CAISO EDAM Benefits Study

Estimating Savings for California and the West Under EDAM Market Scenarios

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Prepared for:

California ISO

Keegan Moyer
Principal
kmoyer@energystrat.com

Daniel Ramirez
Consultant
dramirez@energystrat.com

ENERGY STRATEGIES

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Study Background & Purpose

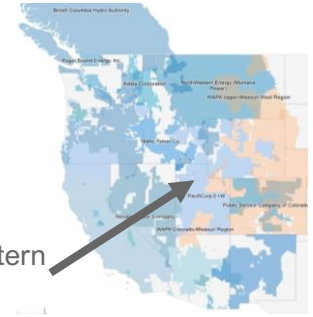
Study Background

- **The CAISO engaged Energy Strategies to estimate the benefits associated with the CAISO's Enhanced Day-Ahead Market (EDAM)**
  - The purpose of the study was to estimate both operational and capacity savings that may accrue due to the formation of the CAISO's new day-ahead market known as EDAM
  - The benefit estimates were calculated for (1) California; and (2) the Western US states in the Western Interconnection
- **The methodology and underlying databases used to perform the assessment were consistent with those adopted by Energy Strategies in performing the *State-Led Market Study,* which was an analysis conducted for the benefit of Western states with funding through a US Department of Energy grant**
  - The *State-Led Market Study* was published in July 2021 and with the goal of helping Western states independently and jointly evaluate benefits of generic organized electricity market expansion options, while enhancing regional dialog on related regulatory and policy issues impacting states
  - The study featured detailed modeling that forecasted the operational benefits, as well as capacity savings, that could accrue to individual states under future market scenarios
  - The modeling explored generic representations of real-time, day-ahead, and RTO market constructs, assuming their implementation across a series of hypothetical footprints selected by the Western states
  - This EDAM assessment differs from this prior work in that it is designed to represent specific elements of a market proposal, whereas the *State-Led Study* was intentionally generic and not focused on representing a particular market proposal or design

Study Goal

Estimate savings for California and the aggregation of Western States assuming a West-wide EDAM footprint, considering both operational efficiencies and load diversity benefits that may accrue in the year 2030

BAU

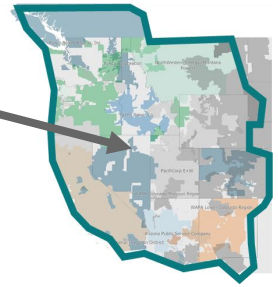


No DA markets. Western EIM and SPP WEIS participation continues

VS.

West-wide EDAM

EDAM scenario includes all WECC BAs



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Annualized Savings ($M/year)

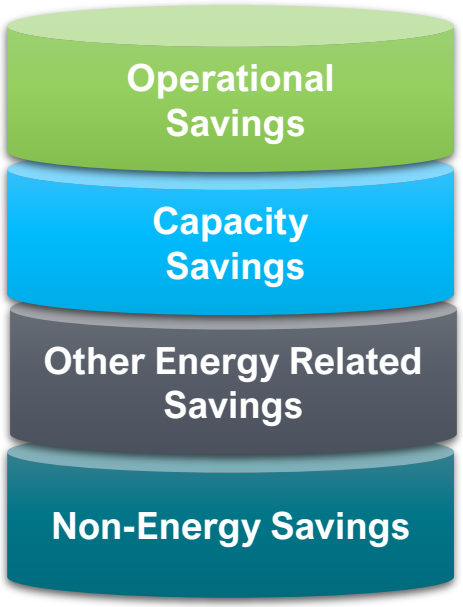
Comparison of BAU versus California and West-wide EDAM used to calculate market benefits

Modeling was performed for a **2030 study year** using models, sourced from WECC, updated to reflect resource plans, transmission expansion, and public policy requirements for that horizon

Methodology

Operational Savings are Focus of Study

- **This CAISO EDAM study focuses on operational benefits of future regional wholesale power markets, featuring modeling intended to reflect specific aspects of the CAISO EDAM proposal**
  - The study sources capacity savings directly from public *State-Led Study* results
- **Operational benefits reflect a relatively small portion of the benefits caused by organized wholesale energy markets**



