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Energy Storage as a Transmission Asset

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Jeremy Twitchell

Jeff Taft

North Carolina Utilities Commission Workshop

U.S. DEPARTMENT OF ENERGY BATTELLE

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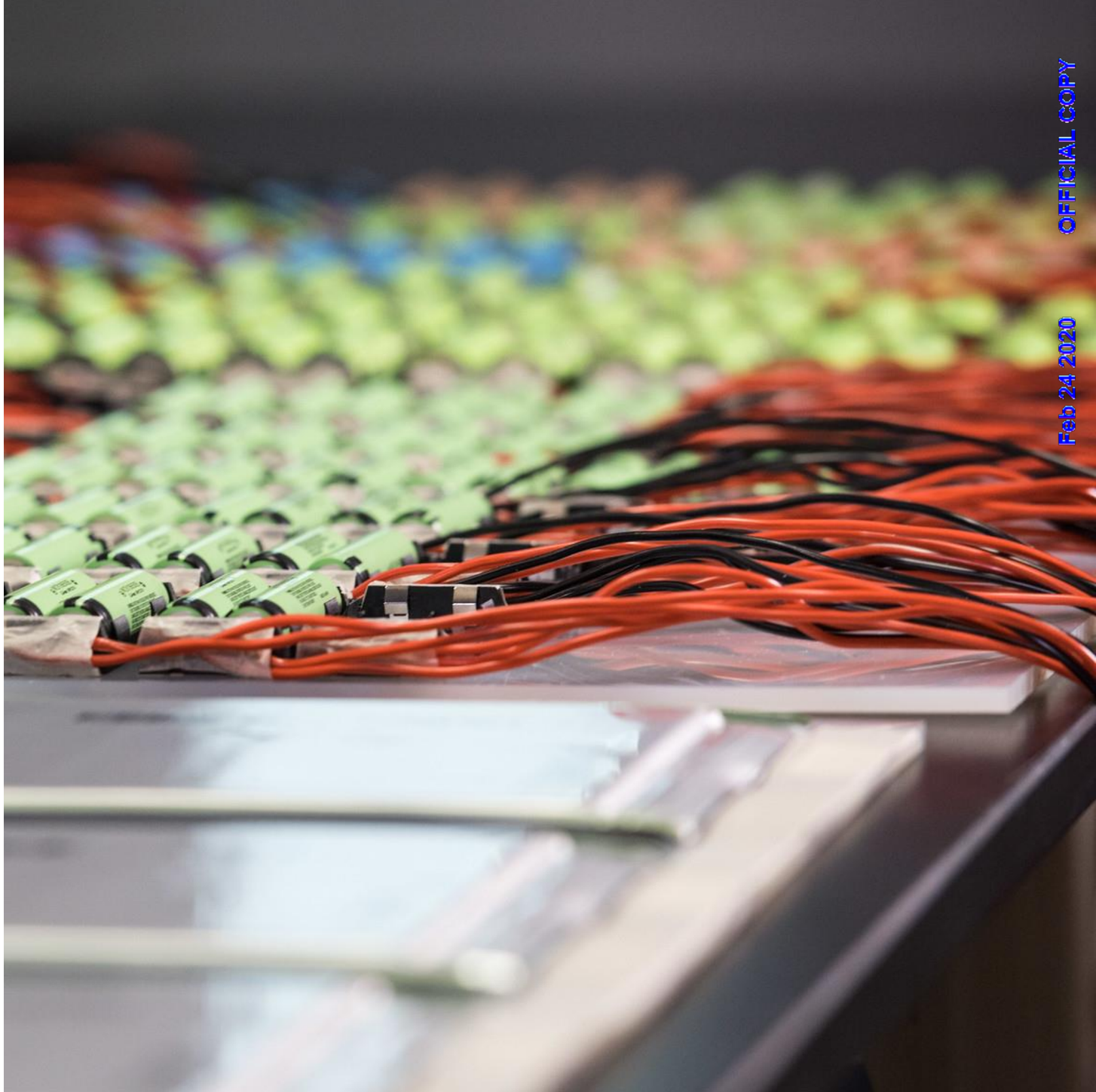

