2022 ISO New England Open Board Meeting

Today's Agenda

1:00-1:10 p.m.	**Welcome**
1:10-1:45 p.m.	**Public Comments**
1:45-2:30 p.m.	Management Presentation and Board Discussion on the **ISO's Strategic Plan**
2:30-2:45 p.m.	**Break**
2:45-3:45 p.m.	Presentation to the Board from **Dr. Robert Armstrong**, Director, MIT Energy Initiative and lead author, ***The Future of Energy Storage***
3:45-4:15 p.m.	Management Update and Board Discussion on **Major Market Projects**
4:15-5:00 p.m.	Management Update and Board Discussion on **Energy Adequacy** and **Winter Operations**
5:00 p.m.	**Concluding Remarks**

ISO Board Members and Committee Assignments





Cheryl LaFleur

- Chair, Board of Directors
- Compensation & Human Resources
- Joint Nominating
- Nominating & Governance

Caren Anders

- Chair, System Planning & Reliability
- Compensation & Human Resources
- Joint Nominating
- Nominating & Governance

Brook Colangelo

- Chair, Nominating & Governance
- System Planning & Reliability
- IT & Cyber Security

Steve Corneli

- Audit & Finance
- IT & Cyber Security
- Joint Nominating
- Markets

Michael Curran

- Chair, Markets
- Audit & Finance
- IT & Cyber Security
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Gordon van Welie
- President and CEO

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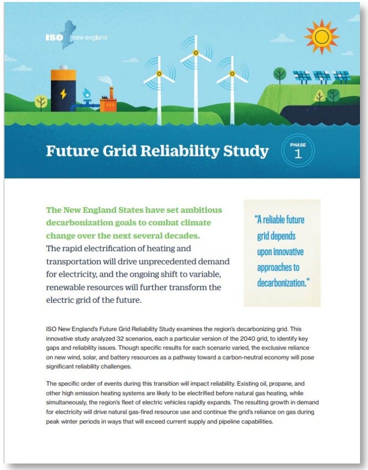
ISO New England Information Resources

[ISO New England’s Strategic Plan]

Our corporate strategy provides our stakeholders with insight into how we intend to fulfill our three critical roles of power grid operation, market administration, and power system planning as the industry and the region transitions to a cleaner power system.

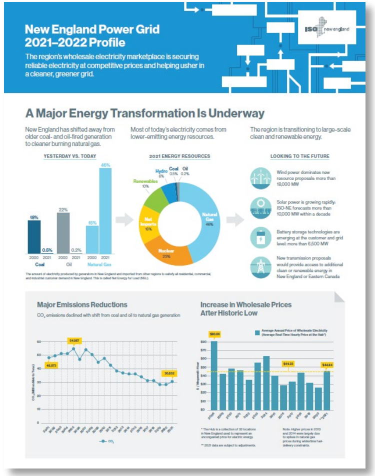
[Regional Electricity Outlook]

Provides an in-depth look at New England’s biggest challenges to power system reliability, the solutions the region is pursuing, and other ISO-NE efforts to improve services and performance



[Future Grid Reliability Study]

Evaluates how a 2040 grid could perform when the system has significantly more renewables and a greater amount of electrification of the transportation and heating sectors



[New England Grid Profile]

Provides key grid and market stats on how New England’s wholesale electricity markets are securing reliable electricity at competitive prices and helping usher in a cleaner, greener grid

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

GET IT ON Google Play

Download on the App Store

WELCOMING REMARKS

PUBLIC COMMENTS

NOVEMBER 1, 2022 | PROVIDENCE, RI

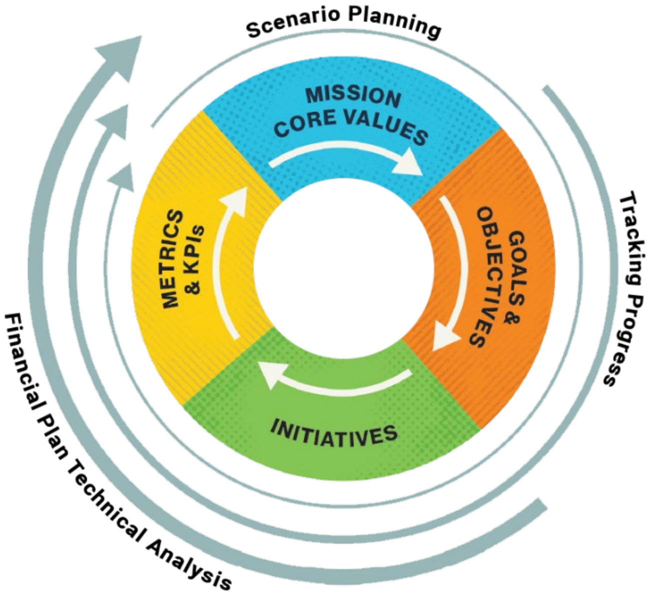
ISO New England Strategic Plan

Vision in Action

Gordon van Welie
PRESIDENT & CEO

Strategic Planning Framework

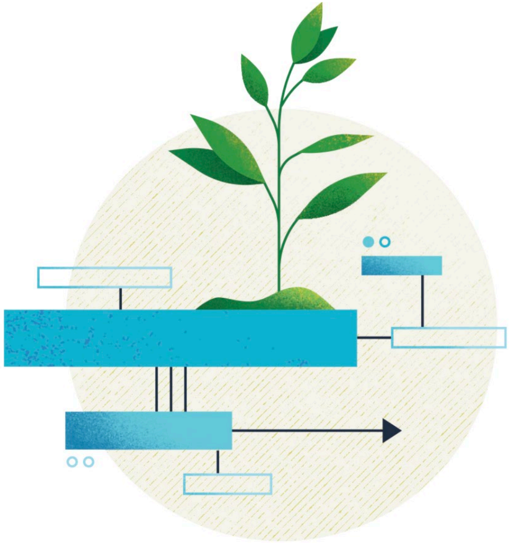
Represents the foundation for the ISO strategy, and guides the development of annual work plans and associated budgets



"This corporate strategy is the result of an iterative process, informed by larger trends affecting the industry and our society, especially as extreme weather becomes more commonplace and we emerge from the pandemic with new global challenges, a changing workforce and a sharper focus on the needs for a successful energy transition."

Our Guidepost: The ISO New England Vision Statement

The ISO-NE Vision Statement is an explicit statement about our intent to achieve a reliable transition to clean energy utilizing competitive markets and transmission planning

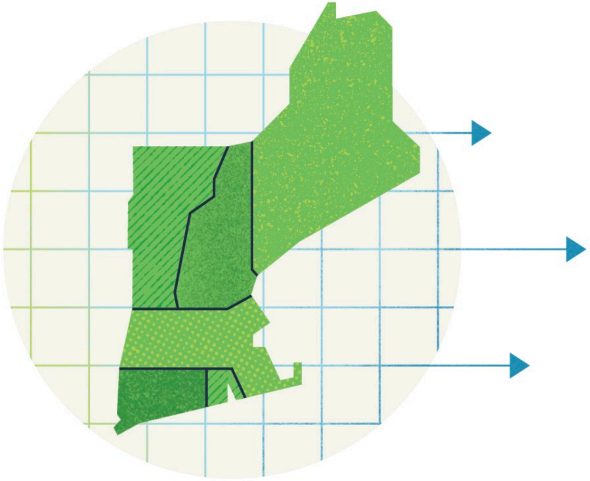


Vision Statement:

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

Our Responsibility to the Region: ISO's Mission

The ISO-NE Mission Statement outlines the core role and responsibilities of the ISO's daily operations



Mission Statement:

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

Four Pillars of Supporting a Successful Energy Transition

New England is on a path to achieve a clean-energy future over the next several decades. Calling upon the results of several key studies, as well as 25 years' experience planning the region's power system, the ISO has identified four pillars critical to supporting the region's clean energy transition

1

Significant amounts of clean energy to power the economy with a greener grid

2

Balancing resources that keep electricity supply and demand in equilibrium

3

Energy adequacy - a dependable energy supply chain and/or a robust energy reserve to manage through extended periods of severe weather or energy supply constraints

4

Robust transmission to integrate renewable resources and move clean electricity to consumers across New England

Trends Impacting the ISO's Strategy

As part of the ISO's strategic planning process, we assess trends inside and outside the industry that impact the execution of our Mission, Vision, and the Four Pillars

- **Changing How the Region Generates and Uses Electricity**
  - Decarbonization goals to reduce GHG emissions to nearly zero by 2050
  - Near net-zero grid will be powered primarily by renewable resources; wind power and battery storage dominate the ISO's Queue
  - Large quantities of long-duration, on demand, balancing energy will be critical to maintaining power system reliability. It's unclear when there will be a technology that can replace the role of natural gas
  - Major transmission upgrades to integrate/transmit clean energy

- **Changing Weather and Winter Challenges**
  - Region is vulnerable to fuel supply shortages when gas pipeline constraints lead the region to rely more heavily on imported LNG
  - Buyers in Europe and Asia have locked in LNG supplies through long-term contracts, potentially limiting availability and driving up New England prices during periods of cold weather
  - Dispatch of oil-fired units, during periods of high natural gas prices, drives increases in regional emissions

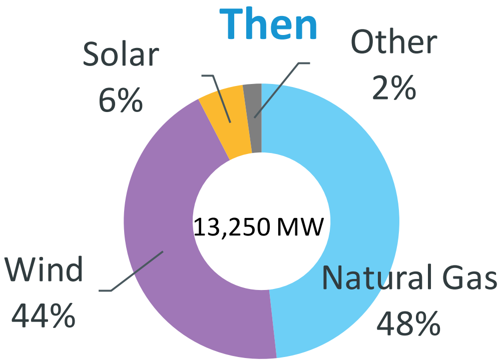
Trends Impacting the ISO's Strategy, cont.

- **Changing Workforce Environment**
  - Progress on the clean-energy transition requires high level of responsiveness to state and stakeholder requests and FERC orders, increasing overall workload
  - Competition for people to fill highly specialized roles is stiff and made more challenging by ISO New England's not-for-profit status

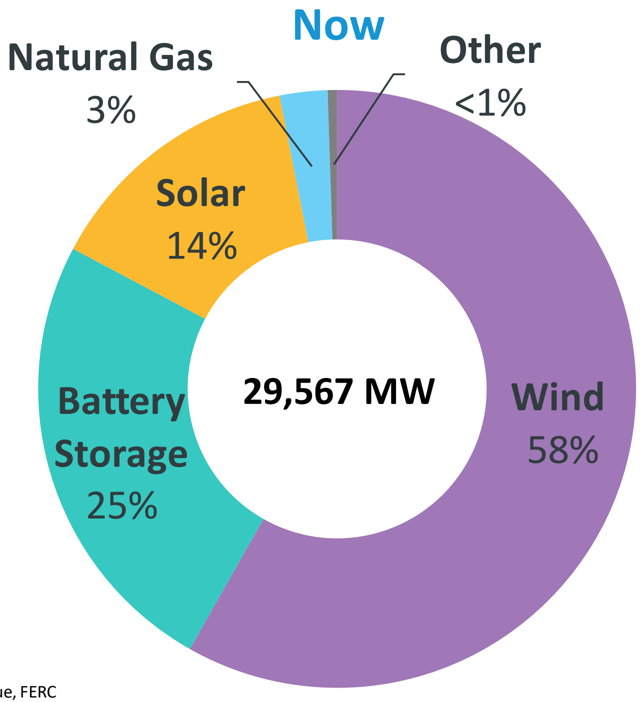
- **Changing Economy At Home and Around the World**
  - Covid-19, Russia – Ukraine war, supply chain and inflation concerns highlight drivers of uncertainty for the region
  - Higher global fuel and energy costs continue to drive up New England power prices, ultimately increasing costs for consumers already facing tighter budgets; rising prices could challenge the pace of electrification
  - Timing of emergence of new energy technologies at scale needed to meet future demand is unclear

The ISO Generator Interconnection Queue Provides Snapshots of the Future Resource Mix

