I-WEST

Intermountain West Energy Sustainability & Transitions

The Future of Electricity Production in the I-WEST Region

Virtual workshop held March 24, 2022

WORKSHOP FACILITATORS

Mary Ewers (mewers@lanl.gov)

I-WEST PRINCIPAL INVESTIGATOR

George Guthrie
(Geo@lanl.gov)

I-WEST PROJECT MANAGER

Rachel Atencio
(Rcatencio@lanl.gov)

SUBMITTED TO

U. S. Department of Energy
Office of Fossil Energy and Carbon Management

LA-UR-22-26525

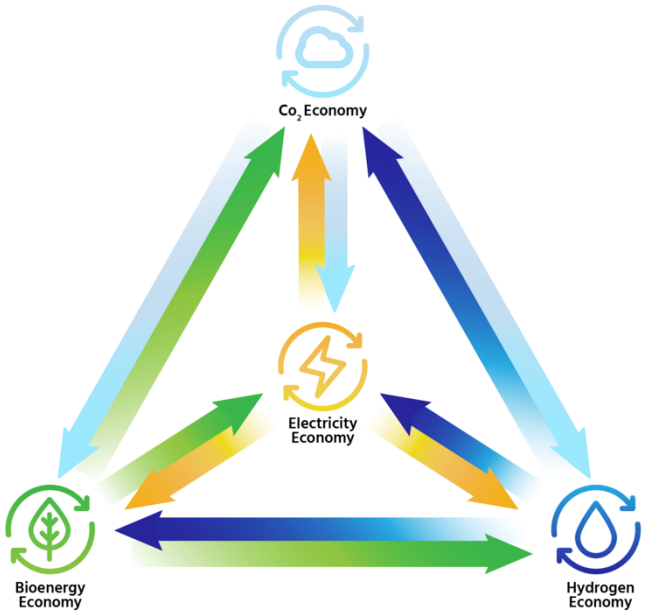
Overview

The Intermountain West Energy Sustainability & Transitions (I-WEST) project is focused on delivering a technology roadmap to transition six states in the U.S. Intermountain West to a carbon neutral energy system. I-WEST encompasses Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming. The project is taking a place-based approach, which prioritizes the unique attributes of the region so that the resulting technology roadmap reflects pathways that are regionally relevant and can be put on an accelerated timeline to deployment.

As part of its Phase-1 assessment, the I-WEST team is holding technology-focused workshops to better understand technology readiness, infrastructure, policy, and societal readiness related to each of the technology pathways under consideration. These include the capture and use of carbon dioxide, the production and use of carbon neutral hydrogen, and the production and use of bioenergy and bioproducts.

The workshops target leaders of current and emerging projects in the region and present opportunities for participants to connect their capabilities with regional stakeholders and technology providers invested in building pathways to carbon neutrality in the region. In order to facilitate vibrant and candid discussions, the workshops are held under the Chatham House Rule, and outcomes are summarized to include input that is not attributed to any one participant.

Results from the technology-focused workshops will inform the final I-WEST report.



The interdependencies between hydrogen, carbon, and bioenergy economies demand a keen understanding of how they interact relative to workforce, common resource and infrastructure needs, and deployment timelines.

Workshop Summary

The transition to carbon-neutral energy over the next 10-15 years will directly impact electricity production and transmission in the I-WEST region. Many options and pathways exist, such as renewables, hydrogen blending, carbon capture use and storage (CCUS), nuclear, biofuels, and technologies that are still to be developed. Carbon-neutral technologies have interdependencies on local resources such as water, land, fuels, and human workforce. Depending on availability of local resources, each state in the I-WEST region will have unique challenges and solutions on the road to low-carbon or carbon-neutral electricity. Understanding the resources, costs, and benefits associated with each technology will be important for developing a roadmap for carbon-neutral electricity.

