Assessment Forecast
  - Seven-Day Capacity Forecast
  - Daily Morning Report
  - Pre-Winter Briefing for Public Officials
  - Seasonal System Outlook and Winter Outlook Factsheet



FOR MORE INFORMATION…

Subscribe to the *ISO Newswire*

ISO Newswire is your source for regular news about ISO New England and the wholesale electricity industry within the six-state region

Log on to ISO Express

ISO Express provides real-time data on New England's wholesale electricity markets and power system operations

Follow the ISO on Twitter

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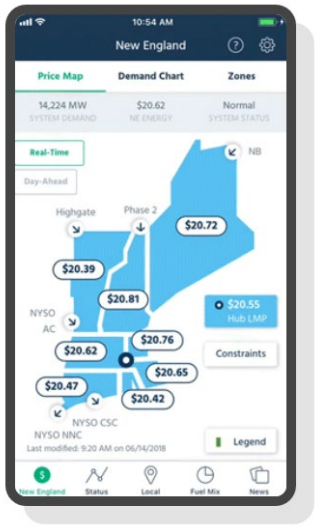
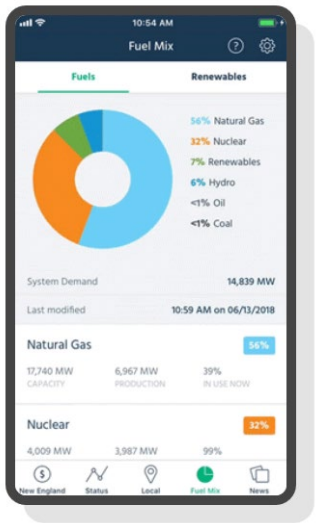
Download the ISO to Go App

ISO to Go is a free mobile application that puts real-time wholesale electricity pricing and power grid information in the palm of your hand





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Panel 1 - Operations and Operational Planning

Moderator:
Chris Pilong
Director,
Operations Planning,
PJM

Panelist:
Jason Bucholtz
Real Time Operations
Manager,
AESO

Panelist:
Mike Knowland
Manager of Operations
Forecast and Scheduling,
ISO-NE

Panelist:
Neil Millar
Vice President of
Infrastructure
& Operations Planning,
CAISO

Panelist:
Rodney O'Bryant
System Operations
Manager,
SOCO

Panelist:
Scott Winner
Operations Research
Analyst,
BPA

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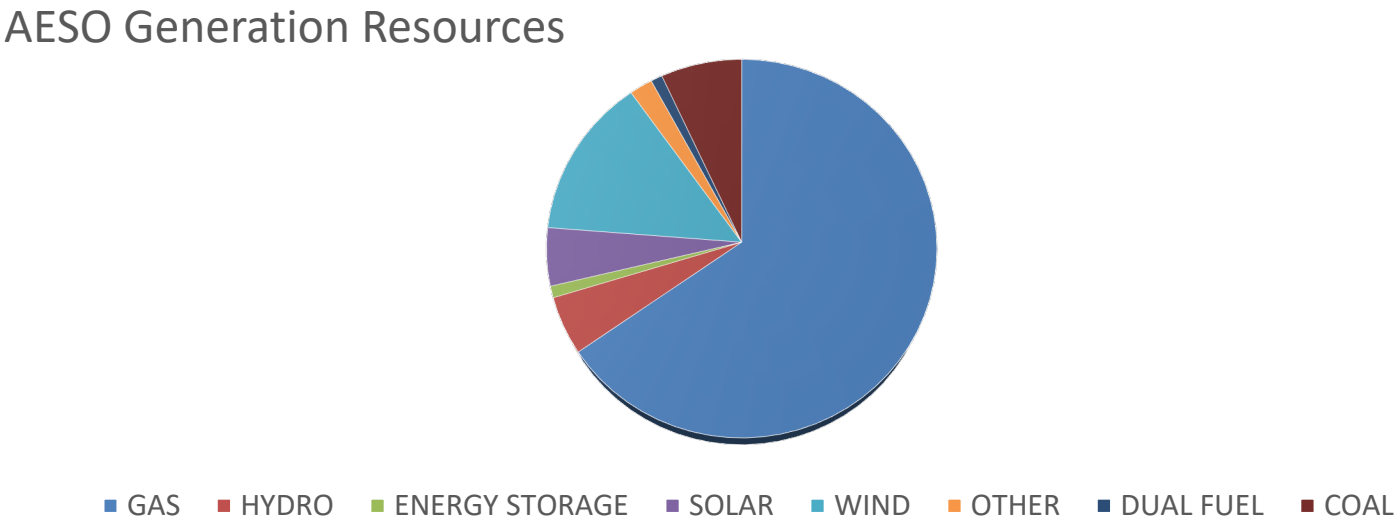
AESO Energy Assessments

February 2022

Alberta Energy only Market

- Generators only receive revenue on power delivered
- Alberta has no capacity payment
- Generators must offer their energy into our market and must comply with dispatch
- Alberta has no unit commitment for day ahead



Energy assessment time horizons

- 24-month supply and demand forecast
  - Report available on AESO website for generators to plan outages
- Seasonal assessments
  - Stressed cases – peak demand and generation unavailability
  - Thermal, voltage and angular studies assessed
- 7-day supply adequacy
  - Report available online for market participants to receive a market signal of when supply may be short
- Real time energy assessments
  - Energy assessments performed daily for current and next day

Key Resources impacting assessments

- Natural gas generating units
  - Interruptible natural gas transactions and impact on generators
- Natural gas supply concerns
  - Receive capacity notifications when constraints occur
- Renewable generating unit forecasts
  - Wind and solar generation can really impact market price and some generating resources will not participate when abundance or renewable resources online
- High load forecast due to extreme temperatures
- Intertie capability

Mitigating concerns

- Better understanding of generation natural gas contract limitations
- Continue to improve renewable forecasts
- Improved communications with natural gas providers
- Improved notifications of natural gas capacity concerns due to unplanned outages during extreme temps
- Investigating potential rule changes to require generators to be more specific in their offers when there are natural gas constraints on the system
- Building in a forecasted inertia into the 7-day supply and demand outlook and monitor in real time

Thank you

Improving Situational Awareness through Energy Analyses at ISO New England

NERC Energy Reliability Assessment Task Force

Mike Knowland

MANAGER, OPERATIONS FORECAST AND SCHEDULING

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Overview of Energy Security Risks in New England

- State decarbonization policies and renewable energy goals may tend to increase the capacity of solar and wind generation in the years to come; coupled with continued retirement of fuel-secure resources this will increase the importance of the performance of energy analysis
- New England's resource mix continues to transition toward a higher penetration of intermittent and limited-energy resources. Variability of weather dependent resources requires improvements in forecast precision and accuracy
  - Improved forecasts required to quantify the impact of cloud cover and variable wind on generation
  - Output of variable resources must be coordinated with the dispatch of traditional resources or storage
- Traditional demand patterns are changing due to the influx of behind-the-meter (BTM) photovoltaic (PV) resources and the forecasted electrification of transportation and heating sectors

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Overview of Energy Security Risks in New England (cont'd)

- Limited supply of pipeline gas available on a daily basis, and supplies are consumed by heating demand before power generation
  - The amount of heating demand is a function of temperature
  - The remaining supply is assumed available for power generation
- There is a finite quantity of stored fuels (oil, coal, LNG) with stressed logistics for replenishment, especially during long-duration cold weather events
  - Weekly generator survey responses provide the majority of information on stored fuel quantities and resupply plans
- These factors highlight the importance of comprehensive energy security assessments covering a wide range of operating conditions

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Overview of Energy Analyses

- Modeling tools look at a series of one-hour intervals, each one historically dependent, through the depletion of fuel
- Weather inputs drive forecasted electric load and gas heating demand. Gas heating demand is subtracted from the total gas supply to determine gas-only generation availability
- ISO's renewable generation forecasts provide fixed hourly quantities of power from wind and solar resources
- Generation is dispatched in a specified order to serve load until fuel is depleted or load is served

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INFORMATION GATHERING

Overview of ISO New England generator surveys

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Forecast and Survey Inputs to Energy Analysis

- Weekly surveys are conducted through the winter months with traditional generators that have potential energy restrictions, such as emissions or limited stored fuel
  - Current inventory, replenishment plans, actual or anticipated environmental limitations
  - Surveys and reporting are performed more frequently than weekly when needed to provide up-to-date information to stakeholders

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ROUTINE ANALYSES

21-Day Energy Emergency Forecast

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Analysis Process

- 504 hours of sequential intervals that calculate the required generation to serve load and meet reserve requirement assumptions (*24 hours X 21 days*)
  - Granularity of forecasts and assumptions depends on the study
  - Deterministic vs. Probabilistic; Forecasts vs. Assumptions
- Constrained and limited-quantity fuels are reflected as MW reductions in the dispatch, based on the nature of the constraint
  - When fuel supplies are fully depleted, that specific plant becomes unavailable and must be replaced by the next plant in line
  - Replenishment results in restored availability
- Results are shown to an analyst to identify the potential need for actions to manage a capacity deficiency or energy emergency
- Report is made available to the public in order to ensure that stakeholders are informed of forecasted system conditions

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REPORTING

21-Day Energy Emergency Forecast Report

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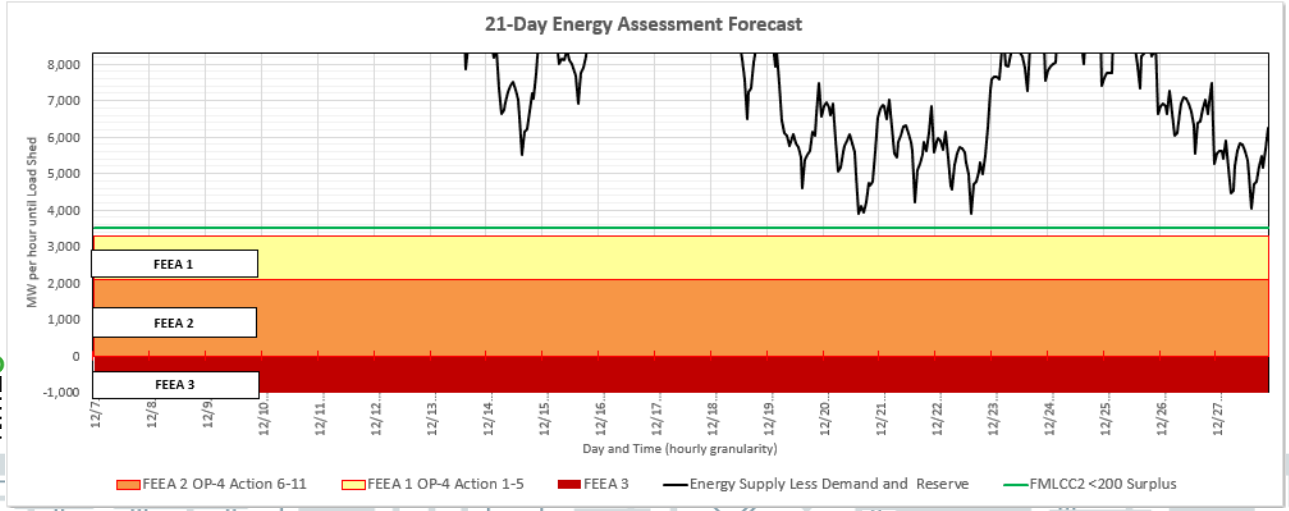
Capacity Surplus Chart

- The final result of the 21-Day Energy Emergency Forecast is a chart showing the capacity surplus in each hour of the study period, after accounting for outages due to depleted fuel or emissions restrictions



Energy Alerts and Energy Emergencies are triggered when system surplus falls below established **thresholds**

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Results of Energy Analysis: Metrics

- FEEA (Forecasted Energy Emergency Alert) levels quantify the forecasted use of procedures to manage capacity deficiency and emergency
  - FEEA Levels are based on NERC EOP-011-1: Emergency Operations
- Energy Alerts and Energy Emergency Conditions provide for actions to take when forecasting energy deficiencies
  - Enhanced reporting and communication
  - Daily surveying of inventory, daily energy analysis
  - Appeals to curtail load on voluntary basis, voltage reductions
  - Operation on fuel that is not in short supply
  - Public appeals from the region's governors

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Ensuring Capacity Sufficiency

NERC Energy Reliability Assessment Task Force
February 16, 2022

Neil Millar, VP Infrastructure and Operations Planning

Assessing sufficiency of resources is addressed in four major processes

- Long term Integrated Resource Planning conducted by the California Public Utilities Commission (CPUC)
- Seasonal – summer – assessments conducted by the California ISO and other assessments conducted by the CPUC and the California Energy Commission
- Resource Adequacy program conducted collaboratively by the California ISO and local regulatory agencies including the CPUC
- Market operations running from week ahead through to real time

