Pacific Northwest
NATIONAL LABORATORY

Energy Storage as a Transmission and Dual-Use Asset

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Agenda

- Storage as a Transmission Asset
  - Foundational Principles
  - Case Studies
- Storage as a Dual-Use Asset
  - Foundational Principles
  - FERC Policy Statement
  - Regional Proceedings
- Enabling Principles for Dual-Use Energy Storage
  - Barriers and Best Practices for Including Energy Storage in Transmission Planning
  - Barriers and Best Practices for Enabling Market Participation by Storage as Transmission Assets

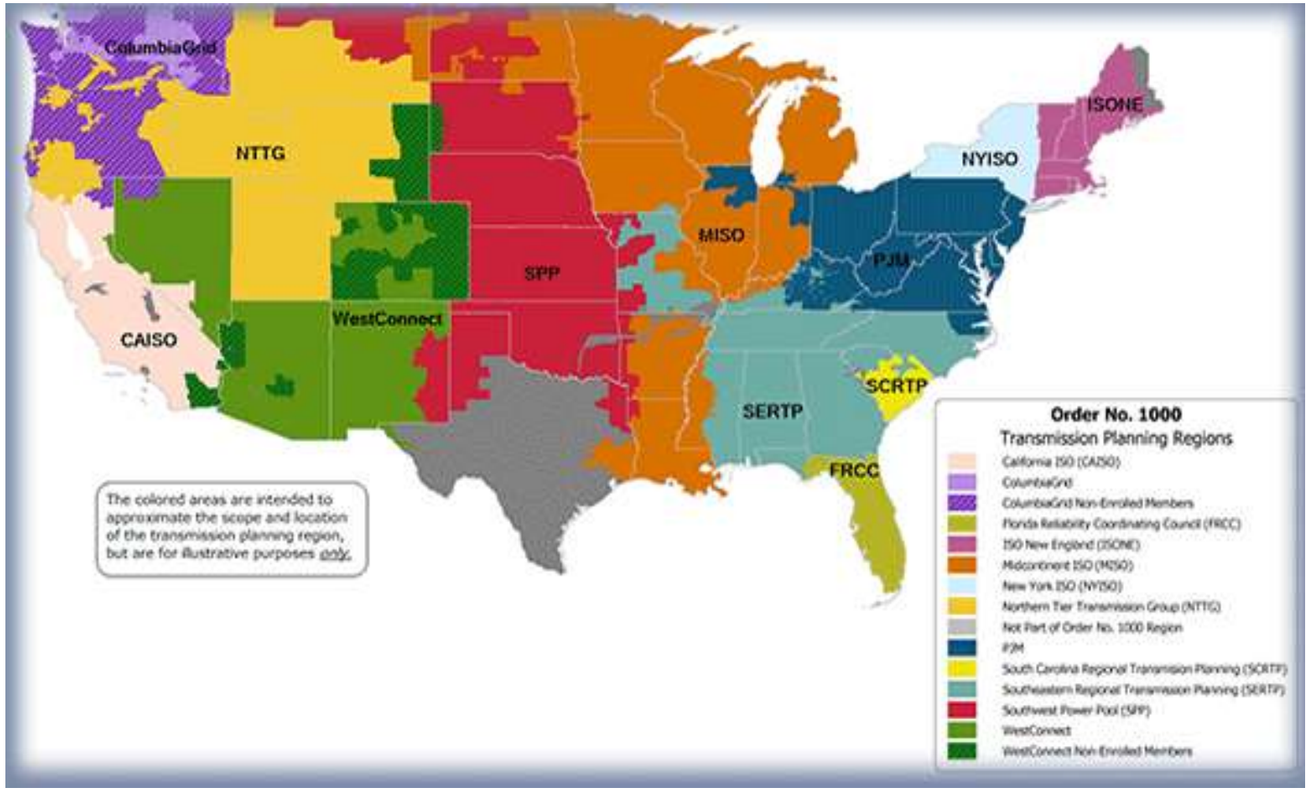
Storage as a Transmission Asset

Key Principle: Thermal Limits

- **Because the metals used in transmission lines are not perfect conductors, they heat up as electrical current moves through them**
  - This is what causes line losses
  - As lines heat up, they expand and begin to sag
  - Because of this phenomenon, the operational limits of transmission lines are set as a function of heat (not necessarily electric load)
- **Energy storage is a potential alternative for alleviating thermal overloading on transmission lines**
  - By siting storage or generation resources within load centers, less energy needs to be delivered over the transmission system
  - Storage can also be used to protect and support transmission infrastructure by maintaining voltage, managing power flows, and absorbing excess power
  - Where feasible, this approach can extend the life of existing assets and defer or displace the need for new transmission infrastructure
  - Storage may be deployed as transmission or in place of transmission

