

EMERGING POSSIBILITIES FOR BULK ENERGY STORAGE

Moderator:

Philip L. Bartlett II, Chairman, Maine Public Utilities Commission

Panelists:

Josh Eichman, Senior Research Engineer, National Renewable Energy Laboratory Greg Padden, Director of Resource Planning & Markets, Great River Energy Jason Houck, Policy and Regulatory Affairs Lead, Form Energy Heidi Bishop Ratz, U.S. Electricity Markets, Manager



WHAT IS NARUC

- The National Association of Regulatory Utility Commissioners (NARUC) is a nonprofit organization founded in 1889.
- Our Members are the state regulatory Commissioners in all 50 states & the territories. FERC & FCC Commissioners are also members. NARUC has Associate Members in over 20 other countries.
- NARUC member agencies regulate electricity, natural gas, telecommunications, and water utilities.





WHAT IS NARUC'S CENTER FOR PARTNERSHIPS AND INNOVATION?

- Grant-funded team dedicated to providing technical assistance to members.
- CPI identifies emerging challenges and connects state commissions with expertise and strategies.
- CPI builds relationships, develops resources, and delivers trainings.





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Chairman,

Maine Public

Utilities

Commission

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Panelist



JOSH EICHMAN

Senior Research Engineer,

National Renewable Energy Laboratory Panelist



GREG PADDEN

Director of Resource Planning and Markets,

Great River Energy

Panelist



JASON HOUCK

Policy and Regulatory Affairs Lead,

Form Energy



Panelist

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U.S. Electricity Markets, Manager

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The value proposition for long duration and seasonal energy storage

Josh Eichman, Omar Guerra, Jiazi Zhang

NARUC CPI Innovation Webinar: Emerging Possibilities for Bulk Energy Storage

October 22, 2020

Background

Why long duration or seasonal energy storage?

- Mismatch in supply and demand (daily and seasonal)
- Resiliency during multiday extreme events

Storage can be generally separated into three categories.

- Short-duration (<10 hours at rated discharge power)
- 2. Long-duration (10-100 hours at rated discharge power)
- 3. Seasonal (>100 hours at rated discharge power)



Electricity storage applications and technologies

Note: CAES = compressed air energy storage; PHS = pumped hydro energy storage.

The role of long duration and seasonal storage in future power systems

• A cost optimized storage portfolio will include a variety of technologies, each providing unique value to support grid operations.



Preliminary modeling of storage portfolios finds that long duration and seasonal storage play a key role in achieving the lowest cost high renewable power system

System Benefits

Benefits include:

- Energy arbitrage
- Ancillary service provision
- Improve efficiency and reduce starts for fueled generators
- Capacity for resource adequacy
- Congestion management
- Transmission and distribution deferral
- Resiliency support

Source:

Zhang, J.; Guerra, O.; Eichman, J.; Pellow, M. (in review) Benefit Analysis of Long-Duration Energy Storage in Power Systems with High Renewable Energy Shares

- Long duration and seasonal energy storage, and highly flexible loads reduce operating costs (see figures to the right).
- This study considered, in detail, the first four items above.

Source:

Valuation of Hydrogen Technology on the Electric Grid Using Production Cost Modeling: Final Report. EPRI, Palo Alto, CA: (Forthcoming). 3002016621.



Considers the benefit (not including capital cost) of a 2GW storage system added to the Western Interconnect with up to 85% renewable shares in 2050 (includes large hydro). Same color points represents different round-trip efficiency values for top figure and different capacity factors for bottom figure

Determining Cost-effectiveness

- A recent publication explored cost competitiveness (benefits versus costs) of seasonal storage in 2025-2045 and 2050-2070 timeframes
- Despite the benefit of longer durations, the added storge capacity cost often means shorter durations are more cost effective.



Considers a 2GW storage system added to the Western Interconnect.

Source: Guerra, O.; Zhang, J.; Eichman, J.; Denholm, P.; Kurtz, J.; Hodge, B. The Value of Seasonal Energy Storage Technologies for The Integration of Wind and Solar Power. Energy Environ. Sci. 2020, 13, 1909–1922. <u>https://doi.org/10.1039/D0EE00771D</u>

- Grid planning and operations need to include consideration for long duration and seasonal storage as well as highly flexible loads (e.g., hydrogen power-to-gas)
- Need to consider the entire range of benefits that long duration storage, seasonal storage, and flexible loads can provide.
- Market design that appropriately compensates longer duration storage systems for the value they provide (an important step to encourage deployment).