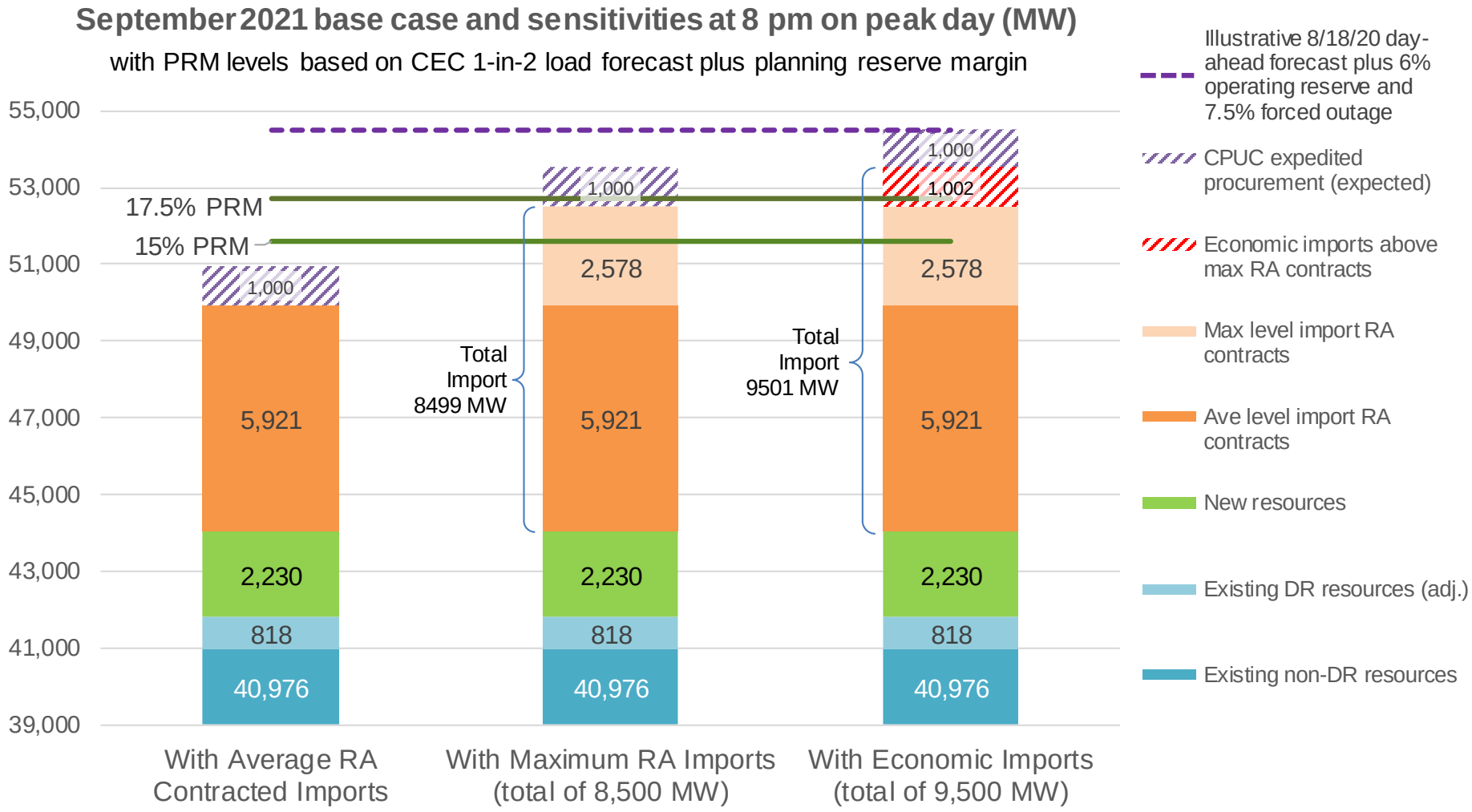
ISO's Summer Assessment is focused on preparing for normal and a range of potential extreme conditions – using a layered approach:

Deterministic assessment of resources (stack analysis)	Stochastic Production Cost Model analysis
Uses the California Energy Commission 2020 1-in-2 forecast for 2021	Uses the ISO developed range of weather driven load forecasts for 2021 to develop the 2,000 scenarios
Based on resource RA "Net Qualifying Capacities"	Based on resource RA "Net Qualifying Capacities"
Solar considered at zero output at post-solar window (8 pm)	Model all hours of the day across the summer
"Effective Load Carrying Capability" base values used for hydro and wind	Generation profiles for renewables, and combination of dispatchability and profiles for hydro
Demand response discounted 50% (reflecting 2020 actual performance of "shown" capacity)	Market based DR not discounted

Note that the California Energy Commission also prepares detailed stack analyses, and is developing stochastic production cost models.

1. California ISO "stack analysis" for summer 2021

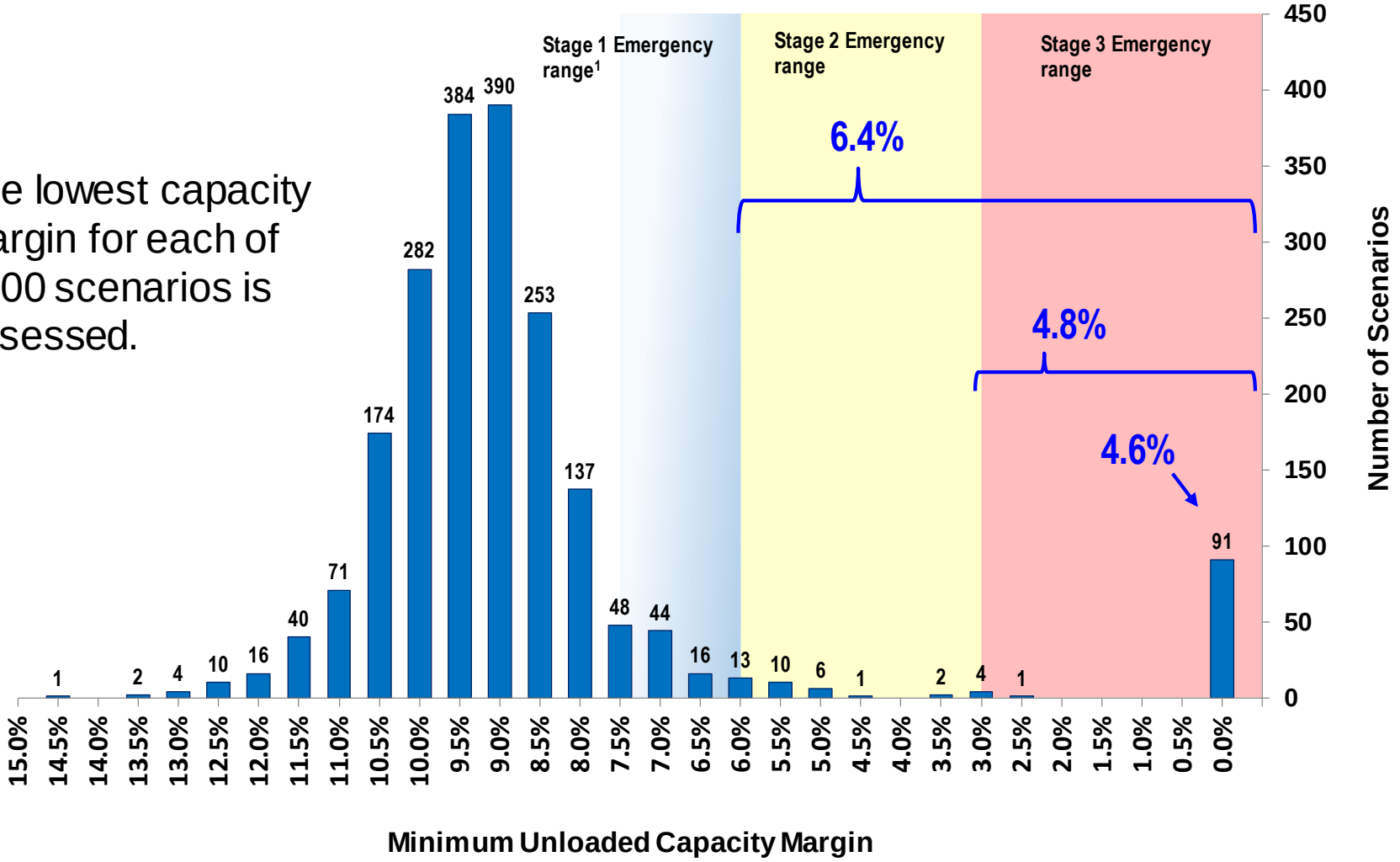
(Key uncertainties include the availability of imports and hydro conditions)



California ISO

2. The stochastic assessment considers a broader range of uncertainties and is compared to past years' experiences

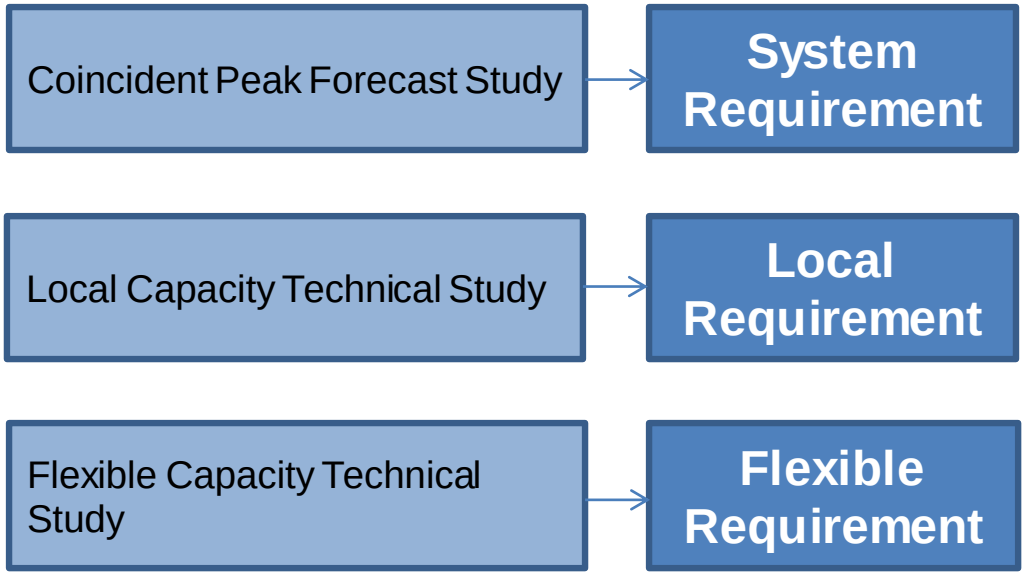
The lowest capacity margin for each of 2000 scenarios is assessed.



[1]Stage 1 range is approximate

The Resource Adequacy program considers three requirements

- A planning and procurement process to ensure that sufficient capacity is provided to the CAISO to ensure the safe and reliable operation of the electric grid
- CAISO collaborates with Local Regulatory Authorities (LRAs) on the establishment and execution of the RA program, with default resource adequacy requirements if needed



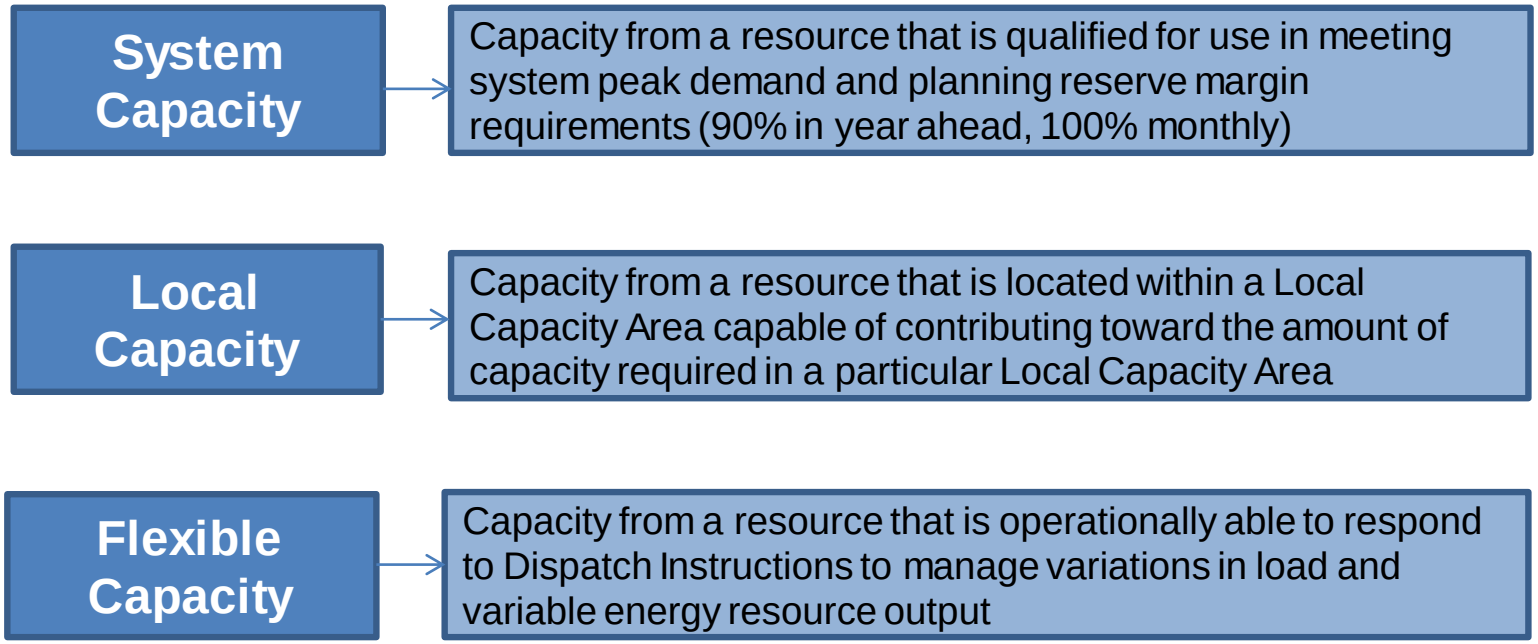
Determined Annually and Monthly by the LRA. LSE has 1 requirement. Must procure load forecast plus planning reserve margin each month.*

Determined Annually by CAISO. LSE has 1 requirement in each Transmission Access Charge area that it serves load. Same requirement all year.

