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Energy Storage as a Transmission Asset

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NARUC Bulk Power System Learning Module

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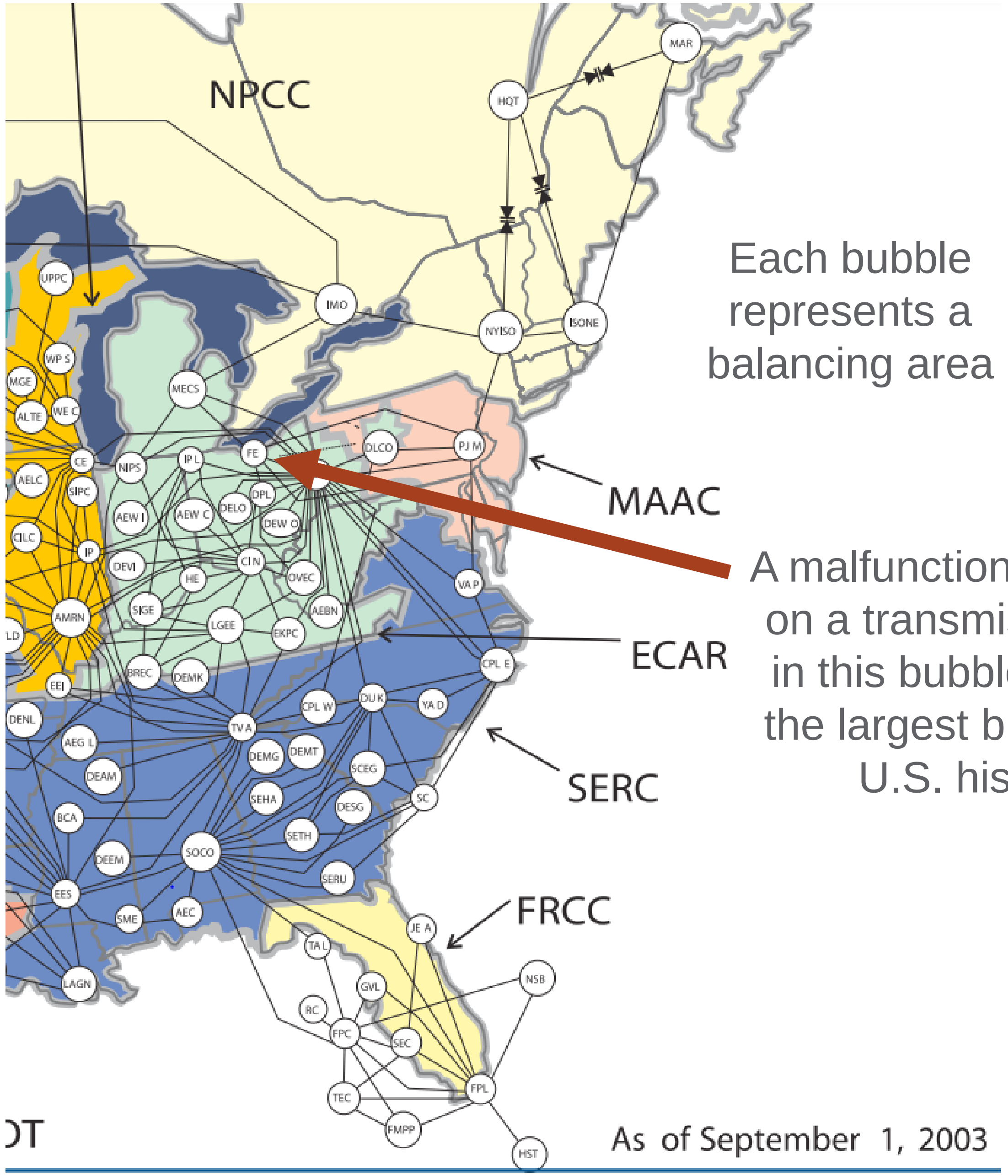
Agenda