Thank you

www.nrel.gov

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NATIONAL RENEWABLE ENERGY LABORATORY

Great River Energy -Long duration storage project

Greg Padden

Director, Resource Planning and Markets

Great River Energy



Great River Energy membership



Total member cooperatives
Total members served 700,000
Total people served 1.7M





GRE portfolio evolution



Natural Gas Peaking Generation



Generation changes in MISO



Active MISO Queued Generator Interconnection Requests





*Source: MISO website - 10/12/2020

Storage as a Minnesota resource

Minnesota electric needs peak in summer and winter. Extreme weather creates reliability needs for days, not hours.

Performance review: nuclear, fossil fuels, and renewables during the 2019 Polar Vortex Wood Mackenzie



Storage still predominantly 2-4 hour duration capacity asset, typically used for evening demand peaks

•••

Storage getting cheaper, but cost effectiveness limited to niche applications at current prices *Wood Mackenzie study after 2019 polar vortex –

18-40 hours of firm dispatch resources would have been needed if had been using a 100% renewable system with no transmission constraints

EAT RIVER ENERGY...



GRE storage pilot project

- 1 MW/150-hour long duration storage project
 - Commercial operation in Q3-2023
 - Located in Cambridge, Minnesota
- Approved by GRE membership
 - Future cost-effective resource
 - Intra-day and multi-day capability
 - Seasonal flexibility
 - Locational optionality
 - Expert technology partner with Form Energy



AT RIVER ENERGY...

Pilot project - goals

- Technology capability at plant scale
 - Proof of concept for future grid scale projects
 - Design modifications and improvements
- Use case analysis future cost savings potential
 - Reliability generation and transmission
 - Energy market hedging
 - Generation optimization
 - Ancillary services
 - Transmission deferral





Summary



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GREAT RIVER ENERGY...



BREAKTHROUGH LOW-COST, LONG-DURATION ENERGY STORAGE Jason Houck, Policy and Regulatory Affairs Lead jhouck@formenergy.com



The electricity world is changing, quickly







US Generation by Source 2001 - 2019

Source: EIA





The future, absent long duration storage

- Solar and wind are the cheapest resources, but
- Fossil resources persist to support grid reliability



Source: IEA, BloombergNEF









Why renewables alone aren't enough Multi-day reliability risks

Multi-Day Weather Event in Winter (Upper Midwest, 2019)

Renewables sized at ~1.5x winter peak

- Insufficient energy to meet demand
- Can't recharge short-duration storage

7,000

6,000

5,000

4,000

3,000

MΜ

2,000

1,000

Source: Xcel Energy 2020-2034 Upper Midwest Resource Plan, May 20, 2019 Workshop









Why renewables alone aren't enough Multi-day reliability risks

Renewables sized at ~4x winter peak

- Insufficient energy to meet demand
- Can't recharge short-duration storage





Multi-Day Weather Event in Winter (California, 2050)

Source: E3: Long-Run Resource Adequacy Under Deep Decarbonization







Why renewables alone aren't enough Multi-day reliability risks

- Transmission outage limits supply
- Local distributed PV can meet some needs but not all.





Lost Power Flow to Substation Due to Grid Outage



Source: Form Energy analysis





Fossil-fueled resources fill the gaps today

- Gas plants run for days during high load
- Short-duration storage alone can't match performance



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Average and Longest Run Times of Gas Peakers in New York



Source: E3: The Potential for Energy Storage to Repower or Replace Peaking Units in New York

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What kind of storage would it take to replace coal or high capacity factor natural gas?

- >24 hours duration
- 10-100X cheaper than lithium ion.









Form Energy was founded to develop long duration storage to eliminate thermal plants

Co-Founders:

- Mateo Jaramillo, CEO; Founder Tesla Energy, Tesla VP
- **Yet-Ming Chiang**, Chief Science Officer; MIT Professor, Founder of 6 companies (incl. A123, 24M, Desktop Metal)
- **Ted Wiley**, President/COO; Co-founder Aquion, HBS, US Army
- Marco Ferrara, SVP Analytics/BD; MIT PhD, VP IHI (ESWare)
- William Woodford, CTO; MIT PhD, Director R&D 24M, TR35

Company:

- 60+ employees in MA and Bay Area, CA
- >1000 experiments to date
- 100's of cells on test
- 55,000 ft² facility in Somerville, MA

Investors:

 >\$100M in venture capital to date from investors including Coatue, NGP Partners, Eni Next, Breakthrough Energy Ventures, MIT's The Engine, Prelude Ventures, Capricorn Investment Group, and Macquarie Capital.