Storage as Transmission – Policy Background

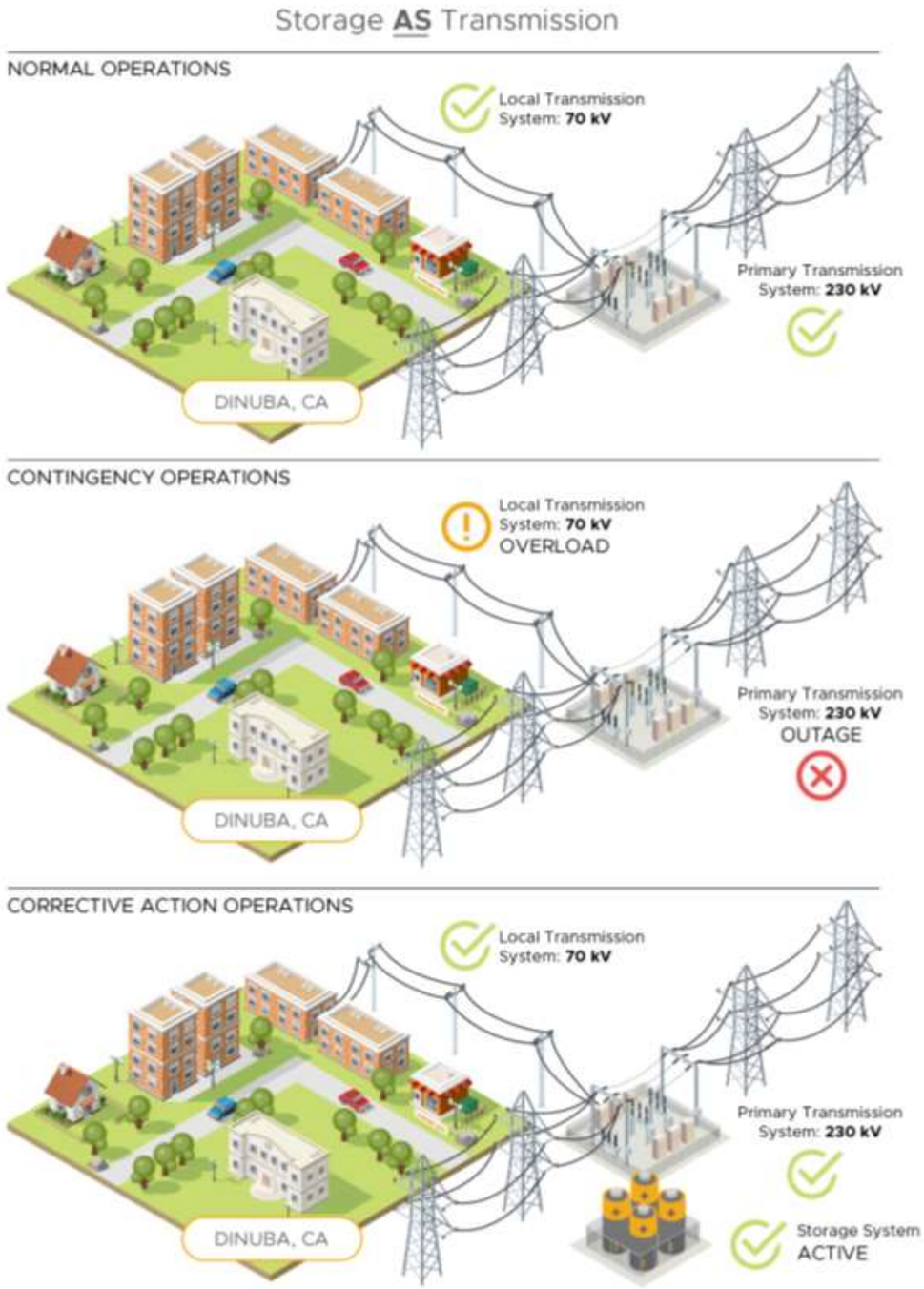
- **Energy Policy Act of 2005**
  - Defines energy storage as an “advanced transmission technology,” which “increases the capacity, efficiency, or reliability of an existing or new transmission facility”
- **FERC Order 890 (2007)**
  - Transmission owners must conduct transparent transmission planning 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