- **Policy framework**
  - Transmission planning processes
  - Supportive policies
- **Defining storage as transmission**
  - Use cases
  - Case studies
- **Dual-use energy storage**
  - FERC Policy Statement
  - Incorporating storage into transmission planning processes
  - Market participation framework for dual-use storage assets

Policy Framework

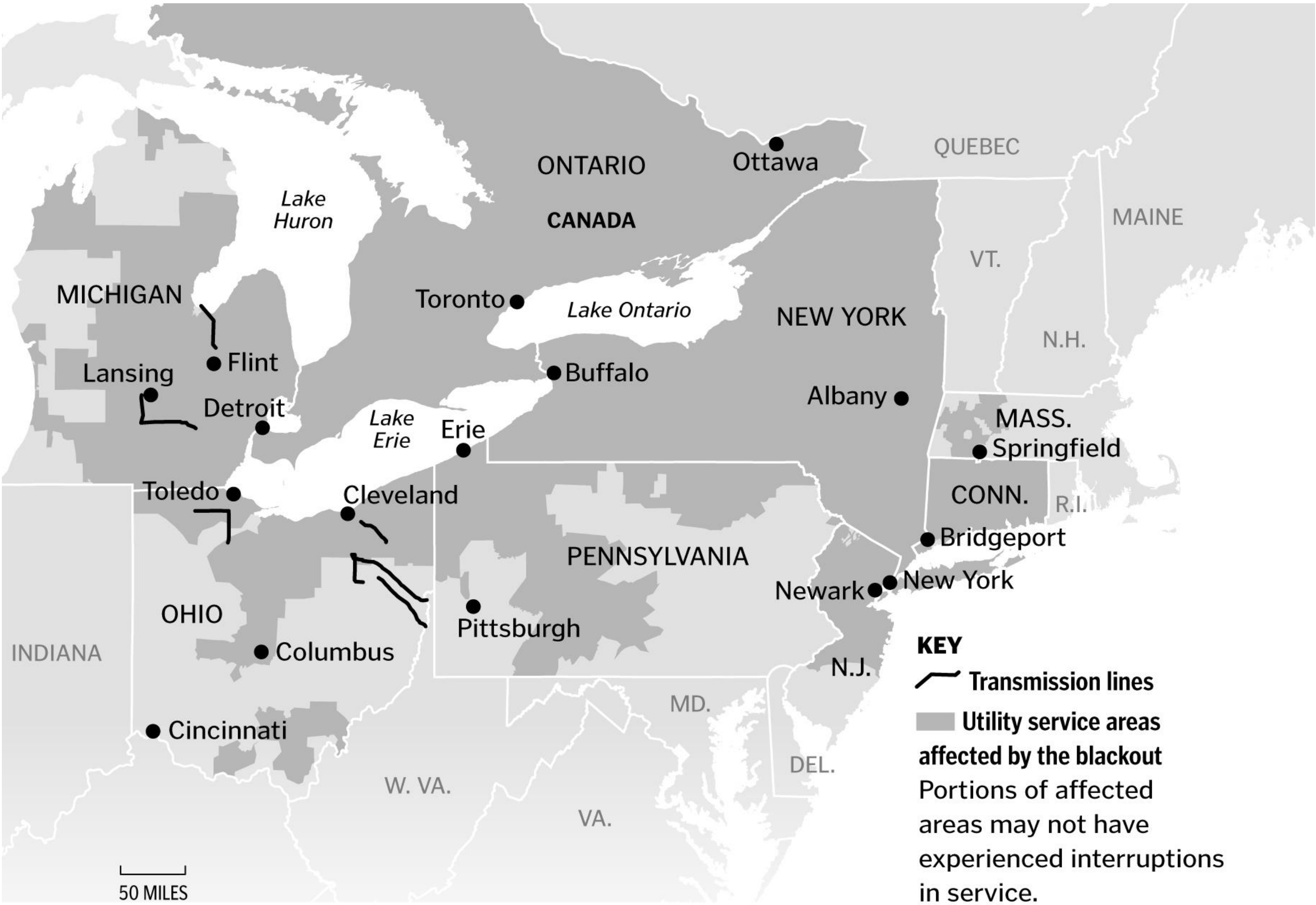
Our story begins in 2003



U.S. Department of Energy

Each bubble represents a balancing area

A malfunctioning switch on a transmission line in this bubble caused the largest blackout in U.S. history:



Boston Globe

Key Takeaway: This outage was not caused by any external factors. A piece of hardware malfunctioned and no one recognized what had happened until it was too late.

What changed after 2003

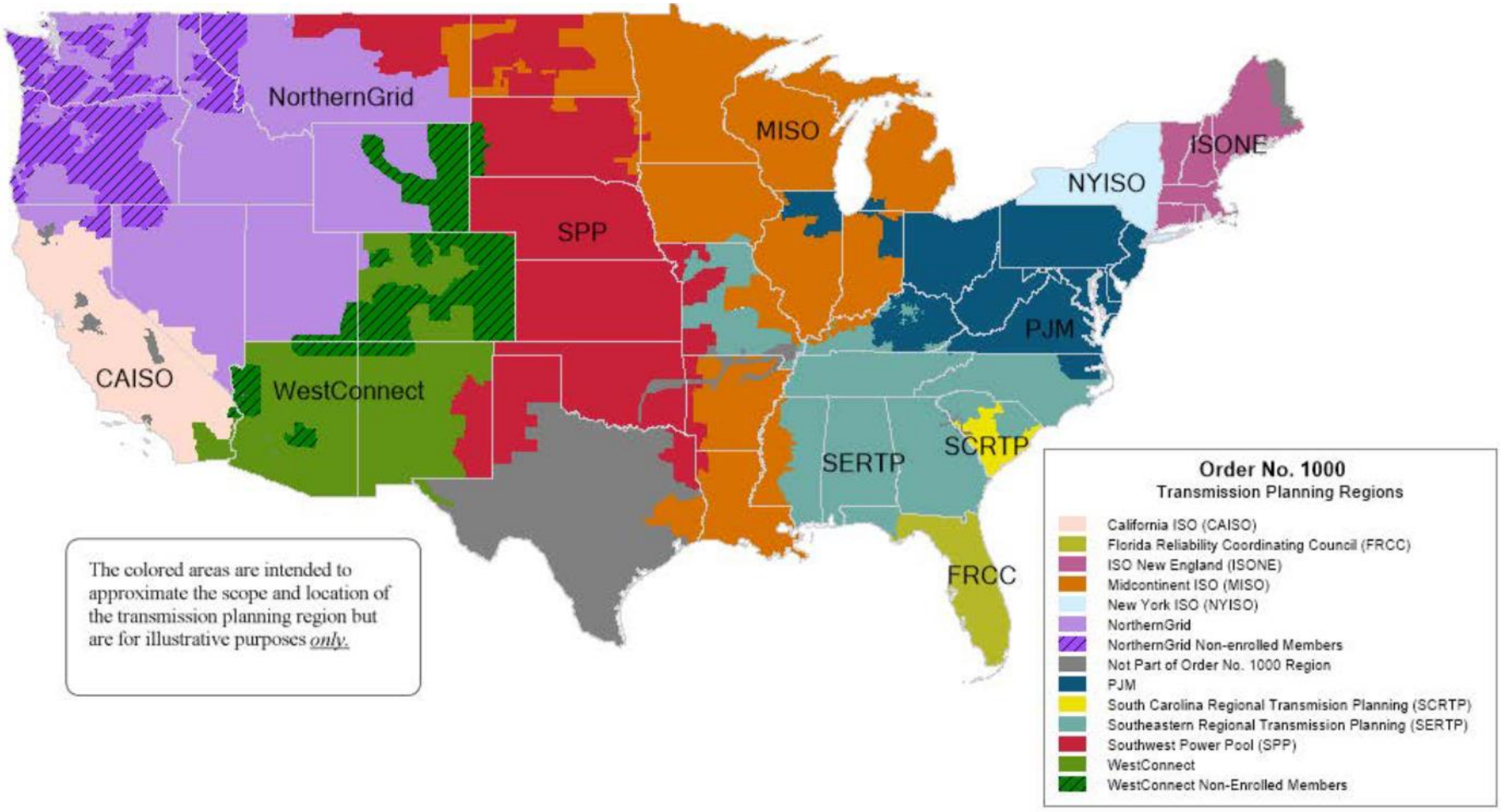
- The North American Electric Reliability Corporation (NERC), which had previously been an industry association that developed voluntary grid reliability standards, was empowered to enact and enforce binding reliability standards.
- NERC's transmission planning standard, TPL-001-5, is a complex document that applies to all transmission-owning entities in the U.S.
- For our purposes, we can simplify the standard into two basic requirements. Every transmission-owning entity must:
  - Develop and maintain a working model of its system
  - Prepare a plan every year that identifies potential grid weaknesses and a strategy for correcting them