The ultimate target: Be more cost effective than coal/gas The equation is simple

ELECTRICITY PRODUCED FROM THERMAL GENERATION HAS A PRICE

Roadmap to hardware commercialization

Piloting

Scale Up

Commercial Expansion

Grid **Transformation**

Market evolution needed to accelerate this technology transition

Barriers	Evolution Needed
Initial Experience	Deploy initial >10MW c
Reliability Framing	Think beyond peak day
Planning Tools	Capture 8,760-hr annua
Resource Valuation	4-hr and 100+ hr storag
Market Designs	The hard part: compens

commercial projects to demonstrate value, bankability.

vs. Ensure reliability over multi-day events, atypical yrs.

al operations. Optimize across atypical years.

ge aren't the same. We should value them differently.

sating reliability without favoring incumbent resources.

Actions we're taking to support this policy evolution

Long Duration Storage Market Study + New Open Source Modeling Toolkit

Funded by California Energy Commission Grant (GFO-19-308)

Energy+Environmental Economics

UC San Diego

White Papers

Demonstrating modeling best-practices, storage value

Long duration storage to replace long-running peakers in New York

(White Paper)

Long duration storage to manage wind farm risk of returns (Form + **Enel Foundation**)

(White Paper)

Best Practice Modeling to **Achieve Low Carbon Grids**

(Forthcoming)

NARUC CPI WEBINAR: LONG DURATION STORAGE-POLICY/REGULATORY RECOMMENDATIONS

Heidi Ratz, World Resources Institute Heidi.Ratz@wri.org October 22, 2020

WRI OVERVIEW

WRI is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity and human well-being.

Locations

U.S. ENERGY TEAM: WHAT WE DO

We work with electricity customers, particularly major companies and municipal customers with large energy use and ambitious clean energy goals, to meet their demand for affordable renewable energy.

We assist utilities grappling with the changing landscape to tap into the strengths they offer to clean energy deployment, such as the low cost of capital, cost-effective renewable energy integration strategies and long-term planning.

We work with community leaders who have set ambitious targets to advance their renewable energy goals and to support cities in the fight against climate change.

We address market and regulatory barriers to the adoption of clean energy to enable the transition to a low carbon electricity grid.

We undertake primary research on renewable energy and leverage the growing body of research to depict the landscape of sustainable energy development for decision-makers and the public.

RECENT ISSUE BRIEF FOR POLICY MAKERS

- Examines the status of storage deployment today and current drivers
- Reviews potential pathways for evolution of technology to meet long duration storage needs
- Offers recommendations on how to advance long-duration technologies to achieve a clean energy future
- Available at: <u>https://www.wri.org/publication/long-</u> <u>duration-energy-storage-deep-</u> <u>decarbonization</u>

HIGH LEVEL ROLE OF POLICY MAKERS AND REGULATORS

- Encourage further development of long-duration storage to widen the range of options available to meet deep decarbonization goals.
- Drive improved **understanding of regional grid needs** and how storage could contribute to deep decarbonization.
- Support and encourage **innovation in storage technology** for future grid applications.
- Develop **new financing and procurement models** that better match the needs of long-duration storage assets.

QUICK REVIEW OF CURRENT POLICY & REGULATORY LEVERS

Federal:

- **Incentives:** tax credits, accelerated depreciation, R&D challenges
- **Demonstration Projects:** Projects out of DOE, ARPA-E, DOD, partnerships with communities and national laboratories

Wholesale Power Markets:

- **FERC Orders**: examples include Order 755 (requires separate compensation structure for fastacting resources bidding into frequency regulation service markets) and Order 841 (requires RTOs to define rules for storage to participate in markets)
- **RTO/ISO Specific Rules and Operational Practices**: examples include PJM's new Effective Load Carrying Capacity (ELCC) working group (establishes a methodology for determining the impact of resources, including storage, on reliability)

State (Legislative and PUC):