Determined Annually by CAISO. LSE has 1 requirement. Requirement varies by month.

* Percentage can vary based on LRA

Three types of capacity must be secured



- Resources have certain must offer obligations and limitations in participating in other capacity procurement
- Resources subject to incentive mechanisms for encouraging availability

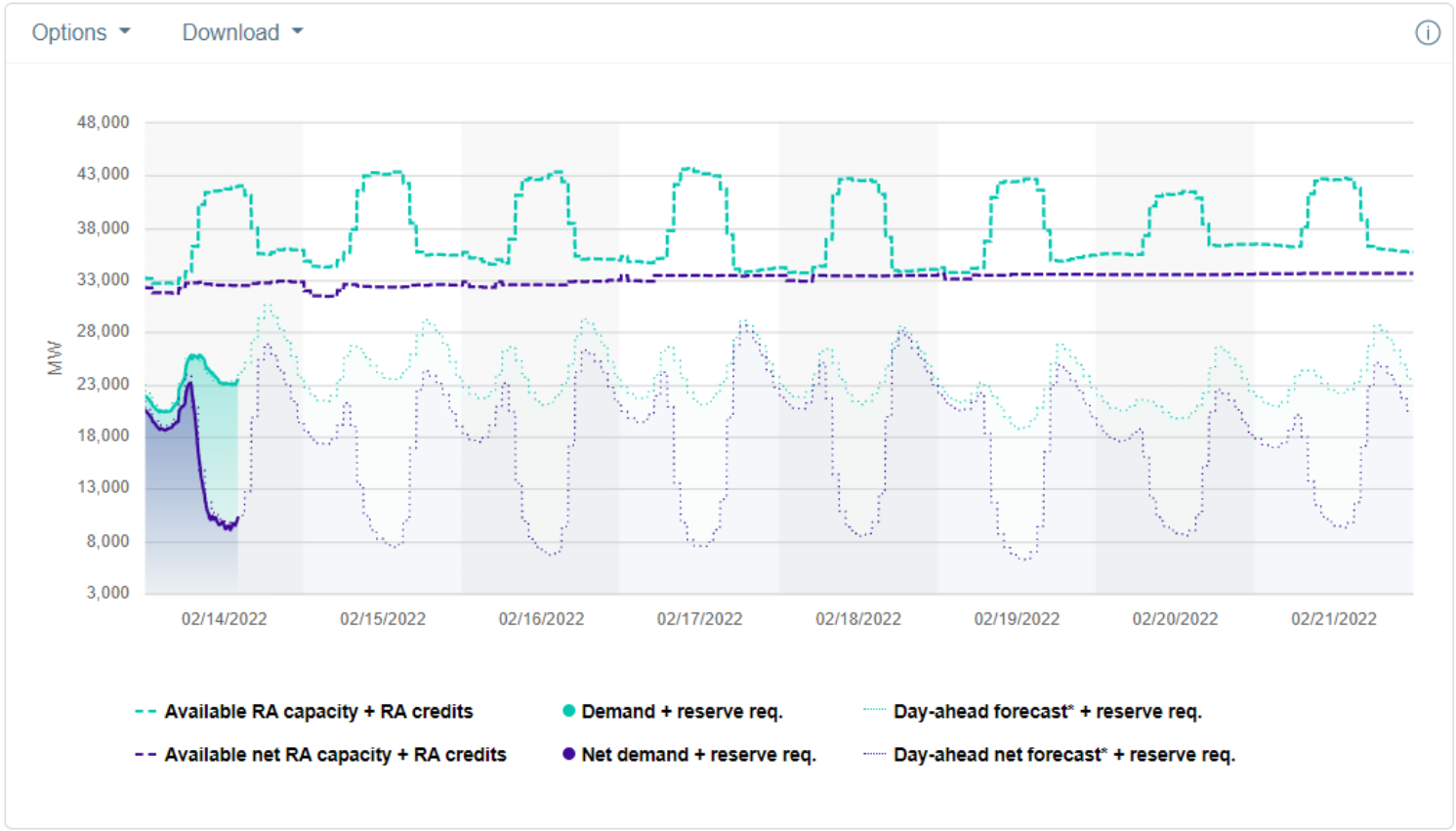
There are prescribed timelines for showings

- Annual Showings:
  - September: Year ahead requirements are finalized
  - October: LSEs and Suppliers make the year ahead showings
  - November: CAISO makes any deficiency determinations and LSEs have a chance to cure
  - December: CAISO may procure backstop capacity through the Capacity Procurement Mechanism (CPM)
- Monthly Showings:
  - Showings 45 days out
  - Validation by California ISO 44 days out
  - Cure period closes 30 days out
  - California ISO procurement (if needed) 25 days out
  - The CAISO has several backstop arrangement alternatives if deficiencies are not cured, and capacity is available.

The CAISO also provides transparency on capacity looking forward 7 days – then we move into day ahead and real time market operation

7-day resource adequacy capacity trend

Resource adequacy capacity forecast for today plus the next 7 days, in megawatts, compared to demand forecast plus reserve requirements.



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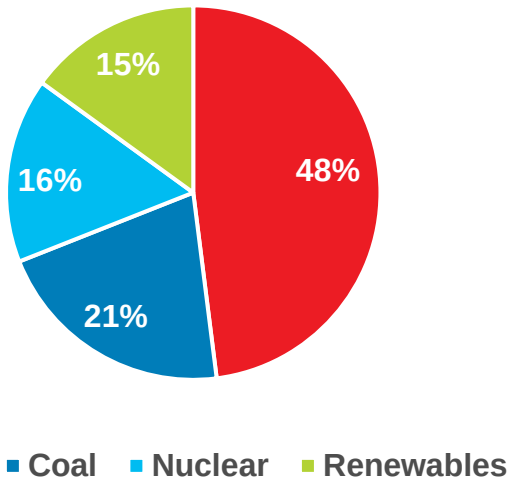
Energy Assessment Considerations

Rodney O'Bryant
Balancing Authority Manager

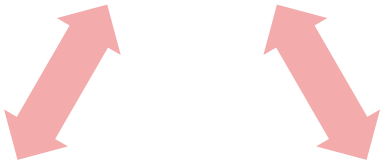
Southern Company Electric Operations

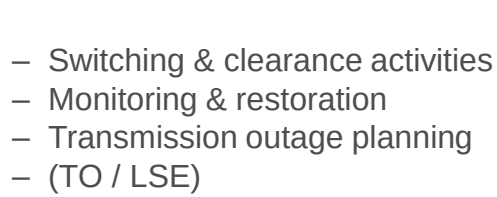
- **Operating Companies in AL, GA and MS**
- **Service to over 4 million electric customers**
- **Vertically integrated**
  - 27,000 miles of transmission lines
  - 3,700 substations
  - 156,000 miles of distribution lines
  - 2021 Energy Mix:

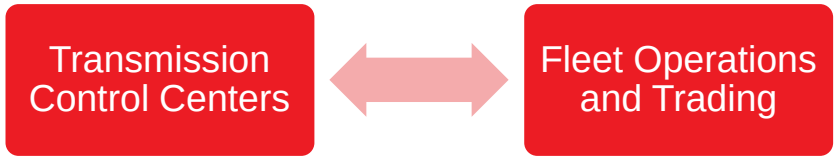


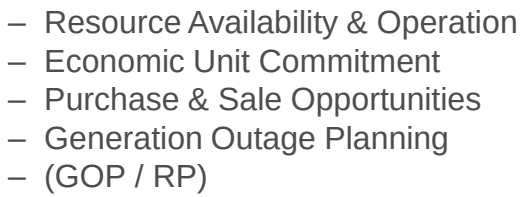
Southern Company Real-time Operations

- Bulk Power Grid Reliability Monitoring & Coordination
- T & G Outage Coordination
- Reliability Based Unit Commitment
- Generation & Load Balancing
- Bulk Power Market Operations
- NERC Compliance
- (RC / TOP / BA /IC /TSP)









Energy Assessment Horizon

Real-Time Operations Horizon

- Daily Assessments
- Weekly Assessments
- Monthly Regulation Targets
- Seasonal Assessments

Operations Planning Horizon

- Seasonal Outage Limits
- Deliverability Evaluations
- Outage Coordination
- Seasonal Assessments

Energy Assessment Components

Adequacy

- Load Carrying Capability
- Deliverability of Reserves and Reserve Targets
- Ramping Requirements (Net Demand)
- Forecast Confidence
- Market Conditions
- FO Sensitivity Considerations
- Seasonal Generation Outage Targets

Resiliency

- Fuel Policy Requirements (FT & Storage)
- Fuel Supply Assessments – (Coal & Oil)
- Generator Winterization Program
- Long-Term Transmission Planning process
- Loss of Fuel Supply Studies
- Contingency Reserve Testing Requirements

Flexibility

- Ability to increase reserves levels based on System Conditions
- Drills – Practice
- Coordinated Transmission and Generation Outage Process
- Demand Side Options
- Market Purchases / Emergency Energy Agreements/ Capacity Benefit Margins

NERC Resources

- NERC Reliability Guideline – Operating Reserve Management: Version 3
- NERC Reliability Guideline – Generating Unit Winter Weather Readiness – Current Industry Practices: Version 3
- NERC Information Resources on Cold Weather Preparation and BPS Impacts (11/22/2021)
- Cold Weather Training Materials (nerc.com)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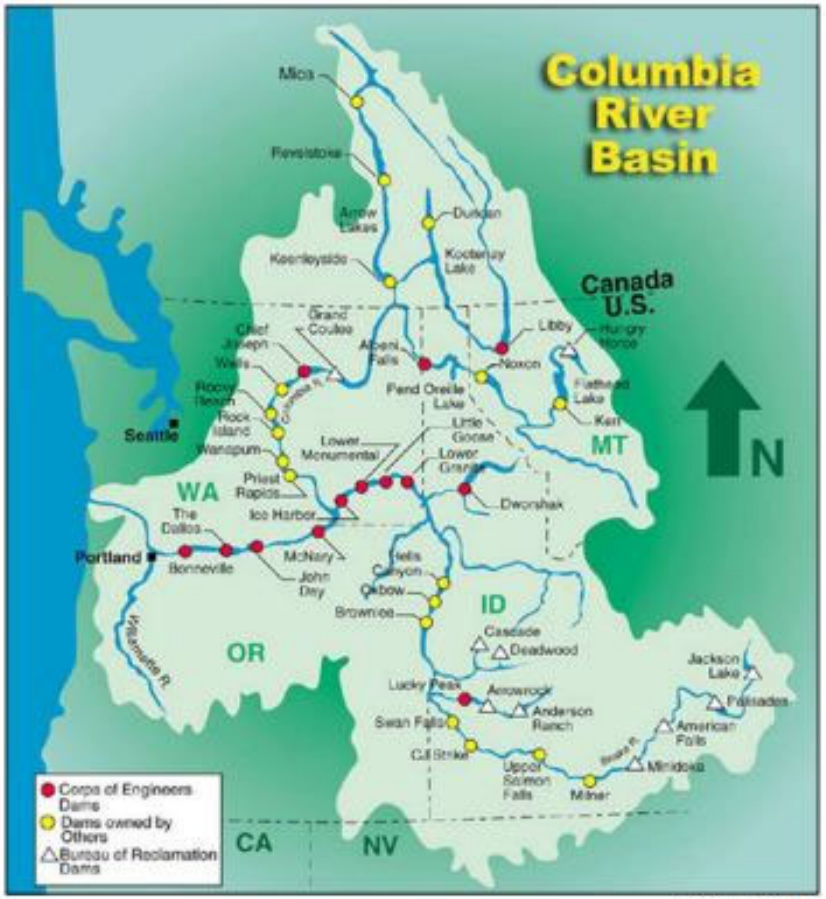
Hydro Operations Planning