The new paradigm: Contingency-based analysis

- To test the reliability of the system, transmission planners simulate what would happen if pieces of it (like a major transmission line or a large power plant) unexpectedly fail
  - “n-1” contingency, where “n” represents the normal system and “1” represents the component that failed
- NERC sets standards for how the system must perform when one of these outages occurs (how far it can spread, minimum voltage requirements, how long it takes the system to re-normalize, etc.)
  - If a contingency study reveals a violation, planners must develop a corrective plan
  - Historically, these corrective plans have focused on increased redundancy through additional transmission infrastructure (poles, wires, etc.)
- But energy storage has emerged as a viable alternative for many transmission issues
  - Storage can’t move energy from Point A to Point B, like a transmission line
  - But it in a contingency event, storage can regulate power flows and reduce or avoid outages
  - Where feasible, this approach can extend the life of existing assets and defer or displace the need for new transmission infrastructure

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
- **FERC Order 1000 (2011)**
  - Requires coordinated, regional transmission planning
  - Non-transmission alternatives must be considered
- **FERC Order 784 (2013)**
  - Created Account 351: Energy Storage Equipment—Transmission



FERC

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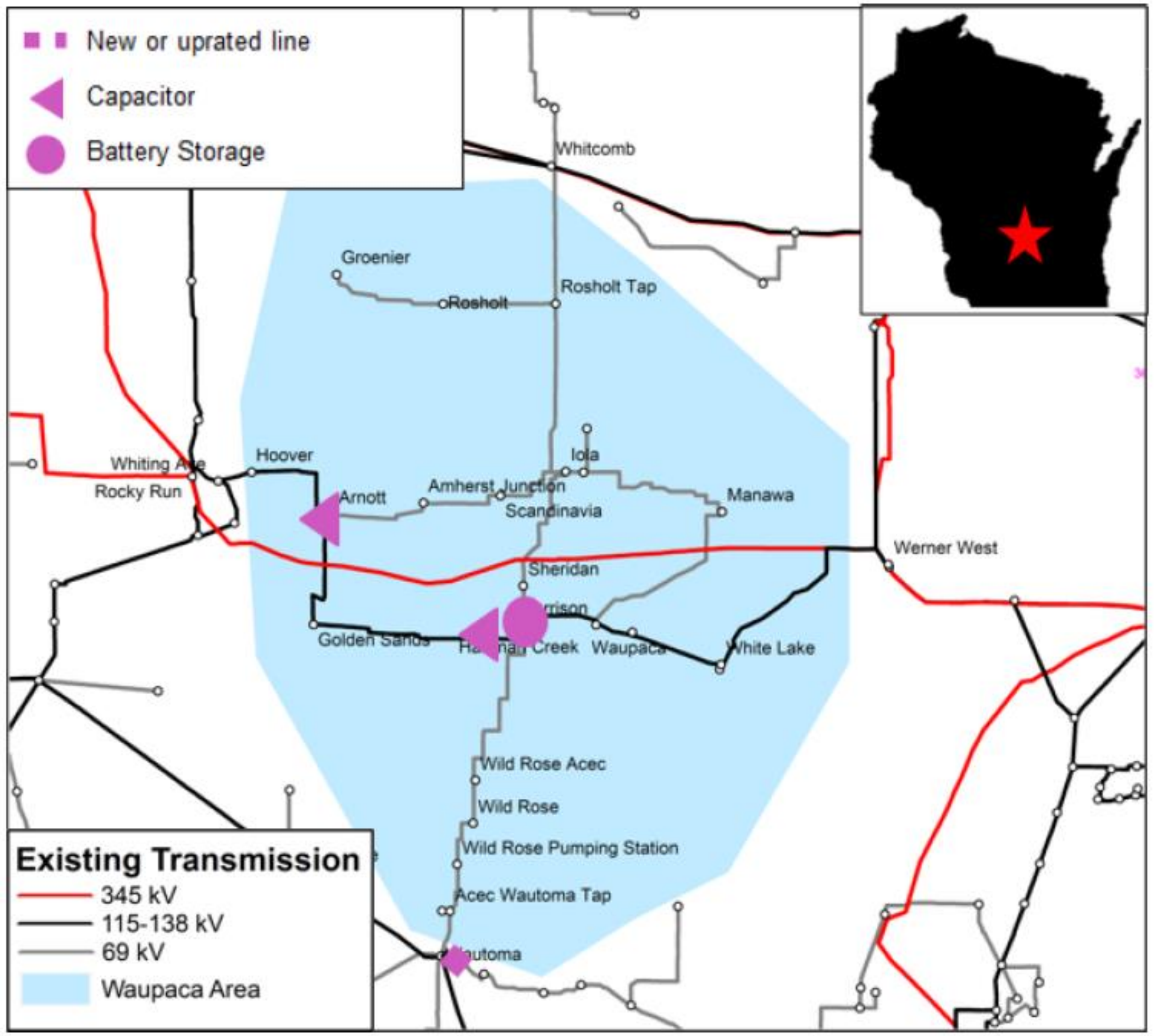
Defining Storage as Transmission

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
- **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 during peak periods when the system is constrained
  - Storage can also be used to protect and support transmission infrastructure by maintaining voltage and managing power flows
  - Storage can maintain loads that would otherwise be lost in a contingency event
  - Storage may be deployed as a regulated transmission asset or in place of transmission as a competitive generation asset

