Extended Day-Ahead Market Participation Benefits Study

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TABLE OF CONTENTS

Executive Summary

This study estimates the customer cost savings from the creation of the Extended Day-Ahead Market (EDAM) to inform the decision-making process of the study participants: the Balancing Authority of Northern California (BANC), Idaho Power Company, the Los Angeles Department of Water and Power (LADWP), PacifiCorp (PAC), and the Sacramento Municipal Utility District (SMUD). The study was designed in collaboration with the participants to simulate the EDAM in 2032, as a proxy year representing the first decade of EDAM operation. It simulates the specific details of the EDAM market design for a plausible EDAM footprint, rather than an approximation of the EDAM based on a generic wholesale market design covering the entire Western Electricity Coordinating Council (WECC) region. We use a nodal production cost model that produces locational prices for all generators and load buses in the WECC. The nodal structure of the model captures transmission constraints, including internal constraints within Balancing Authority Areas (BAAs), to produce system dispatch outcomes that closely align with future market outcomes in the Western Energy Imbalance Market (WEIM) and future outcomes in the EDAM. In this way, the study participants can have greater assurance that the results reasonably approximate the actual function of the EDAM and feel more confident in relying on the study results for their decision-making processes. Based on the market conditions simulated, the estimated benefits are likely conservative.

We estimate $438 million/year of net customer savings for the EDAM footprint analyzed in this study. Figure 1 presents the customer savings and cost metrics that will be impacted due to EDAM participation. We account for efficiency gains and all types of market revenues generated by market participation, assuming that they flow to customers through the regulatory process. We also account for revenue credits that customers receive today that may be lost due to EDAM membership. We estimate $813 million/year in gross benefits, offset by $375 million/year in lost revenues (some of which are addressed through a hold-harmless mechanism for lost short-term wheeling revenues of EDAM transmission service providers), resulting in $438 million/year of net customer savings.

FIGURE 1: EDAM BENEFIT METRICS $MILLIONS)

Benefit Metric	Study Participants	CAISO	Total EDAM
EDAM Benefits			
Adjusted Production Cost Savings	$99	$36	$134
EDAM Congestion Revenues	$186	$83	$269
EDAM Transfer Revenues	$324	$85	$409
Total EDAM Benefits	**$609**	**$204**	**$813**
Other EDAM Related Impacts			
Impact on Wheeling Revenues *[1]*	$14	-$117	-$103
Impact on WEIM Congestion Revenues	-$31	$15	-$16
Reduced Bilateral Trading Profits *[2]*	-$207	-$49	-$256
Net EDAM Benefits	**$385**	**$53**	**$438**

Notes: [1]: Impact on wheeling revenue includes only short-term wheeling revenues. The TRR Settlement process in the EDAM tariff provides EDAM transmission service providers a rebate for lost short-term wheeling revenue. [2]: Reduced bilateral trading profits is the value of exports and imports from EDAM member BAAs, including third-party marketers.

The following components of annual customer savings (listed in Figure 1 above) contribute to the $438 million in net savings:

- **$134 million/year in Adjusted Production Cost (APC) savings** due to a reduction of fuel and operating costs for resources in the EDAM footprint, lower purchased power costs from the market, and an increase in sales revenues due to the market formation. The APC metric captures the change in WEIM operations and related benefits, due to the formation of the EDAM. The APC metric does not capture changes in trade-related revenues or costs between BAAs—such as wheeling revenues, trading profits, or WEIM and EDAM congestion and transfer revenues—which are reported separately in our analysis.
- **$678 million/year in EDAM congestion and transfer revenues** collected by the market based on the difference in import and export prices on EDAM transactions, which is unaccounted for in the APC savings metric, and allocated to market participants.
- **$103 million/year in lost short-term wheeling revenues** due to the elimination of wheeling charges on bilateral trades between EDAM member BAAs.
- **$16 million/year in lower WEIM congestion revenues** because the introduction of EDAM slightly reduces the volume of transactions that take place in the WEIM, reducing the congestion revenues collected in the WEIM by EDAM member BAAs.

- **$256 million/year in lost bilateral trading profits** because the introduction of the EDAM reduces the need for bilateral trading by its members, which includes the effects of reduced intertie trades with the California Independent System Operator (CAISO) and less bilateral trading at the major hubs in the WECC.

The results presented in Figure 1 are for all of the study participants plus CAISO. We have provided company-specific results on a confidential basis to each of the study participants and CAISO. The confidential individual results show that (1) a large portion of total savings accrue outside of CAISO and (2) **all of the assumed EDAM members (including CAISO) are estimated to see customer savings** due to EDAM market participation.

One of the drivers of EDAM savings is a reduction in curtailed renewable energy in the EDAM footprint. The more optimal use of transmission assets and more efficient day-ahead unit commitment and dispatch decisions allow for better management of surplus renewable energy in many hours of the year. This allows the market to transfer more renewable energy from areas of over-supply to areas with thermal generation that can be decommitted to reduce curtailing surplus amounts of renewable energy. We estimated that the EDAM reduces curtailments of renewable energy by almost 2.5 TWh, nearly all from solar resources in California, which allows less reliance on fossil generation with associated cost savings and emissions reduction. The ability to utilize renewable generation that otherwise would need to be curtailed drives a significant portion of the estimated efficiency gain.

In addition to reduced renewable generation curtailments, we find that the EDAM-based optimization allows displacing higher-cost and higher-emitting gas resources with more efficient lower-cost gas generation when capacity is available on the lower-cost resources, especially during periods without solar generation. We see the volume of trades between the EDAM member BAAs increase by 27% compared to trading in the Status Quo Case simulation. This increase in trading indicates that the EDAM facilitates transactions that reduce costs, but that are not feasible under the status quo trading structure due to wheeling fees, trading frictions, and inefficient usage of transmission infrastructure.

Figure 2 shows that other recent market benefit studies in the WECC have similarly calculated the APC benefits of market participation. The Western Markets Exploratory Group (WMEG) study[1] found APC benefits of participation in the EDAM of roughly $60 million/year and the

[1] WMEG Cost Benefit Study, Energy and Environmental Economics, October 23, 2023, p. 12. Accessed here: https://www.bpa.gov/-/media/Aep/projects/day-ahead-market/e3-wmeg-benefits-study.pdf

State-Led Market Study[2] found benefits of a day-ahead market of up to $100 million/year. Figure 2 also includes a sensitivity off of the State-Led study (the "EDAM Sensitivity"), commissioned by CAISO, that looks at the same market footprint of the original study but captures some EDAM design features related to transmission usage and operating reserves. The EDAM Sensitivity found APC benefits of roughly $540 million/year.[3]

The scope of wholesale markets analyzed in each study vary across the studies, but each finds APC benefits through the formation of a day-ahead market in the WECC. However, the types of benefit metrics quantified by each study differ, which lead to varying estimates of total benefits. For example, the State-Led study and the EDAM Sensitivity calculated both APC savings and capacity savings, based on the assumption that a shared resource adequacy framework would be part of the market design.

In addition to quantifying APC savings, we also analyze revenue streams and costs beyond those captured in APC savings. These are revenues earned (or potentially lost) through EDAM participation, such as congestion and transfer revenues, lost bilateral wheeling revenues, and lost bilateral trading profits. Other recent studies have not quantified these benefits and costs of market participation.

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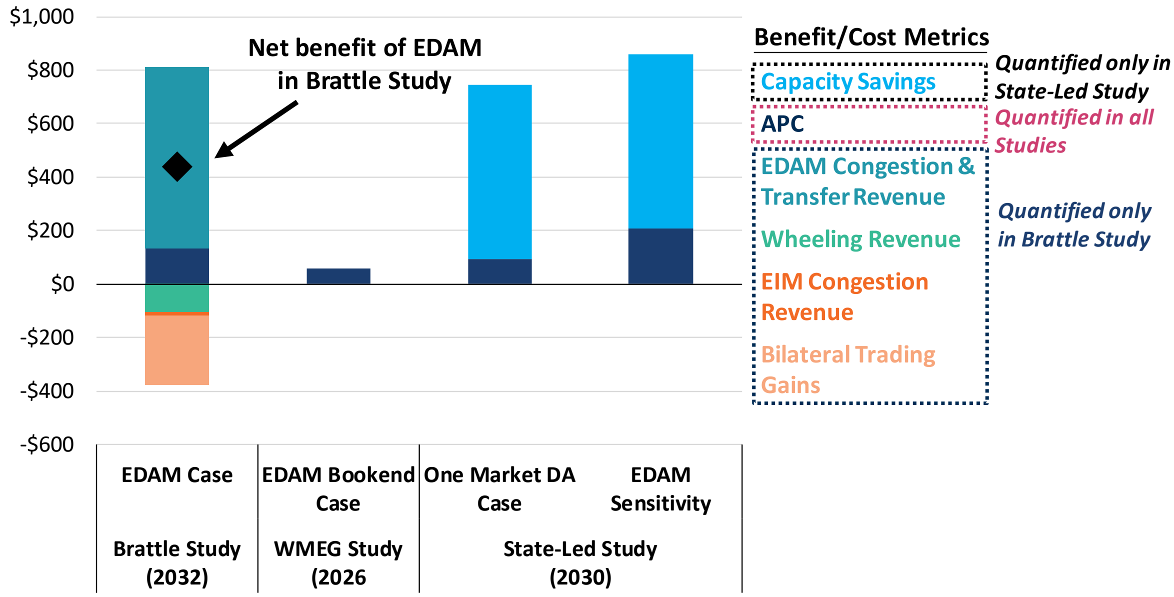
2 The State-Led Market Study, Technical Report, Energy Strategies, July 30, 2021, p. 40. Accessed here: https://static1.squarespace.com/static/59b97b188fd4d2645224448b/t/6148a012aa210300cbc4b863/1632149526416/Final+Roadmap+-+Technical+Report+210730.pdf

3 CAISO EDAM Benefits Study, Energy Strategies, November 4, 2022, p. 13. Accessed here: https://www.caiso.com/Documents/Presentation-CAISO-Extended-Day-Ahead-Market-Benefits-Study.pdf

FIGURE 2: COMPARISON OF BENEFIT METRICS FROM WECC MARKET BENEFIT STUDIES $MILLIONS)



The WMEG and State-Led studies found winners and losers from market participation.[4] In contrast, by quantifying impacts more completely, we find that EDAM participation provides a net benefit to each of the assumed participants, which is consistent with the experience in other regional markets in the U.S.—including the WEIM. In fact, no member of the WEIM has experienced a loss from joining the real-time imbalance market,[5] and our analysis projects a similar outcome for EDAM.

Nevertheless, the benefits calculated in our study are likely understated compared to the benefits customers can expect from EDAM participation. That is consistent with the experience in the WEIM, where estimated benefits prior to market implementation turned out to be smaller than the realized benefits once the market was operating.

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[4] In the EDAM Bookend case, the WMEG study found seven out of the 25 WMEG members experience an increase in APC due to joining the day-ahead market. See WMEG Cost Benefit Study, Energy and Environmental Economics, October 23, 2023, p. 12. The State-Led Market Study found that three of the eleven states analyzed experience an increase in APC due to the formation of a day-ahead market in the WECC. See The State-Led Market Study, Technical Report, Energy Strategies, July 30, 2021, p. 40.