Scott Winner

Bonneville Power Administration

- U.S. Department of Energy (DOE)
- Federally owned hydro project
  - USACE & BOR
  - 31 projects
  - 20 GW capacity



US Army Corps

Inventory studies

- Long term
  - 10 year study, every second year
- Mid term
  - 18 month study, monthly
- Short term
  - 2 week hourly study, daily
    - Climatology and Weather forecasting
  - Near real-time study, next 24 hours
    - Actual discharges, river gauges and side flow forecasts

Load Service

- Load / Resource Balancing
  - Water to energy
  - outages
- Marketing
  - Surplus / Deficit / Opportunities
- Transmission to deliver energy
  - 5,000 miles of transmission lines
  - Interconnect with 18 adjacencies

Panel 1 - Operations and Operational Planning

Moderator:
Chris Pilong
Director,
Operations Planning,
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Panelist:
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Real Time Operations
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System Operations
Manager,
SOCO

Panelist:
Scott Winner
Operations Research
Analyst,
BPA

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NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Lunch

RELIABILITY | RESILIENCE | SECURITY

Panel 2 – Mid to Long Term Planning

Moderator:
Allen Schriver
Senior Manager of NERC Reliability Compliance, NextEra

Panelist:
Dr. Julie Jin
Lead Planning Engineer, ERCOT

Panelist:
Anna Lafoyiannis
Supervisor, Reliability Assurance, IESO

Panelist:
Kayla Messamore
Senior Director, Long-Term Planning, Evergy

Panelist:
Branden Sudduth
Vice President of Reliability Planning and Performance Analysis, WECC

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ERCOT Resource Adequacy Studies

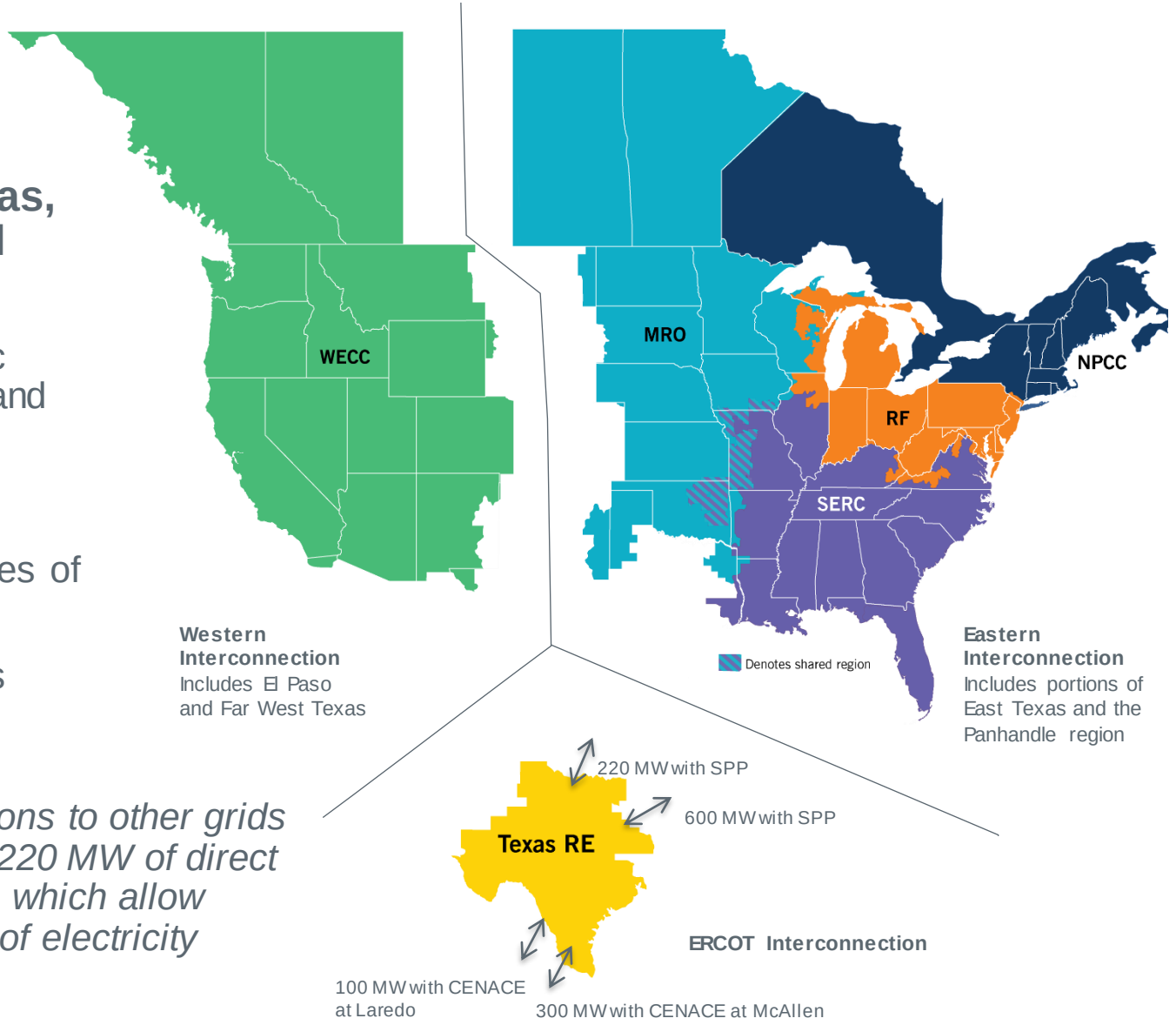
NERC Energy Reliability Assessment Task Force
February 16, 2022

Julie Jin, Lead Planning Engineer

The ERCOT Region

The interconnected electrical system serving most of Texas, with limited external connections

- 90% of Texas electric load; 75% of Texas land
- 74,820 MW peak, August 12, 2019
- More than 46,500 miles of transmission lines
- 710+ generation units (excluding PUNs)



ERCOT connections to other grids are limited to ~1,220 MW of direct current (DC) ties, which allow control over flow of electricity

Capacity, Demand and Reserves Report

- CDR is a deterministic resource adequacy report that looks out ten years
- Reports summer and winter peak hour load and generation capacity
- Provides annual reserve margins and information for individual resources
- Released twice every year (initial in May, final in December)

Seasonal Assessment of Resource Adequacy

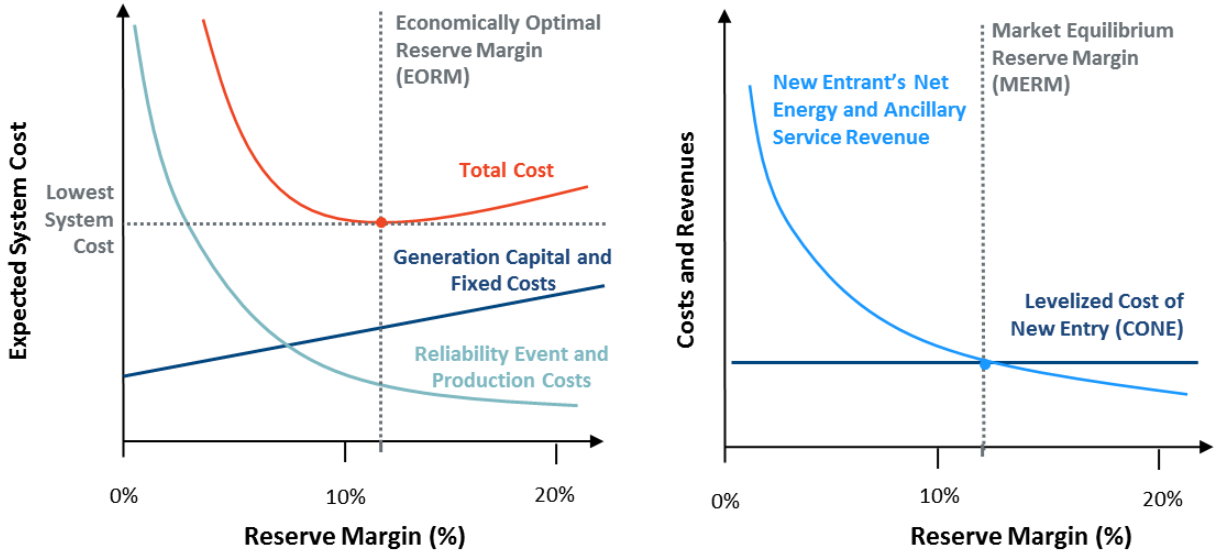
- SARA provides estimates of expected operating reserve capacity at the time of the peak load hour for each season
- Purpose is to show scenarios indicating a reasonable potential range of available reserves needed to avoid emergency actions

Seasonal Assessment of Resource Adequacy

- Scenarios include extreme high load and extreme planned/forced outage conditions
- Includes seasonal-specific scenario conditions:
  - Winter - extreme low temperatures causing additional gas curtailment related outages at time of the winter peak load hour

Reserve Margin Study

- ERCOT also carries out probabilistic studies to find economically optimal reserve margin and market equilibrium reserve margin every other year



ELCC and NERC Probabilistic Assessment

- ERCOT does ELCC study for wind and solar
- ERCOT does NERC probabilistic assessment every other year to calculate reliability indices like LOLH, EUE

Questions

Julie Jin
Julie.Jin@ercot.com

Panel 2 – Mid to Long Term Planning

Moderator:
Allen Schriver
Senior Manager of NERC Reliability Compliance, NextEra

Panelist:
Dr. Julie Jin
Lead Planning Engineer, ERCOT

Panelist:
Anna Lafoyiannis
Supervisor, Reliability Assurance, IESO

Panelist:
Kayla Messamore
Senior Director, Long-Term Planning, Evergy

Panelist:
Branden Sudduth
Vice President of Reliability Planning and Performance Analysis, WECC

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Break

RELIABILITY | RESILIENCE | SECURITY

Panel 3 - Research and Development

Moderator:
David Mulcahy
Power System and Market Model Consultant, IPA

Panelist:
Jeff Dagle
Chief Electrical Engineer, Electricity Infrastructure Resilience, PNNL

Panelist:
Dr. Eduardo Ibanez
Principal Engineer, Power Economics GE Gas Power

Panelist:
Dr. Julia Matevosyan
Chief Engineer, ESIG

Panelist:
Josh Novacheck
Electricity System Research Engineer, NREL

Panelist:
Dr. Aidan Tuohy
Program Manager, Grid Operations and Planning, EPRI

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Pacific Northwest
NATIONAL LABORATORY

NERC Workshop: Energy Reliably Assessment TF

Panel Session: R&D

February 16, 2022

Jeff Dagle, PE
Chief Electrical Engineer
Electricity Infrastructure Resilience
Pacific Northwest National Laboratory

U.S. DEPARTMENT OF ENERGY BATTELLE

PNNL is operated by Battelle for the U.S. Department of Energy

DOE National Laboratories: Our Mission

- Big problems, mission-driven
- High-risk, potentially high-reward
- Large, long-term, multidisciplinary research
- Maintain capabilities and facilities for DOE's mission, the science and technology community, and the nation
- Advances in science generate economic growth and support competitiveness

The U.S. Department of Energy Grid Modernization Initiative

GRID MODERNIZATION LABORATORY CONSORTIUM
U.S. Department of Energy

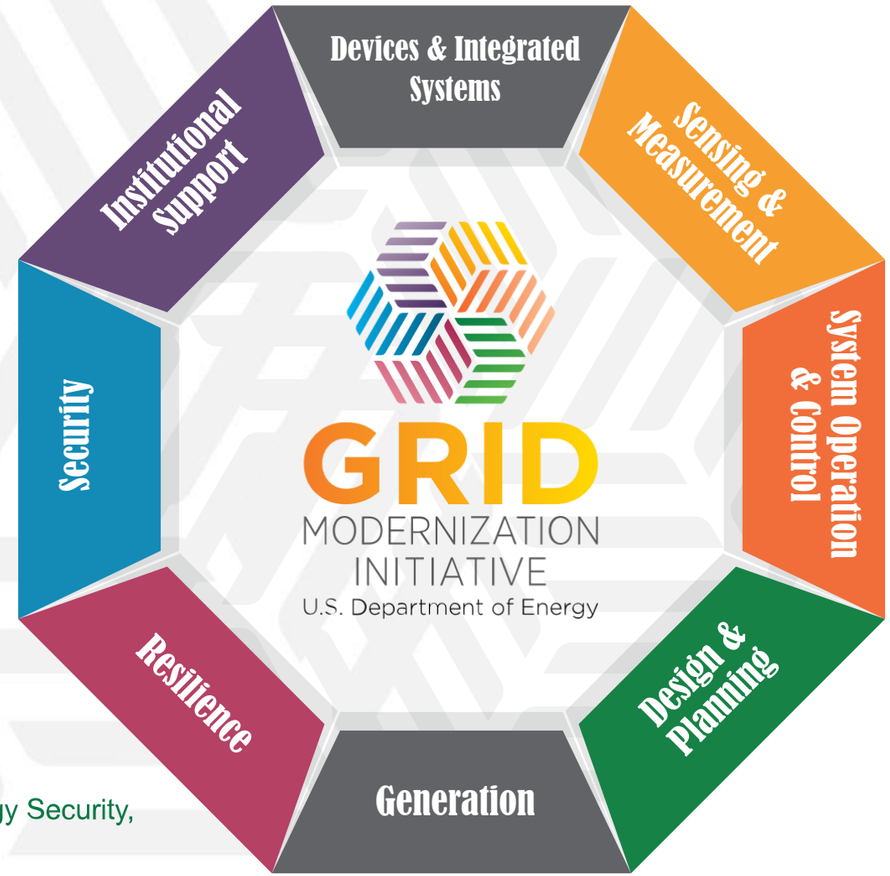
U.S. DEPARTMENT OF ENERGY | Office of Energy Efficiency & Renewable Energy