Market Benefit Categories	Description	Addressed in this study?
Operational Savings	Savings due to more efficient dispatch (via SCED), more efficient management of transmission capacity, lower operating reserve requirements, removal of transmission wheeling costs within market footprint, decrease in trading friction	☑ *Yes, through new market modeling reflecting CAISO EDAM operations*
Capacity Savings	Savings due to lower and regionally shared planning reserve requirements caused by geographical diversity of loads (and generation)	☑ *Yes, by adopting public results from State-Led Market Study*
Other Energy Related Savings	Savings due to more efficient planning of the transmission system, access to lower-cost public policy resources, environmental benefits of reduced emissions, new market products (e.g., hourly vs. block), increased automation of system operations	☐ *No, not quantified in this study.*
Non-Energy Savings	Savings due to lower electricity prices causing indirect economy-wide benefits such as new jobs, changes to household spending, and economic growth	☐ *No, not quantified in this study.*

Adjusted Production Cost (APC) is Primary Metric to Measure Operational Savings

- **Adjusted Production Cost (APC) is a metric commonly used to estimate operational benefits in market studies as it accounts for power trading between buyers and sellers**
  - APC represents the net costs for a given area to serve load, accounting for power generation costs, power purchase cost, and revenues from sales
- **A *decrease* in APC for an area from one market scenario to the next represents operational savings**
  - This study calculates APC on a balancing area (BA) basis and allocates BA-level operational savings to states based on the amount of BA load in that state
- **By comparing changes in APCs, the study estimates how states might experience operational benefits from CAISO EDAM market configurations**

Allocation of Production Cost Savings to States

State A production cost savings benefit = Production cost savings for BA with load in State A × (Load in State A / Total BA Load)

Adjusted Production Cost =

Portfolio Production Cost
Fuel + VOM + Cycling Costs

+

Market Purchase Cost
energy imported to serve load

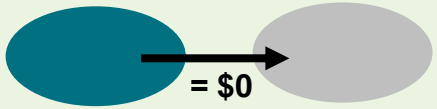
−

Market Sale Revenue
Excess energy from the portfolio exported

Modeling EDAM: Key Assumptions to Represent Market

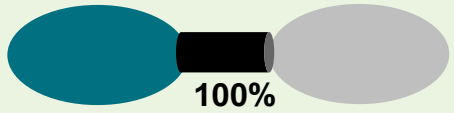
Wheeling costs

- Transmission wheeling costs or "hurdle rate" between EDAM participants are removed. UC and DA dispatch are optimized together.



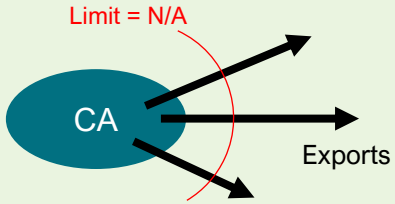
Transmission available to market

- 100% of inter-area transfer capability is available for EDAM day-ahead market optimization



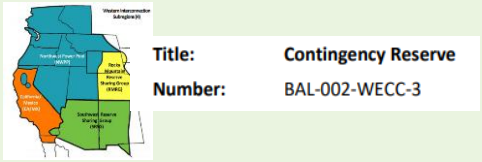
CAISO export limit

- No MW cap on how much power CAISO can export under EDAM



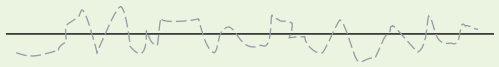
Contingency reserves

- **No change** in BA and reserve sharing group obligations due to EDAM market formation – status quo modeling retained



Regulating reserves

- **No change** to assumption that BAs define and hold regulating reserves locally – Status Quo modeling retained