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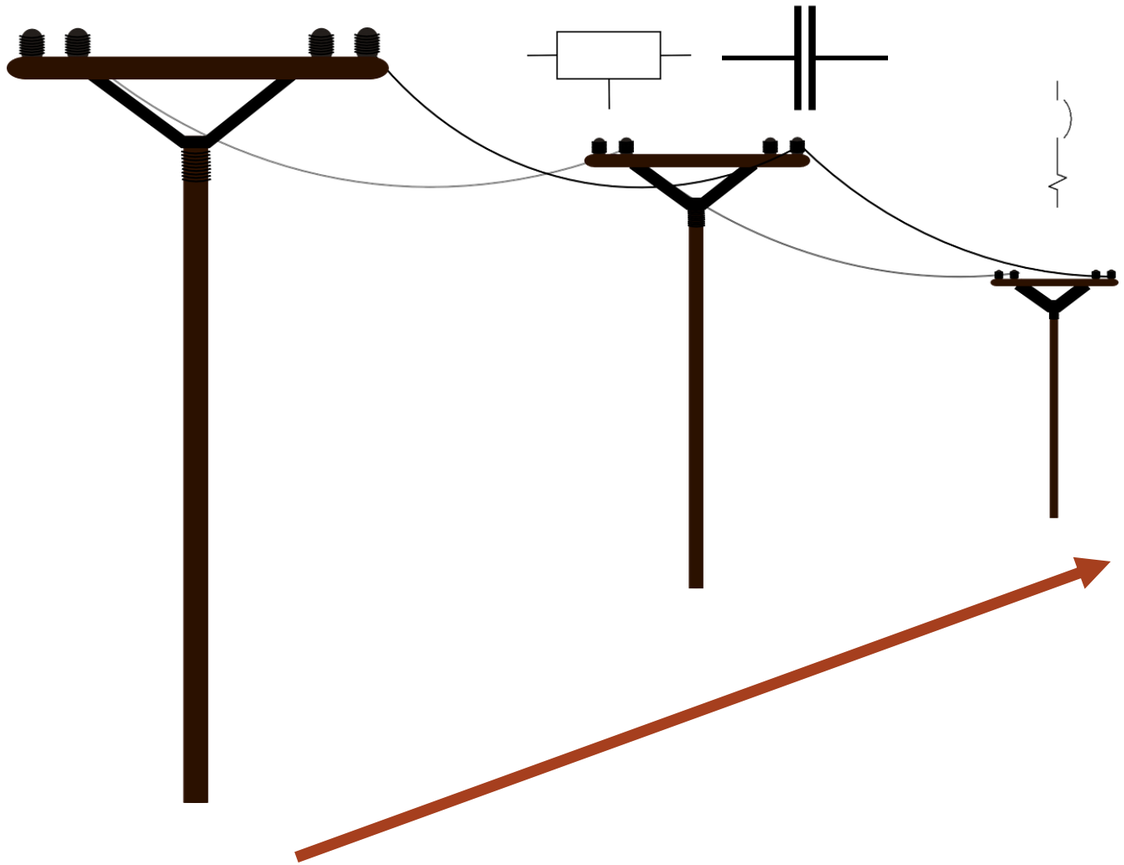
Agenda

- Backfeeding from Distributed Resources
- Storage as a Transmission Asset: The How and Why
- FERC's 2017 Policy Statement and Related Activity
- Current Work: Identifying the Barriers to Storage in Transmission Planning & Operations

Backfeeding Basics

Basic Principle: Distribution feeders were designed for one-way flows



Design implications:

- As we move away from the energization source (substation), voltage decreases
  - **Solution:** Voltage regulators, switched capacitors
- Interruptions (faults) at a single point on the circuit can disrupt the entire circuit
  - **Solution:** Automatic circuit reclosers
- Wire diameters tend to decrease as we move further away from the substation
  - **Implication:** Smaller wires near the end of the feeder have lower thermal ratings

Key Point: Traditional grid architecture and protection schemes are based on one-way power flows