Dramatic shift in types of proposed resources from natural gas to wind



June 2017



September 2022

Offshore Wind

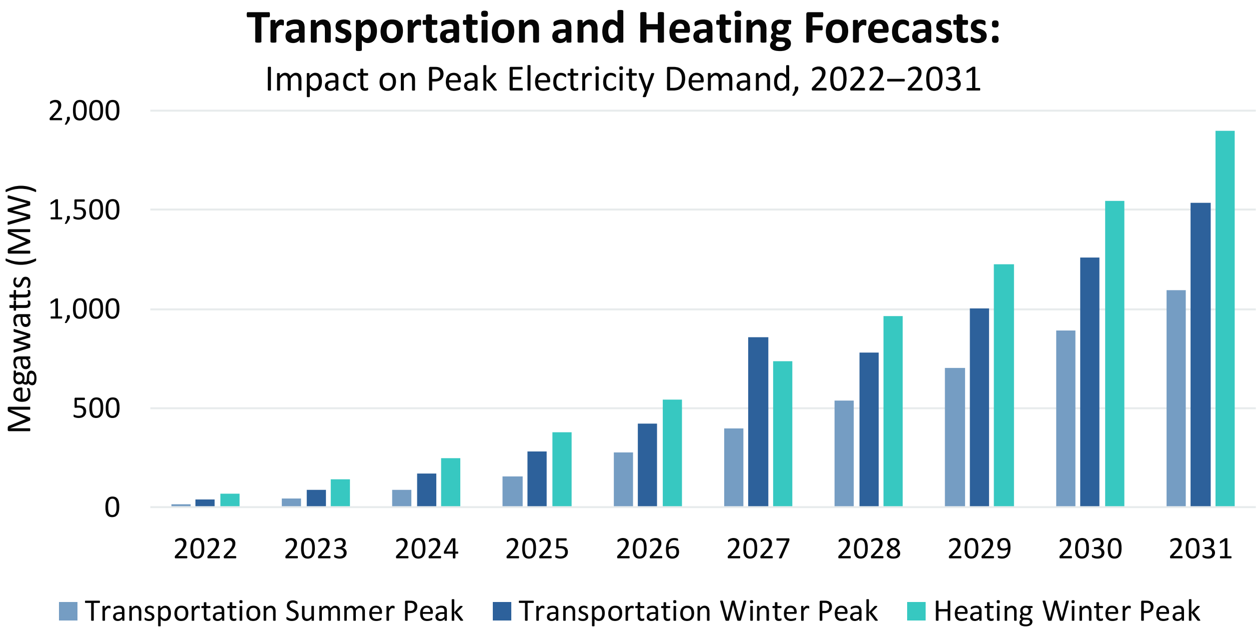
CT	2,400 MW
MA	11,763 MW
ME	12 MW
RI	704 MW

Onshore Wind

ME	2,330 MW

Source: ISO Generator Interconnection Queue, FERC Jurisdictional Proposals; Nameplate Capacity Ratings.

Electricity Demand from Electric Vehicles and Heating Sectors to Grow Over the Next Decade



* Percentage of Net System Peak in 2030: Transportation – summer: 4%; Transportation – winter: 7%; Heating – winter: 8%

Sources: ISO New England 2022-2031 Forecast Report of Capacity, Energy, Loads, and Transmission (2022 CELT Report) (May 2022), 2022 Forecast Data.

2023 Strategic Goals

- **Responsive Market Designs**
  - Improve current market structure, continue to evolve and reposition market design to reflect states' objectives and the transition to high levels of renewables and distributed resources
  - Maintain robust fleet of balancing resources and preserve ability of the market to attract new entry

- **Progress & Innovation**
  - Evolve capabilities to support grid as region transitions to clean energy
  - Support investments in transmission infrastructure to enable renewable energy
  - Facilitate integration of distributed energy resources

- **Operational Excellence**
  - Continuously improve operations and processes, with focus on efficiency and effectiveness, business results, and continuity of reliable operations

- **Stakeholder Engagement**
  - Collaboratively understand and anticipate needs, demonstrate thought leadership through high quality analysis and communication, nurture productive relationships with FERC, states, stakeholders

- **Attract, Develop, and Retain Talent**
  - Develop a sense of community around our Core Values, Mission, Vision, and Goals
  - Prepare the workforce, recognize and reward employee's success and innovation, and honor diversity and promote inclusion

Highlighted 2023 Initiatives

- **Responsive Market Designs**
  - Day-Ahead Ancillary Services Initiative
  - Resource Capacity Accreditation in the FCM
  - Evaluation of Alternative FCM Commitment Horizons (Prompt/Seasonal Market)
  - Preferred Pathway to the Future Grid (for incenting clean energy through the market; dependent on state guidance)
- **Progress and Innovation**
  - nGEM Market Clearing Engine
  - Operational Impacts of Extreme Weather Events (with EPRI)
- **Stakeholder Engagement**
  - Energy Adequacy Considerations and Actions, including building on the EPRI project above to develop an Initial Analysis of Longer-term Solutions
  - Extended term/Long-term Transmission Planning Phase 2
  - 2050 Transmission Study

Looking Ahead: Designing Markets for a Clean *and* Competitive Resource Mix

- Moving beyond the goal of ensuring reliability at the lowest cost, state-level policies and legislation have driven the focus and growth in renewable resources
- During the past 10 years, the ISO's goal has been to reduce or eliminate barriers that inhibit participation on both the grid- and wholesale level
- In the coming decades, ISO will continue to work to ensure the power system can transform the resources it currently uses and also adapt the transmission system and wholesale markets as consumer demand grows from the decarbonization of other sectors

2021 Regional Electricity Outlook

Questions

BREAK

The Future of Energy Storage

An Interdisciplinary MIT Study

The latest in the MIT "Future of…" studies exploring the roles of key energy technologies in a carbon-constrained future

Limiting significant adverse climate impacts will require drastic reductions in global carbon dioxide emissions by mid-century.

Deep decarbonization of the electricity sector combined with electrification of other parts of the economy means that the electric power sector must be deeply decarbonized at reasonable cost.

A decarbonized electricity sector will rely heavily on intermittent wind and solar generation. This leads to the need for electricity storage for economic and reliability reasons.

What kinds of electricity storage technologies and policies would make this most likely? How do these choices vary regionally?

What is the role of energy storage in decarbonizing the electricity grid?

- What does the energy storage toolbox look like?
- How can these be deployed regionally in net-zero emissions electricity systems to make them affordable and reliable?
- How might market designs and regulatory policies be reformed to enable equitable & efficient decarbonization?

Technologies Studied

Electrochemical storage

- Li-ion
- Redox flow batteries
- Metal-air batteries

Mechanical storage

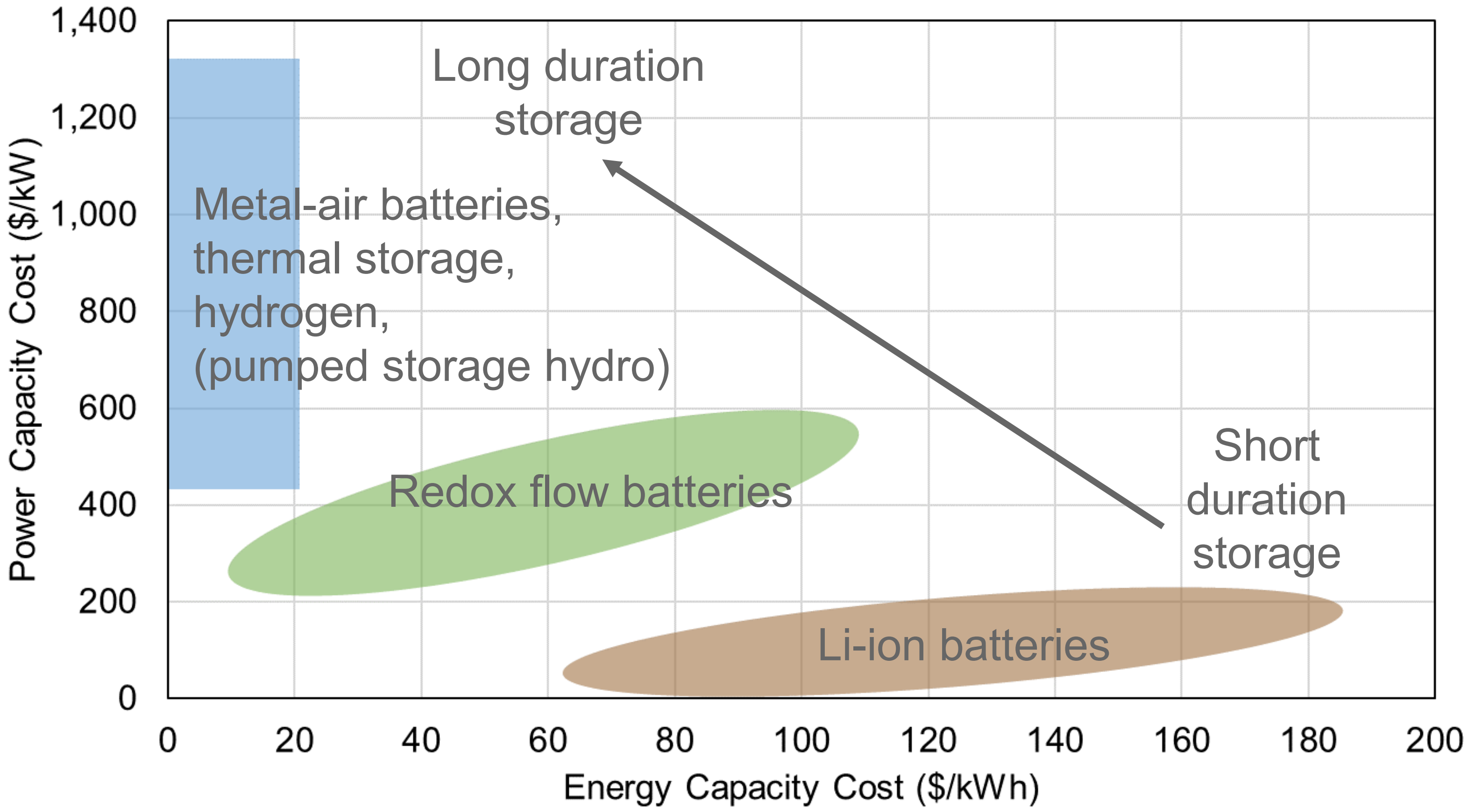
- Pumped storage hydro
- Compressed air storage

Thermal storage

- Molten salt, hot rocks
- Heat pumps

Chemical storage

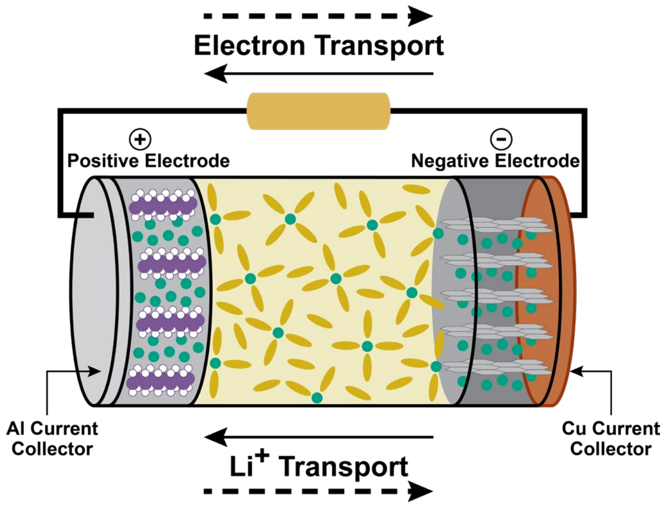
- Hydrogen



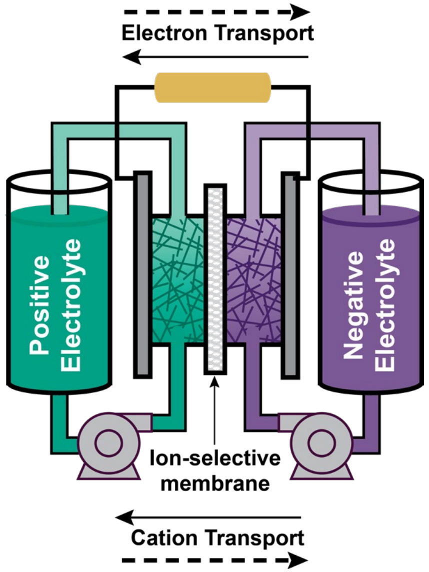
Power capacity cost = cost per MW of maximum instantaneous power
Energy capacity cost = cost per MWh of energy storage capacity
Duration = energy capacity / power capacity