Storage as Transmission: MISO

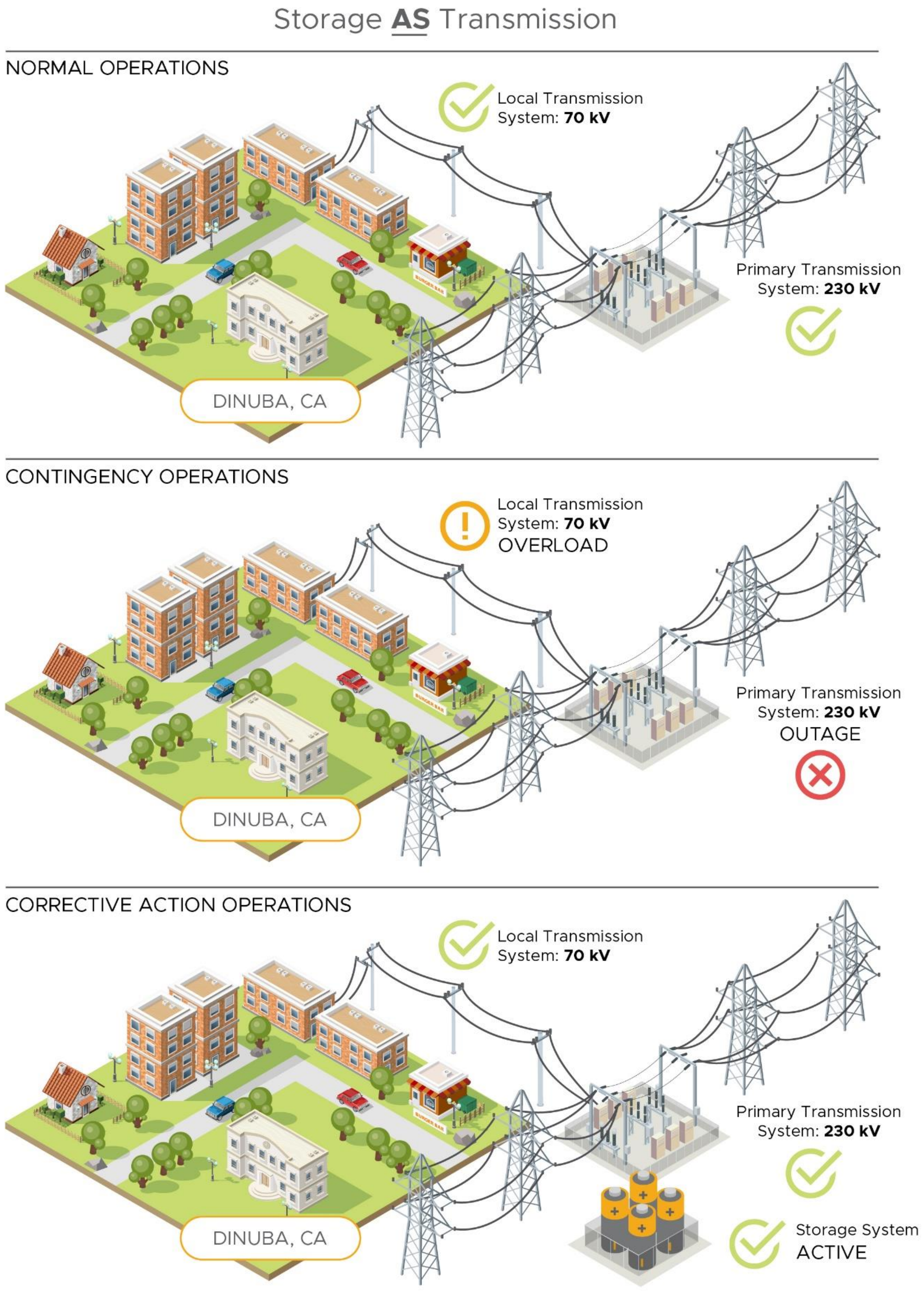


MTEP 2019

- **Primary Use Case: Outage Mitigation**
- **The 2019 MISO Transmission Expansion Plan (MTEP) selected energy storage as a transmission asset**
- **Storage as Transmission: Waupaca, WI**
  - Under certain N-1 contingency scenarios (line outages), 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 sectionalizing, was selected over a $13.1 million project to install an additional circuit
- **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**

Storage as Transmission: CAISO

- **Primary use case: system protection**
- **Contingency scenario:**
  - Dinuba is a small town in Central California that is served by a lower-voltage transmission line (70 kV) that comes off a much higher-voltage line (230 kV) a few miles away
  - An outage on the larger transmission line would overload the Dinuba system before the system could be rebalanced
- **What storage does:**
  - In the contingency event, a battery at the substation where the two lines meet would effectively act as a sponge to absorb the excess power flows before they reach the Dinuba line
  - The storage alternative was estimated to cost $14M, compared to a $16M project to increase the capacity of the Dinuba line



Storage as Transmission: PacifiCorp

VRB Energy

- **Primary Use Case: Voltage Support**
- **Scenario:**
  - Rocky Mountain Power served the Castle Valley, UT area with a very long (209 miles), low voltage (25 kV) distribution line
  - Low voltages at the end of the line were causing high outage rates and preventing new customers from connecting
  - Environmental factors severely limited the potential of augmenting the line
- **What storage does:**
  - By injecting power near the end of the line during high-demand periods, the battery improved voltage
  - One of the earliest examples of storage for infrastructure deferral (2004); also one of the earliest uses of a flow battery