This workshop included participants from the power production and transmission sectors, industrial consumers, regional and rural co-ops, regional universities, and Department of Energy national laboratories. The primary goal was to discuss pathways to clean power production in the next 10-15 years in the I-WEST region. Guided panel discussions sought to address the following questions:

- What are the technical challenges and barriers to deployment of carbon-neutral electricity?
- What are the impacts of the "electrify everything" trend to the power grid?
- How can renewables be integrated into the grid at the community and regional scales?
- What are the resources, costs, and benefits of each technology pathway?
- How can reliability, costs, and environmental impacts be balanced?

This workshop included a brief overview of the I-WEST region, followed by panel discussions with plenty of time for questions and answers.

Key takeaways from the workshop are summarized below and discussed in detail in Section 1.5.

- Electric power industry is considering multiple paths:
    a. Utility scale batteries integrated with renewables and installed close to load
    b. CO_2 capture and storage
    c. Blending H2 with natural gas (NG) for co-fire
    d. Adoption of nuclear, including small modular reactors
- Stakeholders have noted several potential challenges:
    a. Grid oversubscription—there is a need for increased transmission capacity in the region and for getting product to market on the West Coast (HVDC is one technology that was discussed)
    b. "Balkanized grid" (i.e., complex pricing due to multiple regional transmission orgs)
    c. The cost of adoption is the key driver for stakeholder decisions to adopt or not adopt a technology
    d. Renewables are actively increasing the variability of the system. How do we balance and plan for reserve margins with increased uncertainty in production?

1.0 Details on the Workshop

1.1 Workshop Attendees

STAKEHOLDERS

Name	Company Name	Job Title
Daniel Huben	AECOM	Director, Program Management. Growth Manager - New Fuels
Andrew Gregovich	Anthropocene Geoscience	Founder
Ramon Alatorre	City of Flagstaff Sustainability Section	Climate and Energy Coordinator
Lisa Larocque	City of Las Cruces	Sustainability
Bryce Beck	City of Sedona	Sustainability Coordinator
Maria Eisemann	Colorado Energy Office	Senior Transportation Policy Analyst
Phil Solomon	Deseret Power	Vice President
Ian Andrews	ECS	Consultant
Kelly Francone	Energy Strategies	Senior Consultant
Laura Nelson	FJ Management	Director Sustainability
Donald Whisenhunt	GE Global Research	Chemist
Amy Linsebigler Smentkowski	GE Research	Chief Scientist
Ray Lucero	Janix Energy	COO
Luis Reyes	Kit Carson Electric Cooperative, Inc	CEO
Ben Olbrich	Los Alamos County	Engineering Associate
Jordan Garcia	Los Alamos County DPU	Power System Supervisor
Matt Eales	Lucid Energy Group	VP of EHS&R
Tom Kaiserski	Montana Department of Commerce	Industry Development Program Manager
Dan Lloyd	MT DEQ	Bureau Chief
John Bushnell	Northwestern Energy	Manager - Sustainability
Jon Shaer	Northwestern Energy	Manager of Innovations
Matt Mcmonagle	NovoHydrogen	CEO
Clarissa Bhargava	Office of U.S. Senator Ben Ray Lujan	Legislative Fellow

Alberto Ferrer	Power Renaissance	Senior Executive
Jean-Lucien Fonquergne	PRRC NMT	Technical Engineer
Arlo Walje	RAW-Energy, Inc	CEO
Nick Ralston	Sage Green NRG	Director
Raymond Redcorn	Senator Heinrich	Legislative Fellow
Collin Friedrich	SRP	Engineer
Patricia Ewanski	SRP	Sr. Planning Analyst
Joseph Baan	State of Montana	Fiscal Analyst
Indra Bhattacharya	Tri-State Generation and Transmission Association, Inc.	R&D Program Manager
Ninfa Martine	TYR Group	Chief Commercial Officer
Angela Baquero	TYR Logistics LLC	VP Commercial
Marianne Wilkerson	U.S. Senator Ben Ray Lujan's Office	Fellow
Artie Powell	Utah DPU	Manager
Rikki Hrenko-Browning	Utah Petroleum Association	President
Sam Brucker	Utah State Legislature	Managing Policy Analyst