U.S. DEPARTMENT OF ENERGY | Office of Electricity

U.S. DEPARTMENT OF ENERGY | Office of Fossil Energy

U.S. DEPARTMENT OF ENERGY | Office of Nuclear Energy

U.S. DEPARTMENT OF ENERGY | Office of Cybersecurity, Energy Security, and Emergency Response



AMES LABORATORY
Creating Materials & Energy Solutions
U.S. DEPARTMENT OF ENERGY

Argonne NATIONAL LABORATORY

BROOKHAVEN NATIONAL LABORATORY

INL Idaho National Laboratory

BERKELEY LAB

Lawrence Livermore National Laboratory

Los Alamos NATIONAL LABORATORY

NETL NATIONAL ENERGY TECHNOLOGY LABORATORY

NREL NATIONAL RENEWABLE ENERGY LABORATORY

OAK RIDGE National Laboratory

Pacific Northwest NATIONAL LABORATORY

Sandia National Laboratories

SRNL

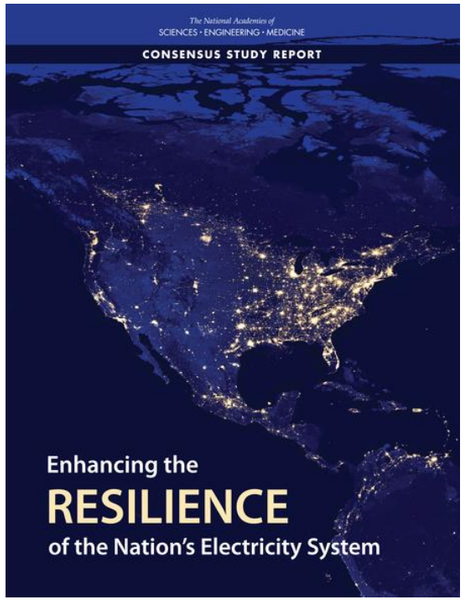
SLAC NATIONAL ACCELERATOR LABORATORY

Information about the DOE Grid Modernization Initiative and Multi-Year Program Plan:
https://www.energy.gov/gmi/grid-modernization-initiative

National Academies Report Released July 2017

The National Academies of
SCIENCES · ENGINEERING · MEDICINE

Board on Energy and Environmental Systems
Division on Engineering and Physical Sciences

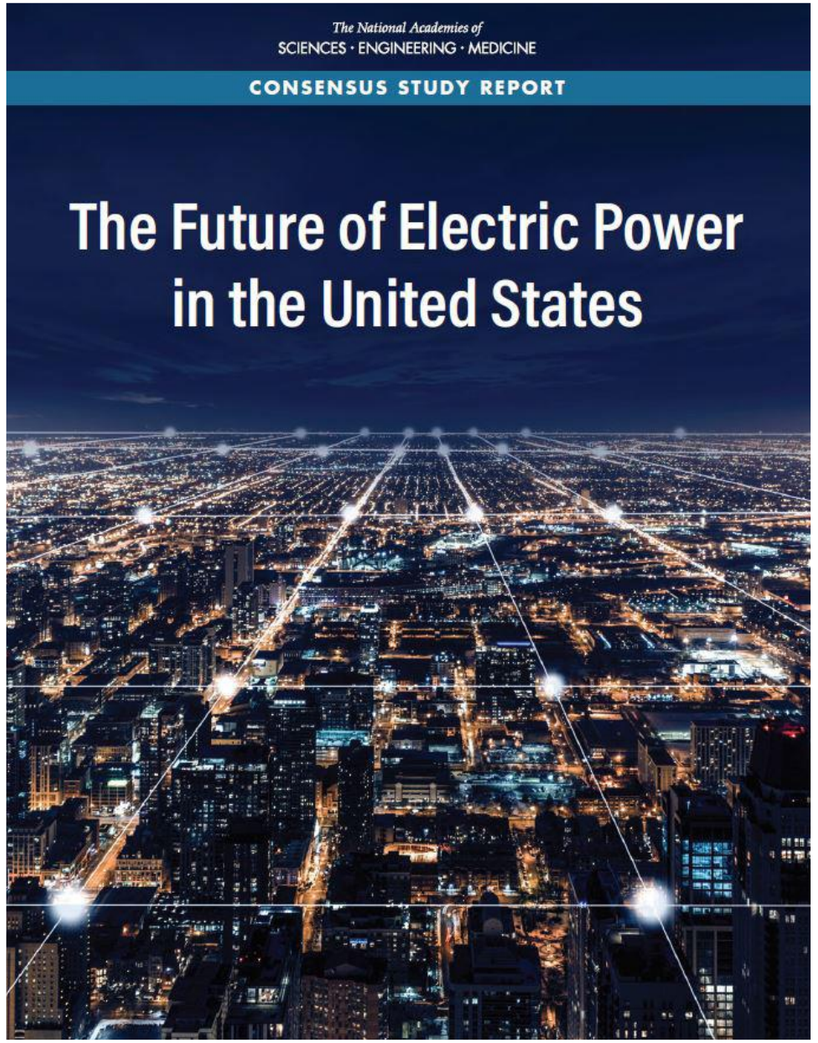


Enhancing the Resilience of the Nation's Electricity System

Download the full report and 4-page summary at:
https://www.nap.edu/24836

The Future of Electric Power in the United States

- Released in February 2021
- Comprehensive evaluation of the U.S. power grid and how it might evolve in response to advances in new energy technologies, changes in demand, and future innovation
- Policy and funding recommendations for:
  - Technology development
  - Operations
  - Grid architectures
  - Business practices
- Also addresses safety, security, sustainability, equitability, and resilience
- Download the report here: **nap.edu/25968**

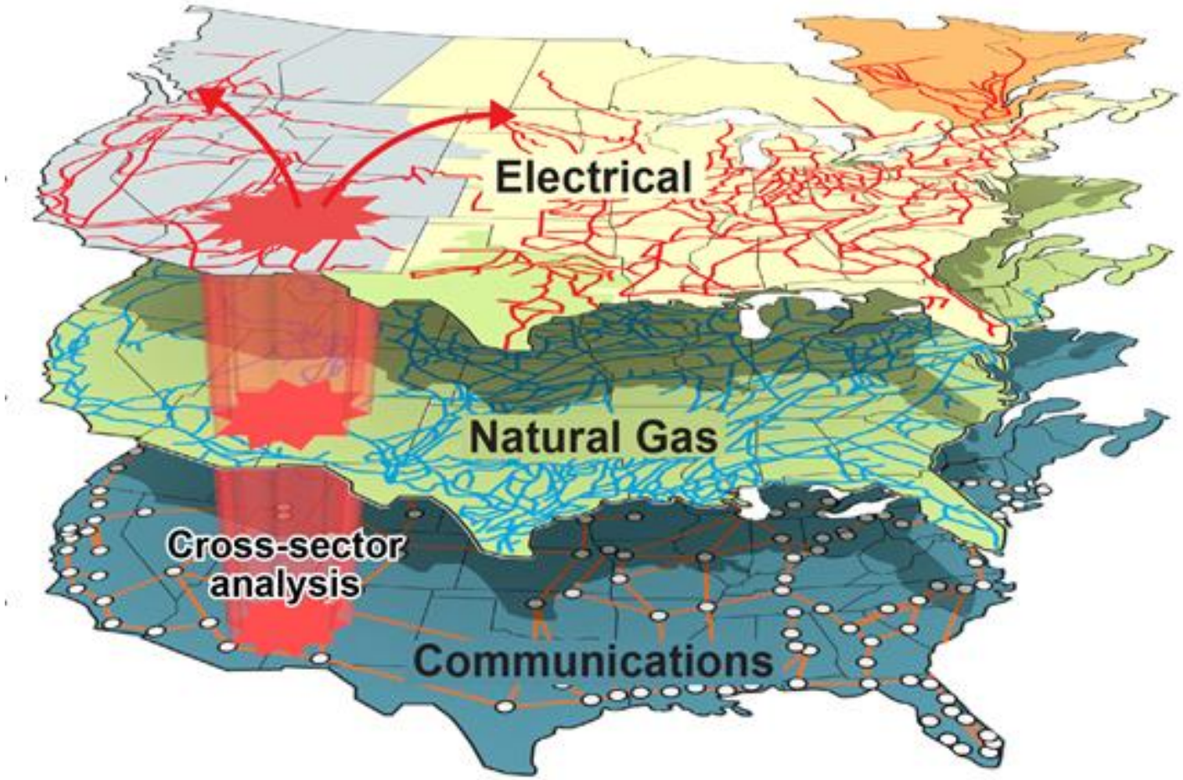


North American Energy Resilience Model (NAERM)

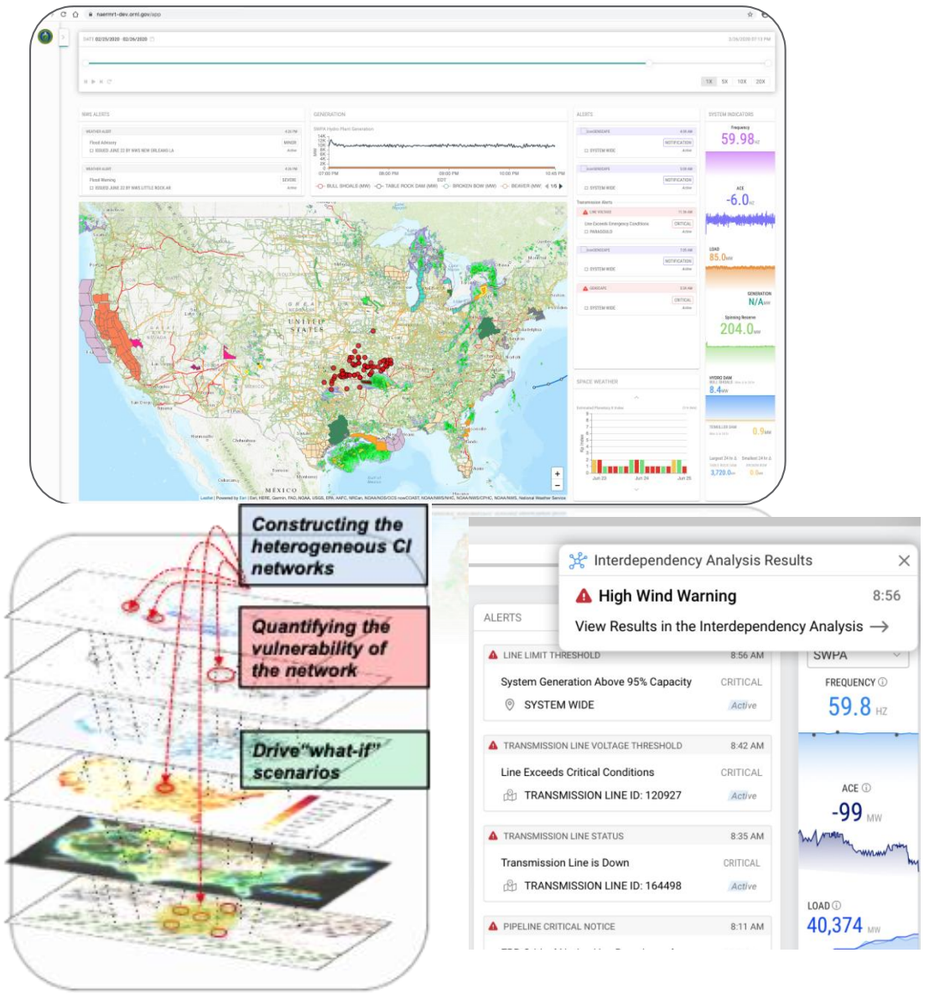
Vision - Rapidly predict energy system interdependencies, consequences and responses to extreme events at a national scale

Mission - Develop and deploy engineering-class modeling system for planning and real-time resilience analysis

Key Objective – Catalyze partnerships with industry, national labs, states/communities and other federal agencies to enhance coordination to support energy resilience



NAERM is federating a suite of tools and data to analyze a wide range of resilience impacts



- Multi-domain contingency analysis for exploring different combinations of potential events simultaneously
- Threat models of wildfires, earthquakes, severe weather, and other hazards and their impact on critical operations
- Distributed Energy Resource models integrated with bulk electric system models to predict impact/benefits of high penetration DER scenarios

https://www.energy.gov/sites/prod/files/2019/07/f65/NAERM_Report_public_version_072219_508.pdf

Pacific Northwest
NATIONAL LABORATORY

DOE-OE Transmission-Related R&D

- **Advanced Controls** to manage system variability and respond to emergencies
- **Modeling and Simulation** tools to examine future portfolios and system technology alternatives
- **Grid Components** to enable efficient power conversion and utilization of transmission & distribution
- **Energy Storage Systems** to provide grid flexibility and resilience
- **Grid Operations** for enhanced situational awareness and decision support systems

https://www.energy.gov/oe/office-electricity

DOE Building a Better Grid Initiative

- **Engaging and collaborating early** with states, tribal nations, and stakeholders to accelerate transmission deployment.
- **Enhancing transmission planning** to identify areas of greatest need such as high-priority national transmission needs and conducting longer-term national-scale transmission planning analysis.
- **Deploying more than $20 billion in federal financing tools**, including through the Bipartisan Infrastructure Law's new $2.5 billion Transmission Facilitation Program, $3 billion expansion of the Smart Grid Investment Grant Program, and more than $10 billion in grants for states, Tribes, and utilities to enhance grid resilience and prevent power outages, and through existing tools, including the more than $3 billion Western Area Power Administration Transmission Infrastructure Program, and a number of loan guarantee programs through the Loan Programs Office.
- **Facilitating an efficient transmission permitting process** by coordinating with federal agencies to streamline permitting, using public private partnerships, and designating corridors.
- **Performing transmission-related research and development** to continue developing and reducing the costs of technologies that enable the transmission system to be used more efficiently.