Electrochemical Energy Storage Technologies*

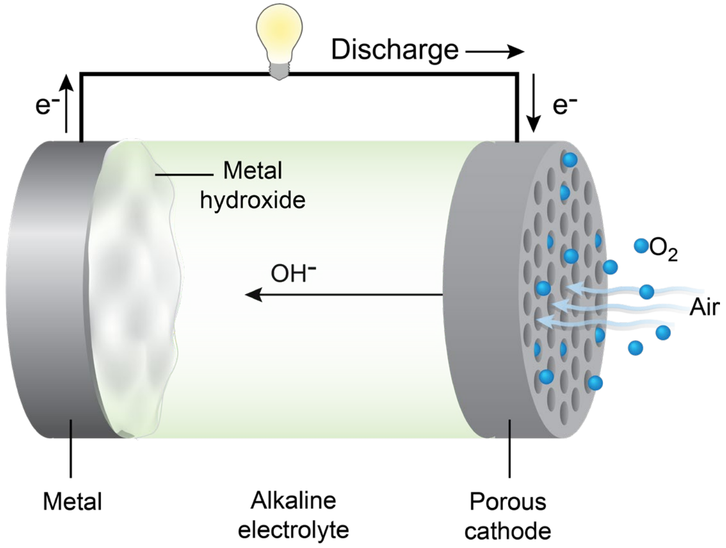
While a diversity of electrochemical storage technologies exist, not all are competitive for large-scale deployment by 2050. **Thus we only consider a subset of possible systems with TRL >6.**



Lithium-ion batteries



Redox flow batteries



Metal-air batteries

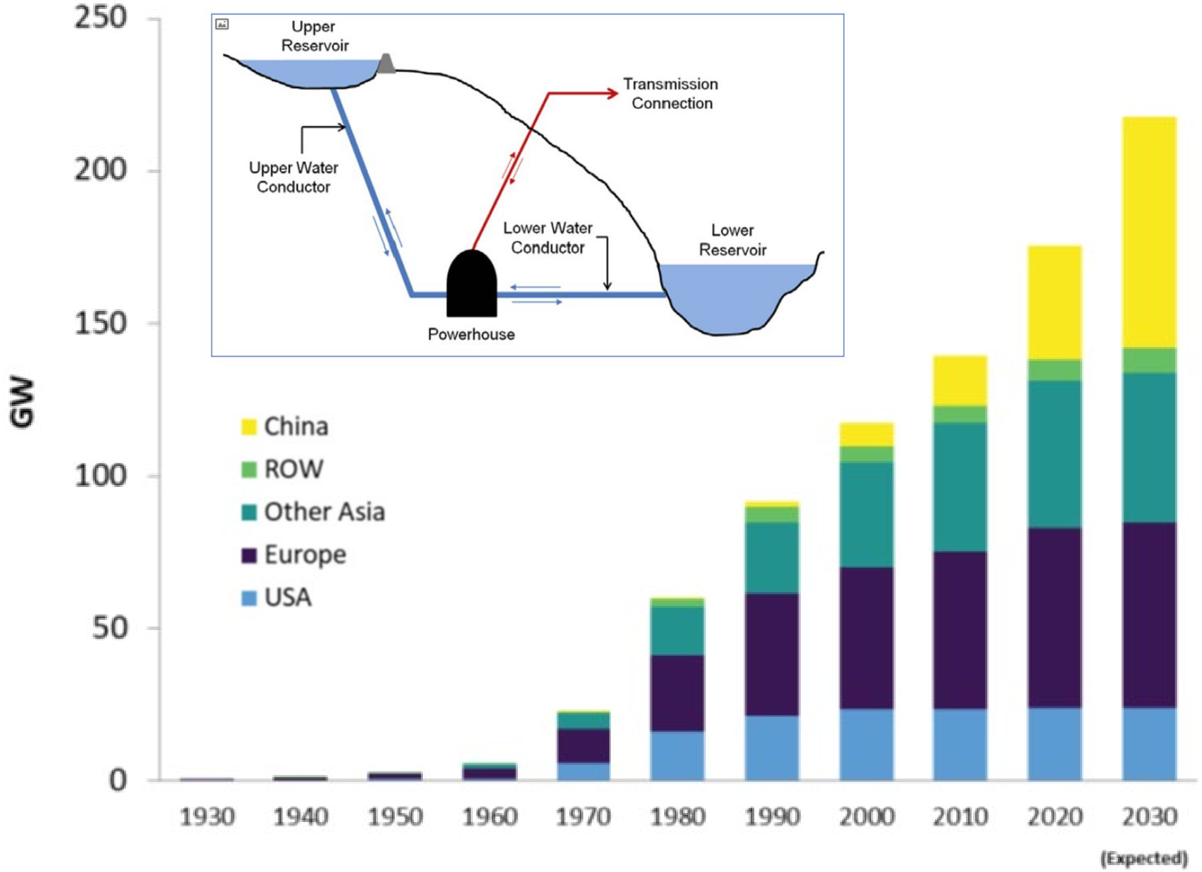
Li-ion appear well-suited for **shorter-duration** grid storage, but the lower materials costs and flexible scaling of **redox flow** and **metal-air** are increasingly attractive for **longer-duration** applications.

Study Team: Andres Badel, Fikile Brushett, Yet-Ming Chiang, Weiran Gao, Kevin Huang, Robert Jaffe, Thaneer Narayanan, Elsa Olivetti, Yang Shao-Horn, Kara Rodby

* Also lead acid and high temperature batteries

Pumped Storage Hydro (PSH)

PSH is a **mature and widely deployed** long duration (10+ h) storage technology. The U.S., Europe, and Japan built significant capacity over 1960-2000. **Since 2000, China led PSH growth**.



- In 2020, PSH was >99% of the energy capacity and >90% of power capacity of the world's total electricity storage
- Over the past 20 years, the economic value of PSH has been challenged by the increasing role of natural gas generation, but a shift to VREs may change the value proposition.
- Benefits: High efficiency, long service life, low energy capacity costs
- Challenges: Environmental impacts / siting, project financing and build times, value of/demand for PHS services uncertain

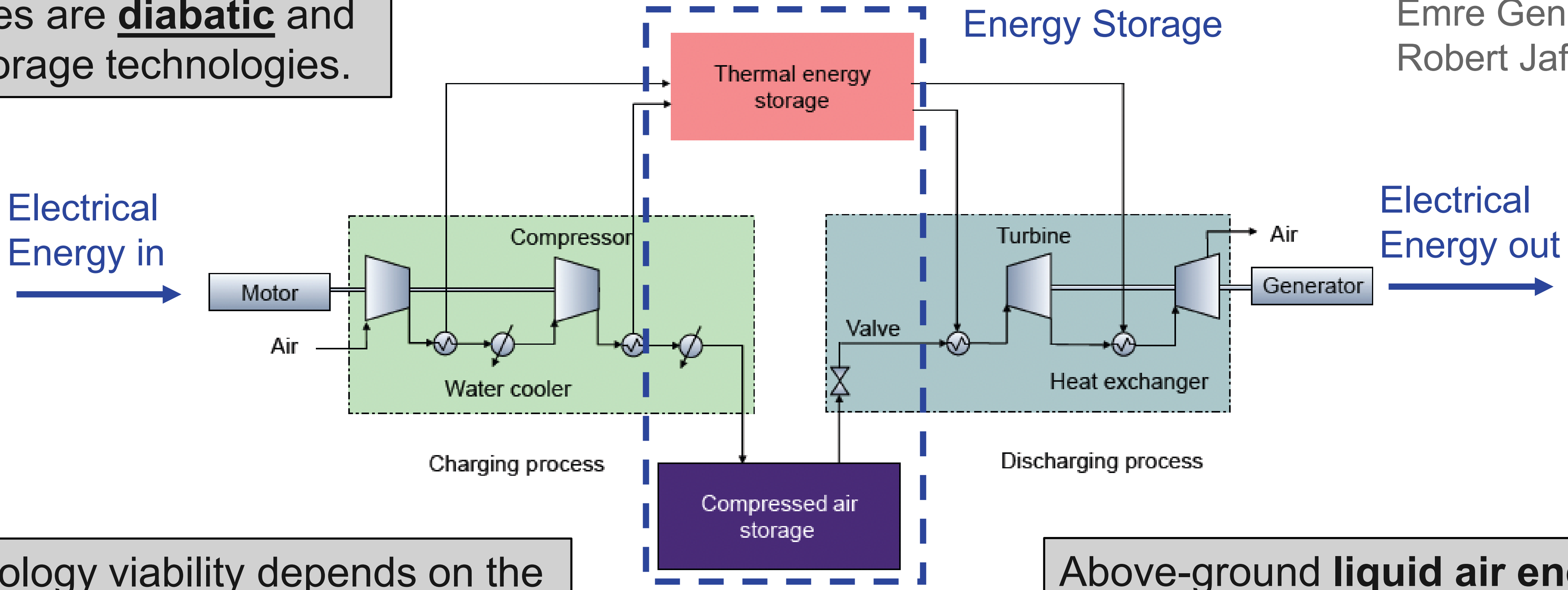
Study Team: Robert Armstrong, Howard Gruenspecht, Chi-Yen Yang

Inset image from Koritarov et al., ANL/DIS-14/7, 2014

Compressed Air Energy Storage (Adiabatic)

Existing compressed air facilities are **diabatic** and not storage technologies.

Study Team:
Seiji Engelkemier
Emre Gençer
Robert Jaffe

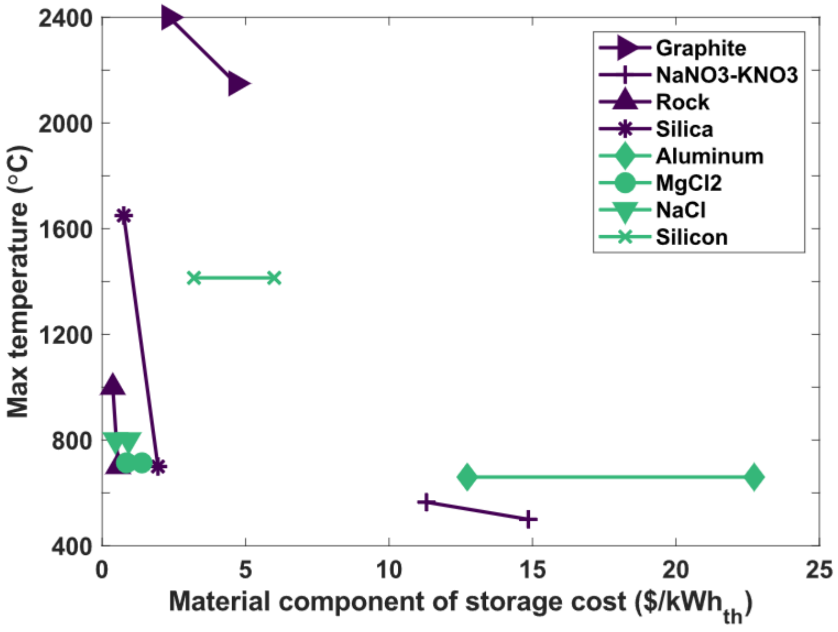


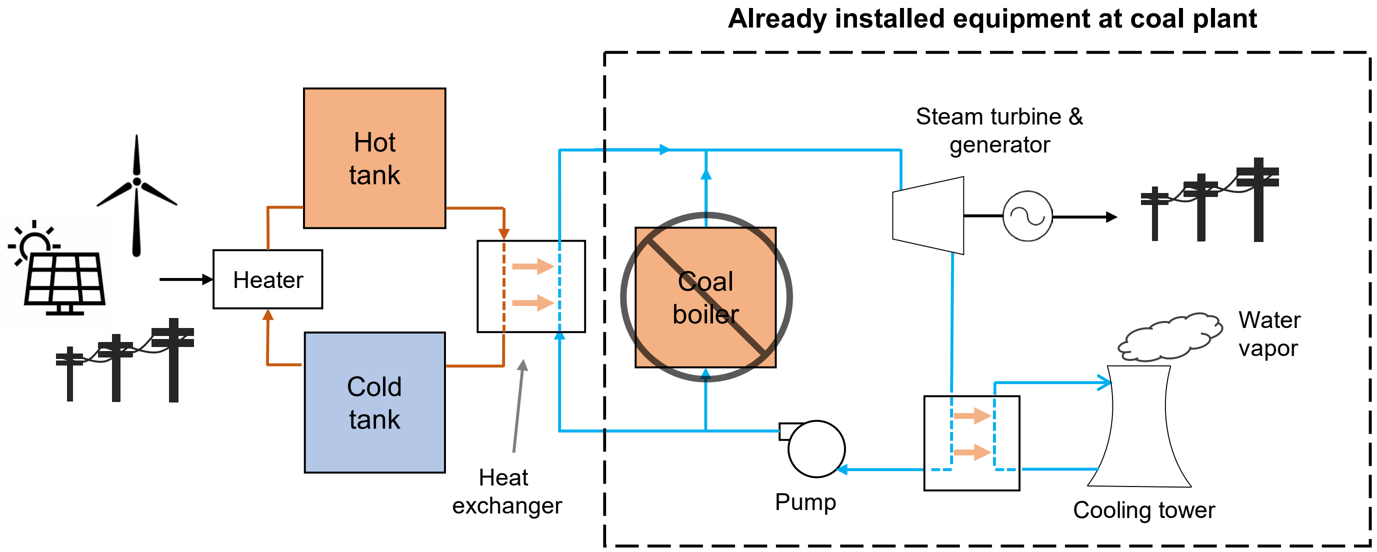
Technology viability depends on the availability of **suitable geological resources** for durable air storage and efficient air recovery

Above-ground **liquid air energy storage** offers siting flexibility and mature component technologies but cost and flexibility are unclear.