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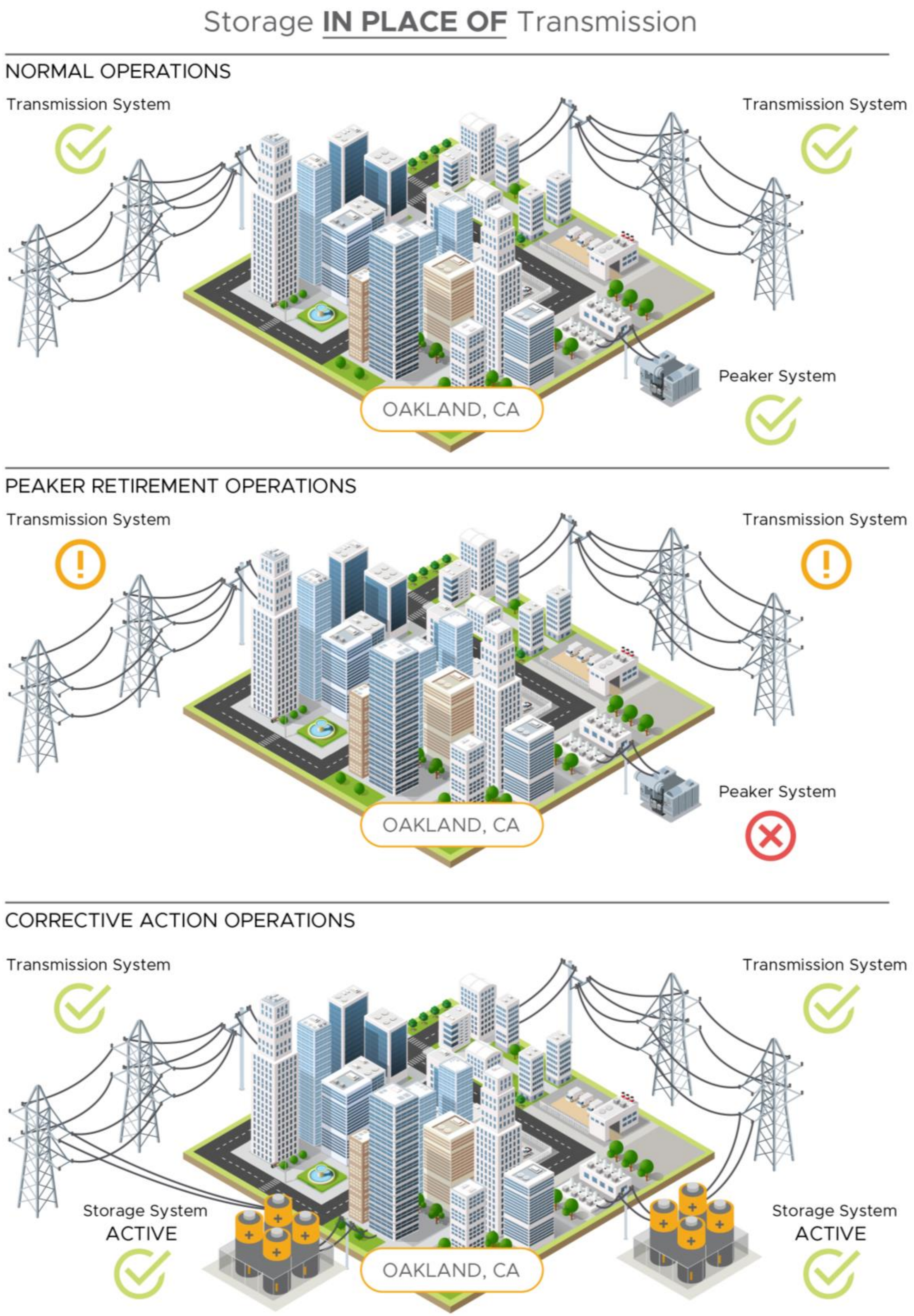
Storage in Place of Transmission: Oakland Clean Energy Initiative