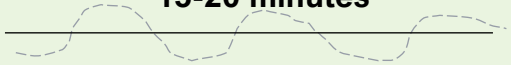


5 minutes

Load following / imbalance reserves

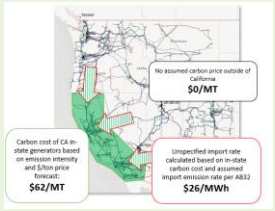
- Assumes EDAM imbalance reserve product causes imbalance reserves to be calculated and held for entire EDAM footprint (versus individual BAs under Status Quo)

15-20 minutes



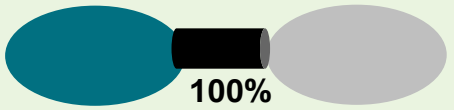
Carbon markets

- **No change** to California carbon price or carbon cost applied to unspecified imports per AB32 – Status Quo modeling retained



Real-time market representation

- 100% of inter-area transfer is available for real-time dispatch with no hurdle rate, among market participants in EDAM



Other Methodology Details: Software, Capacity Savings, and Imbalance Reserves

- **Software:** Energy Strategies used GridView™, a nodal production cost model, to perform this EDAM Benefit Study. The model was populated with a 2030 database consistent with those used to perform the *State-Led Market Study*
  - GridView™ features a security constrained economic dispatch and is commonly used across WECC (including the CAISO) to simulate grid operations, transmission congestion, and energy market performance

- **Capacity savings** were sourced directly from publicly available materials generated from the *State-led Market Study,* which assumed that DA markets may achieve a *range* of capacity savings
  - This study adopts the high-end range for simplicity, but depending on how RA constructs evolve there is the potential that EDAM would result in no direct capacity benefit
  - Details on the methodology to calculate such savings are outlined in *State-Led Study* materials on Energy Strategies' website

- **Imbalance Reserves:** Also known as "load following" or flexibility reserves, help to accommodate intra-hour ramps and forecast error over an approximate 15–20 minute ramp period
  - Statistical methods developed by NREL, which leverage sub--hourly load, wind and solar production and forecast data, were improved upon and used by Energy Strategies to represent imbalance reserves in the simulations
  - Imbalance reserves capture net load variability and forecast uncertainty/error
  - GridView™ sets aside generation capacity within a defined market footprint to meet the reserve requirement, subject to unit ramp rates and eligibility to contribute to reserves

Type	Calculation	Timestep	Confidence Interval
Regulation	$MAX(\sqrt{(1\%\ load)^2 + (Wind\ reqt)^2 + (PV\ reqt)^2},$ $Max\ 20\ minute\ Net\ Load\ Ramp\ within\ hour),$	5-minutes	95%
Load Following	$MAX(\sqrt{(1\%\ load)^2 + (Wind\ reqt)^2 + (PV\ reqt)^2},$ $Max\ 20\ minute\ Net\ Load\ Ramp\ within\ Hour)$	60-minutes	70%

EDAM Study Results

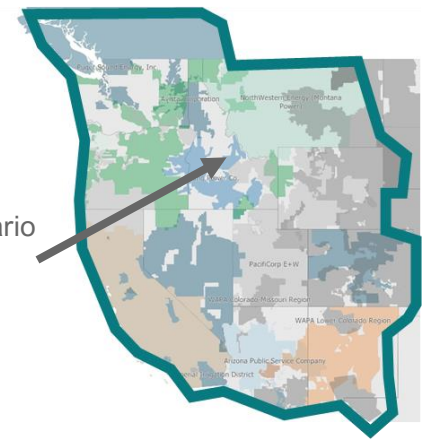
Study Results: West-wide EDAM Scenario

Scenario assumes that all Western balancing areas join EDAM market, which features a market-based imbalance reserve product, no transmission wheeling costs among market participants, and 100% transmission availability for market optimization

Area	Operational Savings ($M/year)	Capacity Savings ($M/year)	Total Savings ($M/year)
California	$214	$95	**$309**
Other Western States	$329	$557	**$886**
Total	$543	$652	**$1,195**

Reduction in CO_2 (million ton/year)
2.92 (1.5%)