[5] See WEIM benefits posted here: https://www.westerneim.com/Pages/About/QuarterlyBenefits.aspx

I. Study Framework and Motivation

The study participants engaged Brattle to conduct a study of customer impacts from joining the EDAM to inform their individual decisions on joining the market. To be useful in utility decision-making processes, the modeling effort simulated the specific EDAM design over a relatively small footprint consisting of only the study participants and the California Independent System Operator (CAISO), compared against a detailed simulation of the bilateral day-ahead market that exists in the Western Electricity Coordinating Council (WECC) today with the real-time Western Energy Imbalance Markets (WEIM).

A. Study Scope and Modeling Framework

The study utilizes the WECC-wide model developed for the 2019 EDAM Feasibility Study, with appropriate updates to reflect system changes since that time. As part of the 2019 study, our team worked for the then WEIM members.[6] At that time, the WEIM entities provided our team with data and information on various aspects of their resource plans, transmission systems, existing transmission contracts, load forecasts, fuel and operating costs, the flexibility (or inflexibility) of their hydro resources, and reviewed our modeling assumptions for accuracy. Our team worked with the WEIM entities to develop a detailed representation of the WECC power system, including the bilateral trading structure and Total Transmission Capability (TTC) between utilities, and other system characteristics that were deemed essential to correctly represent the existing bilateral market and the proposed EDAM.

For this study, we implemented several enhancements to the model developed for the 2019 EDAM feasibility analysis.

- **Day-ahead Forecast Error:** the current model accounts for the inaccuracies of day-ahead forecasted load and renewable production. As shown in Figure 4 below, the model simulates sequential decision cycles, where the first cycle optimizes day-ahead unit commitment decision and day-ahead bilateral or market trading, and later cycles optimize real-time dispatch decision, fast start commitment decisions, and real-time imbalance markets and BAA-balancing functions. The model inputs for renewable production and hourly load are different in the earlier cycles of that model than in the ultimately real-time

[6] The study participants in the 2019 EDAM Feasibility Study were Arizona Public Service, Avista, BANC, CAISO, Idaho Power, LADWP, Northwestern Energy, NV Energy, PacifiCorp, Public Service New Mexico, Portland General Electric, Powerex, Puget Sound Energy, Sacramento Municipal Utility District, Salt River Project, and Seattle City Light.

decision cycle, reflecting day-ahead forecasting errors. Modeled hourly renewable production and load in the day-ahead decision cycles vary from the modeled real-time renewable production and load based on historical forecast data, which was provided by the study participants for their Balancing Authority Areas (BAAs) and pulled from National Renewable Energy Laboratory (NREL) databases and CAISO data for the other BAAs. Therefore, the model optimizes day-ahead unit commitment decisions based on forecasted hourly renewable and load data but, in the final cycle the model, needs to balance updated load and renewable production when it optimizes imbalance markets and BAA real-time dispatch.

- **Weather and Gas Price Volatility:** for this study we updated the 2019 model to account for recent experiences in the WECC with cold snaps and heat waves. Because the standard WECC models used for these types of analyses reflect only weather-normalized load data and forward gas prices, we added more challenging market conditions during two weeks of the simulated year, with higher and more volatile load and natural gas prices. The first week is in February with higher levels and volatility of load and daily gas prices, concentrated in the Pacific Northwest, reflective of recent experiences with cold weather in that region. In that week higher load levels tend to occur during early morning hours, consistent with load patterns during winter cold snaps. The second week is in August with higher levels and volatility of load and gas prices, concentrated in the Southwest, reflective of recent experience with heat waves in that region of the WECC. In this week higher load occurs during afternoon and into evening hours, consistent with load patterns during summer heat waves.
- **Greenhouse Gas (GHG) Structure:** we updated the GHG structure that is applied to the WEIM in both the Status Quo and EDAM Cases, and implemented the GHG design proposed for the EDAM in that case. Many studies of the WECC, including the 2019 EDAM Feasibility Study, only apply a generic zonal representation of the GHG price programs that exist in California, Washington, and Canada. In many instances, this type of zonal approach to GHG modeling applies the same GHG cost to all imports into the GHG states, under-charging higher-emitting resources and over-charging lower-emitting resources. For this study, we implemented a resource-type specific GHG structure that aligns with the existing WEIM structure. Therefore, coal units pay a higher price for selling power into a GHG pricing state than gas units, which in turn pay a higher price than wind, solar, or hydro resources. The updated GHG structure more closely reflects actual GHG pricing in the WEIM and in the proposed EDAM design, and allows us to track the types of resources imported by the markets into the GHG pricing states.

- **New Transmission Infrastructure:** several new bulk transmission projects have moved into advanced development in recent years. The model was updated to include several new large transmission projects that are expected to be online by 2032 that were not included in the 2019 EDAM Feasibility Study, such as the Boardman to Hemingway line and the most recent Gateway projects. However, in the months since we finalized this study, several other large transmission projects have progressed in their development that were not included, such as the Southwest Intertie Project-North (SWIP-North), the SunZia project, and the TransWest Express Transmission Project.. Given that both of these projects will increase transfer capability between the EDAM member BAAs in this study, we anticipate their development will increase benefits beyond what we estimated in this study.
- **Updated Confidential Data from Study Participants:** we collected confidential data from each of the study participants to update how their system is represented in the model. This included load data, planned generation resource retirements and additions, load forecasts for 2032, renewable resource production, generation unit characteristics, forecast error between day-ahead and real-time, plant-specific fuel delivery costs, transmission upgrades, internal system constraints, transfer capabilities to neighboring BAAs, and existing transmission contracts (ETCs).
- **Updated Public Data:** we collected new data from public sources, including utility resource plans to update the generation resource mix and load forecasts for non-study participant BAAs in the model. The projected future resource mix had changed considerably since the 2019 EDAM Feasibility Study. Specifically, significant quantities of new renewable energy resources are planned to come online prior to 2032, and load forecasts have been updated to reflect faster growth and changing demand patterns. We updated transmission path ratings based on the latest WECC Path Rating Catalog and collected new fuel price forecasts to update the model, including plant-specific fuel prices and delivery charges where available.

We simulated 2032 as a representative year for WECC-wide system conditions during the first decade of EDAM operations. By simulating 2032, which is within the typical planning horizon for utilities, we have certainty on the major planned plant retirements and additions, as well as transmission expansion plans.

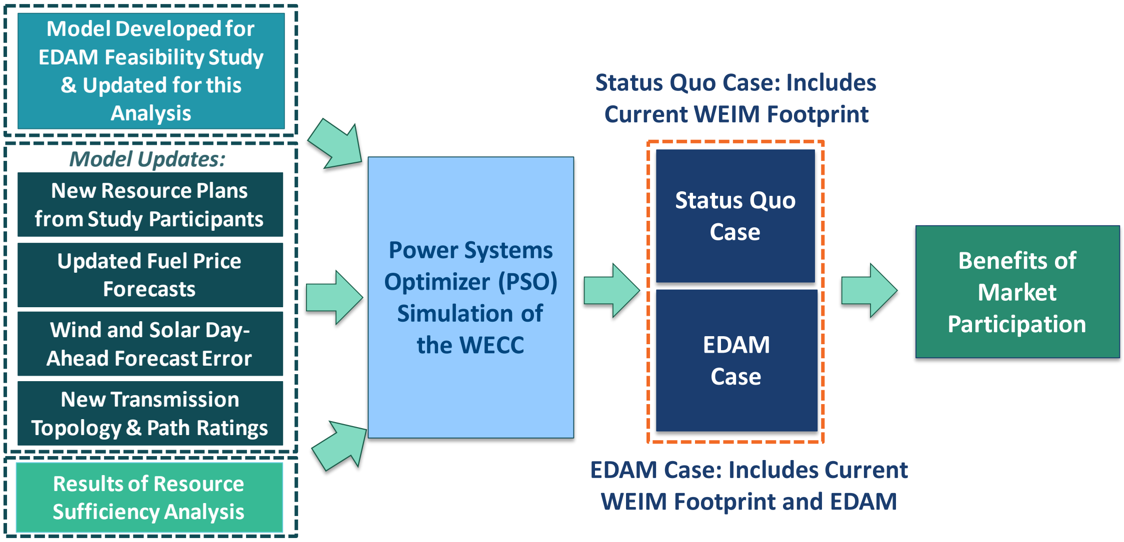
Figure 3 illustrates the study scope and framework. We use the Power System Optimizer (PSO) simulation model, which we license from Enelytix. This is the same simulation tool used in the EDAM Feasibility Study. PSO is a next generation nodal production cost model that includes multiple features that allow us to model nodal wholesale power market operations, power flows subject to physical transmission constraints (e.g., WECC path ratings), bilateral contract-path trading, long-term transmission contracts, contract-path transmission constraints, environmental policies, and hydro flexibility (or inflexibility).

The nodal structure of PSO, compared with zonal models often used for market studies, allows us to simulate power flows and transmission constraints on both actual lines and contract paths and the resulting locational prices for every generation resource and load bus in the WEIM, consistent with how the market currently operates. Pricing and settlement in the EDAM will also operate based on locational pricing. In contrast to a zonal representation, the nodal simulations also capture BAA-internal transmission constraints. Moreover, the nodal simulations capture the *interdependency* of transmission constraints. For example, scheduled power transfers from Arizona to California may create parallel power flows through Nevada utilizing some of the transmission capacity available for transfers into, through, or out of Nevada. This interdependency is captured in a nodal model with a complete representation of the underlying physical transmission topology, such as the model used in this study, but would be missed by zonal models, which approximate transmission topology through a "pipes-and-bubbles" representation.

By capturing internal constraints and the interdependency of transmission paths, a nodal model better represents the actual use of transmission capacity across the system and produces a dispatch solution, including renewable curtailments, more closely aligned with real-world markets (which are also solved on a nodal basis). As a result, the prices from a nodal model will better align with expected future market prices for generation resources and loads, which results in a more accurate APC metric and improved estimates of market congestion and transfer revenues.