I-WEST TEAM

Name	Company Name	Job Title
Sourabh Hanmanthrao Patil	Arizona State University	Researcher
Stephanie Arcusa	Arizona State University	Postdoc
Jeff Simpson	Chandler Gilbert Community College / LANL	Professor & Technical Writer
Dale Keairns	Deloitte Consulting	Specialist Master
Liz Friedman	Department of Energy	Energy Analyst Fellow
Andrew Hegewald	Dominion Energy (Richmond, VA)	Gas Business Development Manager
Scott Matthews	KeyLogic	Principal Scientist
Adam Mate	Los Alamos National Laboratory	Scientist
Arthur Barnes	Los Alamos National Laboratory	R&D Engineer
Aspen Peterman	Los Alamos National Laboratory	Data Analyst
Bailian Chen	Los Alamos National Laboratory	Scientist
Bill Carey	Los Alamos National Laboratory	Scientist
Chris Meyers	Los Alamos National Laboratory	Business Development Executive

Grant Stewart	Los Alamos National Laboratory	Project Director - Utility Operations
James Lee	Los Alamos National Laboratory	Research Scientist
Jeff Heikoop	Los Alamos National Laboratory	Group Leader
Jim Gattiker	Los Alamos National Laboratory	Scientist
Jolante Van Wijk	Los Alamos National Laboratory	DGL
Julie De Leon	Los Alamos National Laboratory	Deputy Group Leader
Mark Hinrichs	Los Alamos National Laboratory	Technical Staff Member
Melissa Fox	Los Alamos National Laboratory	Program Director
Rachel Atencio	Los Alamos National Laboratory	Project Management
Rajesh Pawar	Los Alamos National Laboratory	Scientist
Troy Semelsberger	Los Alamos National Laboratory	Scientist
Wanyi Nie	Los Alamos National Laboratory	Scientist
Lee Spangler	Montana State University	Director, Energy Research Institute
David Morgan	National Energy Technology Laboratory	Physical Scientist
Derek Vikara	National Energy Technology Laboratory	NETL Support Contractor
Luciane Cunha	National Energy Technology Laboratory	Supervisory Research/General Engineer
Tim Grant	National Energy Technology Laboratory	Physical Scientist
Jhih-Shyang Shih	Resources for the Future	Fellow
Kathryn Logan	University of Arizona	Postdoc
Janie Chermak	University of New Mexico	Professor and Chair
Renia Ehrenfeucht	University of New Mexico	Professor
Wilfred Padmore Osei	University of New Mexico	Research Assistant
Yuting Yang	University of New Mexico	Assistant Professor
Brooke Tucker	University of Utah, EGI	Programs Manager
Selena Gerace	University of Wyoming's School of Energy Resources	Research Scientist

1.2 Workshop Presenters

Name	Company Name (location)	Job Title
Mike Mcguirk	Colorado School of Mines	Assistant Professor
Mary Ewers	Los Alamos National Laboratory	Scientist
Russell Bent	Los Alamos National Laboratory	Scientist
Stuart Cohen	National Renewable Energy Laboratory	Energy System Analyst

1.3 Workshop Agenda

10:00 **Welcome, Introduction, & Workshop Objectives** — **George Guthrie**

10:10 **I-WEST State Profiles** — **Mary Ewers**
- Electricity Fuel Mix, Resources, Infrastructure, Population

10:30 **Topic 1: Regional Technology Pathways to Carbon-Neutral Electricity:** — **Mike McGuirk**
Emerging Projects & Future Opportunities—Limitations, Technology Readiness
- Renewables
- Hydropower
- Nuclear - SMR
- Blue/Green Hydrogen with Natural Gas for Base Load
- Biofuels
- Fossil + CCUS

11:30 Break — **Break**

11:45 **Topic 2: Balancing the Grid—Supply Must Equal Demand:** — **Russell Bent**
Local & Intraregional Distribution; Exports to Other Regions
- Integration of renewables and microgrids, smart grid
- Predicting Load growth from increased EV use
- Imports and Exports to/from the I-WEST region
- Utility Scale Battery Storage
- RTOs for balancing and transmission efficiency
- Aging Infrastructure, Resiliency, Reliability