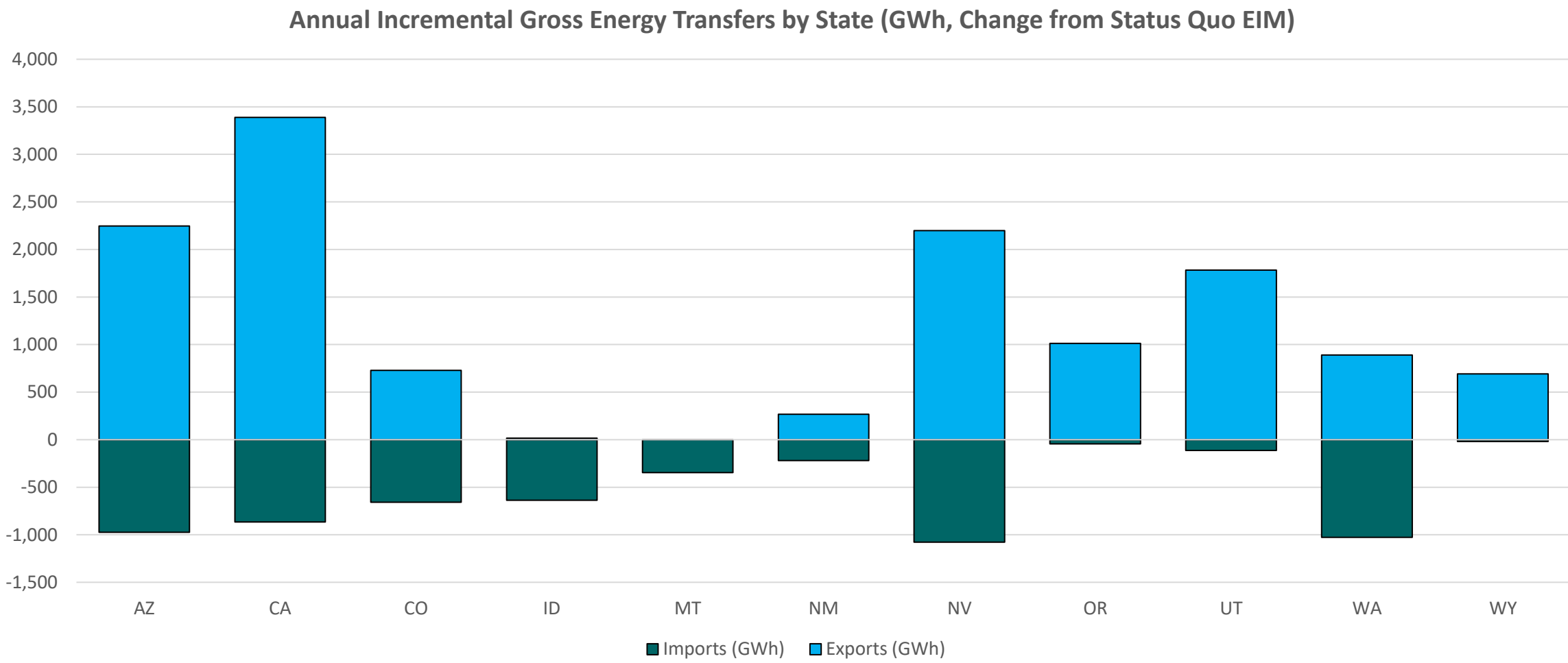
West-wide EDAM



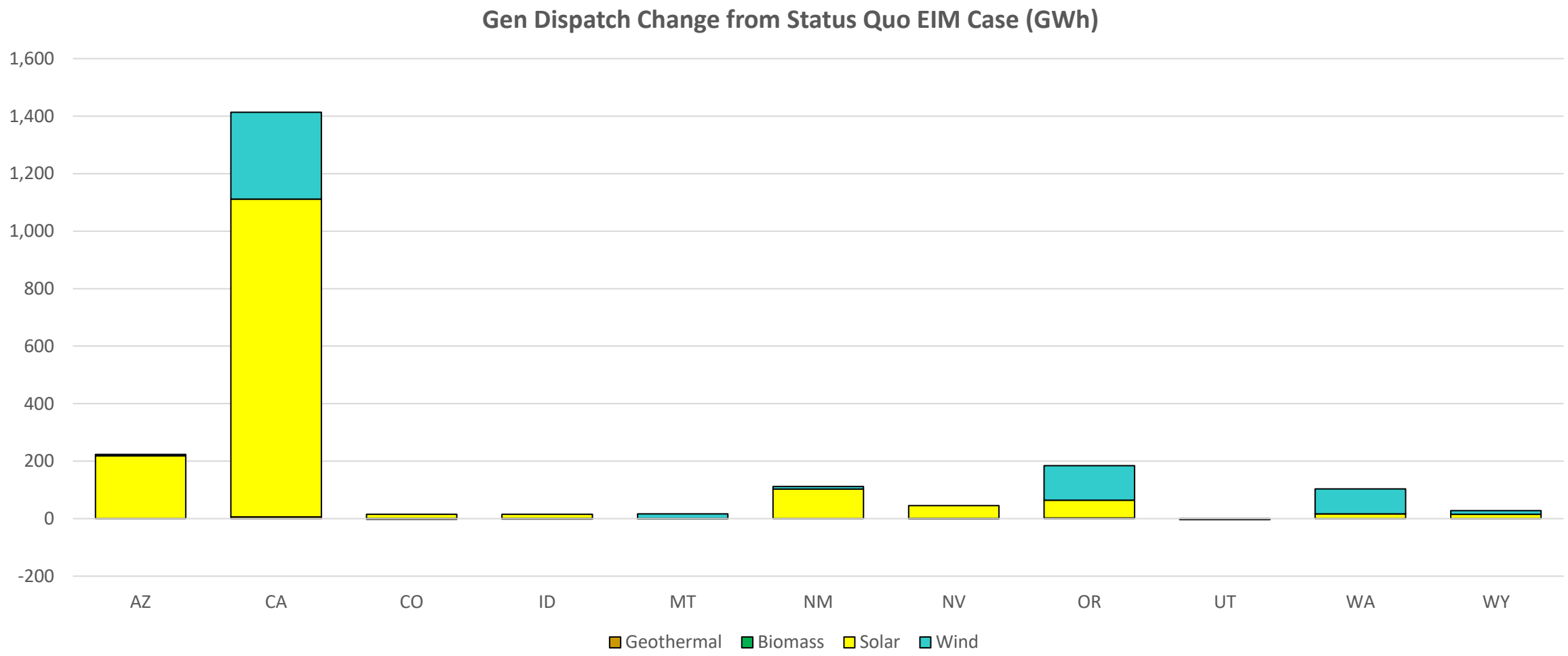
EDAM scenario includes all WECC BAs

- **An EDAM footprint across WECC causes California operational costs to decline by 6.2% from the Status Quo**
  - Due to increased load diversity across the market footprint, California achieves capacity savings of $95 million per year
- **In sum, California saves $309 million per year under a west-wide EDAM**
- **States outside of California also see efficiencies, especially those caused by load diversity, collectively saving $886 million per year**
- **Total savings for the region due to EDAM is nearly $1.2 billion per year**
  - This is more than 2x what the Western EIM saves annually (on average in 2020 and 2021)