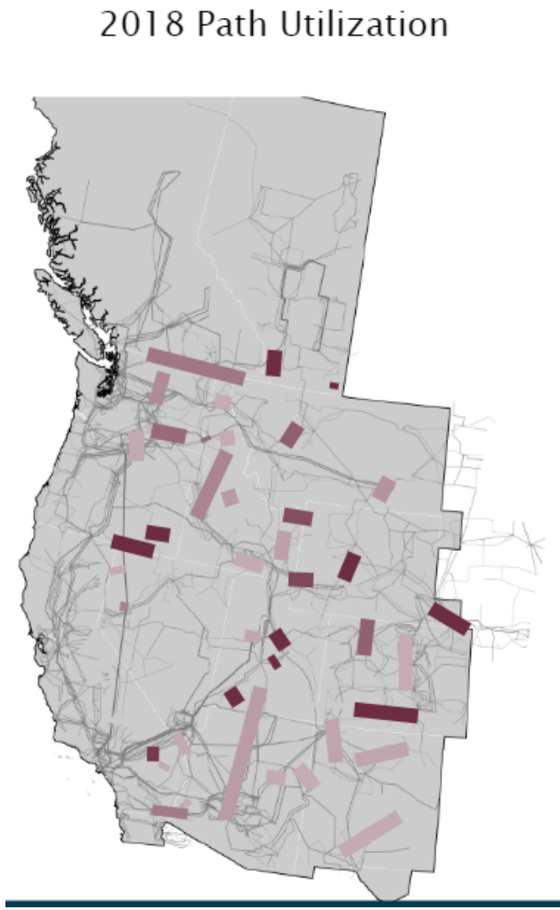
DER Implications on the Distribution System

- **Since grid architecture and protection schemes are designed based on one-way power flow, injecting power at multiple points can interfere with those schemes**
  - Voltage regulators can misinterpret flows and ratchet to the wrong end of their range
  - Automatic circuit reclosers may attempt to isolate a line with a fault, but DERs may keep that section energized, which poses a safety hazard to working crews
- **The point at which backfeeding becomes a problem is highly situational and depends on multiple factors**
  - Wire diameter/thermal rating – Wires near the end of the distribution feeder are likely to have lower thermal ratings, and therefore be less able to accommodate power injection
  - Protection scheme: The type of circuit breakers, the utility's visibility into feeder operations will affect how quickly issues can be identified and resolved
  - Type of interconnection: Legacy interconnection requirements were binary in nature – DERs are either on or off, and do not provide voltage regulation and other services; more recent standards require DERs to provide those services
- **This is why we do interconnection studies – no two feeders are the same**
- **A general threshold at which DERs may begin to cause backfeeding issues is 15% of feeder capacity**

Storage as Transmission – The How

- **Key principle: Even on fully contracted, heavily utilized transmission lines, there is unused capacity *most of the time*.**

- These numbers mean that regionwide, for 93.8 percent of the time in 2018, less than 75 percent of the average transmission line's capacity was being used.
- Conversely, the average line exceeded 90 percent of its rated capacity just 1.3 percent of the time.

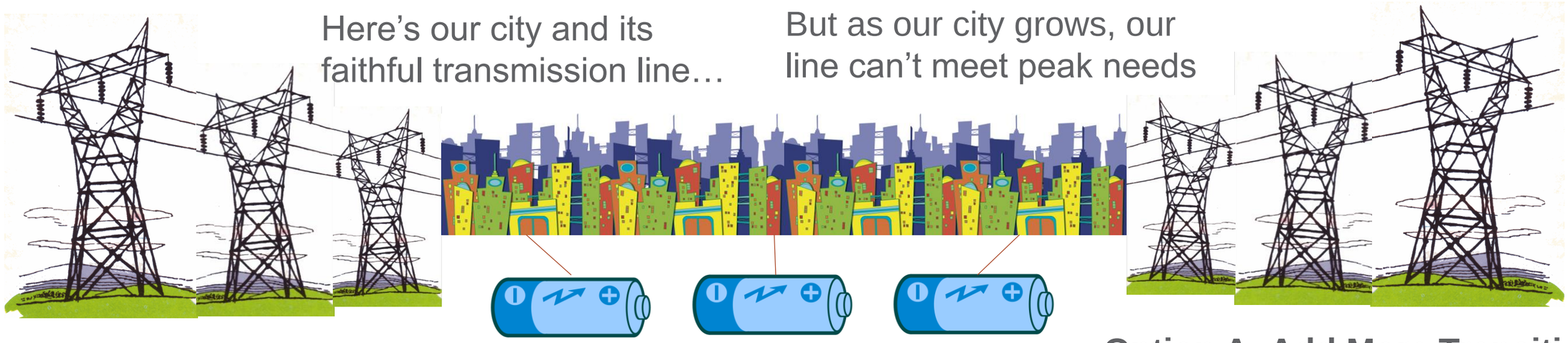


2018 Path Utilization Statistics

Path	U75	U90
Path 1	19.5%	4.1%
Path 3	5.5%	0.7%
Path 4	3.4%	0.3%
Path 5	0.3%	0.0%
Path 6	0.0%	0.0%
Path 8	8.0%	1.2%
Path 14	4.1%	1.6%
Path 16	0.1%	0.1%
Path 17	1.2%	0.1%
Path 18	9.8%	0.0%
Path 19	20.7%	4.0%
Total	**6.2%**	**1.3%**