12:45	Break	**Break**
1:00	**Topic 3: Nontechnical Considerations for Accelerated Transition:** Equity, Societal Readiness, Economic Concerns, Policy Landscape, Workforce ● Transitioning a workforce ● Rural and Tribal community adoption solutions ● Regulatory uncertainty ● Solutions for funding new technologies	**Stuart Cohen**
1:45	Final Comments, Wrap up and conclusion	**Mary Ewers**

1.4 Workshop Prompts/Questions

The following questions were provided to the workshop attendees to address during the round table discussions. Participants were asked to focus on the relevance to the I-WEST region (MT, UT, MT, NM, AZ, CO). Workshop participants were encouraged to formulate follow-up questions prior to the workshop and/or raise them during the roundtable discussion.

Topic 1: Regional Technology Pathways to Carbon-Neutral Electricity: Emerging Projects & Future Opportunities—Limitations, Technology Readiness

Overarching Questions:

1. What are the key strategies and technologies that are being pursued (or should be pursued) to transition regional electricity production to carbon neutral?
2. What are the key remaining technical challenges and barriers to deployment of these strategies and technologies?
3. What is the likely timeline for deployment and transition to lower carbon electricity?

Detailed Questions to Prompt Additional Dialog:

a. In decisions to move forward on transitioning electricity production, what is the relative importance of intra-regional demand and demand from other regions? How is the potential growth in electric vehicles being factored into regional electricity planning?

b. What is the potential within the region for blending hydrogen with natural gas to reduce CO2 emissions associated with electricity production? And how impactful would this strategy be?

c. What is the highest percent of renewables and clean energy that we can reach in the region in the next 10–15 years? What is the most likely level we can reach?

d. Is hydrogen production during off-peak load times an important strategy in the region for renewable electricity producers with wind/solar?

e. What role can/should/will nuclear play in the region as part of transition to low-carbon electricity? Are small modular reactors a significant part of this strategy? CANDU reactors?

f. What strategies are being considered/implemented to manage the Duck Curve within the region (i.e., the variation in production and demand and potentially resulting imbalances)? What is the

relative importance of intra-regional and inter-regional demand in terms of impacting the management strategy?

g. How can we replace the baseload and ramping capabilities that NG currently provides for the system? One major consideration is the need to repower large units such as at San Juan and Four Corners into Synchronous Condenser duty. The high voltage system needs significant inertia and VAR support…spinning iron.

h. For each low-carb pathway (solar, wind, microgrids, batteries, CCUS, nuclear, biofuels) is it better to have smaller decentralized facilities vs. larger centralized facilities?

i. What are the resources and infrastructure needed to make biofuels a viable route to electricity production?

j. What enabling technologies/industries or raw materials are required for each pathway to be sustainable?

Topic 2: Balancing the Grid—Supply Must Equal Demand: Local & Intra-regional Distribution; Exports to Other Regions

Overarching Questions:

1. How are individual strategies considering the impact of new technologies on the reliability of the grid? Are there key technology gaps that, if filled, could lower concerns about reliability and could enable more options for transitioning electricity production?
2. As new technologies are deployed within the region, what is the relative impact on grid reliability of intra-regional versus inter-regional demand? What investments (technology or infrastructure) will be important for the region to ensure grid reliability while facilitating rapid transition of electricity production?
3. How do concerns on balancing the grid factor intersect with the regional potential for increased local electricity production (e.g., increased home-scale solar; community-scale grids; etc.)—particularly within rural parts of the region?