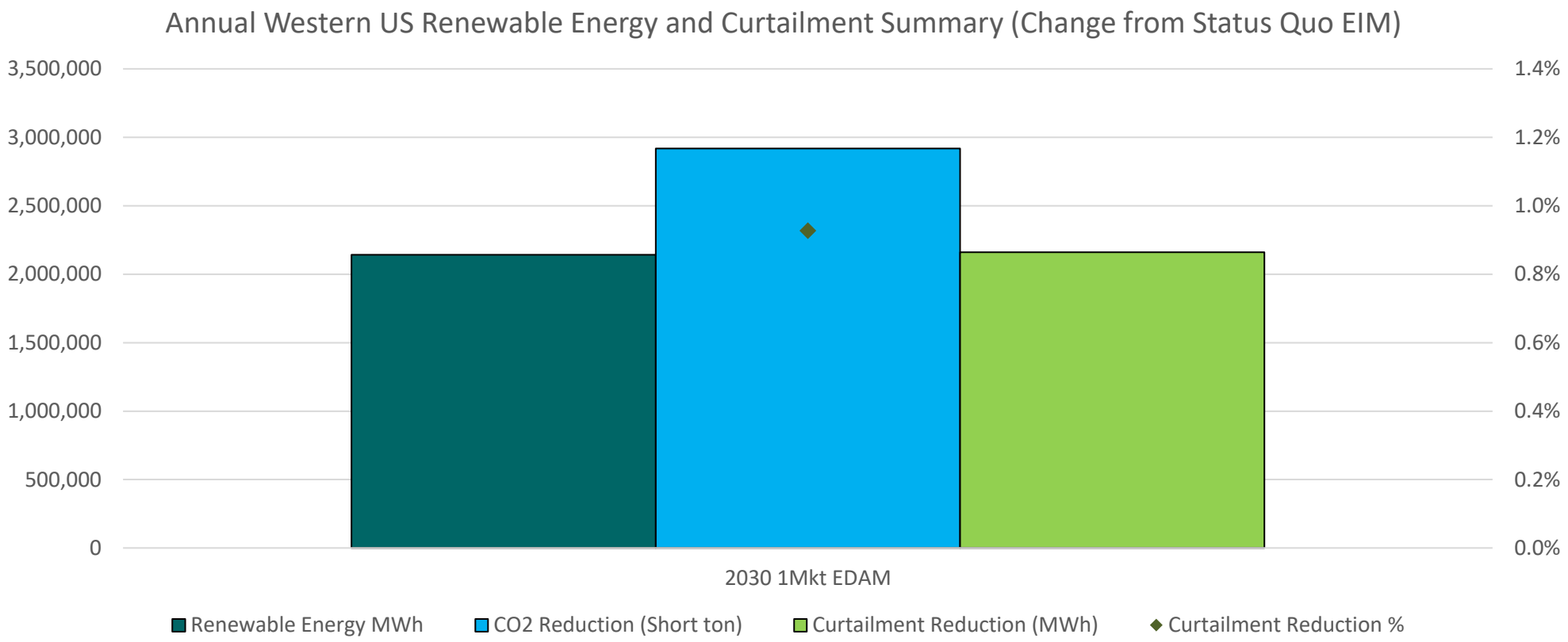
Study Results: Change in Energy Transfers due to West-wide EDAM



Study Results: Change in Renewable Output due to West-wide EDAM

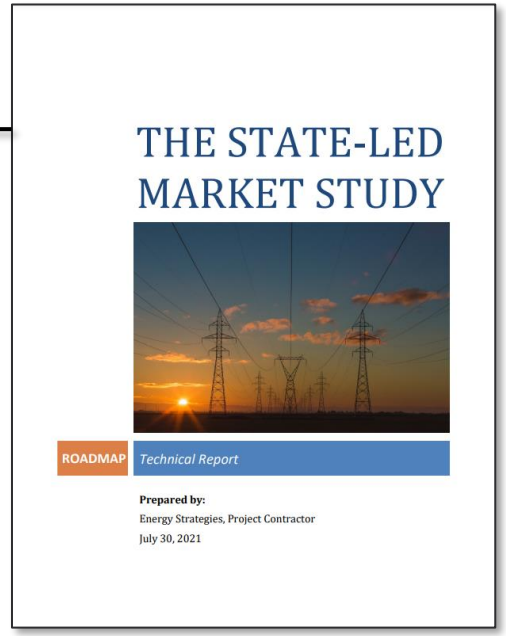


Study Results: Comparison of Energy Transfers and Renewable Curtailments for West-wide EDAM Scenario

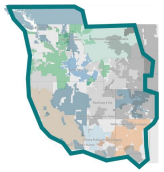


Study Results: Comparison to RTO Futures

- **By comparing EDAM results to those estimated in the *State-Led Market Study* for equivalent RTO footprints, we see that the EDAM achieves 74% of RTO operational savings for California, and 81% of RTO operational savings for the remaining Western states**
- **EDAM, as envisioned in this study, has a market design that removes transmission wheeling costs, consolidates imbalance reserves, and opens up inter-area transfers available for market optimization**
  - Combined, these attributes help achieve most of the operational efficiencies of an RTO
  - Remaining inefficiencies in EDAM otherwise captured in an RTO are due regulation reserves within each BA and contingency reserves being held at the sharing group level