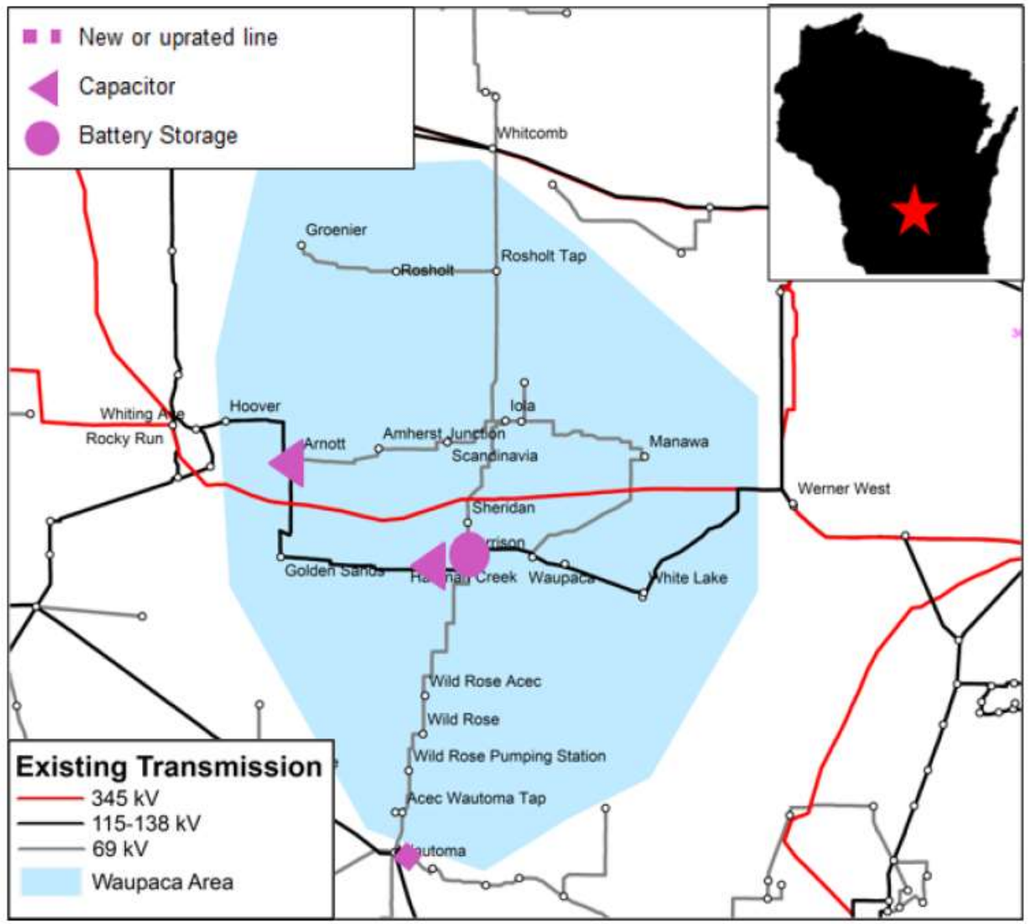
Storage as Transmission: CAISO

- **The California Independent System Operator (CAISO) was the first to identify storage in a regional transmission plan, identifying two projects (one as transmission, one in place of transmission) in its 2018 plan.**
- **Storage as Transmission: Dinuba, CA**
  - 2010 Plan: A potential contingency scenario that would overload the local transmission system would require $16M to reconductor (install new lines) for 10 miles
  - 2018 Plan: Overloads could be managed by an energy storage system at an estimated cost of $14M
  - Utility Pacific Gas & Electric solicited bids for a 7 MW / 28 MWh storage system in February 2019; no public announcement yet
- **As a transmission asset, the storage system's costs will be recovered through CAISO's FERC-approved transmission system rates, and it will not participate in energy markets**