Detailed Questions to Prompt Additional Dialog:

a. At what price point ($) does it make sense to invest in utility scale batteries? Is it better to invest in renewables and use natural gas to balance (baseload)? Or is it better to invest in renewables and BESS (Battery Storage Systems) to balance?

b. What are the advantages/disadvantages of grid intertied battery systems? Frequency response? Fire safety?

c. Are renewables sufficient for charging BESS?

d. What are the grid considerations for deploying CCUS and hydrogen production?

e. What is impeding the build out of new high voltage transmission lines?

f. What would decentralize grid operations look like if the trend is towards Distributed Energy Resources (DER) (PV or microgrids < 5MW)?

g. How will the "electrify everything" trend impact the temporal dispatch of electricity and grid capacity? Will it eventually impact I-WEST power exports to California?

h. What are the smart-grid technologies needed for balancing residential two-way charge/dispatch (solar or vehicle to grid)?

i. Besides other investments, what transmission/generation expansion is needed? What are the key infrastructure investments needed to deploy low-carbon pathways?

Topic 3: Nontechnical Considerations for Accelerated Transition: Equity, Societal Readiness, Economic Concerns, Policy Landscape, Workforce

Overarching Question:

1. What are key nontechnical considerations for facilitating the rapid transition to low-carbon electricity within the region?

Detailed Questions to Prompt Additional Dialog:

a. With the broad geographic variation in the region—urban centers vs. rural communities; Sovereign Nations; communities with long-standing economies tied to the existing energy infrastructure; etc.—what considerations are important in identifying transition strategies that are equitable?

b. How will the workforce be impacted by transitioning to low-carbon electricity production in the region? What regional impacts should be mitigated relative to stranded workforce? Workforce needed for the new energy technologies. What types of jobs will emerge in the development of a low-carbon electricity economy, and what is their nature (skill sets, duration, compensation, etc.)? Are there opportunities to transition existing electricity workforce to these new types of jobs?

c. How will the combined impacts of an evolving climate AND an evolving electricity system impact regional communities? What considerations are important relative to identifying a transition strategy? Is water availability a factor or a concern throughout the region?

d. How do we fund more innovation and deployment of new technologies for the energy transition within the region?

e. What is the current landscape (policy; economic) relative to incentivizing the transition to new, low-carbon electricity production? What are key gaps that may impede deployment?

f. What is the societal readiness for transitioning electricity generation in the region? What could be done to facilitate a higher level of readiness?

g. What is needed to enable greater access to markets outside of the region (e.g., West Coast)?

1.5 Summary of Workshop Outcomes and Key Takeaways

The participants in this workshop were industry leaders in the electricity sector and included utilities, co-ops, generator owners, transmission authorities, power plant construction experts, and turbine experts. These participants are the industry 'boots on the ground' and are the people who will implement the energy transition.

Technologies of Interest in the Electricity Industry:

Utility scale batteries integrated with renewables that are installed close to load: A representative from the industry told the workshop that California has had success stories using utility scale batteries during peak demand hours. California has around 628 MW of battery power available for discharge. The batteries are recharged with renewable energy during hours of overgeneration and then discharged during peak demand hours.

CO2 Capture and storage is a pathway: There are plans to convert the San Juan Generating Station to a Carbon Capture and Storage Facility

Blending H2 with NG for co-firing: We heard about specific pilot plants, one that blends 30% H2 with 70% natural gas, and another that is blending 10% H2 and 90% natural gas. Any reduction in natural gas burn reduces the CO2 emissions from natural gas. Several engineering companies exist that specialize in retrofitting natural gas power plants for blending hydrogen with natural gas. Additionally, this technology will create a demand for hydrogen in the new hydrogen hubs and hydrogen economies that are being envisioned.

Small Modular Reactors SMR: We heard that it is possible to replace MW for MW at a retired coal plant where transmission and water for cooling is already in place. It's an expensive option but the cost to build is only slightly higher than for a coal plant with 90% Carbon Capture and this also reduces emissions.

Identified Challenges in the Electricity Industry:

Grid Oversubscription: If the I-WEST region adds any new generation to the system, the region will need to increase transmission capacity, storage and reserves, and build new pathways for exporting electricity to the West Coast. Additionally, at the distribution feeder level, capacity needs to increase as the region is already seeing residential customers being denied solar interconnections to the grid because their neighborhood feeder is already oversubscribed.