Operational Savings

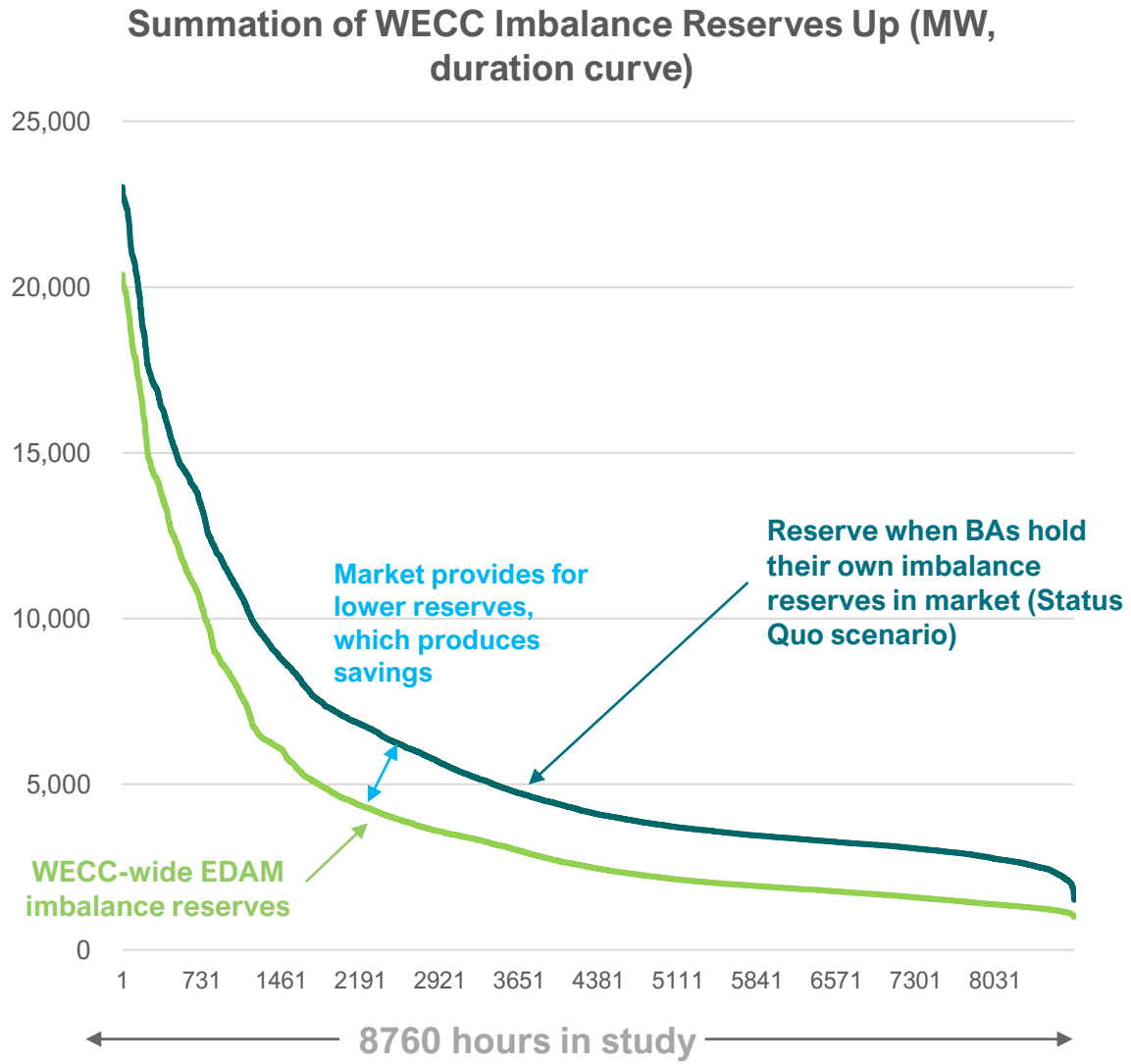
Footprint	Area	EDAM ($M/year)	RTO ($M/year)	% Savings Achieved via EDAM
	**California**	$214	$288	**74%**
	Other Western States	$329	$406	**81%**
	Total	$543	$694	**78%**