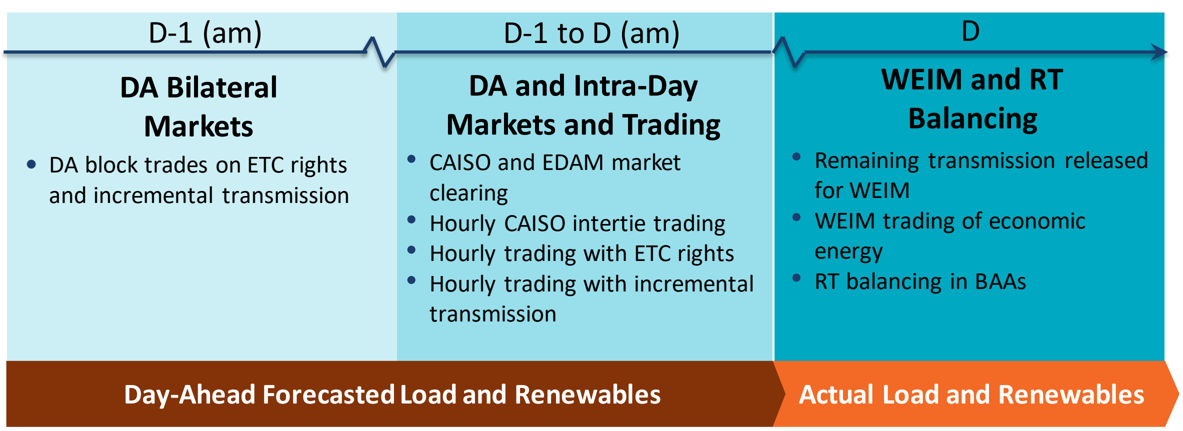
As shown in Figure 3, we began with the model developed for the EDAM Feasibility Study and updated it with new information from the study participants and publicly available resources plans. We simulate two cases, the Status Quo Case that includes the existing bilateral trading structure and WEIM footprint, and the EDAM Case that is identical to the Status Quo Case except it includes the implementation of the EDAM for the BAAs we assume are members. The results of the two cases are compared to calculate the benefit metrics of EDAM participation.

FIGURE 3: STUDY FRAMEWORK



The model includes sequential decision cycles that allow us to simulate market operations and trading at different timeframes approaching real-time. The decision cycles simulated in the model are shown in Figure 4. The first decision cycle optimizes day-ahead unit commitment decisions, allowing for bilateral block trading at the major hubs in the WECC. The second cycle optimizes day-ahead and intra-day economic dispatch decisions, the CAISO day-ahead market, and additional bilateral trading between non-market BAAs. In the EDAM Case, both of these initial decision cycles allow for centrally optimized unit commitment and dispatch across the EDAM footprint. The third and final decision cycle simulates the WEIM and real-time balancing operations within the BAAs.

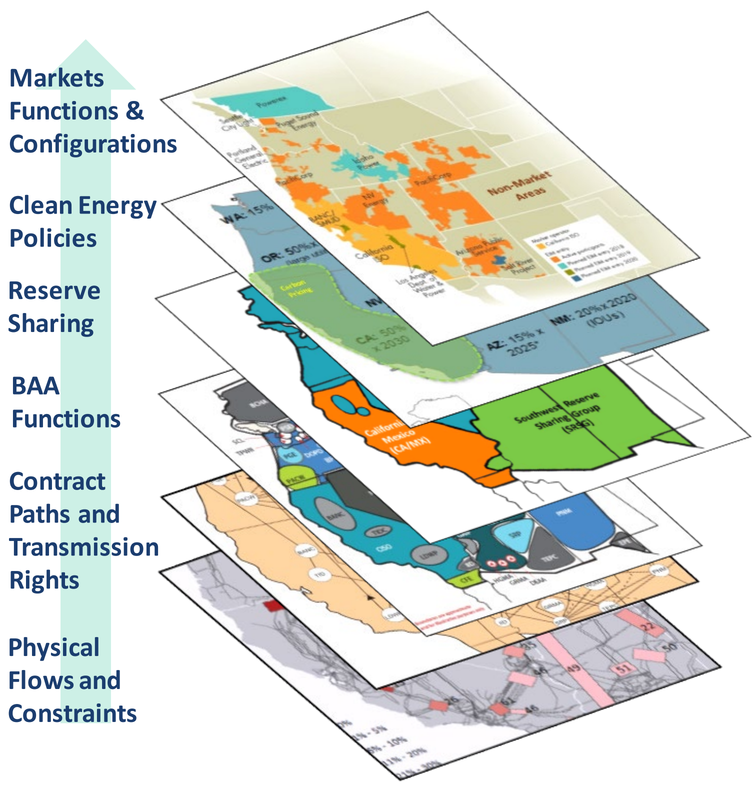
FIGURE 4: SIMULATED DECISION CYCLES



To capture the interactions between day-ahead and real-time market conditions, the simulations reflect the renewable generation and load uncertainty that exists on a day-ahead basis. The model optimizes day-ahead unit commitment and dispatch (the first two decision cycles in Figure 4) based on forecasted load and renewable generation. For the final decision cycle, the model optimizes the WEIM operations and real-time balancing based on an updated view of load and renewables that reflects historical forecasting error. The day-ahead load and renewable forecast error is reflected in both the Status Quo and EDAM Cases to capture the unexpected deviations in load and renewable production that need to be addressed by the WEIM and the balancing areas even in the presence of the EDAM.

The functionality of PSO allows us to simulate the operational and policy complexities of the WECC. PSO is a nodal production cost simulation model that includes the full transmission topology of the WECC, including roughly 20,000 buses, 25,000 transmission assets, over 5,000 generation resources, and the physical transmission limits reflected in the WECC Path Rating Catalog. In addition to representing the physical system in WECC, the model includes a representation of the contract rights that allows us to model the ETCs owned by each study participant and WEIM member. As shown in Figure 5, the model also reflects balancing requirements in all WECC BAAs, clean energy policies in the relevant jurisdictions, reserve sharing groups where applicable, and the existing wholesale market structures in the WECC. The layered model structure allows us to implement changes in a specific area or functionality without disrupting the structure in other areas (e.g., implementing GHG trading structure without altering BAA-level balancing or reserve sharing).

FIGURE 5: MULTI-FUNCTIONAL STRUCTURE IN PSO



B. Study Motivation and Approach

The study participants wanted an estimate of customer impacts for joining the EDAM to inform their internal decision-making processes. To achieve that objective, the analysis conducted in this study was tailored in several ways to provide meaningful and useful results:

- The model simulates the actual EDAM design (including its greenhouse gas framework), based on the tariff language that will govern the market's operations.
- The study assumes membership in the EDAM for 2032, consistent with a feasible market footprint at the time the market goes live.
- The analysis does not conflate EDAM benefits with benefits from membership in the WEIM that customers of the study participant utilities already experience today, measuring only the additional net benefits of joining the EDAM.
- The simulations of bilateral markets used as a comparison against the EDAM captures the existing ability of study participants to trade economic energy in the WECC. To do so, the simulations include both a contract-path representation of the WECC (to define existing transmission rights and constraints on bilateral trades) and a complete nodal representation of the western grid (with physical transmission constraints such as the WECC-defined paths and security-constrained unit commitment and dispatch). The contract path representation of the EDAM was informed by the study participants, and the Brattle team worked hand-in-hand with subject-matter experts within each study participant organization—and additional input received from CAISO staff—to ensure long-term transmission rights and transfer capabilities of EDAM members were accurately reflected in the model.

EDAM Design

To ensure that our modeling effort closely reflected the specific EDAM design and market rules, our team followed the CAISO-administered stakeholder process setup to design the EDAM. That stakeholder process ran through 2022 and into 2023, resulting in the tariff language filed with FERC in August 2023.[7] During that time, our team met with CAISO staff to ensure our understanding of the proposed market design was correct. Considerable time was taken to reflect the proposed market design in the study, including the use of transmission in the market, the imbalance reserve product (developed as part of CAISO's Day-Ahead Market

[7] FERC approved the market design for the EDAM (see *California Independent System Operator Corporation*, 185 FERC ¶ 61,210 (2023)). The details of the TRR settlement process will be finalized in a subsequent FERC order.

Enhancement (DAME) initiative that ran concurrent with the EDAM design process), the Resource Sufficiency Test, and the EDAM Greenhouse Gas (GHG) design.

In particular, we spent considerable time implementing the EDAM GHG structure in the model, as it directly affects the trading that can happen within the EDAM between member BAAs located in California or Washington and non-California/Washington members, and the ultimate benefits from market participation. The EDAM GHG structure imposes resource-specific GHG costs on any sale of power from an emitting resource outside the GHG region into the GHG region.[8] However, non-emitting resources outside the GHG region can sell into the GHG region without incurring any GHG costs, while the market would impose a GHG cost on thermal resources based on their emissions rate if it wanted to dispatch those resources to sell into the GHG region.

The specific EDAM GHG design includes the "GHG Reference Pass" that is used to establish constraints on how much power can be sold from resources outside the GHG region to loads located inside the GHG region (GHG Attributions).[9] The GHG Reference Pass simulates market clearing in the EDAM while excluding trades into the GHG region from resources outside the GHG region, to establish a baseline level of generation for all resources in the market that will constrain GHG Attributions in the final market clearing. We simulated the GHG Reference Pass as described in the EDAM design, and used the results to construct the constraints on GHG Attributions in our EDAM simulation.

The EDAM GHG structure includes two constraints on GHG Attributions. First, the GHG Attribution for each individual resource outside the GHG region is limited to the minimum of the capacity bid to sell into the GHG region by the resource, the resource's upper economic limit less the GHG Reference Pass output of the resource, the resource's final dispatch in EDAM, and must be non-negative. Second, the total GHG Attribution for all resources in a BAA outside the GHG region cannot exceed the net total transfer capability (TTC) of the BAA less the BAA's net exports in the GHG Reference Pass. We reflect both of these constraints in our simulation of the EDAM.

We made one simplification of the GHG structure to improve the tractability of our model. Instead of imposing the GHG structure on a resource-specific basis, we grouped resources that have similar emissions rates together. For example, coal units in BAAs outside the GHG region

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[8] Resources internal to the GHG region have their specific GHG costs embedded in their dispatch cost.

[9] The GHG region in the EDAM is assumed to include all of California (the BANC, CAISO, and LADWP BAAs) and the portion of the PacifiCorp West (PACW) BAA in Washington.

are grouped together and charged the same GHG cost (based on the average emissions rate of coal units in that BAA) to sell into the GHG region. The groupings we used are for coal units, gas-fired combined-cycle units, gas-fired peakers, non-emitting resources, and a final grouping that captures all other resources in the BAA.

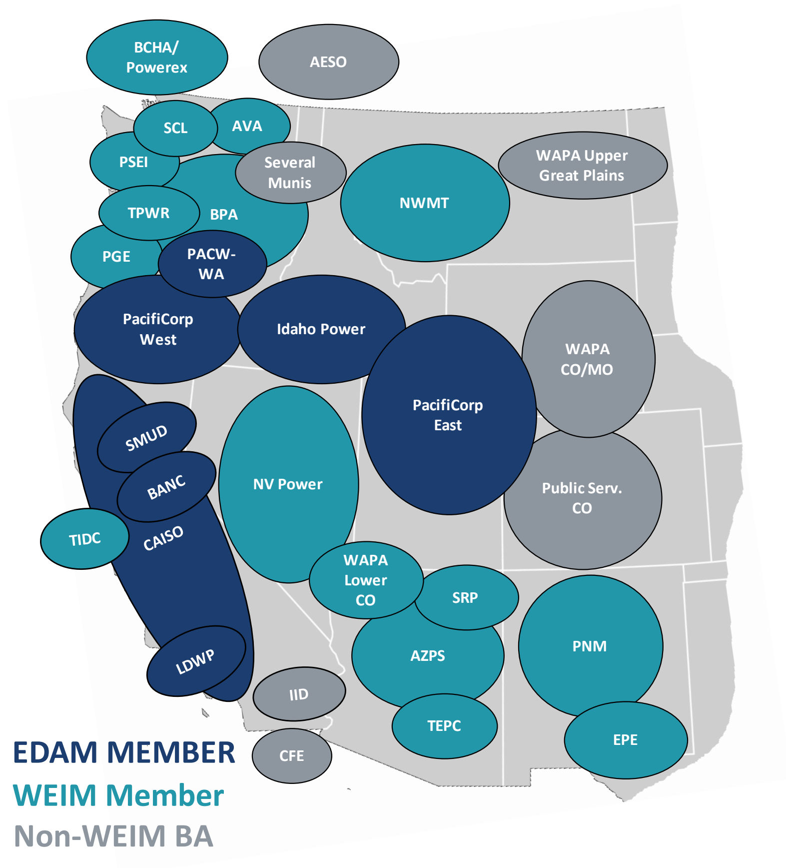
Lastly, we assumed the Washington and California GHG pricing programs would be linked by 2032. Therefore, each state charges the same price for GHG emissions and trading between the GHG states does not incur any GHG cost. This impacts the PACW BAA in the EDAM, and several BAAs in the WEIM. We account for certain BAAs that receive special treatment under the existing GHG pricing programs in the WECC, such as the Asset Controlling Suppliers under the California program.