Thermal Energy Storage (TES) Technologies

TES interconverts electricity and heat storing thermal energy in **low-cost, abundant materials to compensate for the lower discharge efficiency.**



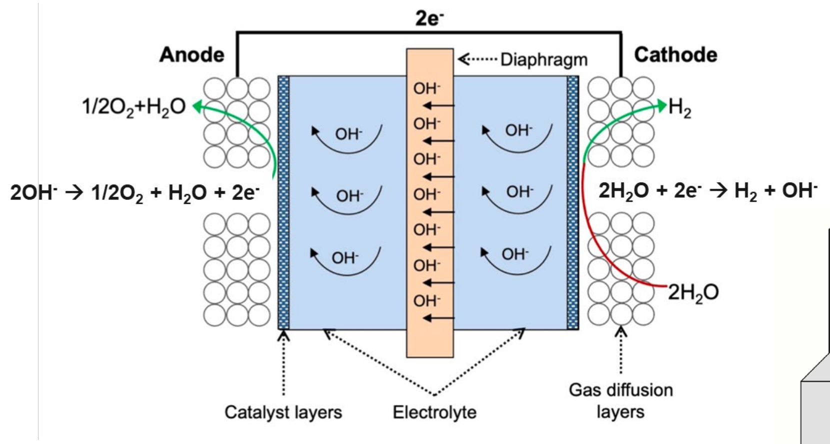


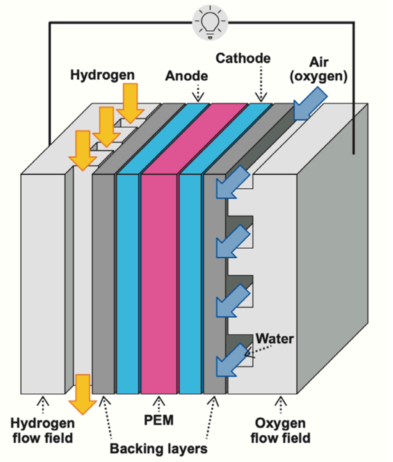
Retrofitting of existing power plants with TES offers an opportunity for near-term deployment while higher temperature approaches (> 1200°C) with increased efficiency but lower TRL have future potential

Study Team: Robert Armstrong, Seiji Engelkemier, Emre Gençer

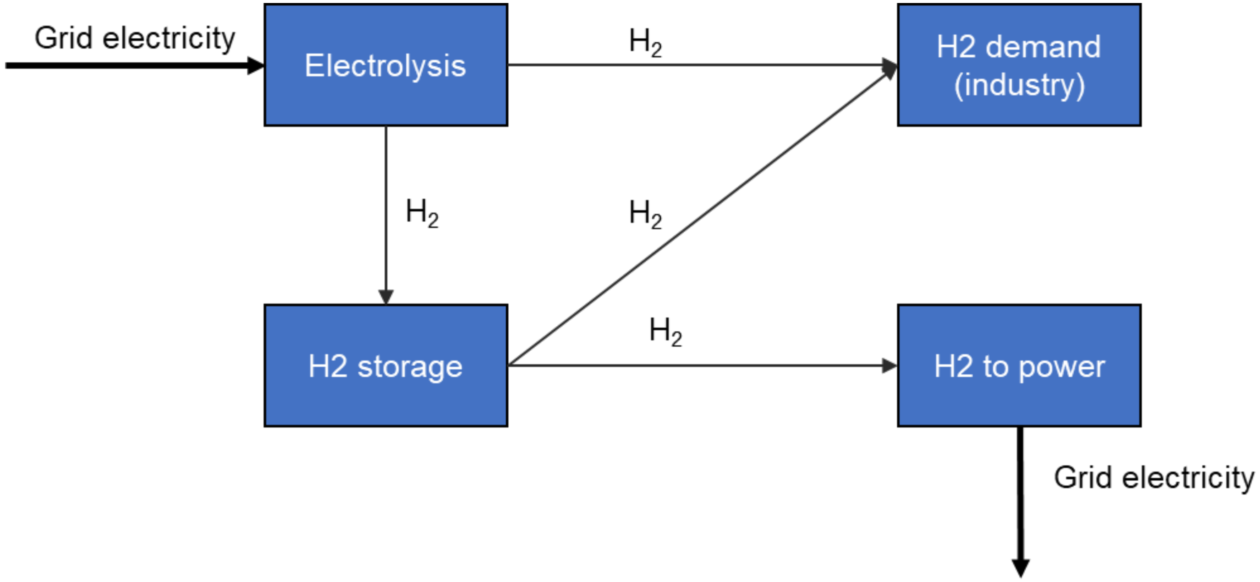
Chemical Energy Storage Technologies (Hydrogen)

Commercially proven technologies exist across the hydrogen (H_2) value chain except for **electricity production via H_2, which is expensive compared to thermal generation**





Electrochemical technologies for H_2 generation & consumption



The role of H_2 as a form of energy storage for the electricity sector will **depend on the extent to which H_2 is used in the overall economy.** (H_2 production, transportation, storage, end-use)

Study Team: Drake Hernandez, Emre Gençer

Materials supply is production rather than resource limited: Example of NMC chemistry

* **Years of current production for 100 TWh of Li-ion batteries**

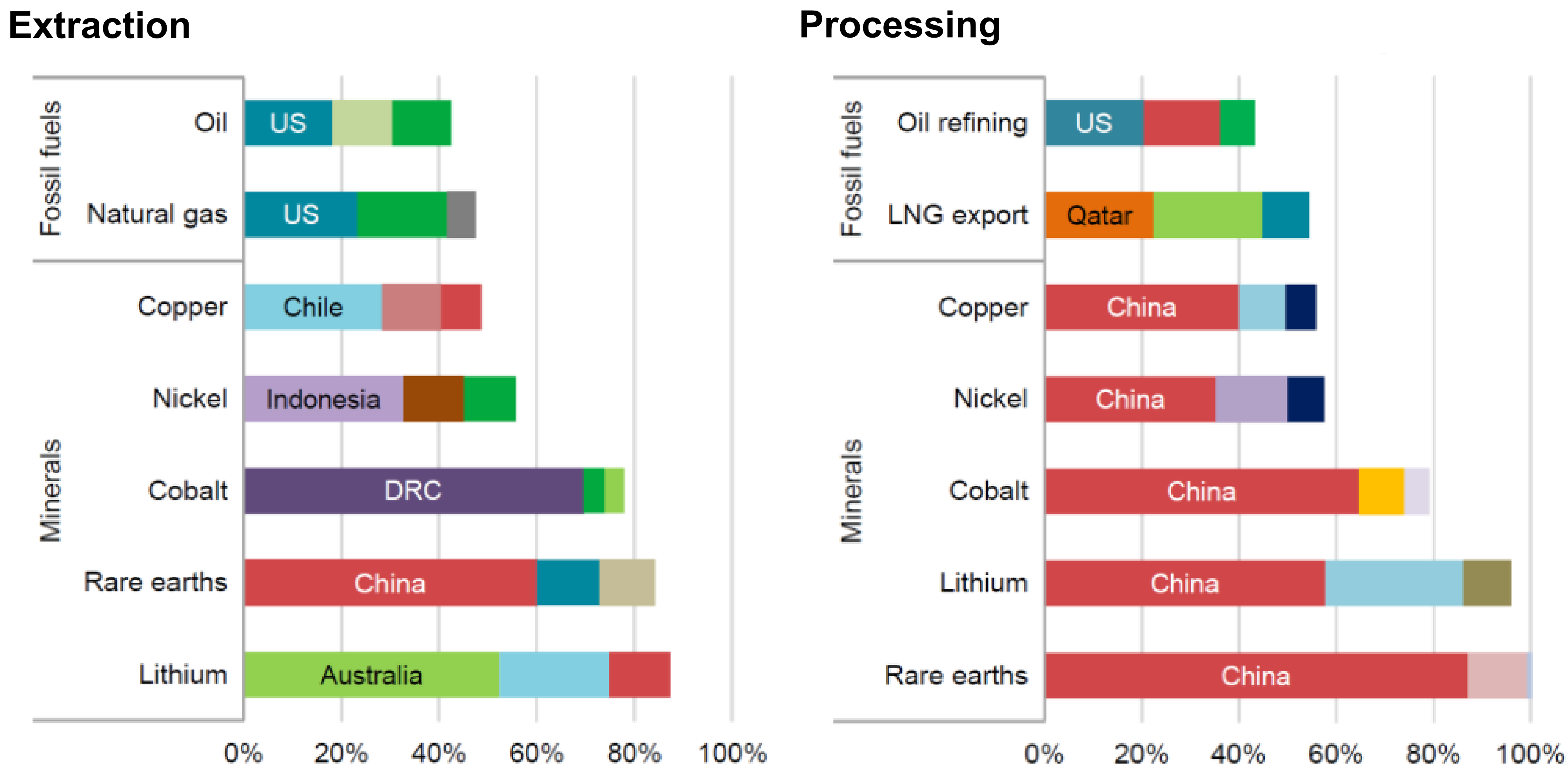
Composition	Li [y/(100 TWh)]	Co [y/(100TWh)]	Ni [y/(100 TWh)]
[Ni:Mn:Co] [111]	167	281	15.7
[622]	152	153	25.6
[811]	133	67	30.0

395 y of current production for 100 TWh of vanadium RFB

Rapidly scale to meet high demand, primarily in EV and secondarily for grid-scale storage.

Technology needed should match technology used; Lower energy density chemistries for stationary grid storage

Extraction and processing of energy transition minerals is more geographically concentrated than resources for today's fossil fuel system



Share of top three producing countries in production of fossil fuels and selected minerals

Key Conclusions: Technology Toolbox

- Lithium-ion batteries possess high energy density, high power density, and high roundtrip efficiency, facilitating their near-ubiquitous commercial use in electric vehicles and their widespread use in short-duration (today typically 4 hours or less) electricity system storage applications.

- To enable economical long-duration energy storage (> 12 hours), DOE should support research, development, and demonstration to advance alternative storage technologies that rely on earth-abundant materials.

- Thermal storage retrofits of fossil energy power plants can provide near term benefits in providing electricity storage capacity while eliminating CO_2 emissions from these generators.

- Hydrogen's role as a form of energy storage for the electricity sector will likely depend on the extent to which hydrogen is used in the overall economy, which in turn will be driven by the future costs of hydrogen production, transportation, and storage, and by the pace of innovation in hydrogen end-use applications.