We heard concerns that **IWEST region is carved into several different balancing authorities** and would probably benefit from the creation of a regional transmission org as a single balancing authority, like CAISO is in California, SPP is in the Midwest, or ERCOT in Texas. SPP has expanded westward into the I-WEST region but does not have full coverage.

Cost of each technology is key; Economics will drive decisions and decarbonization will not occur unless there is an economic reason to do so.

Renewables are actively increasing the variability of the system. The I-WEST needs to find new ways to balance and plan for reserve margins when uncertainty in production increases.

And finally, workshop participants were reminded that all **decisions made for electricity in the I-WEST must fit into the broader regulatory requirements of the WECC region** as a whole.

Topic 1: Regional Technology Pathways to Carbon-Neutral Electricity: Emerging Projects & Future Opportunities—Limitations, Technology Readiness

Small Nuclear Modular Reactors (SMR) was the first technology discussed with several utilities expressing interest. Participants noted aSMR project started in Utah. However, utilities also mentioned that transmission is a big blocker, and the I-WEST region needs to increase transmission capacity. One participant noted that for 6 modules of a 462MW SMR, the cost estimate is $40/mwh. Line subscription is the holdup for the Utah SMR project. Another participant noted that we need natural gas for flexible generation and asked if SMR is capable of load following? Regarding nuclear practicality: a participant noted that the industry cost $/kw must be considered. SMR can ramp fast and can run baseload. It was also noted that it is possible to have 50 small modules at 74MW per module and the generation comes from steam turbines, not gas.

Transmission Challenges: Wind is currently fully subscribed on many transmission lines. It is possible to deploy utility scale batteries that lasts 4 hours but it is still a struggle at night to find resources. **Transmission hasn't caught up with production.** In short, a participant remarked the cost is being spread over less Mwh, and if more access to transmission is needed, to get there it will cost a fortune. **The west needs a single RTO** - to assign different prices for different nodes as energy just flows where it flows. The state of New Mexico has proposed the Zia 500 Kv line that will "tie the cash registers together" between I-WEST and California market. Finally, it was noted that the region must maintain reliability standards.

H2 blending in NG is a very viable way to go. Engineering firms exist that specialize in retro fitting natural gas plants to burn a blend of H2/NG to reduce CO2. They feel H2/NG is ready to implement as a solution today and can fast ramp. Green hydrogen uses electrolysis technology powered by renewable energy such as wind and solar. Blue hydrogen is extracted out of CH4. However, there is no real good storage solution for hydrogen. One utility noted a pilot project in a small community that is blending 5% H2 into select natural gas distribution lines with success. It is a 4-phase project that monitors for Nox flashback and there are no red flags yet. The project is planning to increase to 10% H2 going to a public community. Another utility is planning to blend 30% H2 with natural gas for co-firing generation. This technology reduces Nox and allows plants to be retrofitted for fusion combustion. Both utilities agreed that this technology is a viable way to decarbonize. Another participant mentioned that hydrogen systems have been in existence in the Gulf Coast for some time, however the pipeline size diameter is smaller (14-16 inch) than normal natural gas pipelines, but for electricity generation **larger diameter pipelines for H2 are required.**

Carbon Capture technologies have challenges: water and CO2 exhaust streams and create acidic effluent that will destroy pipelines when integrating CCUS. H2O injection into gas turbines lowers flame temperature and increases flow efficiently and lowers Nox emissions. Some participants felt that CCS on coal plants is not a viable pathway. SJCC is converting to a carbon safe project for sequestration.