Market Footprint

The study assumes a relatively small group of utilities are members of the EDAM by 2032. While the model includes the entire WECC and WEIM footprint, the limited EDAM participation assumed in the study implies that the benefit calculations are more aligned with what customers can expect during the initial years of market participation.

Figure 6 shows the market participation simulated in the study. In the Status Quo Case, we simulated the current or announced market participation plans at the time of the study (early 2023) for all BAAs in the WECC. The Status Quo Case includes all members of the WEIM, which are shown in teal and blue in Figure 6. In the EDAM Case, only the study participant BAAs (BANC, Idaho Power, LADWP, and PacifiCorp East (PACE) and PacifiCorp West (PACW)) and CAISO are assumed to join the EDAM, as is shown in blue in Figure 6. In the EDAM Case, the WEIM members that are not modeled as part of the EDAM remain in the WEIM. We do not model any other day-ahead markets in the WECC.

FIGURE 6: MARKET FOOTPRINTS IN THE EDAM CASE



We made two modifications to the BAA structure. First, the load buses and generation resources in the PACW BAA that are physically located in Washington were modeled separately from the rest of the PACW BAA so that it could be included in the GHG region. Second, the BANC BAA was split into two areas in the model, one for SMUD and one for the remainder of the BANC BAA. This was a request by study participants to allow for SMUD's benefit metrics to be easily calculated independent of the rest of the BANC.

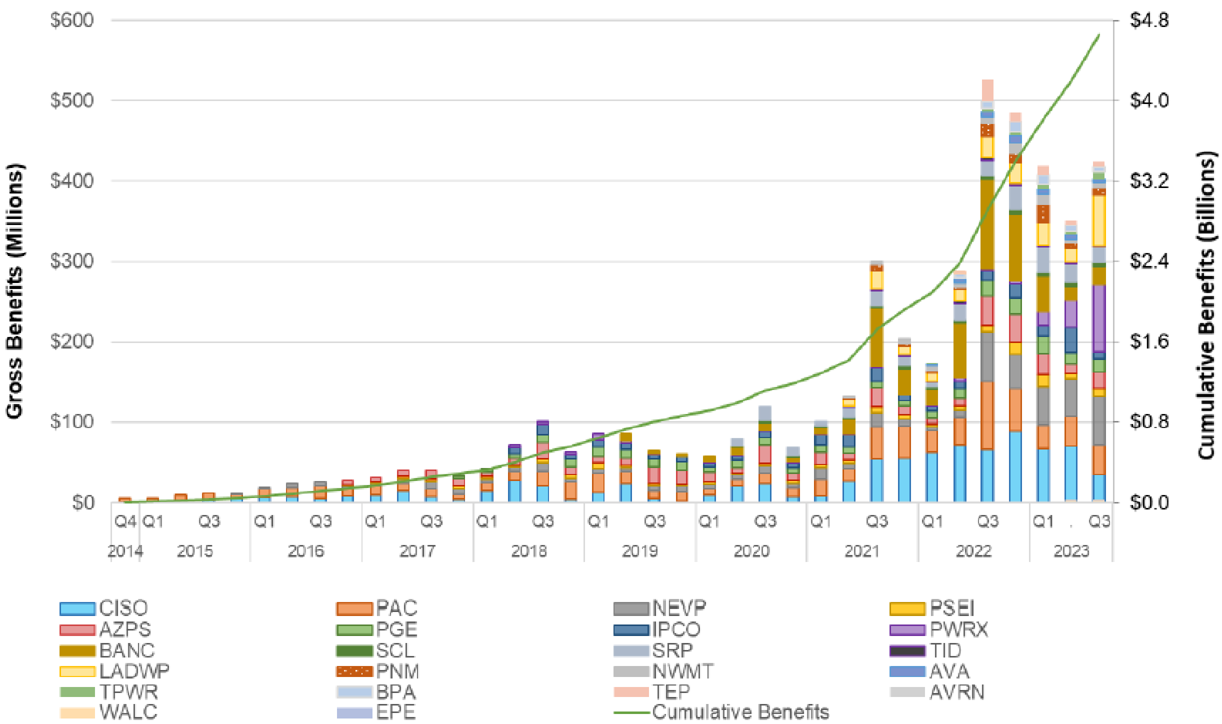
As illustrated in Figure 6, the assumed EDAM footprint is relatively limited compared to current participation in the WEIM. As a result, the amount of transmission capacity available to the market is similarly limited compared to what is potentially available for use in the WEIM, and the benefit estimates are conservative relative to other recent studies that have assumed the entire WECC joins the market. We expect benefits would increase if we assumed more BAAs joined the EDAM, as more transmission, generation resources, and load in the market is likely to lead to more market transactions, production cost savings, and congestion and trading revenues.

Accounting for Benefits of WEIM Participation

The study participants wanted to ensure that we captured the ***incremental*** benefits of joining EDAM above the benefits customers already experience from participation in the WEIM. Therefore, the results of the study would be useful to inform the specific market membership decision facing each participant (i.e., to join the EDAM or remain only in the WEIM).

Figure 7 shows the benefits from the WEIM accruing to customers in each quarter since the market went live in 2014, broken out by BAA. The figure shows that the five WEIM members assumed to join EDAM in this study have together seen benefits of over $200 million per quarter over the last year due to their WEIM participation. The figure also shows the cumulative benefits customers have received from WEIM participation across all members since the beginning of the market, which reached nearly $4.7 billion in the third quarter of 2023.

FIGURE 7: REALIZED BENEFITS FROM WESTERN WEIM PARTICIPATION



To ensure that our study does not conflate the realized benefits of WEIM participation with the benefits of joining EDAM, we simulate the operation of the WEIM in our Status Quo Case with all current and planned members. The model simulates the hurdle-free usage of available transmission capability between all WEIM members in the real-time decision cycle, which replicates the real-time footprint-wide system dispatch optimization that takes place in the WEIM today.

The assumed transmission capability between WEIM members comes from various sources, including data provided by the study participants, the information received from study participants in the original EDAM Feasibility Study, and the CAISO quarterly WEIM benefits reports that include information on transfer capability between members. The model applies a constraint across decisions cycles, to limit the transmission available in the real-time cycle for the WEIM based on how much is utilized in previous cycles for day-ahead and intra-day trading. The modeled representation of the WEIM also includes the existing GHG structure applied in the WEIM, which limits trading into California, Washington, and Canada[10] from other jurisdictions in the WEIM. The WEIM GHG structure is similar to the structure applied in the simulation of the EDAM, except there is no GHG Reference Pass. Instead, the baseline level of dispatch for all resource-types in the WEIM comes from the final dispatch level in the model's day-ahead decision cycle.

The results of the Status Quo Case, with this detailed representation of the WEIM, is compared to the results of the EDAM Case to calculate the benefit metrics for participating in the EDAM. Therefore, the benefit metrics calculated for EDAM participation are incremental to the efficiency gains and benefits achieved through the WEIM.

Representation of Bilateral Markets

To provide an accurate comparison with EDAM participation, the Status Quo Case not only simulates the operation of the WEIM but seeks to accurately represent the bilateral trading opportunities that exist in the WECC today. Utilities have significant opportunity to engage in day-ahead and intra-day power trading throughout the WECC at the various liquid trading hubs, directly with other utilities, and/or at CAISO interties. Utilities also engage in long-term power trading under power purchase agreements covering longer time horizons. Long-term power trading and transmission service contracts that exist today are assumed to remain in place after EDAM implementation. We worked with the study participants to account for these long-term contracts, and ensure that the Total Transmission Capability (TTC) available for use the WEIM

[10] For purposes of this study, we assume that the California and Washington GHG programs are linked by 2032. That implies that the same GHG price is applied in both jurisdictions and trading between CA and WA entities can take place without additional GHG charges. To be consistent across market structures this assumption applies in our representation of the WEIM and the EDAM.

and EDAM reflects any long-term contractual obligations that are likely to be in place in 2032 that will encumber the use of that TTC.

The appropriate comparison to EDAM participation has to take into account the benefits accrued to customers through the existing bilateral trading structure in the WECC, which we represent in our Status Quo Case. In the EDAM Case, the bilateral trading structure is replaced by centralized unit commitment and dispatch across the EDAM footprint. However, the bilateral trading structure continues to exist in the EDAM Case for the entities that are not part of the assumed EDAM footprint and at the EDAM seam.[11]

The accurate representation of the bilateral trading structure in the model is achieved in multiple ways. First, through a detailed representation of the transmission rights that each utility controls, which allow them to execute bilateral trades using their own transmission assets and beyond their own transmission systems through the WECC. Second, by representing the several different trade types available to utilities in the WECC, available at different trading locations (e.g., at major hubs, at interconnection points with neighboring systems, at CAISO intertie points) and available at different timeframes (e.g., day-ahead, intra-day, and real-time). Lastly, by applying hurdle rates to account for the appropriate transmission wheeling fees, scheduling and administration costs, and trading margins needed to execute bilateral trades, which can vary by location, transmission used for the trade, timeframe, and trade type. The assumptions on hurdle rates applied to each type of trades were originally developed for the 2019 EDAM Feasibility Study, with input from all the study participants in that effort, which included the power marketing teams in those organizations. The Brattle team worked with all sixteen organizations represented in the 2019 study (see Footnote 6) to determine reasonable levels of trading margins required by buyers and seller to execute various types of bilateral trades in the WECC.

The modeling assumptions on the transmission rights and capacity were originally developed as part of the EDAM Feasibility Study, based on data and information provided by all the study participants in that effort. At that time, our team collected data on the TTC that exists between each BAA in the model, as well as the Existing Transmission Contract (ETC) rights controlled by each study participant in the 2019 EDAM Feasibility Study. ETC rights, if available, allow their owners to execute bilateral trades without paying a wheeling fee, which is reflected in our bilateral trading structure.

[11] The proposed EDAM design and the existing WEIM rule allow market participants to enable economic bidding at the seam of the market. However, to date, the only WEIM entity that has enabled economic bidding is the CAISO. In this study we assume that continue to be the case in the WEIM in 2032 and is also the case in EDAM.