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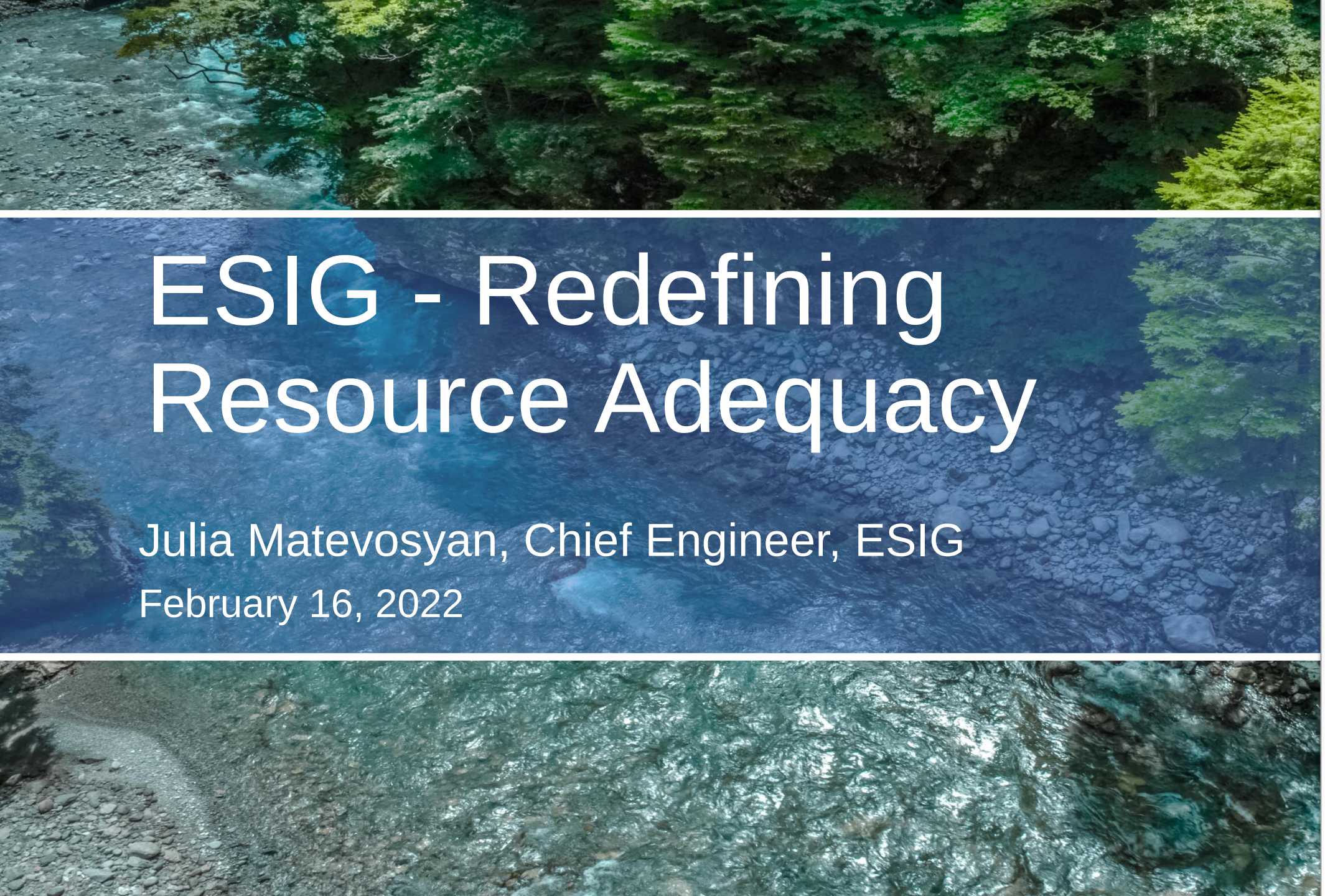
Thank you



ESIG - Redefining Resource Adequacy

Julia Matevosyan, Chief Engineer, ESIG

February 16, 2022

ESIG

ENERGY SYSTEMS INTEGRATION GROUP

Energy Systems Integration Group

- Membership-based non-profit educational association that provides workshops, resources and education (190 industry members globally)
- Addresses the technical challenges for transforming energy systems through collaboration, education and knowledge sharing working with all industries, energy vectors and applications globally
- Through a number of Working Groups and Task Forces, convenes industry collaboration on emerging topics to facilitate reliable, economic and sustainable energy systems transformation:
  - System Planning Working Group **(includes Resource Adequacy Task Force)**
  - Reliability Working Group
  - System Operation and Market Design Working Group
  - Distributed Energy Resources Working Group
  - Research and Education Working Group
  - Plant Operations & Maintenance Users Group

Redefining Resource Adequacy

The project supported by ESIG as part of the Resource Adequacy Task Force.

Derek Stenclik of Telos Energy led the project team of industry experts.

Project goals:

- to provide an overview of key drivers changing the way resource adequacy needs to be evaluated,
- identify shortcomings of conventional approaches, and
- outline first principles for practitioners to consider as they adapt their approaches.

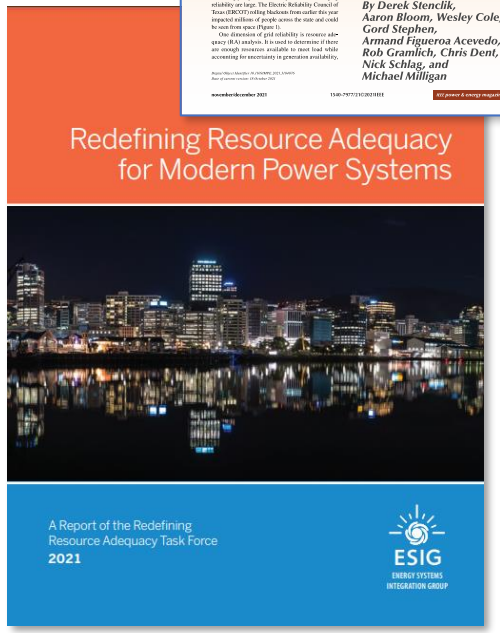
ESIG Whitepaper: Redefining Resource Adequacy for Modern Power Systems

ESIG Blog: Five Principles of Resource Adequacy for Modern Power Systems

ESIG Webinar: Redefining Resource Adequacy for Modern Power Systems

ESIG/GPST Policy Brief: The Intersection of Resource Adequacy and Public Policy

IEEE PES Power and Energy Magazine article

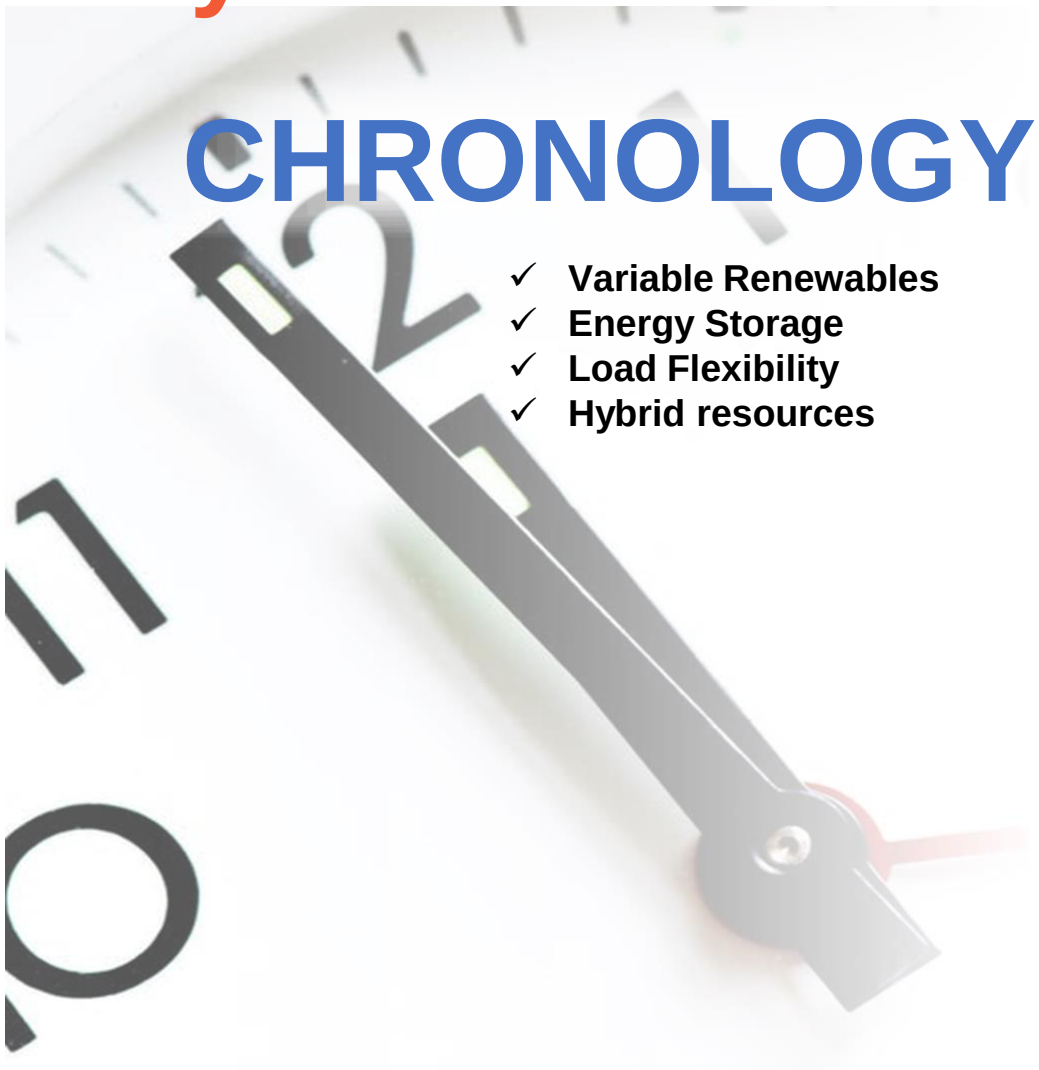


Lessons from Recent Extreme Weather Events

- **Not all shortfalls are alike**… need to characterize size, frequency duration, and timing of events
- **Risk is shifting**… periods of concern longer occur during gross-peak load, need to look across an entire year of operation
- **Weather** is the single most important driver for resource adequacy…
  - Cross-disciplinary power systems and meteorological expertise is necessary
  - We need a North-American Weather Dataset for correlated wind, solar, and load
  - Climate trends should be considered
  - Correlated events are the issue!

- **Resource sharing** is critical, transmission is a capacity resource

Why is Resource Adequacy Broken?



CHRONOLOGY + CORRELATION

- ✓ Variable Renewables
- ✓ Energy Storage
- ✓ Load Flexibility
- ✓ Hybrid resources

- ✓ Weather
- ✓ Combined Outages
- ✓ Modular Technology
- ✓ Climate Trends

Six Principles of Resource Adequacy for Modern Power Systems

1. Quantifying size, frequency, duration, and timing of capacity shortfalls is critical to finding the right resource solutions
2. Chronological operations must be modeled across many weather years
3. There is no such thing as perfect capacity.
4. Load participation fundamentally changes the resource adequacy construct.
5. Neighboring grids and transmission are a key part of the RA challenge
6. Reliability criterion should not be arbitrary, but transparent and economic.