WECC, 2019 State of the Interconnection, https://www.wecc.org/epubs/StateOfTheInterconnection.

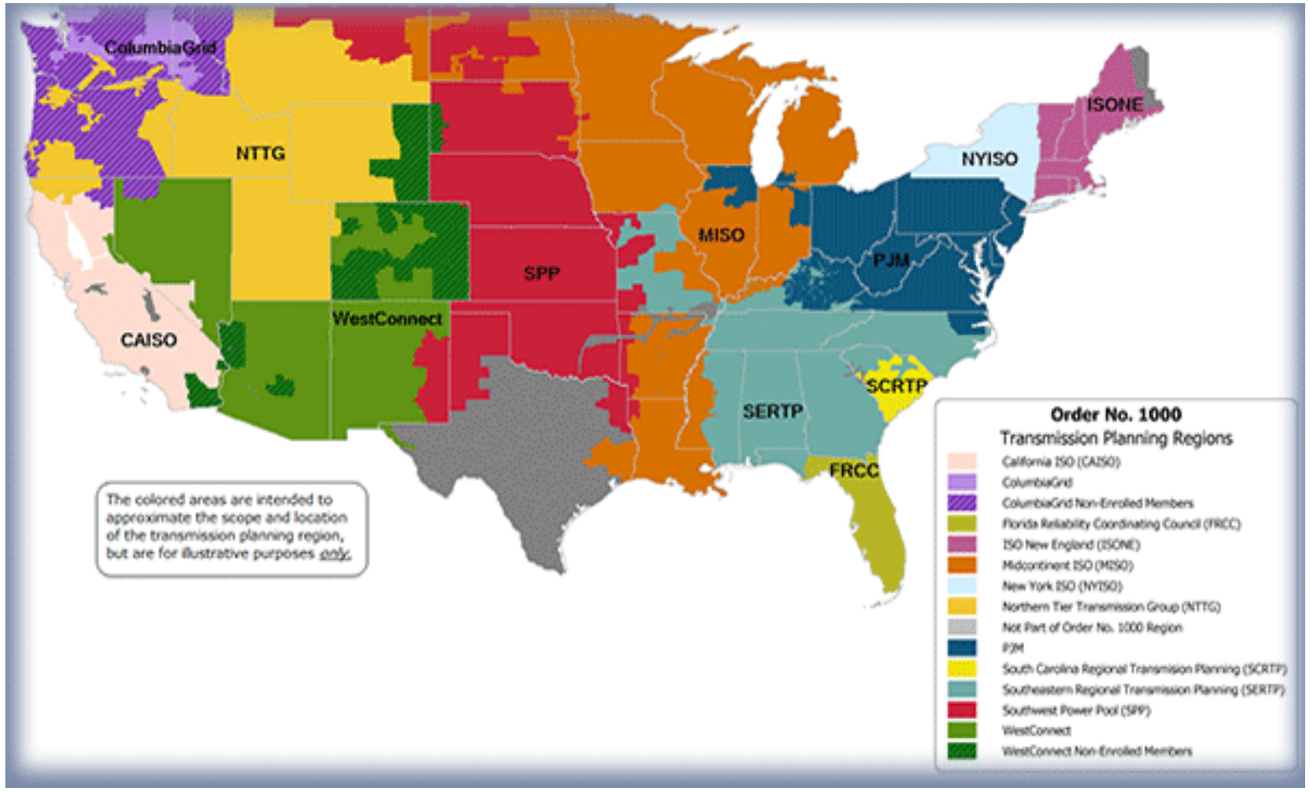
Storage as Transmission – The How (with clipart!)