The model used in the current study included all the data on TTC and ETC rights from the EDAM Feasibility Study, which were updated based on information provided by the current study participants. The study participants indicated that they plan to make all their transmission capacity available for use in the EDAM without a usage fee, which is allowed for under the EDAM design. Therefore, we model all TTC between EDAM member BAAs as available for EDAM transactions. Our team also met with CAISO staff to gather information on the TTC available between CAISO and its neighboring entities.

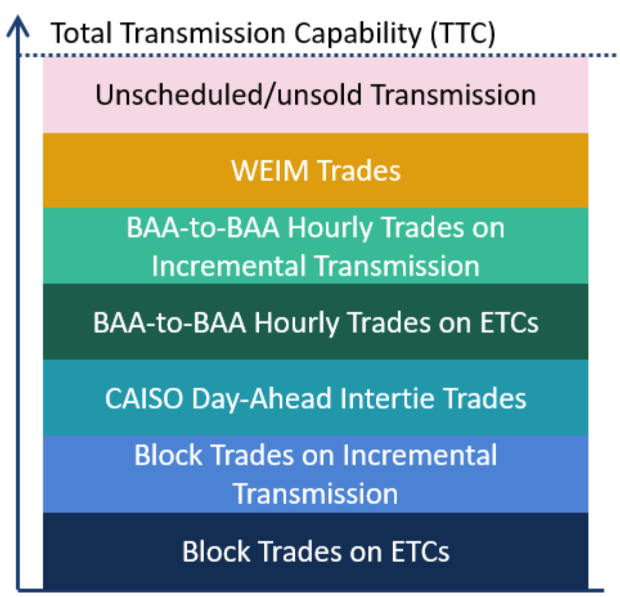
To capture the various bilateral trading opportunities in the WECC, we modeled the following trade types.

- **Peak and Off-Peak Block Trades:** are available for entities that have rights to the major trading hubs (Palo Verde, Mid-C, Malin, NOB, and Mead). Block trades have a relatively low hurdle rate of $1.5/MWh (before wheeling fees, if applicable, are assessed), reflecting the high liquidity at the major trading hubs. For block trades, the model forces buyers and sellers to transact the same amount of power in each hour over the entire peak or off-peak period in the trading day. Therefore, although block trades have a relatively low hurdle rate, they are restricted by the requirement that purchases/sales must be for the entire duration of the peak/off peak period. Block trades occur in the first decision cycle in our model, simultaneous with unit commitment decisions for long-lead time resources. Once the model executes block trades in that decision cycle, they are locked in for subsequent decision cycles and the transmission capacity used for block trades is unavailable for subsequent trade types. Block trades can be executed using ETC rights to the trading hub, in which case there is no wheeling cost assessed on the trade or using incremental transmission to the hubs (if available) with the applicable wheeling cost.
- **Hourly Trades:** are available between two BAAs or at the major trading hubs, as long as there is transmission capability available to execute the trades. They are assessed a higher hurdle rate than block trades to reflect lower liquidity for hourly bilateral trades compared to block trades but can be executed for as little as one hour. Hourly trades can be reflected in the unit commitment cycle of the model with a hurdle rate of $8/MWh or during the day-ahead/intraday economic dispatch decision cycle with a hurdle rate of $4/ MWh. Once hourly trades are executed in either cycle, they are locked in for subsequent cycles and any transmission capability used to execute the trades is unavailable for trading in subsequent cycles. Hourly trades can also be executed using ETC rights from the selling BAA to the buying BAA in which case there is no wheeling cost assessed on the trade, or by using incremental transmission with the applicable wheeling cost.

- **CAISO Intertie Trades:** are available for BAAs that have TTC into the CAISO day-ahead market. Intertie trades are assessed a lower hurdle rate of only $1.5/MWh. The lower hurdle rate reflects the liquidity of the CAISO day-market and the ability to submit economic import and export bids into the market at the seam, which significantly reduces barriers to trading at the CAISO seam. CAISO intertie trades are available in the day-ahead/intraday economic dispatch decision cycle and are locked in for subsequent cycles. Transmission capacity used to execute CAISO intertie trades is not available for trading in later cycles. CAISO intertie trades can be executed using ETC rights from the selling BAA into CAISO, in which case there is no wheeling cost assessed on the trade. If ETC rights are not available, CAISO intertie trades can be executed using incremental transmission capacity with the applicable wheeling cost.

After the execution of all types of bilateral trades, the model can use any remaining transmission capability between WEIM members to execute WEIM trades in the final real-time decision cycle of the model. WEIM trades are hurdle free and do not incur wheeling costs. Figure 8 lists the different trade types in the Status Quo Case. The figure illustrates how the various trade types utilize the TTC, starting with block trades executed in the earliest decision cycle of the model, through WEIM trades executed in the final real-time decision cycle that are limited to the available transmission capacity remaining after all the other trade types have been executed.

FIGURE 8: TRADE TYPES MODELED IN THE BILATERAL DAY-AHEAD MARKET AND WEIM



In the EDAM Case, the same trade types are available but a new trade type, EDAM trades, is available between BAAs in the EDAM that are connected with TTC. EDAM trades are not assessed any hurdle rate or wheeling charge and can be executed in the day-ahead unit commitment and economic dispatch cycles of the model. EDAM trades utilize the full physical capability of the grid, with security-constrained optimization and nodal generation prices. Where EDAM transmission capabilities are provided by contract path rights, the sum of all trades cannot exceed the TTC on those contract paths. To the extent that the EDAM is utilizing available transmission capabilities (physically or contractually), doing so will reduce the amount of transmission capability available for WEIM trades.

II. EDAM Participation Benefits

The study finds $438 million of customer benefits due to EDAM participation for the six BAAs in the analyzed market footprint. As shown in Figure 9, we found over $800 million in gross benefits. However, we assess potential losses from market participation, such as lost wheeling revenue from allowing the market to utilize transmission assets without a cost and lost profits from bilateral trading activity that is lost due to market participation.

FIGURE 9: BENEFITS OF EDAM PARTICIPATION ($MILLIONS)

Benefit Metric	Study Participants	CAISO	Total EDAM
EDAM Benefits			
Adjusted Production Cost Savings	$99	$36	$134
EDAM Congestion Revenues	$186	$83	$269
EDAM Transfer Revenues	$324	$85	$409
Total EDAM Benefits	**$609**	**$204**	**$813**
Other EDAM Related Impacts			
Impact on Wheeling Revenues *[1]*	$14	-$117	-$103
Impact on WEIM Congestion Revenues	-$31	$15	-$16
Reduced Bilateral Trading Profits *[2]*	-$207	-$49	-$256
Net EDAM Benefits	**$385**	**$53**	**$438**

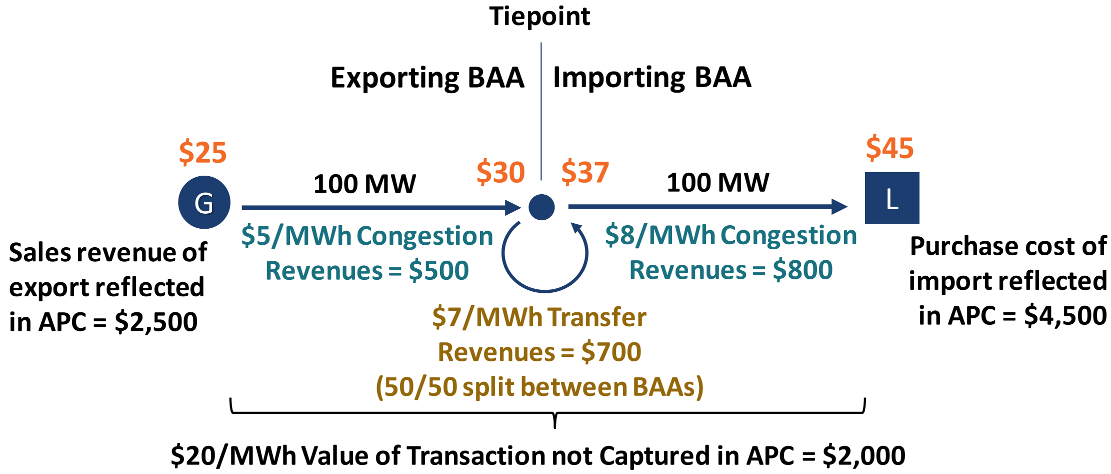
Notes: [1]: Impact on wheeling revenue includes only short-term non-firm wheeling revenues. The TRR Settlement process in the EDAM tariff provides EDAM transmission service providers a rebate for lost short-term wheeling revenue. [2]: Reduced bilateral trading profits is the value of exports and imports from EDAM member BAAs, including thirty-party marketers.

We calculate the following benefit metrics, which represent savings (or costs) to customers due to EDAM participation.

- **Adjusted Production Cost (APC):** captures three potential customer savings from market participation. First, lower fuel and operating costs for resources in the EDAM footprint, including startup costs, emissions costs, and other variable costs of generation. Second, reduced purchased power costs. Third, higher revenue from market sales. A reduction in APC demonstrates how the EDAM utilizes the lowest-cost resources possible to serve load by transferring power from areas of low-cost production to areas of higher prices. This will reward the owners of low-cost generation resources with increased revenue from market sales that are passed on to customers, and reward customers in higher-priced areas of the market with reduce purchased power costs and lower fuel and operating costs.
- **EDAM Congestion and Transfer Revenues:** are collected by the EDAM market administrator (CAISO) and allocated back to market members as specified in the EDAM design. In the market, generators are paid the price at their location, which is accounted for in the APC calculation as revenue from market sales. Similarly, load pays the price at its location, also accounted for in the APC metric as the cost of purchased power. However, due to congestion on the system when trading between member BAAs, the locational price paid by load in most instances is higher than the locational price paid to generators. Therefore, on EDAM transactions between member BAAs, the money collected from load is typically greater than the money paid out to generators. The EDAM design mandates that this additional money be allocated back to member BAAs. The same process is in place today in the WEIM, and WEIM members currently receive allocations of congestion revenues collected in the market.

  Figure 10 shows an example EDAM transaction between two member BAAs, and illustrates how the Congestion Revenues and Transfer Revenues account for different market revenues than the APC metric.

FIGURE 10: EXAMPLE OF CONGESTION AND TRANSFER REVENUES



The example in Figure 10 shows an example EDAM transaction between two member BAAs, and illustrates how the Congestion Revenues and Transfer Revenues account for different market revenues than the APC metric.

Figure 10 shows two EDAM member BAAs with a market transaction between them of 100 MW. The exporting BAA has a generator price of $25/MWh and the importing BAA has a load price of $45/MWh. Generators in the exporting BAA are paid $25/MWh for their production, which is captured in the APC metric. Similarly, load in the importing BAA pays $45/MWh for the power, which is also captured in the APC metric. For this market transaction the market administrator (CAISO) would collect $45/MWh ($4,500) from load in the importing BAA, but would only pay $25/MWh ($2,500) to generators in the exporting BAA. After settlement with load and generators there is an additional $20/MWh ($2,000) left to allocate to market participants.