Storage as Transmission: MISO

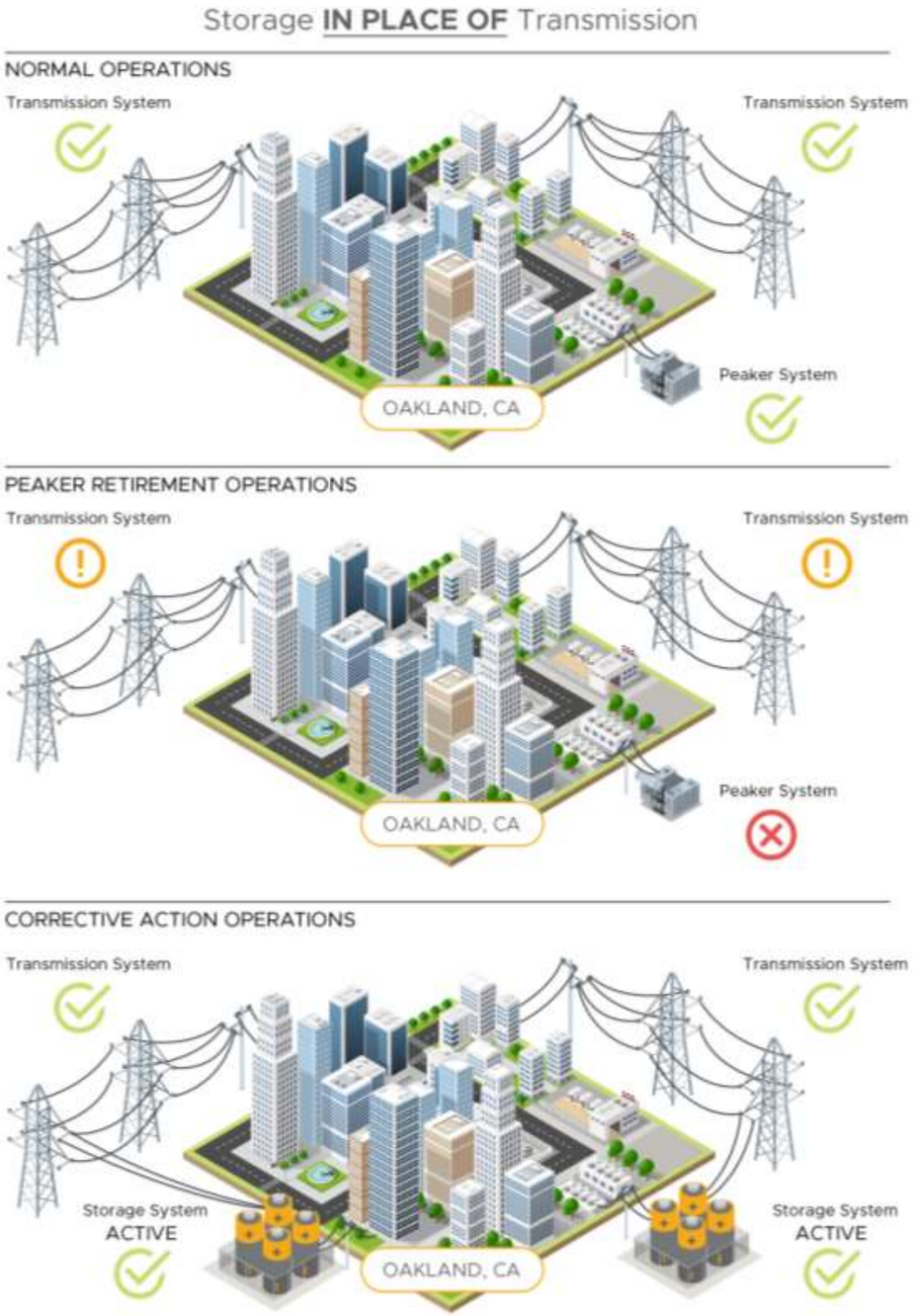
- **The 2019 MISO Transmission Expansion Plan (MTEP) was the second regional transmission plan to select energy storage as a transmission asset**
- **Storage as Transmission: Waupaca, WI**
  - Under certain N-1 contingency scenarios, the Waupaca area would be cut off
  - At $12.2 million over 40 years, a 2.5 MW/5 MWh energy storage system, coupled with line sectionalization, was selected over a $13.1 million project to install an additional circuit
  - Expected in-service date: December 2021
- **As a transmission asset, the storage system's costs will be recovered through MISO's FERC-approved transmission system rates, and it will not participate in energy markets**