Sensitivity Study

Impact of Imbalance Reserve Product

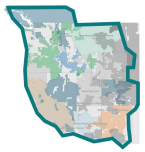
Imbalance Reserves and Geographic Diversity

- **Due to the benefits of geographical diversity and netting out of load, wind, and solar errors across a large footprint, imbalance reserves for the EDAM scenario was 32% below the Status Quo, which assumes Western BAs define and hold their own imbalance reserves (based on variability and error on their own areas)**
  - This is demonstrated in the figure, which shows the sum of all hourly imbalance up reserve requirements in WECC with an without the EDAM imbalance product (noting that imbalance reserve *down* has similar results)
    - Reserves are modeled chronologically in GridView™ but are sorted here from largest to smallest for viewing
- **To test the implications of EDAM *not* including an imbalance reserve product, a sensitivity was performed in which the EDAM scenario was simulated with the Status Quo imbalance requirements across the Western BAs**
  - This effectively removes the EDAM imbalance reserve product but retains other EDAM features, such as $0/MWh wheeling rate between BAs, 100% transmission availability for market optimization, and the removal of the California export limit



Study Results: Imbalance Reserve Sensitivity

Sensitivity assumes that EDAM forms across the West, but that the market does NOT include an imbalance reserve product and BAs continue to define & retain their own imbalance reserves

EDAM Scenario	Area	Operational Savings ($M/year)	Capacity Savings ($M/year)	Total Savings ($M/year)	Reduction in CO_2 (million ton/year)
West-wide EDAM w/o Imbalance Product 	California	$86	$95	**$181**	1.44 (0.8%)
	Other Western States	$120	$557	**$677**	
	Total	$206	$652	**$858**	

- **Operational savings are materially lower under the sensitivity, with California realizing only $86 million/year in operational savings**
  - This is a reduction of $128 million/year from the $214 million/year of operational benefits estimated when the imbalance reserve product is retained (a ~60% reduction in operational savings)
- **Other Western States see operational savings fall from $329 to $120 million/year (↓ 63.5%) when the EDAM imbalance reserve product is removed from the market**
- **CO_2 emission reductions are partially compromised as well**

Key Takeaways

Key Takeaways

- **The CAISO EDAM has the potential to reduce operational costs in California by $214 million per year if the market footprint covers the entire West**
  - These savings represent a decrease in operational costs of 6.2% in California (from the Status Quo)
  - Other Western states, in aggregate, see $329 million in annual operational savings (↓ 4.5% from Status Quo)
  - In addition, the EDAM market could help avoid nearly 3 million tons of CO_2 per year
- **The inclusion of an imbalance reserve production in the CAISO EDAM is critical to the efficiency of the market as it drives 60% of California's operational savings forecasted for EDAM**
  - Removing the imbalance product from the EDAM market design causes California's benefits to *decrease* by $128 million per year
  - Other Western States operational benefits are also similarly compromised when the imbalance product is removed (benefits ↓$229 million/year)

Study Summary: Annualized Operational Savings
($M/year)

Scenario	California	Other Western States	TOTAL
West-wide EDAM	$214	$329	**$543**
No Imbalance Product	$86	$120	**$206**

- **EDAM is estimated to achieve 78% of operational savings forecasted for an RTO with the same WECC-wide footprint**
  - The components of EDAM market design reflected in this study capture many of the efficiencies offered by an RTO
- **If capacity savings are realized due to the formation of EDAM, total market benefits may reach $309 million per year for California, and $1.2 billion per year for all Western states (combined, including California)**

Thank You!

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