- To ensure that we allocate congestion revenues to the appropriate EDAM member BAA, we determine the congestion revenue on three segments of the path between generators in the exporting BAA to load in the importing BAA. First, there is physical congestion between generators in the exporting BAA and the intertie point with the importing BAA. In the example in Figure 10 the generator price in the exporting BAA is $25/MWh and the price on the exporting BAA's side of the intertie point is $30/MWh. This means there are $5/MWh ($500) of congestion revenues located entirely within the exporting BAA. This $500 of revenue is included in the EDAM Congestion Revenue metric for the exporting BAA. Second, there is a price different on the intertie between the BAAs, causing the price on the exporting BAA's side to be $30/MWh and the price on the importing BAA's side to be $37/MWh. This means there are $7/MWh ($700) of transfer revenues at the intertie, which is split 50/50 and included in the EDAM Transfer Revenue metric for both BAAs. Third, there is physical congestion between the intertie point and load in the importing BAA. The price at the importing BAA's side of the intertie is $37/MWh and the price load pays is $45/MWh. There are $8/MWh ($800) of congestion entirely between the transfer point on the intertie and load within the importing BAA, which is included in the EDAM Congestion Revenue metric for the importing BAA. Overall, of the $2,000 of congestion and transfer revenues collected by the market in the example, the exporting BAA is allocated $850 ($500 Congestion Revenue plus $350 Transfer Revenue) and the importing BAA is allocated $1,150 ($800 Congestion Revenue plus $350 Transfer Revenue).

- **Wheeling Revenues**: EDAM members tend to collect less wheeling revenue compared to the Status Quo Case because all EDAM participants allow their transmission to be used in the market absent the normal wheeling fee. Therefore, EDAM members are likely to sell less short-term transmission service as a result of being in the market, and collect less wheeling revenue.
- **WEIM Congestion Revenues**: members of the WEIM receive congestion revenues that are collected by CAISO and allocated to members. In both the Status Quo Case and the EDAM Case, we calculate WEIM congestion revenues and allocate them to all member BAAs in the WEIM. However, in the EDAM Case for the EDAM member BAAs, we see a slight reduction in the amount of congestion revenue collected from the WEIM because the implementation of the EDAM reduces the amount of economic markets transactions in the WEIM.
- **Bilateral Trading Profits:** the last line item in Figure 9 shows the lost profits from day-ahead bilateral trading due to EDAM participation. In joining the EDAM, some of the members bilateral trades are replaced by EDAM trades. EDAM members will continue to trade bilaterally, particularly with non-EDAM members or with EDAM members prior to when the market clears. However, the volume of bilateral trading is likely to decrease with EDAM membership. This bilateral trading profit metric includes all types of bilateral trades discussed in the previous section, including CAISO intertie trades, block trades at the major hubs, and BAA-to-BAA hourly trades. It represents an offsetting reduction in revenues for EDAM members, as profitable bilateral trades will be now be executed within the EDAM. Some of this loss may be borne by third-party power marketers. If third parties are currently using short-term transmission service from EDAM members to executive bilateral transactions those trading opportunities may displaced by EDAM after the day-ahead market is implemented.

We also calculated the **Transmission Revenue Recovery (TRR) settlement** amount for each study participant and CAISO, which reflects the process outlined in the EDAM design to compensate members for lost wheeling revenues. The process calls for transferring revenue between members based on their relative net loss of wheeling revenue due to EDAM participation. Figure 9 does not show this result, because on a footprint-wide basis the settlement mechanism sums to zero. However, we calculated the settlement for each study participant and provided that on a confidential basis to each company.

This study did not look at the **administrative charges** each EDAM member will need to pay to operate the market. Rather, each study participant accounted for these costs, as well as any additional company-specific costs associated with market participation (if any), in their own decision-making process.

The benefits estimated in this study are likely conservative and understate the customer savings due to EDAM participation. This is consistent with the experience in the WEIM, where simulated ex-ante estimates of customer benefits were lower than the ex-post savings realized after market implementation.

There are several reasons our simulated results tend to understate realized savings.

- The assumed EDAM footprint (consisting only of the study participants and CAISO) is relatively small, which limits the scale of EDAM benefits. The experience with the WEIM demonstrates that, as more entities join the market, benefits tend to grow for both new and existing members. We expect the same will be the case for EDAM as its footprint grows over time.
- The simulated Status Quo is more efficient than the actual status quo in the WECC. This is because our Status Quo simulation assumes that each BAA utilizes a Security Constrained Unit Commitment (SCUC) and Security Constrained Economic Dispatch (SCED) to fully optimize the operation of their generation resources subject to system constraints. However, that is not the case for most BAAs, making the simulated commitment and dispatch solution more optimal than what is currently achieved. The EDAM will fully optimize the use of generation resources in the EDAM footprint using a system-wide SCUC and SCED. Therefore, comparing the solution of our Status Quo Case to the EDAM Case understates the efficiency gains from implementing the EDAM.
- Inefficient utilization of transmission due to bilateral scheduling inefficiency and the inefficient re-sale of transmission rights are not fully modeled in our Status Quo Case, leading to an understatement of the benefits from pooling and fully utilizing transmission assets in the EDAM.
- Transmission outages are not modeled in our simulation. This will understate the value of the EDAM because a market-based optimization is better than bilateral markets at finding

lower-cost solutions when faced with unexpected events or more severe transmission constraints on the system.

- The simulations mostly rely on weather-normalized loads and simple averages for projected monthly natural gas prices and geographic price differences (“basis differentials”). Except for two weeks in the simulated year that reflect heat wave and cold snap conditions, the model does not reflect actual geographic variations in loads and gas prices. Incorporating more variation in the model will tend to increase estimated customer savings, as the market optimization can better utilize low-cost resources in one part of the footprint to serve unexpectedly high loads or avoid higher gas prices in another part of the footprint. Tight market conditions, characterized by unexpectedly high load and natural gas prices, tend to be the periods when bilateral markets perform poorly and experience reduced liquidity—a real-world inefficiency not captured in our Status Quo simulations.
- We have not quantified the extent to which the EDAM may reduce investment costs associated with lower operating reserve requirements. Participation in the EDAM allows member BAAs to meet reliability needs with fewer operating reserves, which reduces the amount of capacity needed by each member utility. Over the long term, customers are likely to see savings in the form of lower generation investment costs
- We assume EDAM participants will not enable economic intertie bidding for their BAAs (except for CAISO where intertie bidding is already in effect). This assumption is consistent with realized practice in the WEIM, where only CAISO has enabled intertie bids. Therefore, we assume that transaction costs (i.e., hurdle rates) associated with sales and purchases into and out of the EDAM footprint are no lower than the costs associated with individual bilateral trades. If EDAM member BAAs enable intertie trading, we would expect more efficiency gains and customer savings for market members (and non-members located at the EDAM seam).

III. Benefit Drivers

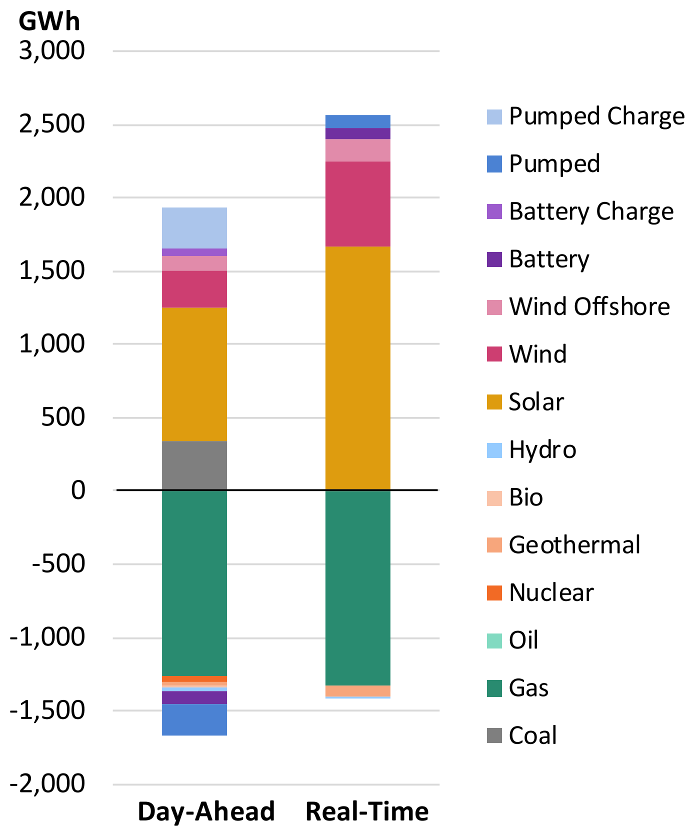
The simulation results highlight several important changes in system operations and outcomes due to EDAM formation that can help demonstrate what creates customer savings in the market.

Change in Generation Dispatch

The following changes in generation by fuel type (illustrated in Figure 11) occur due to the implementation of the EDAM.

- The EDAM drives a reduction in gas generation, as can be seen by the green bar in Figure 11 dropping below the zero axis. This is mostly caused by an increase in solar and wind production (i.e., a reduction in curtailments), which is shown by the yellow and red bars in Figure 11.
- EDAM member BAAs export more power to BAAs outside the EDAM footprint after market formation than they did prior to market formation in the bilateral markets. In Figure 11, in the real-time, the total bar above the zero axis is larger than the total bar below the zero. The reduction in curtailments caused by the EDAM and the availability of other low-cost power sources creates the opportunity for EDAM member BAAs to export more energy outside the EDAM footprint.
- The EDAM does not cause any significant change in the dispatch of coal units in the footprint. The day-ahead schedules of coal units increase slightly, but actual dispatch is almost exactly the same as the dispatch in the Status Quo Case. There are two main reasons for this. First, there are few coal units in the EDAM footprint as almost all existing units will retire by 2032. Second, the coal units that are left in the EDAM footprint are usually not marginal, and therefore their operation is not impacted significantly by market formation. In other words, because the few coal units left are not marginal, it is economic to run them at roughly the same level regardless of the formation of the EDAM.

FIGURE 11: GENERATION DISPATCH BY FUEL TYPE STATUS (EDAM CASE—STATUS QUO CASE)



Reduction in Renewable Energy Curtailments

The study shows almost 2.5 TWh fewer curtailments in the EDAM Case relative to the Status Quo, which is almost all from solar resources in CAISO. This is illustrated in Figure 11, by the yellow and red bars above the zero axis, which indicate higher solar and wind production in the EDAM Case relative to the Status Quo Case. The reduction in curtailments comes from the more efficient use of transmission and the optimized day-ahead unit commitment and dispatch in EDAM. The market optimization is more efficient than the bilateral markets at finding opportunities to back down or decommit costly thermal resources to make room for the renewables.

While the 2.5 TWh reduction in curtailments represents a large amount of energy made available because of the EDAM, there are an additional 20 TWh of curtailed renewable energy in California alone in the EDAM Case. As such, there is the potential for significantly more renewable energy to be made available in the market, creating additional customer savings, as more participants join. Particularly if the new participants bring additional transmission capacity in and out of California into the EDAM.