MTEP 2019

Storage in Place of Transmission: Oakland Clean Energy Initiative

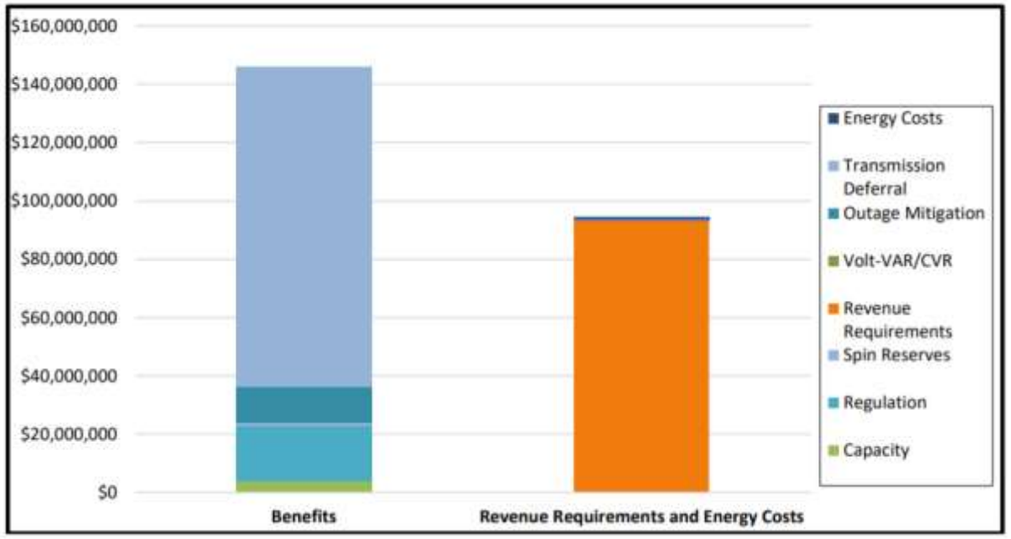
- **The Jack London Power Plant is a 165 MW, jet fuel-powered combustion turbine**
  - Identified for retirement in 2017, but local transmission system would exceed thermal limits under N-1 scenarios without it
  - Alternatives: transmission system upgrades, new local generation (up to 45 MW), energy storage
- **CAISO identified a joint proposal from transmission system owner Pacific Gas & Electric and local community choice aggregator East Bay Community Energy to procure energy storage and distributed generation as the least-cost option**
  - PG&E will procure two utility-scale energy storage projects totaling 43.25 MW/173 MWH; EBCE working with customers to deploy distributed PV and storage in the load pocket
  - None of this storage would be a regulated transmission asset; all dispatch and recovery would happen through energy markets and utility programs (net metering and other incentives)



Storage in Place of Transmission: Nantucket Island

- **Load growth and reliability requirements would soon require a third undersea cable to meet peak demand on Nantucket Island, MA**
  - Permanent population is 11k residents, but it swells to 50k during summer
  - Two existing transmission lines provide 71 MW; two combustion turbines on the island provide another 6 MW
  - Under a contingency scenario in which one of the lines is out of service, remaining assets would not be able to meet load during high-demand periods

- **Replacing the onsite generation with a new, 16 MW combustion turbine and a 6 MW/48 MWH battery, can cost effectively defer the third cable for 13 years**
  - Peaker + Storage: $93.9M, with $122M in benefits (including NPV of transmission deferral)
  - Transmission deferral only needed for 145 hours per year, leaving significant opportunities for market participation
  - Reduced outages valued at $240k/year