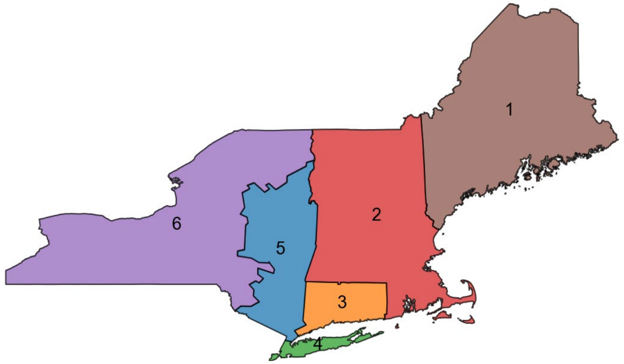
What is the role of energy storage in decarbonizing the electricity grid?

- What does the energy storage toolbox look like?
- How can these be deployed regionally in net-zero emissions electricity systems to make them affordable and reliable?
- How might market designs and regulatory policies be reformed to enable equitable & efficient decarbonization?

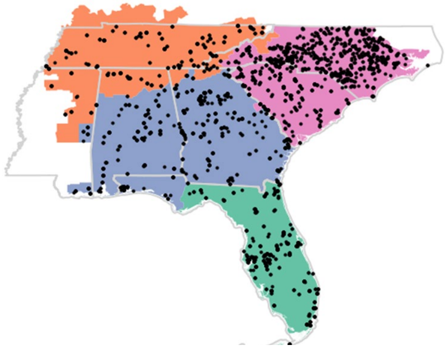
The Future of Energy Storage study explored the role for storage in carbon-constrained, mid-century power systems in 3 rather different US regions

U.S. Regions

U.S. Northeast



U.S. Southeast



Texas

Grid CO_2 emissions intensity (2018)[1]:

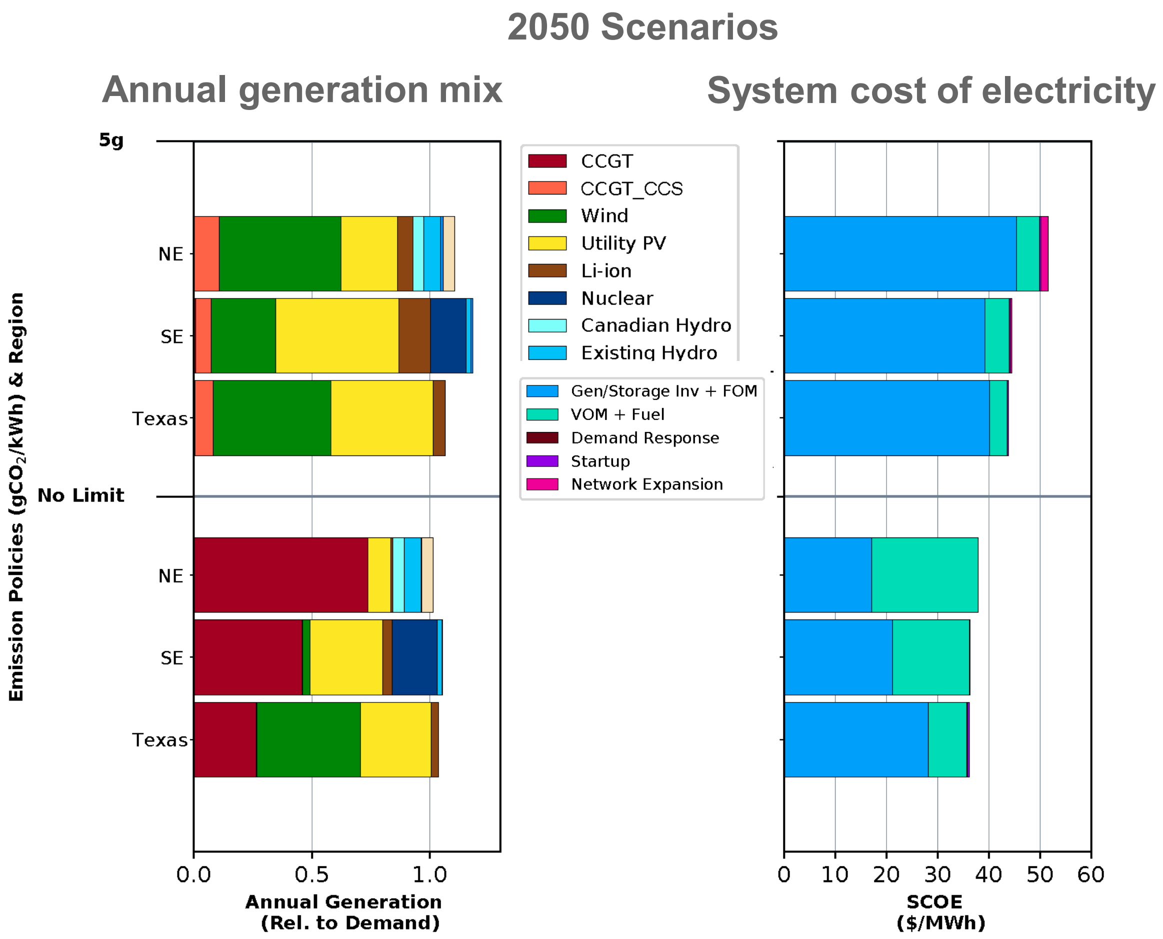
- U.S. Northeast: 249 gCO_2/kWh
- U.S. Southeast: 387 gCO_2/kWh
- Texas: 481 gCO_2/kWh

Findings are based on modeling **<u>economically efficient net-zero emissions power systems</u>** under a wide range of technological and policy assumptions, including

- CO_2 emissions intensity limits ranging from 50 gCO_2/kWh to 5 gCO_2/kWh
- Projection of **<u>substantial increase in electricity demand</u>** consistent with a highly electrified economy
- **<u>Continued cost reductions for VRE and Li-ion storage</u>** by 2050
- Continued availability of existing zero-carbon supply (e.g. nuclear in Southeast, hydro in Northeast)
- Sparing use of natural gas generation with carbon capture and sequestration (CCS)
- **Perfect foresight** assumed throughout. No tractable alternative, but could understate the value of storage

1. Data from Independent System operators and EIA State Electricity Profiles

Near-complete decarbonization by mid-century is feasible without sacrificing reliability or incurring significant cost penalty using VRE and Li-ion storage



Results presume favorable cost reduction trends continue for Li-ion batteries and VRE capacity

Challenges of "getting to zero" vary across regions based on their resource endowments and demand patterns

Energy storage can substitute or complement all other elements of a power system (transmission, generation, demand management)

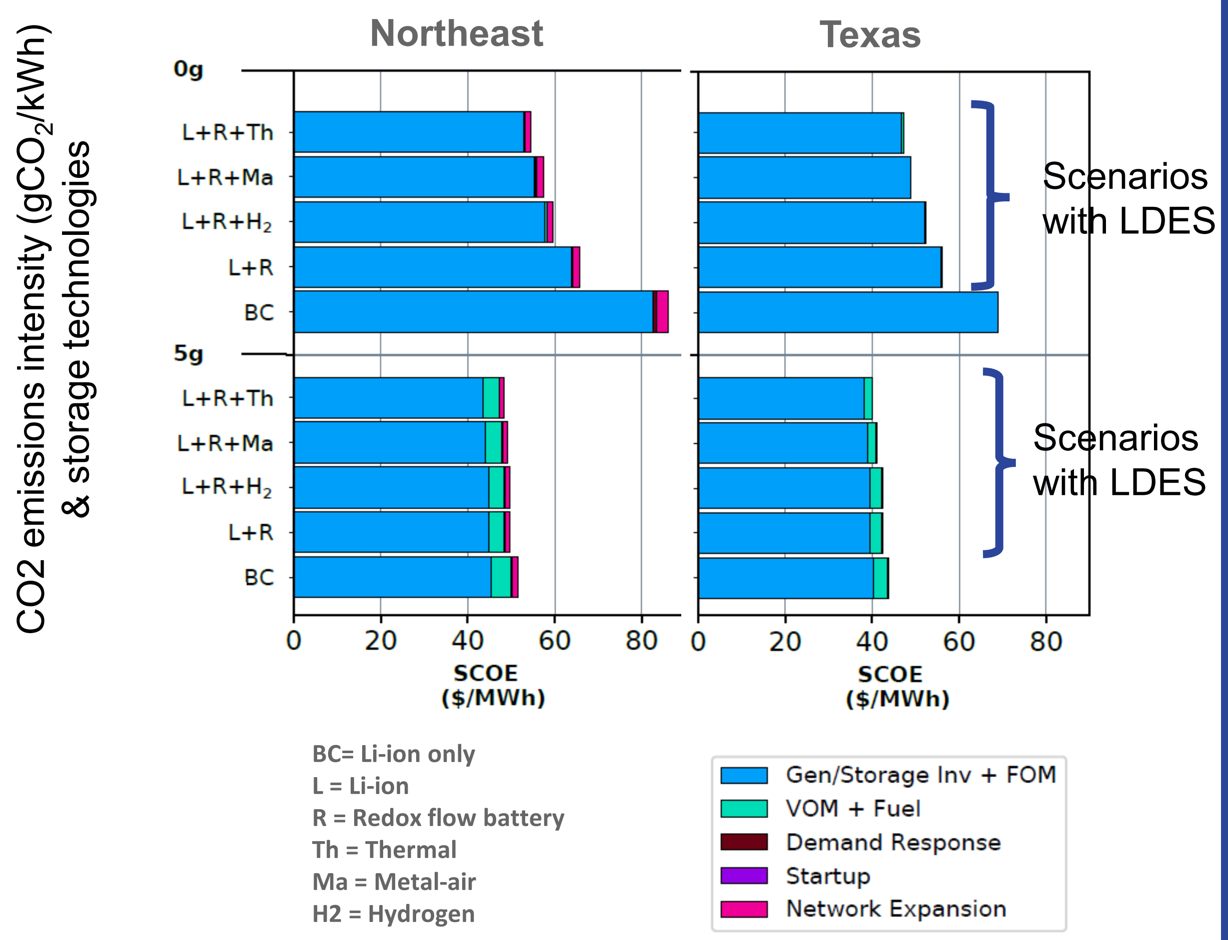
→ More sophisticated analytical tools are needed to plan, operate, and regulate power systems

Transmission expansion can play an important role in reducing grid decarbonization costs and directly competes with storage

→ Need for statutory and regulatory changes to reduce barriers to transmission expansion

The availability of emerging long-duration energy storage (LDES) technologies can reduce the cost of grid decarbonization

System cost of electricity (SCOE) in 2050

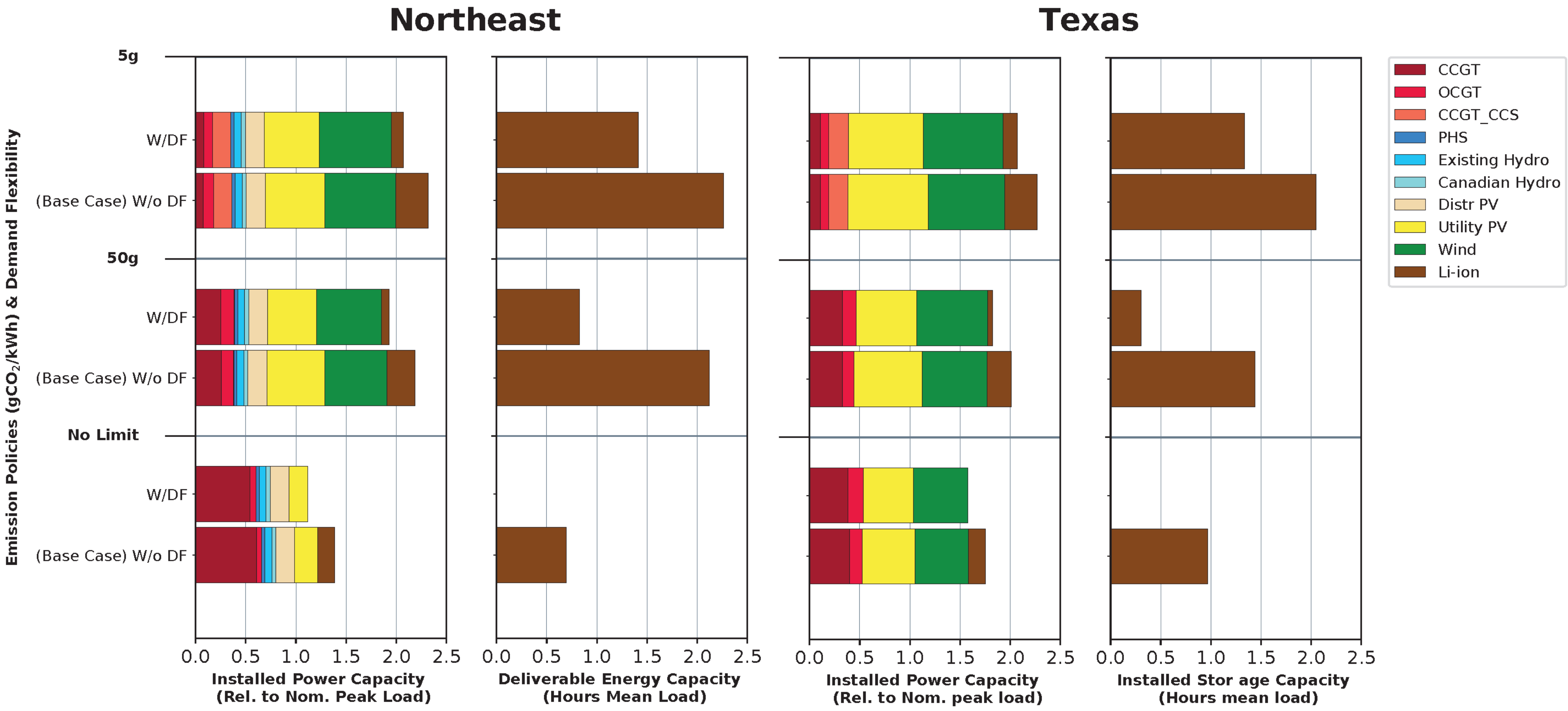


Cost impacts of long-duration storage are greatest when natural gas generation is not an option (i.e. 0 gCO_2/kWh)