- **Primary Use Case: Transmission Deferral**
- **The Jack London Power Plant was 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 43.25 MW/173 MWH utility scale storage; EBCE will work with customers to deploy DG and storage
  - $102 million project; next-best alternative was $367 million
  - None of this storage would be a regulated transmission asset; all dispatch and compensation through markets and utility programs



Dual-Use Energy Storage

Key Principle: Transmission Utilization

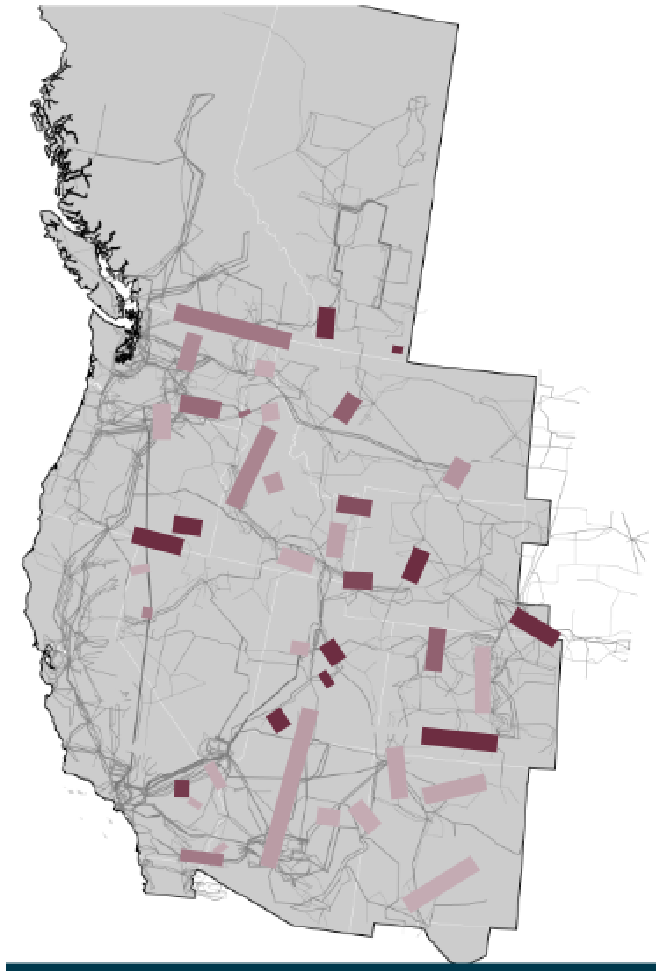
- **Key principle: Even on fully contracted, heavily utilized transmission lines, there is unused capacity *most of the time*.**

- These numbers mean that regionwide, for 93.8 percent of the time in 2018, less than 75 percent of the average transmission line's firm 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.

2018 Path Utilization



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 may also provide market services and generate 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
  - The California Independent System Operator (CAISO) and Midcontinent Independent System Operator (MISO) are the only entities to voluntarily respond to the policy statement; both ISOs terminated their proceedings

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**

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 five 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
- For dual-use assets, 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?
  - Objective: Allow asset owner to make informed bids into day-ahead markets
- **How** will the asset participate in the market?
  - Objective: Allow for instant, no-fault dispatch and redispatch of dual-use assets
- **Where** will the asset recover its costs?
  - Objective: Create appropriate signals for market participation that balance competing objectives of transmission and market uses

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:

- **When: 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

- **How: 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

- **Where: 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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PNNL Report on dual-use participation:
https://www.osti.gov/servlets/purl/1846604

ANL Report on the economics of dual-use:
https://publications.anl.gov/anlpubs/2022/09/177099.pdf