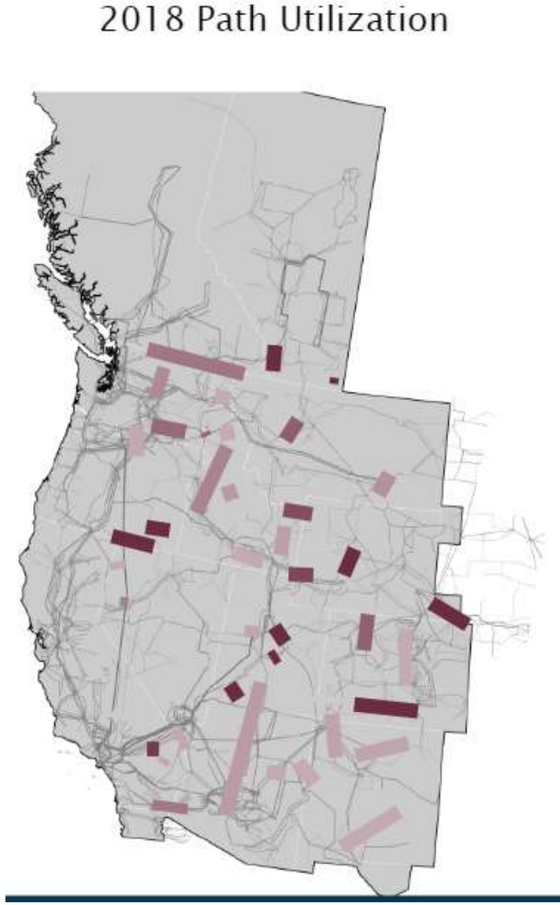
Balducci et al, "Nantucket Island Energy Storage System Assessment." 2019.

Storage as a Dual-Use Asset

Key Principle: Transmission Utilization

- **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.
- Implication: If deployed as transmission, energy storage would likely have significant opportunities to provide other grid services outside of peak periods.



Season
- All
- Winter
- Spring
- Summer
- Fall

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, 2018 State of the Interconnection, https://www.wecc.org/epubs/StateOfTheInterconnection.

FERC Policy Statement on Dual-Use Storage (2017)

- **Policy Statement: Once deployed as a transmission asset, energy storage will likely have significant opportunities to provide energy services in the market, thereby generating offsetting revenue that can be shared with customers to reduce system costs.**
- **Therefore, energy storage can be a dual-use (transmission and generation) 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