Reduction in GHG Emissions

With the reduction in curtailments offsetting gas-fired generation, the EDAM creates a reduction in GHG emissions across the WECC. The simulation results show fewer GHG emissions in the EDAM Case compared to the Status Quo Case both inside the GHG region (California and Washington) and outside the GHG region in EDAM. As well as across the WEIM footprint and the entire WECC. This suggests that the GHG structure developed for the EDAM helps to avoid resource reshuffling. In other words, we do not see significant emissions increases in states without GHG pricing programs so that non-emitting resources in those states can be sold into California or Washington.

Figure 12 shows the GHG emissions in the Status Quo Case versus the EDAM Case. The first three columns in the table show that emissions fall inside the EDAM, in both the GHG and non-GHG regions. The last two columns show that emissions across the WEIM footprint and the entire WECC also fall relative to the Status Quo Case.

FIGURE 12: GHG EMISSIONS REDUCTION DUE TO THE EDAM (IN MILLIONS OF METRIC TONS)

	EDAM			WECC	
Case	**EDAM GHG Region**	**EDAM Non-GHG Region**	**Total EDAM**	**Total EIM**	**Total WECC**
Status Quo Case	16.31	19.31	35.62	125.37	170.70
EDAM Case	15.78	19.20	34.98	125.13	170.42
EDAM - Status Quo	***-0.54***	***-0.11***	***-0.65***	***-0.24***	***-0.29***

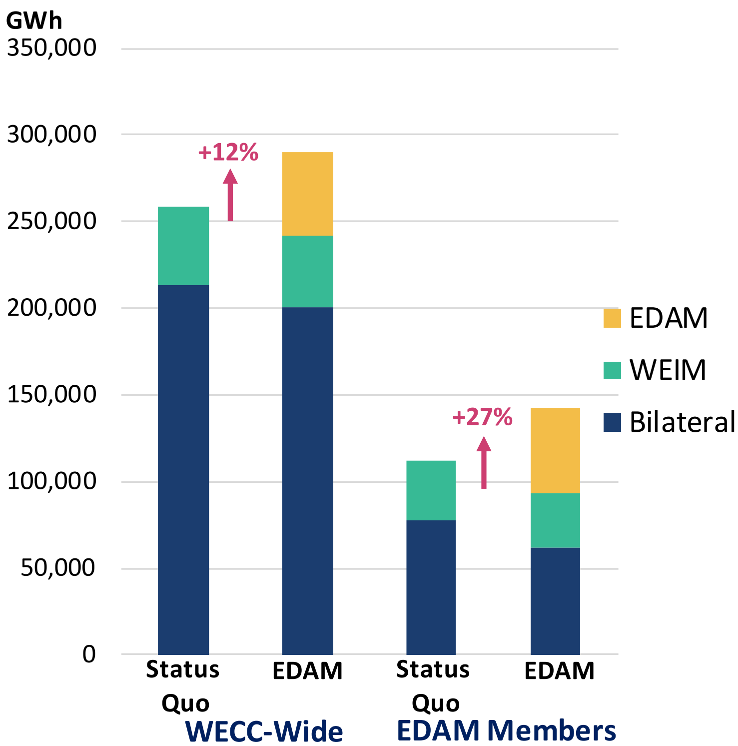
Increased Trading of Economic Energy

There is a large increase in the trading of economic energy in the EDAM Case compared to the Status Quo Case. Similar to the WEIM, the EDAM creates more economic transactions than the bilateral market due to the elimination of wheeling charges in the footprint, the more efficient usage of transmission capacity, and the day-ahead unit commitment and dispatch optimization that occurs in the market. With the increase in economic energy transactions comes increased efficiency and considerable customer savings.

Figure 13 shows the change in trading between the Status Quo Case and the EDAM Case for the WECC as a whole and the EDAM member BAAs. For the EDAM participants, we observe an increase in trading of 50 TWh/year due to the implementation of the EDAM, which amounts to a 27% increase in trading. WECC-wide we see a similar outcome, with trading increasing by 12% in the EDAM Case compared to the Status Quo Case.

The different colored bars in Figure 13 show the different types of trades. As shown in the figure, bilateral trading decreases with the formation of the EDAM (the blue bar), as do trades in the WEIM (the green bar). However, the additional trading created by the EDAM (the yellow bar) is larger than the decrease in bilateral and WEIM trades, resulting in higher overall trading of economic energy after EDAM implementation.

FIGURE 13: INCREASED TRADING OF ECONOMIC ENERGY IN EDAM

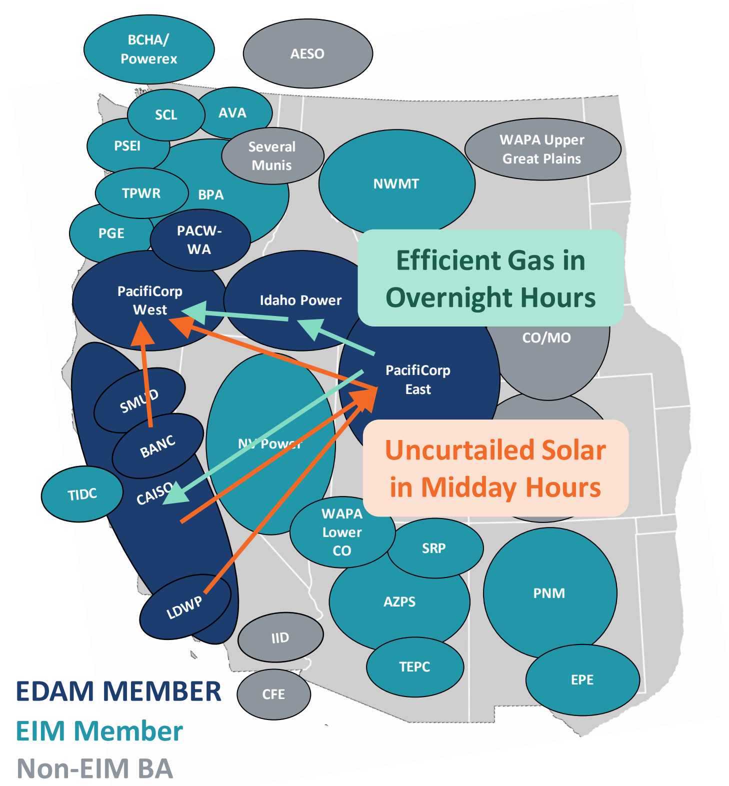


Trading Patterns in the EDAM

There are two broad trading patterns, illustrated in Figure 14, that occur in the EDAM. First, surplus solar from California in midday hours, especially during the summer months, is sold in the market from California to the PACE BAA, and then through Idaho Power to the PACW BAA. During the same hours, when solar production is elevated, we also see power sold in the market from California north to Oregon into the PACW BAA. The ability to increase the flow of solar out of California from the pooled usage and de-pancaking of transmission in the EDAM creates the reduction in curtailments and the emissions reductions described above.

Second, in the overnight hours, efficient gas generation in the PACE BAA increases production, which is sold into California to displace higher cost and higher emitting gas generation. This substitution creates production cost savings and partly explains the drop in emissions due to EDAM.

FIGURE 14: TRADING PATTERNS IN THE EDAM



IV. Comparison with other Recent Market Benefit Studies in the WECC

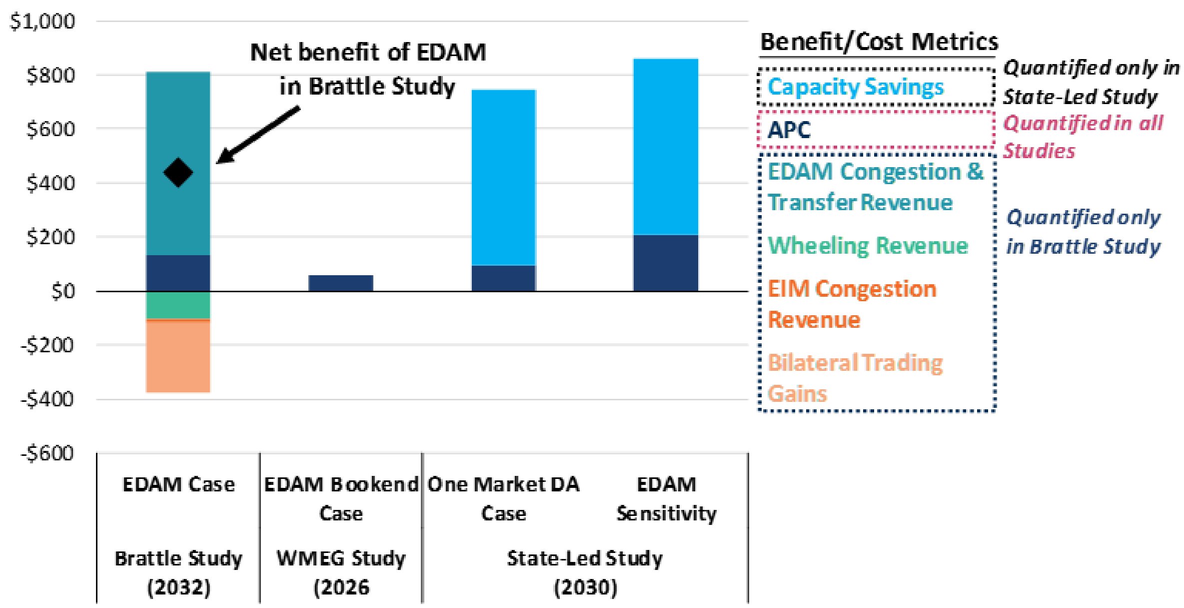
We compared the results of our study with other recent studies of benefits from market participation in the WECC. Specifically, two recent studies of market benefits. First, the State-Led Market Study that analyzed a several market configurations, including a follow-up sensitivity (the EDAM Sensitivity in Figure 15) conducted on behalf of the CAISO that analyzed updated assumptions on transmission usage and operating reserves needed in the EDAM.[12]

[12] The State-Led Market Study, Technical Report, Energy Strategies, July 30, 2021. Accessed here: https://static1.squarespace.com/static/59b97b188fd4d2645224448b/t/6148a012aa210300cbc4b863/1632149526416/Final+Roadmap+-+Technical+Report+210730.pdf

Second, the WMEG Cost Benefit Study that analyzed participation in the EDAM and the Markets+ across several years and different WECC-wide market footprints.[13]

Figure 15 compares the customer savings of this study with the customer savings calculated in the WMEG and State-Led studies. All three studies calculate the APC customer benefit metric. This study found an APC customer benefit of $134 million/year, the WMEG study's EDAM bookend case found APC benefits of $60 million/year, and the State-Led study that found APC benefits of $85–$95 million/year in the original study, and APC benefits of roughly $540 million/year in the EDAM Sensitivity. Figure 15 also shows the various other customer benefit and cost metrics calculated in our study, described earlier in this report, that are not estimated in the other two studies. Note that the State-Led study calculated capacity savings, as the market construct studied would include resource adequacy sharing.