Next Steps for Resource Adequacy TF

- CIGRE Paper on Evolving Resource Adequacy Metrics (ongoing)
- Best Practices of Weather Data Modelling (topic for 2022)
- Capacity Accreditation Alternatives (topic for 2022)
- Revising Resource Adequacy Metrics (future topic)

Thank You!

ESIG
ENERGY SYSTEMS
INTEGRATION GROUP

Energy Systems Integration Group is a non-profit educational association that provides workshops, resources and education on the evolving electricity and energy systems.

ESIG supports engineers, researchers, technologists, policymakers and the public with the transformation of energy systems in a way that is economic, reliable, sustainable, thoughtful and collaborative.

www.ESIG.energy

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Energy Assessment with High Contributions of Variable Renewable Energy

Josh Novacheck

NERC Energy Reliability Assessment Workshop

16 February 2022

Resource Data Sets

WIND Toolkit

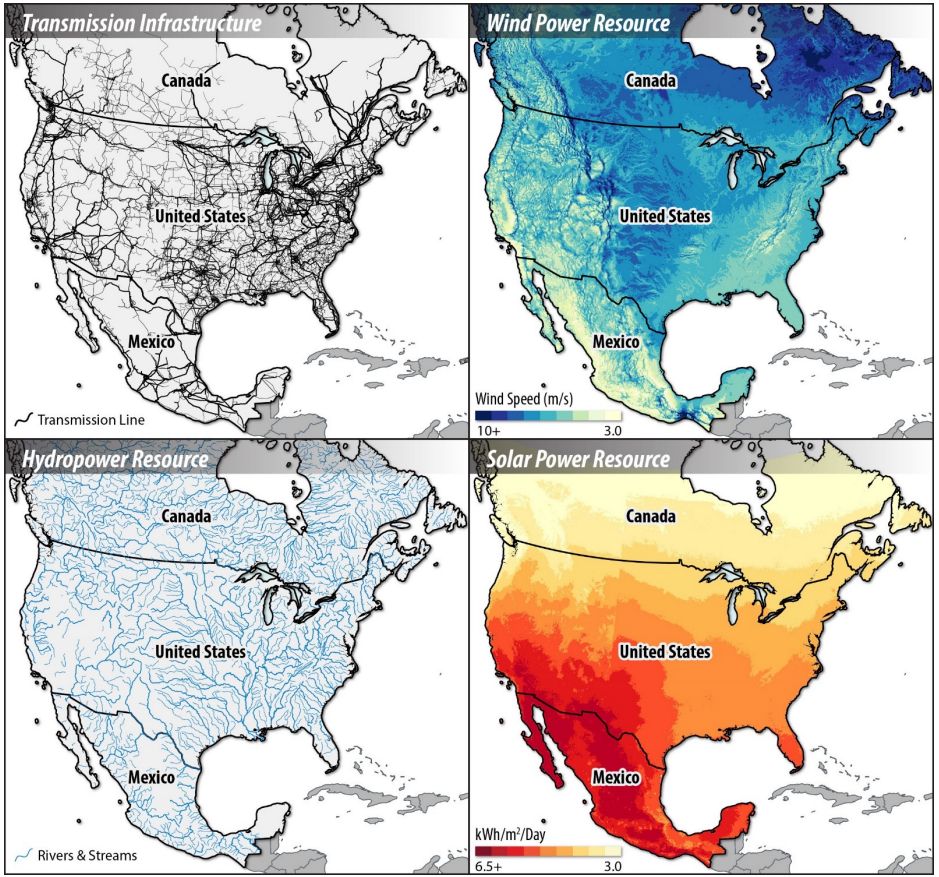
- 2007 – 2013
- 5-minute resolution
- 2km x 2km spatial resolution

National Solar Radiation Database (NSRDB)

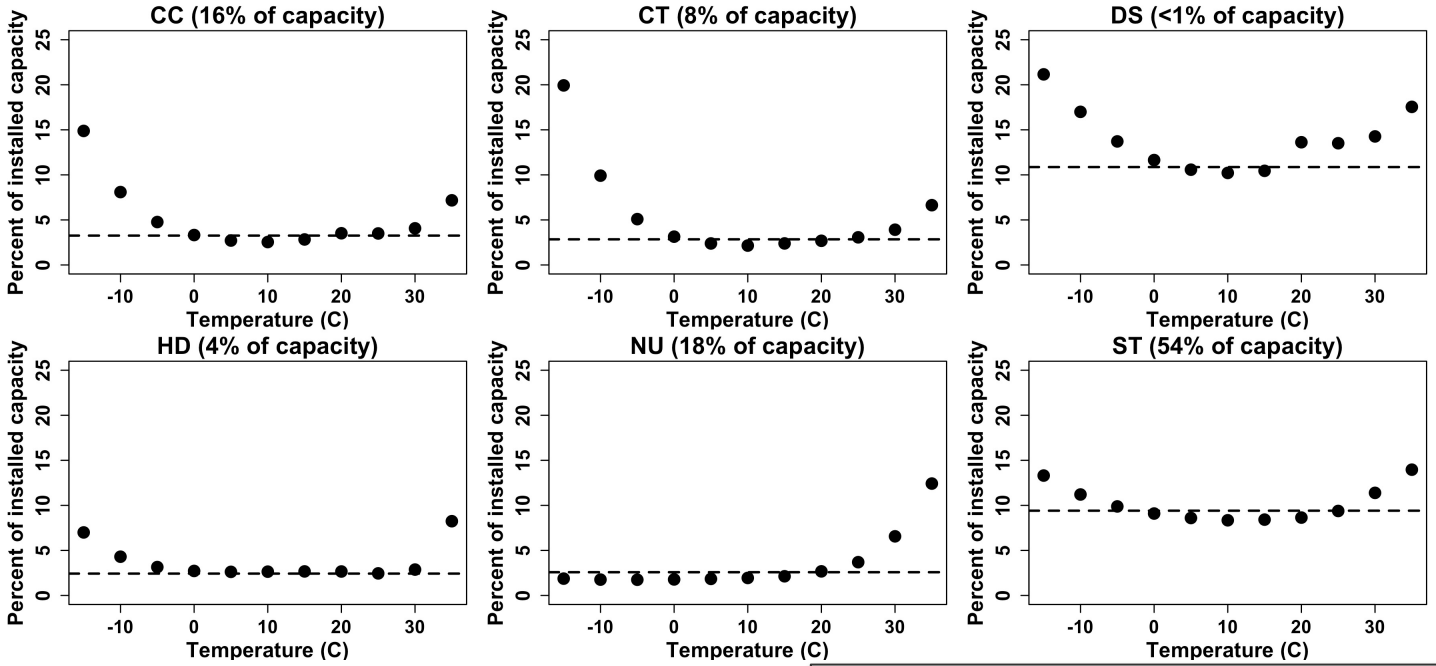
- 1998 – 2020
- 30-minute resolution
- 4km x 4km spatial resolution

Hydropower Resource

- EIA-923 plant level generation data to adjust maximum energy limits.



Temperature dependence in PJM thermal/hydro generators

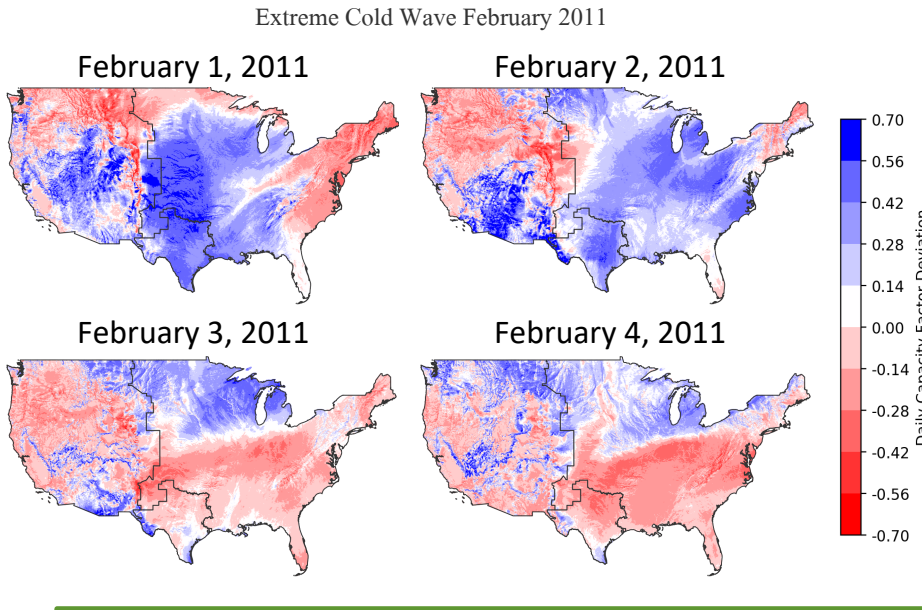


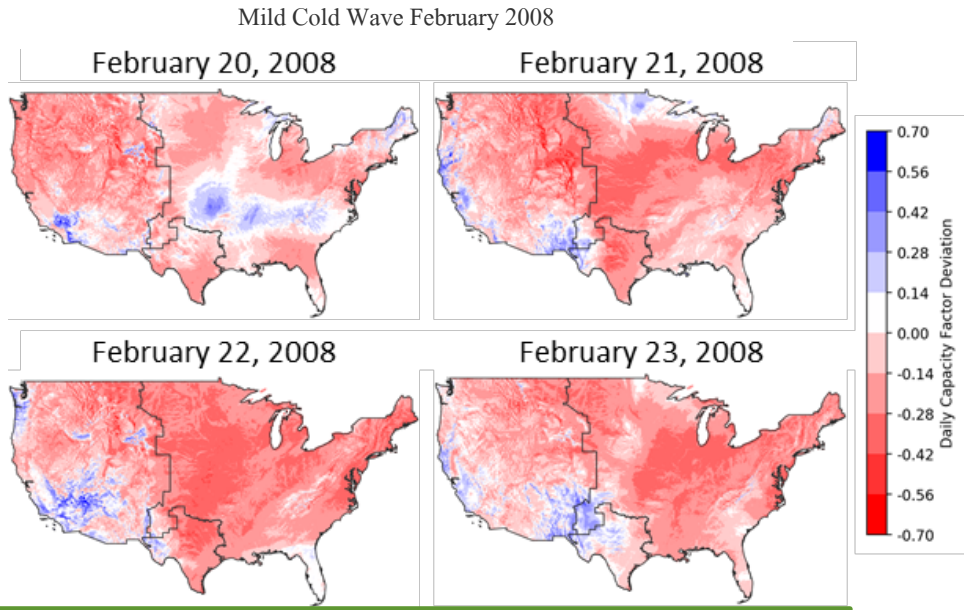
Murphy, S., Sowell, F., Apt J. "A time-dependent model of generator failures and recoveries captures correlated events and quantifies temperature dependence." Applied Energy. November 2019. https://doi.org/10.1016/j.apenergy.2019.113513

Unit type key:

CC: combined cycle gas	HD: hydroelectric
CT: simple cycle gas	NU: nuclear
DS: diesel	ST: steam turbine (coal)

Evolution of Weather Events with Higher Contributions from Variable Renewable Energy

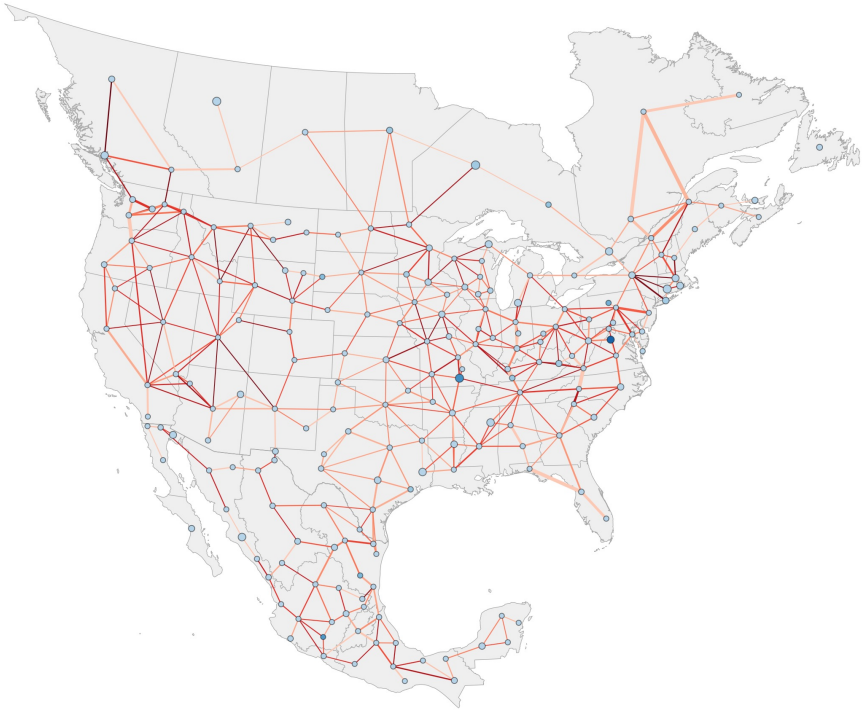




The challenge for operators and planners are the days that follow. As the cold stays, the wind dies down. How much is uncertain, but our 2007 – 2013 dataset suggests milder cold waves lead to lower wind resource in the days following the cold wave.