→Focus Public and Private RD&D on improving cost and performance attributes of emerging LDES

With proper incentives, intra-day demand shifting from applications like EV charging reduces the optimal level of short-duration (Li-ion) storage

Power and energy capacity impacts due to demand-side flexibility under various carbon constraints (2050)



Key Findings: Planning for deployment of storage as part of regionally-tailored, net-zero electricity systems

- **The complex role played by storage and its impact on system costs and greenhouse gas emissions means that more sophisticated analytical tools are needed to plan, operate, and regulate the power systems of the future, and to ensure that these systems are reliable and efficient.**
  - This effort should be led by DOE in cooperation with independent system operators and regional transmission organizations (ISOs/RTOs).
  - The available scope for load flexibility and demand response to reduce grid storage needs and associated costs must be included.
  - The current likelihood that cost-effective transmission projects to bring generation from areas with high-quality VRE resources to major load centers will face extended delays or possible rejection suggests the need for statutory and regulatory changes to reduce barriers to transmission expansion.

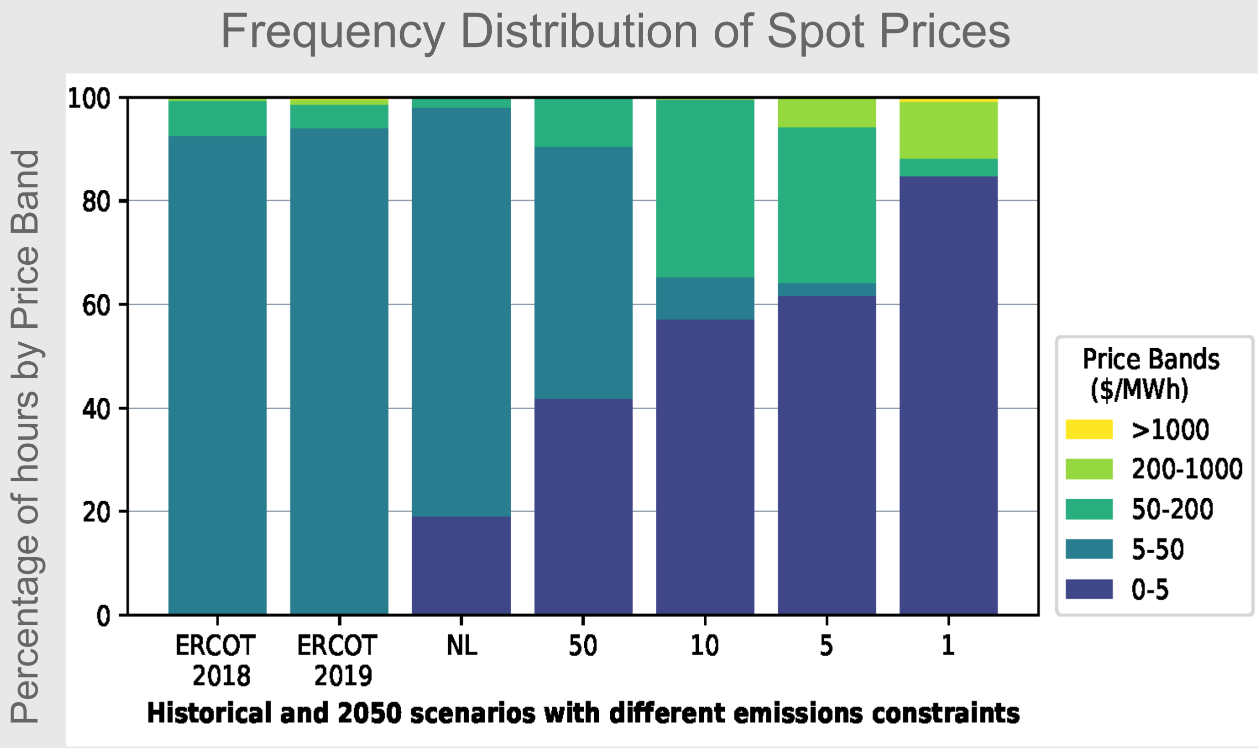
What is the role of energy storage in decarbonizing the electricity grid?

- What does the energy storage toolbox look like?
- How can these be deployed regionally in net-zero emissions electricity systems to make them affordable and reliable?
- How might market designs and regulatory policies be reformed to enable equitable & efficient decarbonization?

Two Important Features of Future Efficient Decarbonized Electric Power Systems:

Wholesale spot prices will be MUCH more volatile than spot prices in today's markets

Small-scale generation & storage can have important grid-level effects – already a reality in some systems



Necessary Wholesale-Level Reforms (FERC, ISOs, States) for Efficient Production

Increased spot market volatility will make market designs without price caps & capacity markets even less attractive than at present

Need to redesign capacity markets to value wind/solar generation ***and storage*** properly

Payments for capacity, subsidies need to be lump-sum to avoid distorting dispatch

Customer premises generation & storage need to see wholesale prices *on the margi*n (perhaps via aggregators) to avoid distorting wholesale energy & other markets

Necessary Retail-Level Reforms (States) for Efficient Consumption

More volatile wholesale markets implies much higher social cost of today's time-invariant rates

Efficient economy-wide decarbonization requires retail rates to be very low *at the margin* when wholesale spot prices are low to encourage electrification

Also need incentives to cut demand when wholesale prices are high, but charging per-kWh retail rates equal to wholesale prices would involve intolerable risk

Research/experimentation needed on reducing consumer risk while preserving incentives

- Will need higher, *equitably differentiated* fixed charges to cover the system's higher fixed costs
- Will need to devise & use insurance schemes, load management contracts, other devices

Energy storage can play a key role in decarbonizing the electricity grid by mid-century

- R&D should focus on long-duration storage technologies to support affordable, reliable future electricity systems.
- Energy storage technologies can enable regionally tailored, cost effective net-zero emissions electricity systems.
- Market designs and regulatory policies need to be reformed to enable equitable & efficient decarbonization.

The Future of Energy Storage

An Interdisciplinary MIT Study

Thank you!

- Questions?

NOVEMBER 1, 2022 | PROVIDENCE, RI

Management Update on Wholesale Markets Projects

ISO New England Board of Directors

Vamsi Chadalavada

EXECUTIVE VICE PRESIDENT AND CHIEF OPERATING OFFICER

Markets Anchor Projects Underway to Support a Reliable, Clean-Energy Transition

- Today's presentation provides an update on two wholesale market initiatives that the ISO, the states, and stakeholders consider anchor projects, or fundamental enhancements to promoting reliability and managing grid evolution
  - Day-Ahead Ancillary Services Initiative (DASI)
  - Resource Capacity Accreditation (RCA) in the Forward Capacity Market (FCM)

- An overview of nearly 10 wholesale market enhancement initiatives currently underway and planned over the next year can be found in the ISO's 2023 Annual Work Plan, published October 12, 2022, and also reflected in the strategic plan presented today

DAY-AHEAD ANCILLARY SERVICES INITIATIVE (DASI)

About the DASI Market Design Proposal

- This anchor project seeks to develop new day-ahead market (DAM) constructs for the ISO to procure and transparently price ancillary services needed to ensure a reliable, next-day operating plan in a system with a rapidly evolving and more weather-dependent resource mix
- Currently, resources are not compensated in the wholesale competitive markets for services the ISO relies on to meet two key reliability requirements in its next-day operating plan
  - Sufficient physical supply capability to meet the load forecast
  - Sufficient operating reserves to meet reserve requirements
- With DASI, the day-ahead ancillary services needed to satisfy these reliability requirements will be procured and compensated from resources through the following DAM products:
  - **Energy Imbalance Reserve (EIR)** that would cover the “gap” when the DAM’s physical energy supply awards are below the ISO’s forecast real-time load
  - **Flexible Response Services (FRS)** that would procure day-ahead the fast-start and fast-ramping (10- and 30-minute) capabilities needed to enable the system to recover from sudden source-loss contingencies and respond quickly to fluctuations in net load during the operating day

How DASI Addresses Reliability and Clean Energy Considerations

- The DASI proposal provides the appropriate pricing for ancillary services that are increasingly critical to the ISO’s next-day operating plan; it:
  - Creates efficient incentives by giving financial positions in the DAM to the resources we rely upon to meet these requirements
  - Yields transparent prices that signal the competitive, market-based incremental costs of each key reliability service
  - Provides a non-discriminatory and technology-neutral approach that allows these reliability needs to be met by any technologies physically capable of providing the required ancillary services
- Other key DASI market design elements include:
  - Call-option settlement design that provides efficient incentives for sellers of day-ahead ancillary services to be able to perform in real-time
  - Option for voluntary participation, with a market mitigation design that will address physical and economic withholding concerns
  - Retirement of the Forward Reserve Market

Impact Analysis and Stakeholder Considerations

- The ISO's DASI proposal leverages aspects of the ancillary services design work and stakeholder feedback provided during the prior Energy Security Improvements (ESI) effort in 2019-2020
- Because DASI includes only a subset of the day-ahead ancillary services proposed in ESI, the ISO will perform a revised impact analysis as part of this initiative to analyze simulated pricing and clearing outcomes, expected change in consumer costs, and other qualitative and quantitative results for other scenarios/approaches
  - The ISO will provide an overview of its impact analysis plans at the November Markets Committee meeting and will present results in spring 2023
- The ISO will gather and respond to stakeholder feedback on the DASI proposal, including the impact analysis and design framework
- The ISO plans to file the DASI proposal with FERC by the end of 2023, and is targeting implementation in Q4 2024/Q1 2025

RESOURCE CAPACITY ACCREDITATION (RCA) IN THE FORWARD CAPACITY MARKET (FCM)

About the RCA Initiative

- The capacity accreditation process uses a resource's physical characteristics (e.g., their nameplate capability, technology, location, etc.) to determine its accreditation value, which is the maximum amount of capacity that the resource can sell in the FCM
- Capacity accreditation allows resources with disparate features that may have different reliability contributions toward resource adequacy to sell the same uniform capacity product in the FCM
- This anchor project seeks to implement a revised accreditation approach across resources ranging from gas-fired to renewable resources, plus associated resource modeling enhancements, that will more accurately quantify/accredit resources' capacity contributions to resource adequacy in the FCM
  - These reforms further the clean energy transition by ensuring reliability and market efficiency as the resource mix transforms

Objective 1: Update Capacity Accreditation Framework

- The first objective is to reform the capacity accreditation framework to better reflect different resource contributions toward resource adequacy
- The ISO is proposing to apply a marginal reliability impact (MRI) methodology to capacity resources
- This approach sets a resource's accredited capacity based on the marginal reliability impact of an incremental change in its size (i.e., a resource's MRI value measures the incremental impact of its 'last' MW on system reliability)
  - This differs from "average" approach that sets a resource's accredited capacity based on the average reliability impact of each resource's respective class
  - Marginal accreditation methods emphasize substitutability across resources, which enable direct comparison of different resources' costs to determine which resources should be procured to best meet resource adequacy requirements at lowest cost
  - The ISO already applies the MRI to its capacity demand curves; by applying the same concept and consistent resource mix assumptions to both supply and demand sides of FCM, supply and demand will properly align