- By adding storage behind the constraint, we can charge it using the line's excess capacity during off-peak hours and use it to meet load during peak hours
- While congestion relief/infrastructure deferral is likely the highest-value transmission application for storage, storage can also provide additional services (voltage support, relieving thermal overloading)

Storage as Transmission – The Why

- **Energy Policy Act of 2005**
  - Defines energy storage as an “advanced transmission technology,” which “increases the capacity, efficiency, or reliability of an existing or new transmission facility”
- **FERC Order 890 (2007)**
  - Transmission owners must conduct transparent transmission planning processes
  - Demand response a viable transmission alternative
- **FERC Order 1000 (2011)**
  - Requires coordinated, regional transmission planning; establishes cost allocation
  - Non-transmission alternatives must be considered (tech neutral)



FERC

FERC Policy Statement (2017)

- **Prompted by two notable proceedings involving pumped storage hydro (PSH) facilities**
  - Nevada Hydro (2008): FERC **rejects** developer's petition to build a PSH project and require CAISO to assume operational control and operate it as a transmission asset; bid in market at $0
  - Western Grid (2010): FERC **approves** developer's petition to build a PSH project that will be operated as a transmission asset at CAISO's direction, no market bids
- **Policy Statement: Storage can be a dual-use (market and transmission) asset, subject to three clarifying principles:**
  - Avoid double recovery of costs
  - Minimize adverse impacts on markets
  - ISO/RTO independence must not be compromised
- **A policy statement is a nonbinding document; no action required**
  - The California Independent System Operator (CAISO) and Midcontinent Independent System Operator (MISO) are the only entities to initiate a direct response to the statement

CAISO Proceeding

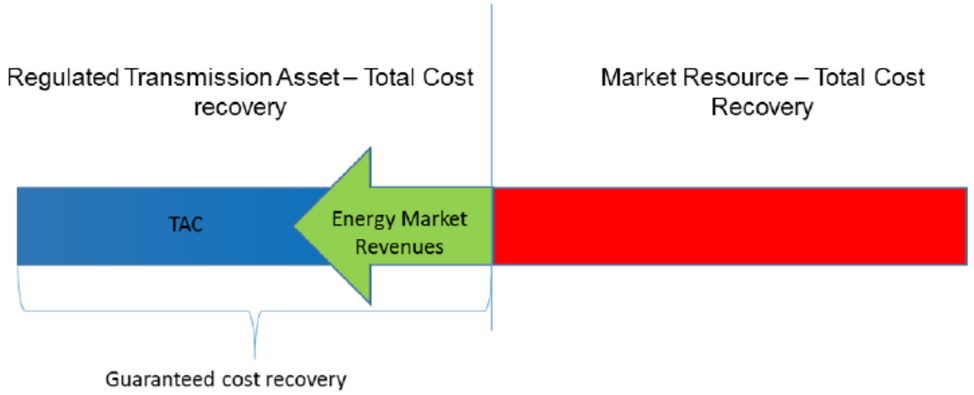
- **CAISO's key principles:**
  - Storage asset must be selected as part of the transmission planning process (TPP)
  - Market participation contingent upon transmission need the asset is serving
    - Unpredictable reliability need: prohibited
    - All other needs: Determined on case-by-case basis during TPP
  - Asset control varies
    - Transmission: CAISO control
    - Market: Owner/operator control
  - CAISO's principles for transmission procurement and cost allocation will apply
    - Who is responsible for procuring an asset and how its costs are recovered depend on whether the asset connects at/above or below 200 kV

CAISO Proceeding

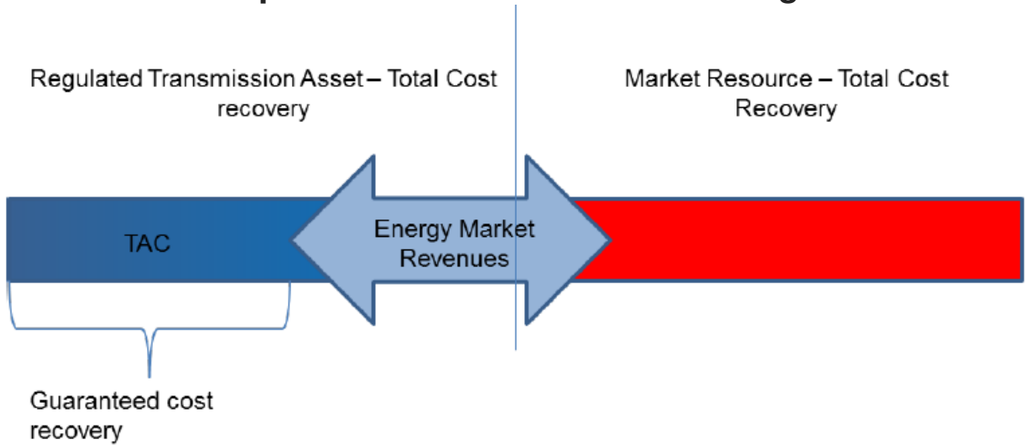
The CAISO proceeding dealt with several complex issues:

- **Cost recovery**

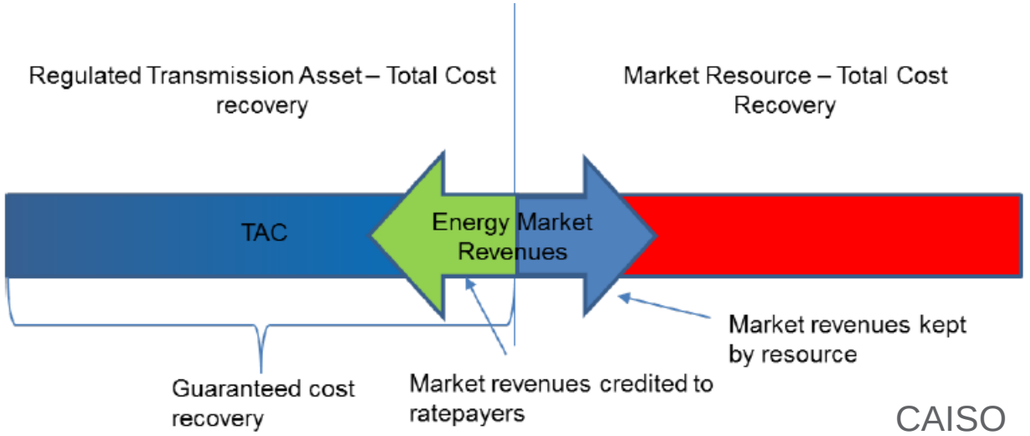
Option 1: Full Market Crediting



Option 2: Partial Market Crediting



Option 3: Full Market Sharing



The challenge: How do we create the opportunity for storage to provide lower-cost transmission services, and establish appropriate signals for asset owners to pursue that opportunity?

CAISO Proceeding

Additional challenges:

- How does storage fit into the TPP?
  - Many stakeholders wanted more clarity on this point; CAISO said that discussion belongs in TPP
- Contract terms
  - Transmission (regulated) and market (competitive) functions are fundamentally different paradigms
  - No precedent for a resource that operates in both; new contract terms needed
- The regulatory weeds
  - Notification: How to determine when the asset can be released to the market
  - Recall: How will released assets be recalled for transmission if necessary? Will damages apply?
  - Bidding rules: How can storage resources be limited from distorting the market?

Many of these issues affect all types of non-generating resources; CAISO suspended the proceeding in January 2019 pending the resolution of the Energy Storage and Distributed Resources – Phase 4 proceeding (expected resolution in Q3 2020).