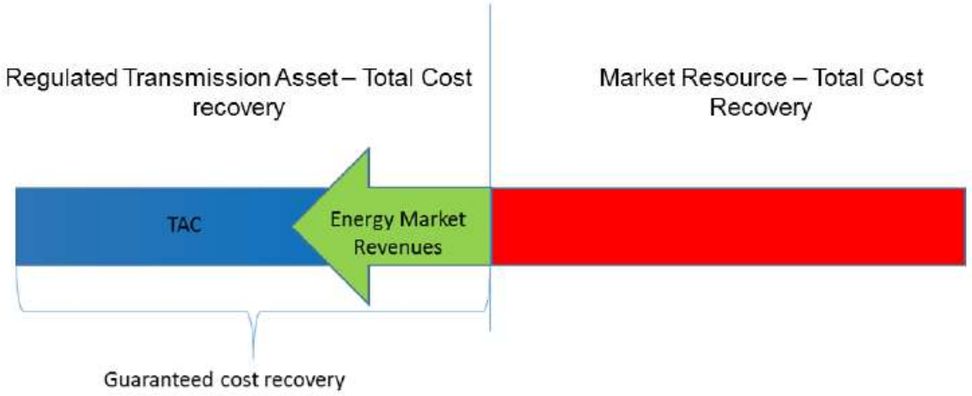
CAISO Proceeding

- **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

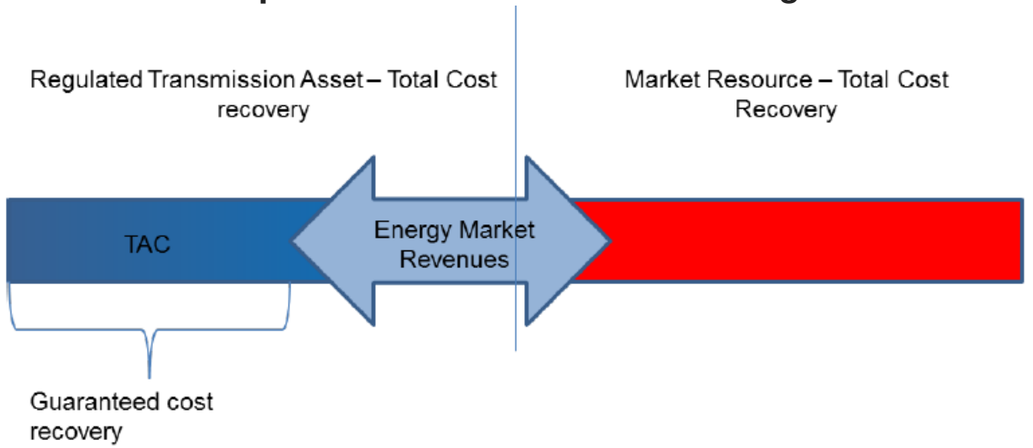
CAISO Proceeding

The CAISO proceeding extensively explored the question of cost recovery:

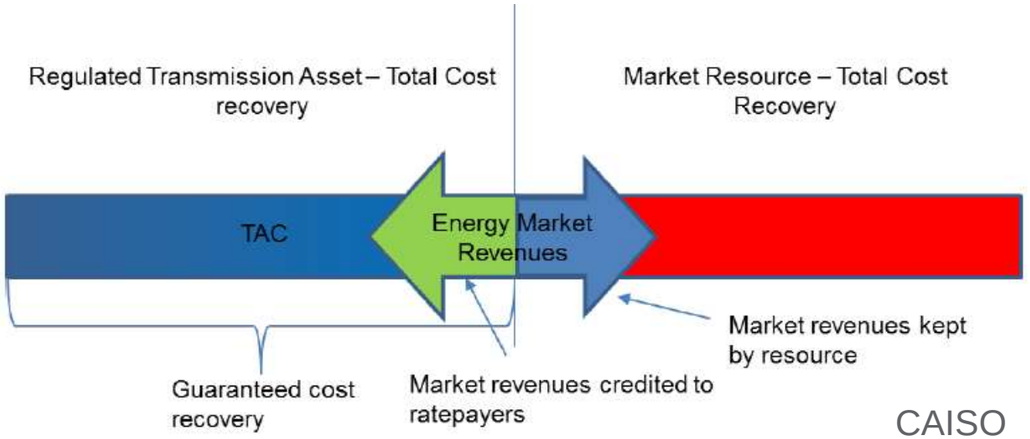
Option 1: Full Market Crediting



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

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 ultimately 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 tariff:
  - 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)

Enabling Principles for Dual-Use Storage

Project Overview

Generic Example of Revenue Sharing Impacts

Year	Transmission Revenue Requirement	Market Revenue Credit	Net Transmission Revenue Requirement
1	($1,250,000)	$50,000	($1,200,000)
2	($1,225,000)	$50,000	($1,175,000)
3	($1,200,000)	$50,000	($1,150,000)
…			
38	($325,000)	$50,000	($275,000)
39	($300,000)	$50,000	($250,000)
40	($275,000)	$50,000	($225,000)
Total	($30,500,000)	$2,000,000	($28,500,000)
Net Present Value	**$10,000,000**		**$9,511,047**

Project Structure:

- Two-year, joint project between PNNL and Argonne National Laboratory
- Funded by DOE's Water Power Technologies Office, through the HydroWIRES initiative.

Project Objectives:

- Identify a participation mechanism by which energy storage may be deployed as a transmission asset, but also earn offsetting revenue through market participation, then quantify the resulting benefits.
- Objectively inform future proceedings on dual-use storage.

Barriers to Storage in the Transmission Planning Process

Despite clear support for using energy storage as a transmission asset dating back to 2005 – from both Congress and FERC – regional transmission planning processes have been slow to incorporate storage technologies.