Objective 2: Enhance Resource and Load Models

- The second objective is to enhance resource and load models used in the resource adequacy assessment (RAA) process to capture the expected output of all resources with more accuracy and better simulate system conditions on an hourly basis
  - The RAA process calculates the capacity requirements (demand side) and resources' reliability contribution (supply side) used in the FCM
  - The RAA process must reflect on an hourly basis: performance of different resources (including unplanned outages, planned outages, and output fluctuation due to weather and fuel constraints); interaction among different resources; and correlation between resources' performance and system loading variations
  - Refinements to load modeling will include updates to how behind-the-meter PV is modeled
  - Resource modeling updates will include solar, wind, pumped storage hydro
  - Gas system limitations will be integrated into the RAA
- Relatedly, the ISO will be proposing some winter-related modeling updates, such as resource ratings during winter, seasonal tie benefits evaluation

Impact Analysis and Stakeholder Considerations

- As part of this initiative, the ISO is conducting an analysis to provide market insights into the RCA design and capacity market impacts
  - Proposed accreditation changes and modeling enhancements will be included in the Impact Analysis
  - Stakeholder discussions on the ISO's proposed impact analysis approach and methodology began in September 2022; ISO is collecting stakeholder feedback; sensitivity scenario details will be finalized in the coming months
  - The ISO plans to present initial results in Q1 2023 and issue final report in Q2 2023
- The ISO will gather and respond to stakeholder feedback on the RCA proposal, including resource modeling, gas constraint modeling, and impact analysis
- The ISO plans to file the RCA proposal with FERC by the end of 2023, and implement changes for Forward Capacity Auction 19

New England Winter Outlook 2022/2023

ISO New England Board Meeting

Open Session

Vamsi Chadalavada

EXECUTIVE VICE PRESIDENT & CHIEF OPERATING OFFICER

Introduction

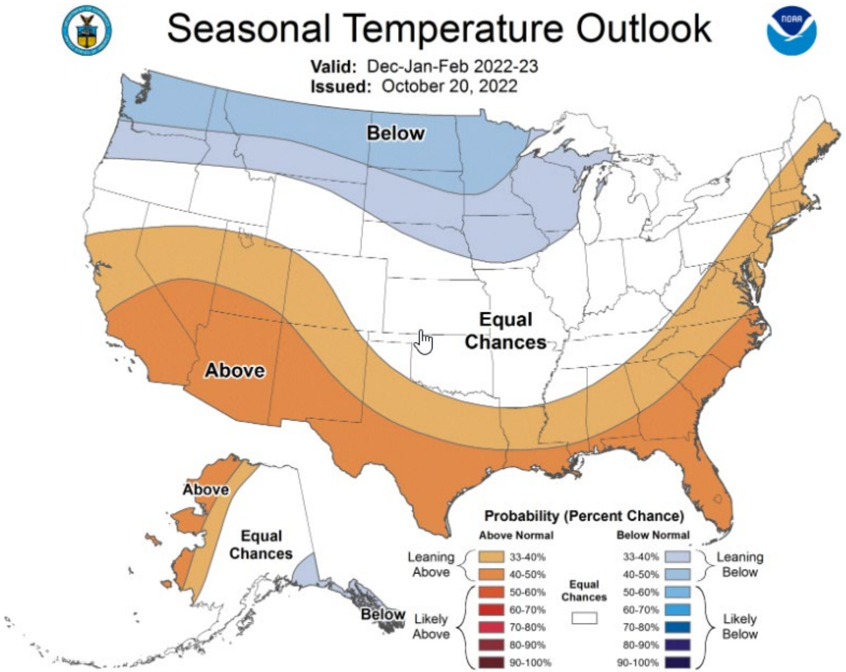
- This presentation is intended to accomplish the following:
  - Offer a current outlook of the 2022/2023 winter
  - Provide the results of a few modeled scenarios for the 2022/2023 winter
  - Present next steps

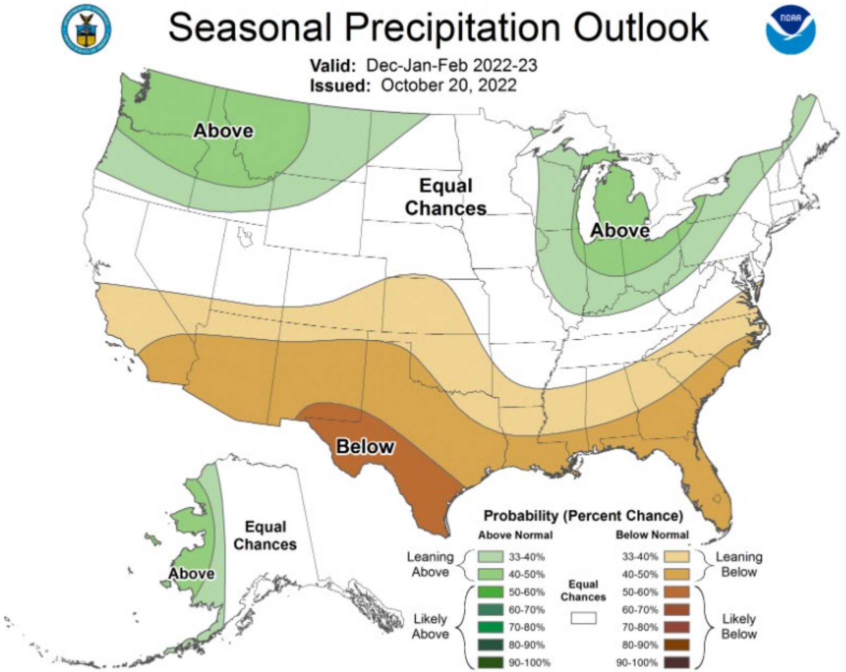
WINTER OUTLOOK 2022-2023

Highlights

- **Winter Outlook**
  - The seasonal **temperature** outlook for the winter months of December-January-February indicates a 33-40% probability of above normal temperatures for southern New England and equal chances of above average or below average temperatures for the rest of New England
  - A 33-40% probability of above normal **precipitation** is forecasted for extreme northern New England while equal chances for above average or below average precipitation is forecasted for the rest of New England
  - **Capacity analysis** for the 50/50 and the 90/10 load forecasts indicates a surplus even after accounting for generation at risk due to gas supply
    - Capacity analysis is generally limited in that it assumes all resources that are not de-rated can supply energy when called

Winter Temperature & Precipitation Probability





Winter Expectations 2022/23

- **Winter Demand Forecast**
  - 50/50 winter peak demand forecast of 20,009 MW, which is 299 MW (1.5%) higher than the 2021/22 forecast
  - 90/10 winter peak demand forecast of 20,695 MW, which is 346 MW (1.7%) higher than the 2021/22 forecast
- **Scheduled Generation and Transmission Outages**
  - All generation and transmission outages continue to be coordinated to minimize adverse transmission or capacity conditions
  - No significant generation or transmission outages are currently scheduled
- **Transfer Capability**
  - Transfer capability on the New York Northern AC ties will be increased from 1,400 to 1,600 MW for the winter period (*pending final verification from NYISO*)

Winter Expectations 2022/23, cont.

LNG Replenishment

- Over the past ten winters (Dec-Feb), the region has averaged ~31.7 Bcf of LNG usage; the highest usage was ~42.9 Bcf in 2012/13, lowest usage was ~20.0 Bcf in 2021/22

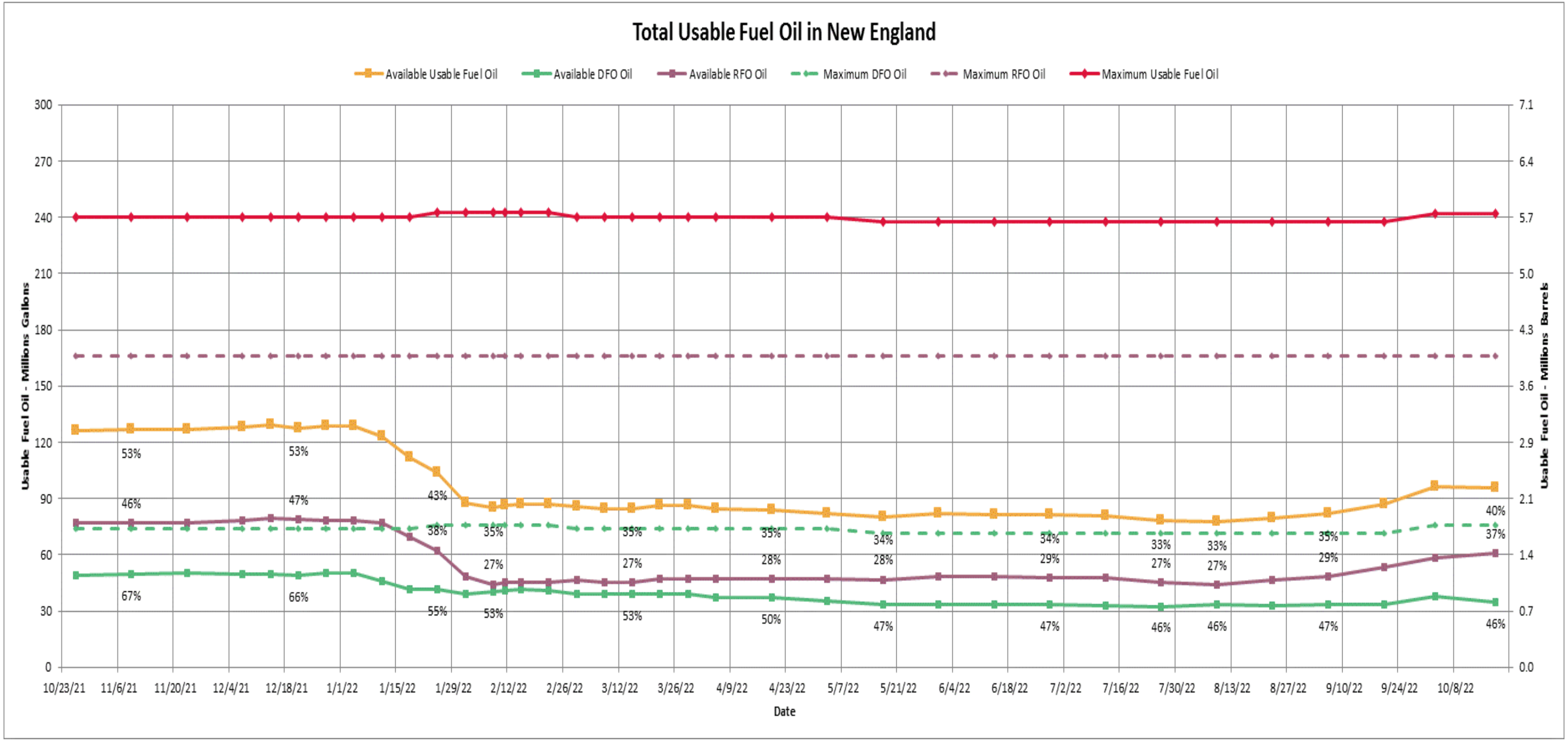
- **Winter 2022/23**
  - Europe met its intended LNG fuel storage target ahead of winter
  - European natural gas prices continue to remain higher than in New England
  - In early October, European prices for January delivery were ~$60/MMBtu
    - Since then, the prices have trended down
  - Cost-of-Service contract with Mystic provides greater certainty of LNG availability this winter
  - ISO's current expectation is that ~31 Bcf will be available

Winter Expectations 2022/23, cont.

Fuel Oil Replenishment

- Due in large part to declining forward prices for fuel-oil, many stations have waited until fall to procure and finalize replenishment plans
- Based on recent replenishment activities and discussions with resource owners, ISO anticipates additional replenishment prior to winter
  - Additional fuel-oil replenishment is expected to increase the region's aggregate fuel-oil inventory from ~92M gallons (~39% of max) to ~120M gallons (~50% of max) prior to winter
- Discussions with resource owners have identified some level of concern with regard to the Distillate Fuel Oil (DFO) supply chain
- No concerns have been noted with regard to the Residual Fuel Oil (RFO) supply chain and RFO stations have robust replenishment plans in place
- The potential for emissions limitations at some dual-fuel units will have to be monitored closely in the event of significant oil burn

Total Usable Fuel Oil in New England



Winter Expectations 2022/23, cont.