MISO Proceeding

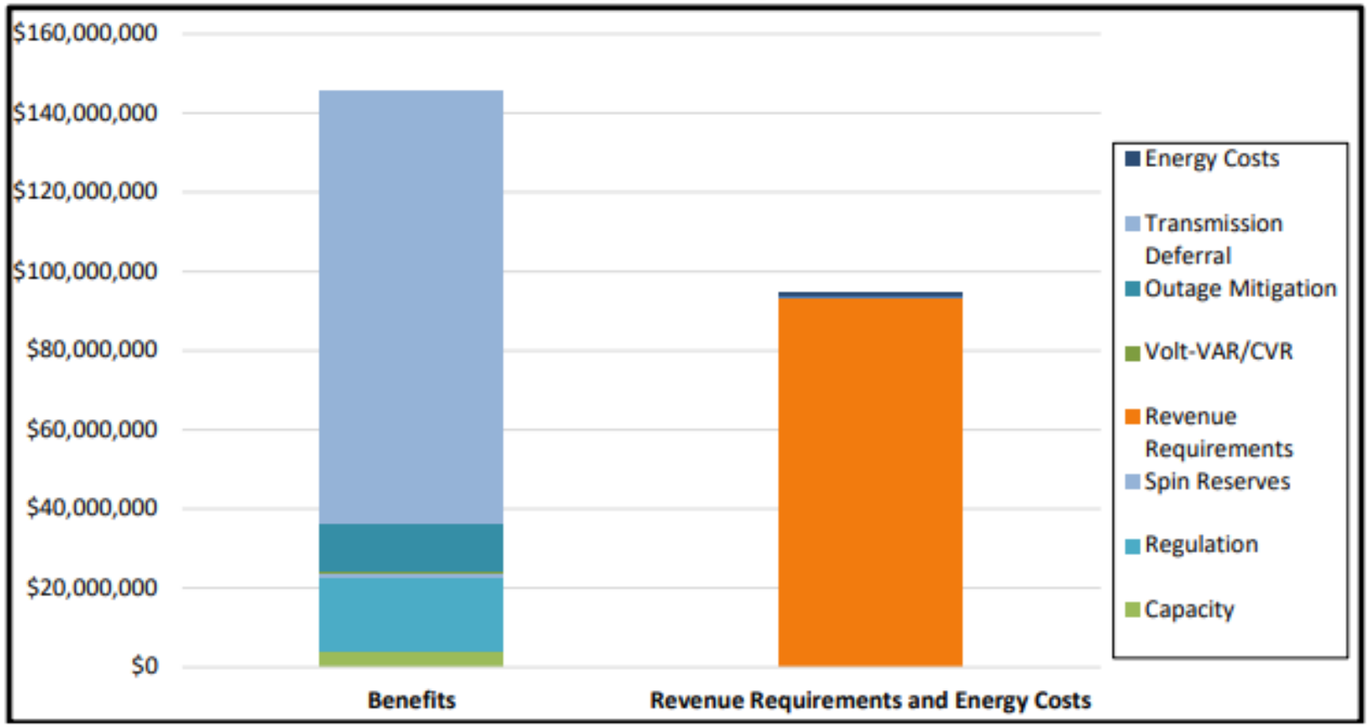
MISO initiated a proceeding, Energy Storage as a Transmission Reliability Asset, in Q2 2018. FERC's policy statement was identified as one of the driving factors.

- Where CAISO focused on the details of enabling dual-use storage and set aside the question of transmission planning, MISO focused on transmission planning and set aside the question of dual-use storage.
  - SATOA – Storage as a Transmission Asset Only; dual-use storage should be a market resource
- From draft tariff language presented in October 2019:
  - To be included in the MISO Transmission Expansion Plan, a SATOA device must demonstrate "a need to resolve the Transmission Issue(s) through the storage facility's function as a SATOA *instead of* as a resource that participates in the Transmission Provider's markets." (Emphasis added)
  - "SATOA may only participate in the Transmission Provider's markets to the extent necessary to receive Energy from the Transmission System and to inject Energy into the Transmission System to provide the services for which the SATOA was included in the MTEP. *SATOA may not otherwise participate in the Energy and Operating Reserve Markets and/or the Planning Resource Auction*." (Emphasis added)

Storage as Transmission: A familiar challenge…

Storage as a dual-use asset essentially faces the same challenge as storage as a single-use asset: accounting for the full range of values