- Storage Mandates and Goals: several states have set binding mandates or goals for utilities to procure certain levels of storage
- Incentives: state property incentives, grants, rebates, tax incentive
- **Demonstration Projects:** demonstration projects are funded (state provides funding in exchange for data), authorized (state allows utilities to invest but do not provide funding), and facilitated (state facilitates between utilities and developers)
- **Utility Regulation**: regulations shaping utility asset ownership, rate recovery, avoided cost determination, interconnection, permitting, renewable energy procurements, integrated resource planning

QUICK REVIEW OF RECOMMENDATIONS

🔆 WORLD RESOURCES INSTITUTE

ESTABLISH NEW TARGETS AND PROCUREMENT MODELS FOR LONG-DURATION STORAGE

- State storage goals can target technology characteristics or technology-specific carve-outs
- Targets could also focus on services and not just overall power capacities
- Explore the role of utility all-source bidding to drive storage evolution

ENCOURAGE INNOVATION IN UTILITY RESOURCE PLANNING

- IRP processes are advancing to better quantify the benefits and costs of storage services
- State regulators should support more robust reviews of storage in IRP processes
 - Improved cost data or operational assumptions
 - Expand range of services and benefits considered
 - Transparency and information sharing across utilities

FUND HIGH-VALUE DEMONSTRATION PROJECTS THAT ADVANCE LEARNING AND HELP COMMERCIALIZE NEW STORAGE TECHNOLOGIES

- Demonstration projects provide needed data on performance, cost and value
- Federal demonstrations can:
 - focus on producing this data with regional context
 - Target high-value or high-risk projects venture capitalist may not have appetite for yet
- States can also support utility demonstrations and share data

MAINTAIN RELIABLE FUNDING FOR STORAGE RD&D

- The federal government can support RD&D that utilities and others cannot currently undertake
- Continued RD&D creates a pipeline of technology improvements
- The Department of Defense can leverage experience with storage and benefit from resilience
- Deploying RD&D at different stages of development can encourage technology diversity

CONDUCT SCREENING ASSESSMENTS FOR POTENTIAL SITES

- Long duration technologies such as, compressed air storage, and others are geographically limited resources- federal and state government assessments of potential sites can decrease costs
- Understanding specific land-use issues related to future long-duration storage technologies is important as well

DRIVE SOPHISTICATED MODELING OF STORAGE SERVICES AND PROMOTE REGIONAL STUDIES OF STORAGE NEED

- In addition to improve IRP modeling and state studies:
 - Region-specific modeling can highlight needs and options that differ based on grid characteristics, consumption patterns, and resource mixes
 - Deep Decarbonization studies should robustly model storage contributions and interactions with non-utility sectors

ENABLE FINANCING THAT BETTER MATCHES THE NEEDS OF LONG-DURATION STORAGE ASSETS

- Days or weeks of storage will require capitalintensive infrastructure, with higher financial risk, that is dispatched infrequently
- Financing models used for infrastructure, such as electrical transmission infrastructure, may be more appropriate

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WRI Digest weekly newsletter: https://www.wri.org/sign-wri-digest

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Q&A

Please send us your question to panelists, by name.

NARUC Innovation Webinar series

Hosted one Thursday each month from 3:00 p.m. to 4:00 p.m. ET *Register at: https://www.naruc.org/cpi-1/emerging-issues/innovation-webinars/*

- Where the Wind Blows: Offshore Wind Outlook for State Regulators November 19, 2020 | 3:00 – 4:00 pm Eastern
- Threat Information Sharing Around Cybersecurity (Webinar)

December 10, 2020 | 3:00 - 4:00 pm Eastern

NARUC thanks the U.S. Department of Energy for support.

NARUC CPI Updates

National Council on Electricity Policy - Register at: <u>www.electricitypolicy.org</u>

• Introduction to Wholesale Markets (Webinar)

October 26, 2020 | 3:30 – 4:30 PM (ET)

• Annual Meeting

December 7-9, 2020

CPI Reports

- New Report: <u>Battery Storage Technology Adoption & Electric Utility Structure</u>
- Report Coming Soon: Artificial Intelligence for Natural Gas

DOE Funding Opportunities

- Notice of Opportunity for Technical Assistance to Support Hydropower Decision Making
 - An informational <u>webinar</u> will take place on November 4 at 2PM (ET).
- Notice of Opportunity for Technical Assistance for Connected Communities
 - purpose is to demonstrate how buildings plus DERs serve the grid

Join our listserv to receive updates. NARUC thanks the U.S. Department of Energy for support.

THANK YOU

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HTTP://WWW.NARUC.ORG/CPI