- **Natural Gas Deliverability**
  - Continue to monitor natural gas deliverability throughout the winter
  - Approximately 4,100 – 5,100 MW[1] may be at risk due to constrained natural gas pipelines
- **Winter Capacity Outlook**
  - Projecting the lowest 50/50 operable capacity margin of ~3,900 MW and lowest 90/10 operable capacity margin of ~2,300 MW for the week beginning January 7, 2023[1]
  - Extended periods of cold weather may rapidly deplete stored fuel inventories and capacity outlook will be adjusted accordingly

[1]-Based on resource Winter Seasonal Claimed Capabilities

Winter Preparations 2022/23

- **Energy Shortfall Exercise**
  - Hosted a region-wide energy shortfall tabletop exercise on October 12, 2022
- **Winter Readiness Seminar**
  - Will host a Generator Winter Readiness Seminar with Market Participants on November 14, 2022
- **Winter Generator Readiness Survey**
  - Will distribute a Winter Generator Readiness Survey to all generating resources in the region by November 1, 2022 with responses due by December 1, 2022
- Completed the annual **Natural Gas Critical Infrastructure Survey** process to ensure critical infrastructure is not part of automatic or manual load-shed schemes
- **Generator Fuel and Emissions Surveys** will be of weekly or daily frequency during the winter season
- **21-day energy assessment** will be performed weekly with results published to the ISO public website
  - The assessment will performed daily if necessary

21-Day Energy Assessment & Alert Thresholds

- In order to identify and communicate potential reliability issues, the ISO performs a weekly 21-day energy assessment and posts the results on the ISO public website
  - The energy assessment is based on latest responses to generator surveys, as well as planned outages, load and weather forecasts, and anticipated LNG injections

- ISO's OP-21 describes the thresholds for declaration of an Energy Alert or Energy Emergency based on the 21-day energy assessment results
  - ISO will declare an **Energy Alert** if the energy assessment indicates either the use of OP-4 Actions 6-11 (voltage reduction and conservation appeals) or OP-7 Action in at least **1 hour on 1 or more consecutive days in days 6 through 21**
  - ISO will declare an **Energy Emergency** if the energy assessment indicates the use of OP-4 Actions 6-11 (voltage reduction and conservation appeals) or OP-7 Action in at least **1 hour on 1 or more consecutive days in days 1 through 5**

Requests for Government and Cross-Sector Assistance

- ISO and resource owners may request New England State and Federal Government Assistance
- In order to minimize or alleviate need for extreme operational measures, the ISO and/or resource owners may request:
  - Jones Act waivers
  - Waivers of emissions and/or air permitting limitations (if alternate fuel is available) under 202c of the Federal Power Act or state statutes
  - Waivers of Department of Transportation restrictions on drivers for fuel deliveries
  - Activation of military staff and equipment to move fuel supplies
  - Multi-day emergency conservation measures under OP-4 and request states to assist with cross-sector energy appeals for conservation of liquid fuels and natural gas

WINTER 2022/23 SCENARIOS

Introduction – 2022/23 Winter Scenarios

- The ISO routinely performs scenario assessments to prepare for the winter
- The following slides illustrate the qualitative and quantitative aspects of three scenarios
  - Scenario 1 assumes a mild winter as represented by the 2021/22 winter
  - Scenario 2 assumes a mild winter, but with a 13 day cold spell, as represented by the 2017/18 winter
  - Scenario 3 assumes a ‘colder than normal’ winter as represented by the 2013/14 winter
- Unless otherwise noted, scenarios assume the following:
  - Expected starting fuel oil inventories; fuel oil replenishment assumptions range from minimal to moderate
  - No LNG injections assumed beyond current projections
  - No significant or long-duration generator or transmission contingencies
  - System demand reduced to account for distributed PV resources
- The ISO’s 21-day energy forecast tool will signal any potential energy emergencies, thereby alerting the market to procure necessary fuel replenishments, both to meet their obligation and to protect against scarcity

Scenario 1 – Mild Winter, Similar to 2021/22

- **Winter 2021/22 overview**:
  - Milder than normal winter with very few days staying below freezing
  - Average temperature departure from normal was +1.0°F (i.e., warmer than normal)
  - Winter peak load of 19,623 MW
  - Total energy modeled is 30,591 GWh
  - During some periods, fuel oil was more economic than natural gas for power generation
  - Approximately 80M gallons of fuel oil was burned
- ISO anticipates that there would be sufficient capacity and energy available to meet the expected peak loads and energy

Scenario 2 – Moderate Winter with a Deep and Prolonged Cold Spell; Similar to 2017/18

- **Winter 2017/18 characteristics**:
  - Milder than normal outside of a two-week span of significantly below normal temperatures
  - Average temperature departure from normal was +0.5°F degrees
  - The region was impacted by an extended stretch of cold weather between December 25 and January 9; all major cities in the region experienced temperatures below normal for at least 13 consecutive days, of which 10 days averaged more than 10°F below normal
  - Winter peak load of 20,631 MW
  - Total energy modeled is 31,291 GWh
  - The cold snap was marked by reductions in natural gas availability and price inversion contributed to high fuel oil usage; several oil-fired resources were postured to maintain fuel reserves

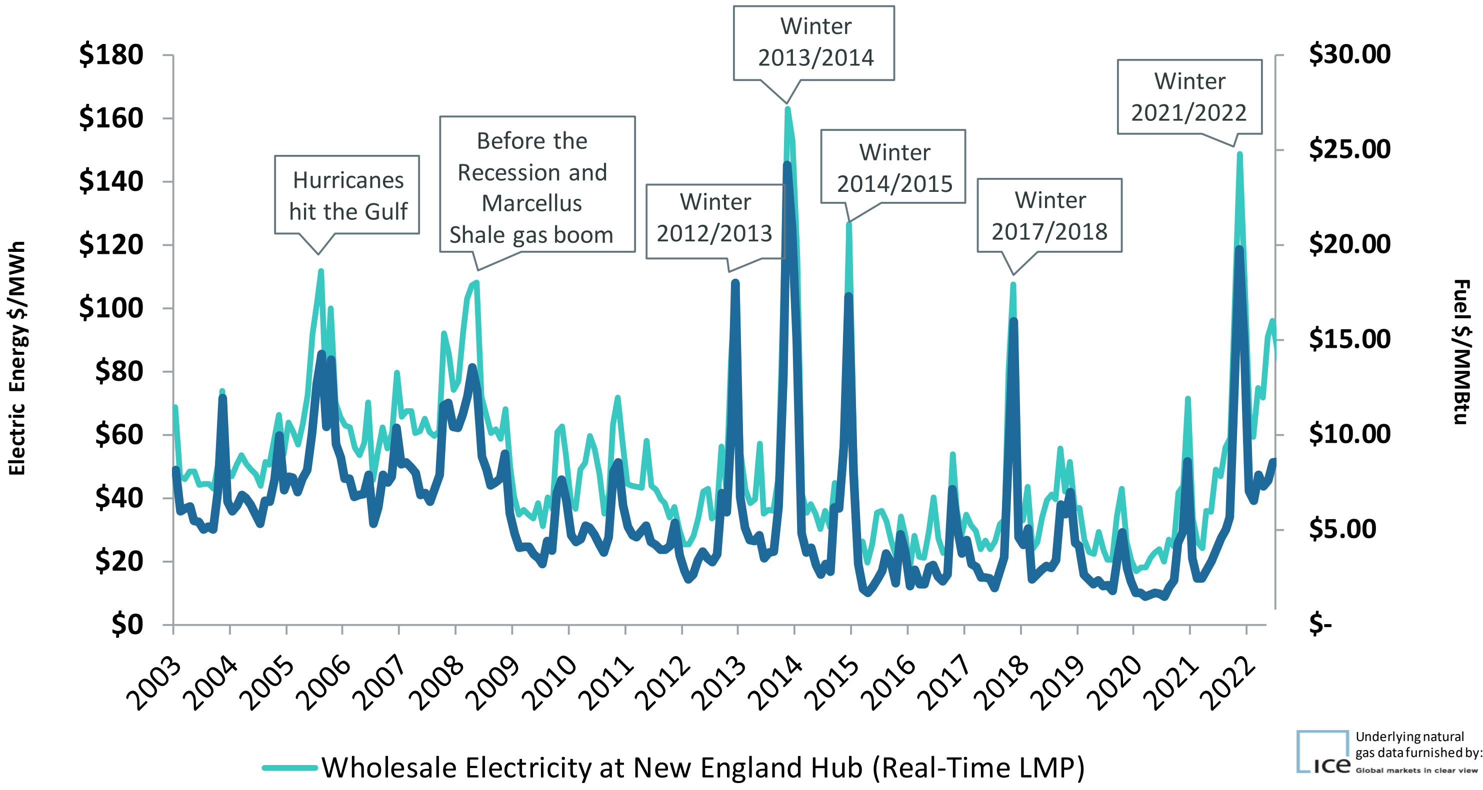
- ISO anticipates that system reliability will be maintained, but may require the use of capacity deficiency actions under OP-4 on 5-7 days

Scenario 3 – Cold Winter with Several Cold Stretches; Similar to 2013/14

- **Winter 2013/14 characteristics**:
  - Colder than normal overall highlighted by a polar vortex event which resulted in significant stretches of cold weather in New England and surrounding areas
  - Average temperature departure from normal was -2.3°F degrees
  - The region experienced six cold weather stretches of four or more consecutive days, including a stretch of ten consecutive days at or below freezing
  - Winter peak load of 21,514 MW
  - Total energy modeled is 33,881 GWh
  - Significant energy usage caused high demand on both the electric and natural gas systems
- Significant usage of all available capacity deficiency actions under OP-4 (including public appeal actions) may be necessary across several weeks, including the use of OP-7 across several days
  - In-season fuel replenishment will greatly mitigate this risk

Natural Gas and Wholesale Electricity Prices Are Linked

Monthly average natural gas and wholesale electricity prices at the New England hub



Underlying natural gas data furnished by: ICE Global markets in clear view

NEXT STEPS ON ENERGY ADEQUACY

Looking Ahead: Energy Adequacy Anchor Project

- NEPOOL, the New England States, FERC, and the ISO agree that energy adequacy discussions and actions are a top priority
- The ISO is currently working with EPRI on developing a probabilistic energy adequacy model to study the performance of the power system under extreme events – this project will help inform the scope of solutions
  - Upcoming work is outlined on the next slide
- To guide discussions, the following time horizons are considered:
  - **Immediate-term**: Winter 2022/23
  - **Short-term**: Winters 2023/2024 and 2024/2025
  - **Medium-term**: The subsequent seven winters–2025/2026 through 2032/2033
  - **Longer-term**: Beyond 2033 (roughly a decade from now)
- Defining timelines should offer clarity as various solutions are considered

Looking Ahead: Energy Adequacy Anchor Project

- **Q4 2022**
  - Immediate-term: Confirm protocols to work with the DOE on emissions restrictions; maintain lines of communication for potential Jones Act waivers
  - Short-term: Update the Inventoried Energy Program for Winters 2023/2024, 2024/2025
  - Short/medium-term: Continue regional dialogue with respect to the Everett LNG Facility
  - Medium/longer-term: Present and gather feedback on the EPRI energy adequacy study model
- **Q1 2023**
  - Short-term: Review 2022/23 winter and confirm readiness plans for winter 2023/2024
  - Medium/longer-term: Present preliminary results of the EPRI study
  - Medium/longer-term: Finalize problem statement
- **Q2 2023**
  - Medium/longer-term: Discuss scope and viability of energy adequacy solutions and define the list of options to pursue, which could include:
    - Market enhancements, a modernized strategic energy reserve, and infrastructure options such as transmission

Questions

CONCLUDING REMARKS

Today's Presentations Will Be Posted

- Today's presentations will be posted to the ISO website:

  www.iso-ne.com:
  > About Us
  > Government and Industry Affairs
  > Presentations, Speeches, Papers, and Other Materials

Thank you for being a part of today's meeting