Nantucket Island Energy Storage System Assessment



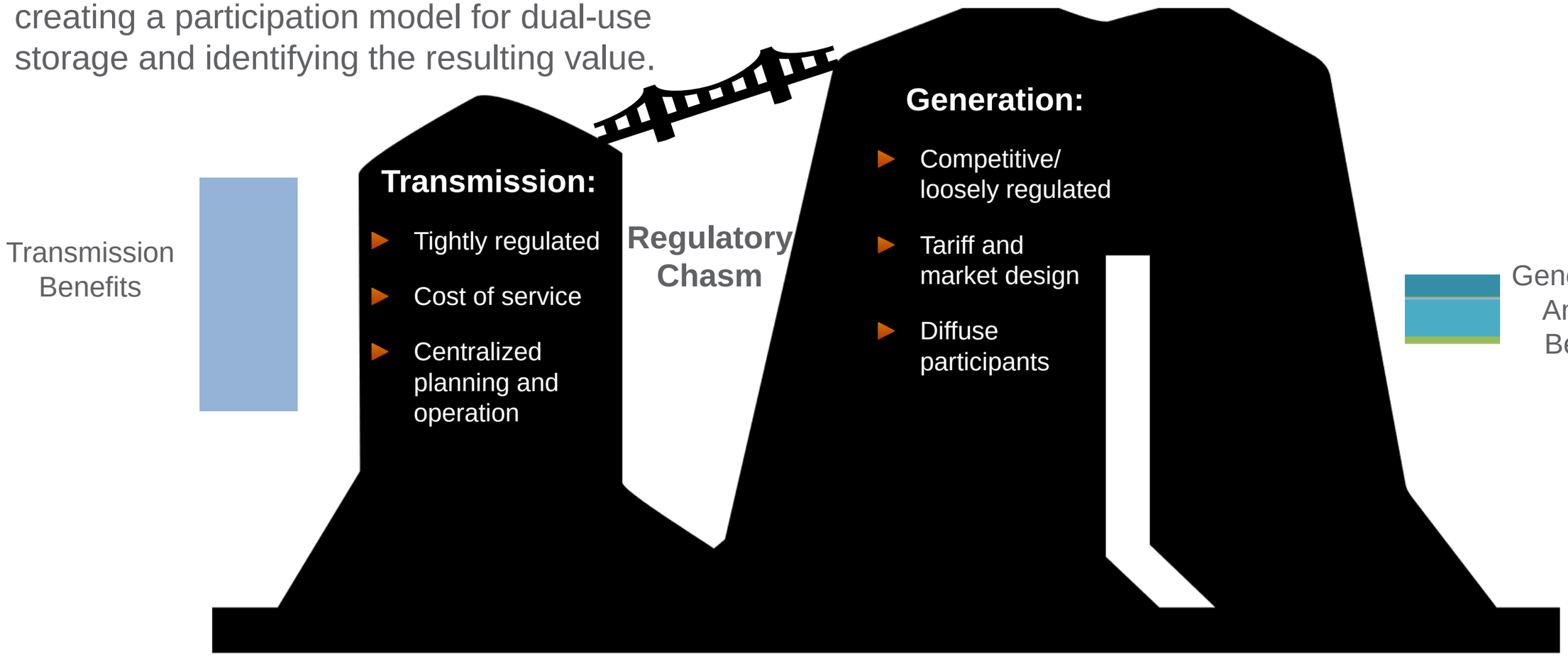
Balducci et al, 2019. Nantucket Island Energy Storage System Assessment. PNNL-28941, Pacific Northwest National Laboratory, Richland, WA.

Takeaways:

- Energy storage valuation requires tools that can optimize across multiple services, accounting for performance and opportunity costs
- Transmission deferral is a potentially high value application for energy storage
- Regional planning and cost allocation practices make monetization difficult
  - National Grid able to monetize benefit in this case because of ISO-NE rules on local transmission projects

… with a new wrinkle (and more clipart!)

Our project aims to bridge that chasm by creating a participation model for dual-use storage and identifying the resulting value.



Our Project

About the HydroWIRES initiative:

- Goal: To understand, enable and improve hydropower and PSH's contributions to reliability, resilience, and integration in a rapidly evolving electricity system.

About our project:

- Two-year, joint project between PNNL and Argonne National Laboratory
- Three deliverables:
  - Year one: Identify barriers to PSH in transmission system planning and operations; create a participation model for dual-use storage (PNNL)
  - Year one: Transmission/energy storage capacity equivalence model (ANL)
  - Year two: Techno-economic analysis of the full value of energy storage as a dual-use asset
- Why approach through the lens of PSH:
  - Large-scale asset capable of providing services at transmission voltages
  - Capital requirements, development time more akin to transmission than generation

Calls for Input

Stakeholder involvement is a key component of the HydroWIRES Initiative. We're looking for people who have been involved in these proceedings, or who have experience in transmission system planning and operations in general, and who are willing to advise us in this process. If that's you, please reach out.

Additionally, DOE has recently launched a new initiative called the Energy Storage Grand Challenge.

- Technology Development
- Technology Transfer
- Policy and Valuation
- Manufacturing and Supply Chain
- Workforce Development

Regional workshops are scheduled for March 6 in Seattle, March 10 in Austin, March 16-17 in Chicago, and March 26 in D.C. A request for comments will also be issued at the end of March.

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Thank you

jeremy.twitchell@pnnl.gov
971-940-7104