Our review identified give specific challenges:

- Lack of clarity for stakeholders about how and when storage alternatives will be considered
- Difficulty representing storage in power flow models
- Weak links between transmission and generation planning processes
- Financial disincentives for utilities to consider storage alternatives
- Lack of regulatory review

Facilitating Storage's Inclusion in the Transmission Planning Processes

Identifying cost-effective opportunities for the deployment of energy storage in the transmission planning process consists of two principles:

- Establish clear, transparent processes for the proposal and study of energy storage
  - CAISO: Preferred resources policy creates an informal expectation for planning staff to proactively identify storage alternatives and consider stakeholder proposals
  - MISO: SATOA tariff creates a clear, formal structure for analyzing storage alternatives
- Prepare a reasonable forecast of future market revenues to quantify the net present cost of the asset to transmission customers
  - Over time, market revenue sharing reduces the cost of the asset to customers; forecasting and accounting for those revenues on an upfront basis ensures that the true cost of the asset is reflected in the decision and increases the accuracy of planning outcomes

Market Barriers to Dual-Use Storage

To overcome the barriers between regulated transmission operations and competitive market operations, a dual-use participation process must answer three basic questions:

- **When** will the asset participate in the market?
  - Can participation models be defined in advance?
  - What happens if the asset is cleared for market participation, but then recalled for a reliability event?
  - Could an oversized asset always provide market service independent of transmission function?
- **How** will the asset participate in the market?
  - How can dual-use storage asset's unique characteristics be operationally defined?
  - How will FERC's operational control requirements be enforced, and how will markets be protected?
  - How will the impacts of market use on the asset's useful life be mitigated?
- **Where** will the asset recover its costs?
  - What costs will be recovered from regulated services, and what costs will be recovered from market operations? How will market incentives be maintained while guarding against over-recovery?

Dual-Use Energy Storage Participation Framework

In developing a framework for storage assets deployed as transmission to also participate in the market, we were guided by three principles:

- **Reliability**: A dual-use asset's market participation must not jeopardize its ability to serve the transmission function for which it was initially selected
- **Incrementalism:** Dual-use participation models should be based in established market practices and principles to the greatest extent possible
- **Balance:** A dual-use participation model must recognize competing priorities and seek to balance them

Dual-Use Energy Storage Participation Framework

Differing regional policies and market structures preclude the possibility of a universal participation model.

To maximize adaptability, we identified the key elements of a dual-use participation model and the points of flexibility for grid operators and stakeholders to adapt the model to different projects and situations.

This framework has three elements:

- **Establish market participation windows in advance**
  - To allow the asset owner to make informed bids into the market as well as enable reasonable forecasts of market revenues

Points of flexibility:

- Pre-determined eligibility windows (at least day ahead) based on projected transmission needs
- Managing the device's state of charge to maintain sufficient capacity to meet transmission need at any time

Dual-Use Energy Storage Participation Framework

- **Create flexible market products and resource definitions**
  - To ensure that a dual-use asset's unique characteristics are codified in market operations and allow for instant, no-fault redispatch when transmission emergencies arise

Points of flexibility

  - Asset definition: Existing resource definitions for similar use-limited or reliability-constrained assets may be adapted to dual-use storage
  - Market product creation: New market products may be created that allow a resource to bid into energy and ancillary service markets while being flagged for transmission service at the grid operator's discretion
  - Bidding rules: Market mitigation rules are common; bidding rules that require dual-use assets to accurately reflect their costs in market bid formation can protect market integrity
  - Market limitations: To manage an asset's useful life and limit its market impacts, it may be appropriate to limit how much capacity the asset can commit to the market

Dual-Use Energy Storage Participation Framework

- **Balance cost recovery mechanisms to incent market participation**
  - In determining how an asset's cost recovery will be split between regulated and market functions and how market revenues will be divided, a balance must be struck between giving the asset owner a reasonable opportunity to recover investment expenses and preserving an incentive for the owner to participate in the market and earn offsetting revenue.

Points of flexibility

- Partial fixed recovery with revenue retention
- Full fixed recovery with revenue sharing
- Hybrid approach: CAISO staff proposed a mechanism that would reduce an asset's regulated cost recovery each time it participates in the market, commensurate with the impact of the market usage on the asset's useful life
- Cap and floor mechanism: United Kingdom regulators instituted a cap and floor mechanism to incent merchant transmission development, which would establish a guaranteed revenue floor that projects would earn through regulated rates and a cap on total revenue that they could earn through market rates.

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Thank you

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