Topic 2: Balancing the Grid—Supply Must Equal Demand: Local & Intra-regional Distribution; Exports to Other Regions

Batteries: what are the barriers to adapting the technologies? **Grid oversubscription**. WECC is focused on reliability of the Grid. The challenges are in assuring sufficient generation capacity and reliability services (frequency response) and resource flexibility, capacity. There is a need for Capacity-Energy Reliability through weather events: heat waves, heat domes, cold/wind/tornadoes. There is a huge role in new technology to mitigate intermittent power. The region needs to integrate smart grid technology

as fast as possible. The August 2020 heat wave demonstrated resource short falls and transmission constraints in the west. Generation needs to be brought on to the grid faster. California has **success stories with batteries using them at the "peak demand hour" of the year. But given variability, nondispatch ability, and electrification, I-WEST needs to evolve away from "peak demand analysis" and evaluate the shoulder seasons and middle of the night problems.**

Reliability involves planning. Reserve margins are getting tighter. The region needs to identify other reliability metricsOne participant believes the I-WEST will not really have the duck curve as California does now. With more electrification of transportation, the region will need more energy. These are opposite forces acting together. How does the region plan reserve margins based on energy resources and not use the "capacity factor"? The capacity factor for wind and solar is not the right metric to focus on. A 5% capacity factor is not a controllable capacity factor for wind and solar. A key question is **how does the I-WEST region include variable uncertainties when calculating reserve margins?**

It was noted that it is difficult to plan for every hazard event, if natural gas is removed, then the region is now relying on variable generation. This reduces flexibility and reliability. **Renewables are ACTIVELY increasing the variability of the system.**

In California, battery systems were installed due to the August 2020 heat wave event. A WECC study on battery systems advises installing batteries closer to the load systems. Transmission in the west has evolved and takes advantage of resources across the region. Transmission expansion: it takes longer to build transmission than to build generation. The challenges for transmission expansion are siting, land barriers, permitting, cost allocation, FERC order 1000 planning process, inter-regional processes, and population nimby. Utilities anticipate where the load increases will occur, and they actively purchase land for assets. Interconnection is the big question, there are lots of proposals but only a few will get approved.

Pumped hydro is like a very large battery and will give energy storage a buffer. The I-WEST region currently has overgeneration with renewables and curtails some wind during solar peak hours. The region needs large energy storage and long duration storage, such as 8-10 hours of "compressed advanced air". But hurdles remain for new transmission, and someone needs to pay. A $200 million project impacts cost and must be passed to customers. Also, it was noted that China has a monopoly on transformers which also makes new transmission hard. Geothermal is also an option, but at small scale. There is a 10MW power project energy from thermal in the south.

Energy storage and balance during extreme events: how do we balance the system without fossil fuels? On 1-1-2018 there was 150 BTU natural gas withdrawal from storage. Back of envelope calculation: the region would need 3.26 billion powerwall batteries to cover that cold weather event. Batteries alone is not a viable solution. **The energy density in fossil makes it a very powerful tool for mitigating extreme events.**

The region can't make a rapid energy transition without a similar rapid transition in the permitting process. Maybe look at how foreign countries do this and copy.

Topic 3: Nontechnical Considerations for Accelerated Transition: Equity, Societal Readiness, Economic Concerns, Policy Landscape, Workforce

Rooftop solar, microgrids, DER, is that a viable solution? A small battery system, 100kw for 4 hours, to address load at a unique local location works. There is value in microgrids also as a backup for Hospitals and other emergency systems to form their own microgrids. There are suggestions to do a quick study

to see which option is better: transmission upgrade vs batteries. Batteries are a high cost when serving an isolated load. If you design a battery system for a 4-hour outage, the cost might be comparable to current costs. There is value in conventional upgrades to the transmission system. There is geographical diversity across a wide area. Load is the independent variable; it is what it is and will only increase.

Another option is in how load is controlled. Demand response with price points has had success in Hawaii. There are also success stories using customer incentives to control load.

IF the EV fleet increases by 20%, it triples the load. A rate structure is needed to incentivize EV charging during low demand hours.

How about the ability to control water heaters of large customers? There is a large vehicle manufacturing plant that worked with their utility to have firm/unfirm gas. Adjusting the load is easier than trying to aggregate the load. This could also be applied to aluminum smelters.

Everyone is sensitive to cost. Is society willing to pay the cost. Is the utility commission allowing the region to do this? Will customers say yes?