Novacheck, Sharp, et al. 2021. "The Evolving Role of Extreme Weather Events in the U.S. Power System with High Levels of Variable Renewable Energy" https://doi.org/10.2172/1837959

Probabilistic Resource Adequacy Suite (PRAS)

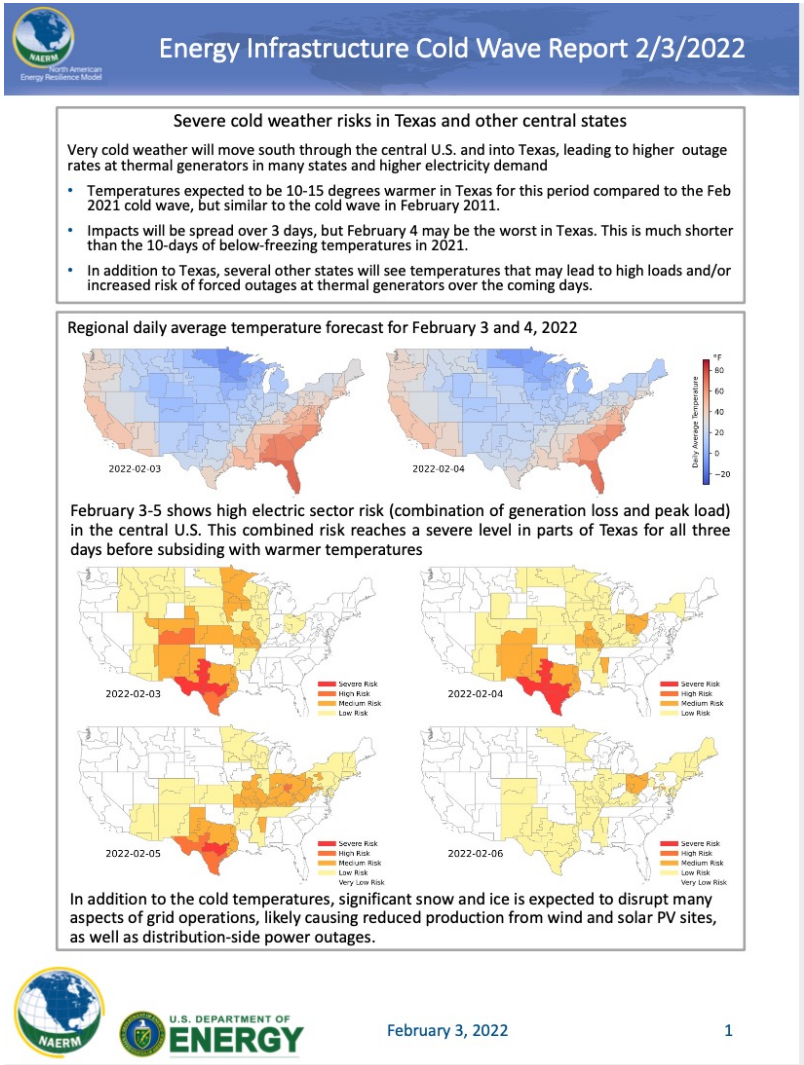


Probabilistic Resource Adequacy Suite: NREL's collection of tools for studying unserved energy risk in electric power systems, across space and time

Resource adequacy assessment: Quantifies shortfall risk using standard probabilistic metrics such as Loss-of-Load Probability (LOLP), Loss-of-Load Expectation (LOLE), Expected Unserved Energy (EUE), Normalized Expected Unserved Energy (NEUE)

Capacity credit calculation: Determines resource adequacy-based capacity credit metrics such as Equivalent Firm Capacity (EFC) and Equivalent Load Carrying Capability (ELCC) of individual resources

Free and open-source software: Get it now at nrel.github.io/PRAS



NAERM Cold Wave Report

Combining the research presented earlier, along with numerous other NAERM capabilities, NAERM is developing a beta version of a **cold wave report** to provide system operators awareness of forecasted cold weather and winter storms and the associated power system risks.

- Increased generator outage
- Regions with above normal forecasted load
- Snow and ice impacts on T&D infrastructure, wind power, and solar power

Energy Reliability Assessment

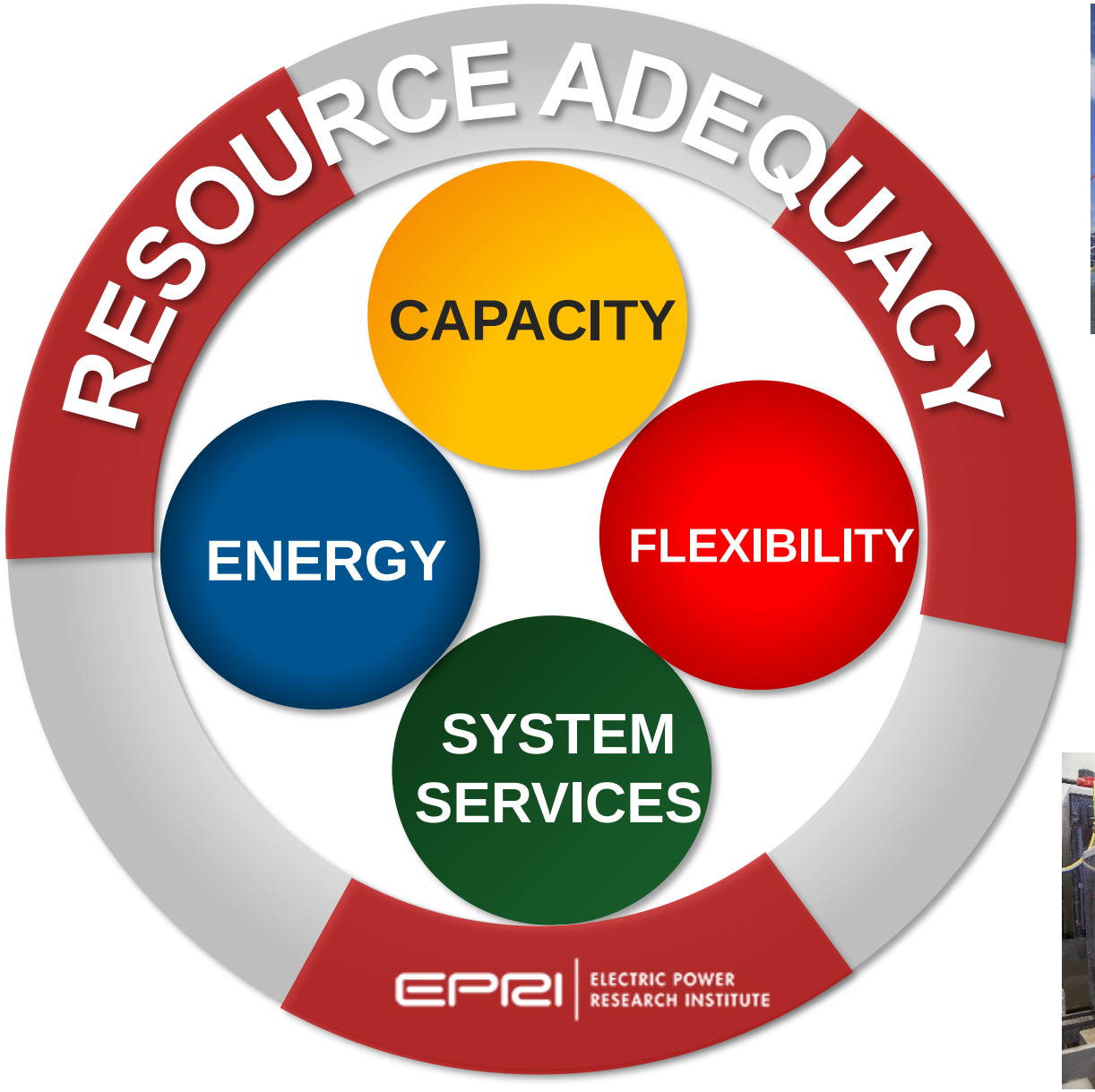
Ongoing R&D

Aidan Tuohy
Program Manager, Grid Operations and Planning
atuohy@epri.com

NERC Energy Reliability Assessment Workshop
Feb 16, 2022

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



EPRI Resource Adequacy Initiative

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

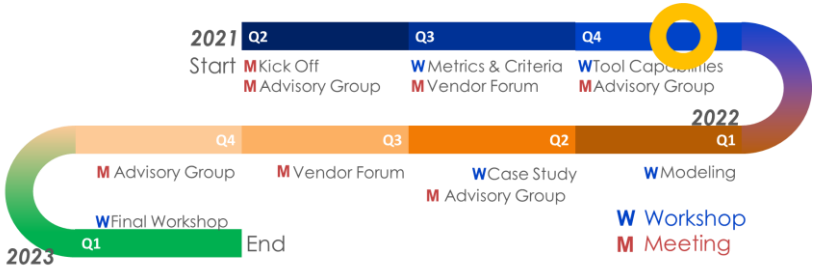
Case Studies — Evaluation of existing and development of new capabilities based on 4-6 regional RA case studies covering differing RA issues and tools.

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

27+ Participants

Southern California Edison, CPS Energy, Duke Energy, Associated Electric Cooperative Inc., Hawaiian Electric, American Electric Power, LCRA, Con Edison, Ameren, TVA, Austin Energy, New York State Power Authority, LA DWP, Arkansas Electric Cooperative Corporation, Southern Company, SRP, NERC, MISO, SPP Southwest Power Pool, aps, ISO New England, PJM, Entergy, evergy, New York ISO, Manitoba Hydro, NPCC

Schedule



Collaboration & Partners

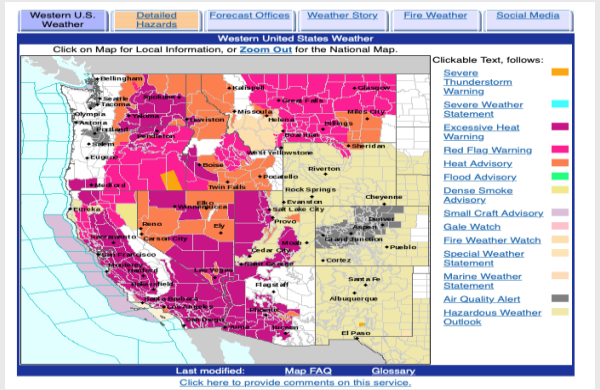
External Advisory: NARUC, RROs, DOE, ESIG, ENTSO-E, EEI, ISO/RTOs, G-PST, et. al.

R&D Partners: Vendors, Nat. Labs, Consultants, Universities

Scenario Analysis and Data– Key Questions/Topics

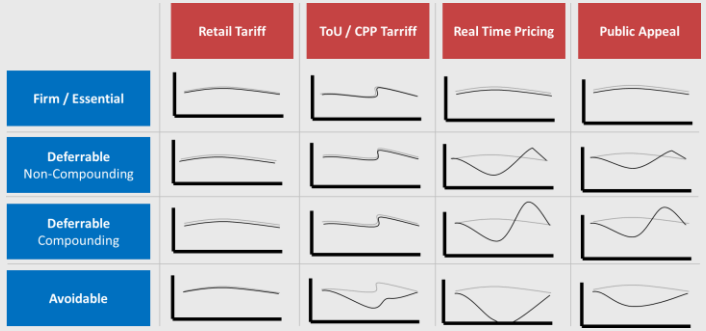
Long Term Scenarios

- Load forecasting
- Consistent scenarios for tech adoption
- Consideration of climate



Operational Scenarios

- Extreme weather events
- Chronology and range of operational outcomes
- Representation of markets



Data

- Costs and performance
- Customer behavior
- Tools to parameterize models

Are we studying the right conditions using the right data?

Major questions arise for gas/electric coordination

- What type of gas risks have the largest potential for significant impacts on electric system adequacy?
  - Supply outages, gas network outages, extreme gas heating demand or market coordination issues?
- What types of electric system risks pose the largest risks for gas supply?
  - Supply outages, transmission outages, grid protection, or market coordination issues?
- How can detailed representation of the gas network improve RA assessments?
  - E.g., How does a transient pipeline model impact RA metrics?
- Can correlated outages be modeled for gas pipelines?
  - What information is needed and do models or metrics need adjustment?
- What operational detail is needed for gas operations?
  - E.g., Would concurrent ramping of multiple generating units served by the same pipeline segment require pipeline support that is physically infeasible?

Together...Shaping the Future of Energy™

More information: www.epri.com/resource-adequacy

Panel 3 - Research and Development

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Program Manager, Grid Operations and Planning, EPRI

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NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Closing Remarks

Jim Robb, President and Chief Executive Officer, NERC

February 16, 2022

RELIABILITY | RESILIENCE | SECURITY




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Questions and Answers

If you have any questions or comments, please send an email to elsa.prince@nerc.net or pbrandien@iso-ne.com.

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