FIGURE 15: COMPARISON OF BENEFIT METRICS FROM WECC MARKET BENEFIT STUDIES $MILLIONS)



The one area where our study is not consistent with other recent studies is in the distribution of benefits across market members. Every member of the EDAM experiences a cost reduction due to market participation. This is consistent with the experience in WEIM[14] where all members of

CAISO EDAM Benefits Study, Energy Strategies, November 4, 2022. Accessed here: https://www.caiso.com/Documents/Presentation-CAISO-Extended-Day-Ahead-Market-Benefits-Study.pdf

[13] WMEG Cost Benefit Study, Energy and Environmental Economics, October 23, 2023. Accessed here: https://www.bpa.gov/-/media/Aep/projects/day-ahead-market/e3-wmeg-benefits-study.pdf

[14] See WEIM benefits posted here: https://www.westerneim.com/Pages/About/QuarterlyBenefits.aspx

the market see cost reduction due to membership. However, the WMEG study found that large portions of the footprint did not benefit from formation of the EDAM. The WMEG study, in the EDAM bookend case, finds that seven out of 25 WMEG members experience an increase in their APC due to EDAM participation.[15] The experience in the WEIM, which includes roughly 80% of the WECC and has not seen a single member experience cost increases due to participation, suggests that we would see a similar outcome in the EDAM, as confirmed by this study.

V. Conclusion

This study estimates the customer savings from the creation of the Extended Day-Ahead Market (EDAM) with the objective of helping the study participants make informed market entry decisions. The study simulates a plausible EDAM footprint in 2032, to provide an estimate of likely benefits in the first decade of EDAM operation. The study analyzes the specific EDAM design for a plausible EDAM footprint, rather than a generic wholesale market design covering the entire WECC.

We estimate $438 million/year of net customer savings for the EDAM footprint analyzed. We account for efficiency gains and all types of market revenues generated by participation in the EDAM. We also account for revenue credits that customers receive today that may be lost due to EDAM membership. We estimate $813 million/year in gross benefits, including $134 million/year in APC benefits and $678 million/year of EDAM congestion and transfer revenues. The efficiency gains and new market revenues created by the EDAM are offset by loss of wheeling revenues ($103 million/year), reduced WEIM congestion revenues ($16 million/year), and lower bilateral trading profits ($256 million/year). After offsetting the efficiency gains and new market revenues with lost revenue credits, we estimate EDAM will create $438 million/year of net customer savings. We estimate that EDAM participants (i.e., the individual study participants and CAISO) all benefit from participation.

For several reasons discussed in Section II, the customer savings estimated in this study are likely conservative and understate the customer savings due to EDAM participation. This is consistent with the experience in the WEIM, where simulated estimates of customer benefits were lower than the savings realized after market implementation.

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[15] WMEG Cost Benefit Study, Energy and Environmental Economics, October 23, 2023, p. 12. Accessed here: https://www.bpa.gov/-/media/Aep/projects/day-ahead-market/e3-wmeg-benefits-study.pdf

Appendix A

Model Description and Features

MODELING APPROACH

Overview of Modeling Approach

We utilize the WECC ADS production cost model as a starting point imported into Power System Optimizer (PSO), as refined during the EDAM feasibility study and follow-on engagements

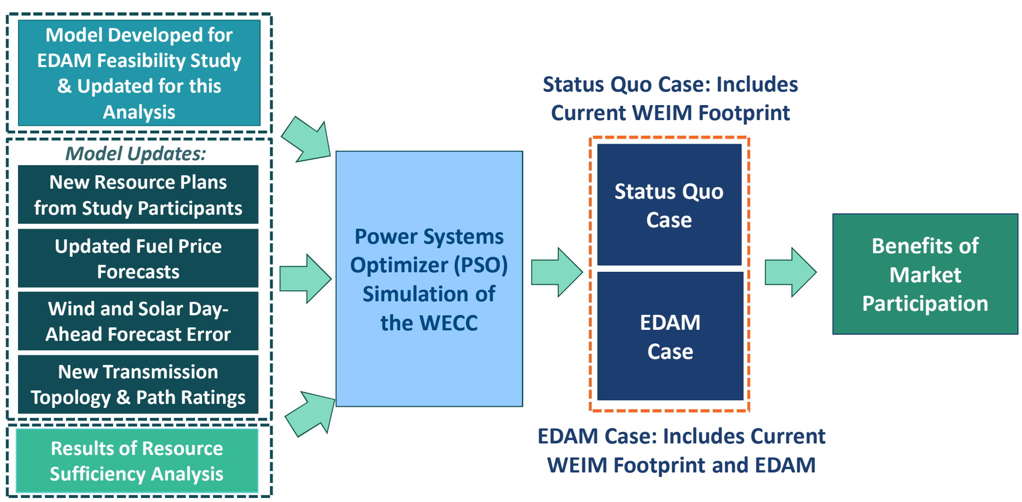
Utilized Power System Optimizer (PSO), an advanced market simulation model

- Nodal mixed-integer model representing each load and generator bus in the WECC
- Licensed through Enelytix
- Detailed operating reserve and ancillary service product definition
- Detailed representation of the transmission system (both physical power flows and contract paths)
- Updated modeling assumptions to reflect the most recent utility resource plans and forecasts of system conditions and costs
- Hourly granularity due to limited data availability, but model can be enhanced for sub-hourly analysis

PSO is uniquely suited to simulate bilateral trading, joint dispatch, imbalance markets, and RTOs because it can simulate multiple stages of system operator decision making

EXECUTIVE SUMMARY

Study Framework and Benefits Calculation



Status Quo Case vs. EDAM Case

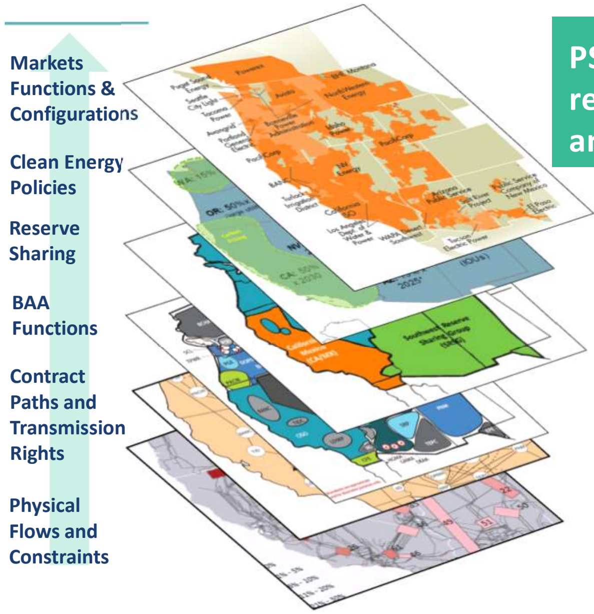
The change case makes alterations to assumed transmission costs, GHG trading structure, reserve limits, transmission paths, and an hourly limit on CAISO exports

Assumptions Changes from Status Quo to EDAM Case

Model Assumptions	Base Case	EDAM Case
Transmission Between EDAM Entities	Day-Ahead cost of **OATT rate plus $4 - $8/MWh trading friction**	Fully optimized **hurdle free transmission** in all cycles
Transmission Limits	Base limits provided by utilities *(both physical and contractual)*	**New path from PACE to CAISO** opens using IPP rights
Unit Commitment	**BA-specific**, with trading allowed at OATT + $8/MWh friction	Entire footprint optimized, **trading with no hurdles during commitment**
Reserves	BA-specific requirements **served individually**	**Entire footprint serves reserves together**
Imbalance Reserve Product	BA-specific requirements **served individually**	**Entire footprint serves reserves together + 35% reduction in requirement** due to resource diversity
CAISO Export Limit	5 GW per hour limit in unit commitment, 7 GW per hour limit in economic dispatch or EIM	No limit
EDAM Non-GHG Exports to EDAM GHG Region	**Day ahead generic import hurdle** for all sales equal to a gas CC emissions rate (~$30/MWh)	**Unit-type specific hurdle rates**, with trading limits based on the GHG reference pass

MODELING APPROACH

Multi-Functional Simulation of WECC



PSO employs multi-layer simulations to represent the various physical, policy, and operational facets of the WECC

- Physical grid with ~20k buses, ~25k lines and ~5k generators; SCUC and SCED based on DC power flow (nodal prices)
- 38 balancing areas (BAAs)
- WECC reserve sharing groups
- Diverse state clean energy policies
- Major trading hubs (e.g., Mid-C, Malin, PV)
- Bilateral transmission rights
- Renewable diversity, day-ahead forecast uncertainty, real-time operations
- CAISO, WEIM and WEIS market footprint(s), and future Western RTO(s)

MODELING APPROACH

Independent Simulation of Multiple Time Horizons

PSO simulates multiple independent decision cycles to capture day-ahead vs. real-time unit commitment and dispatch

D-1 (am)

DA Bilateral Markets

- DA block trades on ETC rights and incremental transmission

D-1 to D (am)

DA and Intra-Day Markets and Trading

- CAISO and EDAM market clearing
- Hourly CAISO intertie trading
- Hourly trading with ETC rights
- Hourly trading with incremental transmission

D

WEIM and RT Balancing

- Remaining transmission released for WEIM
- WEIM trading of economic energy
- RT balancing in BAAs

Independent real-time decision cycle used to simulation WEIM functions

Day-Ahead Forecasted Load and Renewables

Actual Load and Renewables

Decision cycles capture bilateral trading, market clearing, BAA functions in DA and RT, and market cycles (EDAM "GHG reference" pass, EDAM market, and WEIM)

Independent real-time decision cycle used to simulate DA vs. RT, including forecast errors for wind and solar

Simulating Several Wholesale Market Cycles in PSO

The model is setup for wholesale market simulation efforts and contains several cycles to simulate unit commitment and dispatch decisions in different timeframes and in different market structures. For example, cycles simulated can include:

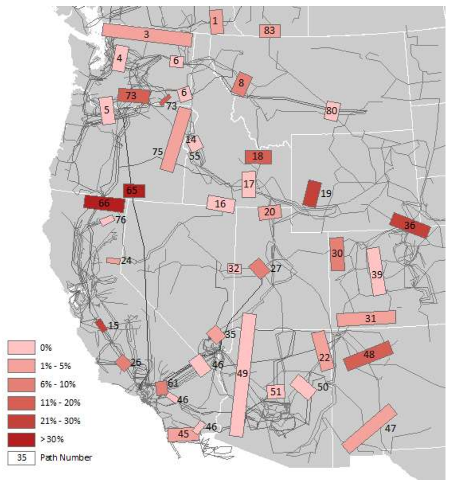
- **Day-Ahead Unit Commitment Cycle:** the model optimizes unit commitment decisions, 24 hours at a time (with 48-hour look ahead), for long-lead time resources such as coal and nuclear plants, based on their relative economics and operating characteristics (e.g., minimum run time, maintenance schedules, etc.), transmission constraints, and trading frictions. The model ensures that enough resources are committed to serve forecasted load, accounting for average transmission losses and the need for ancillary services. Separate regions' commitment decisions are segregated through higher hurdle rates on imports and exports. Trading within a single balancing area, like the various RTO sub-zones, is not subject to any hurdles.
- **Day-Ahead Economic Dispatch Cycle:** the model solves for the optimal level of hourly day-ahead dispatch and trading in 24-hour forward-looking optimization cycles, with 48-hour look ahead periods. Dispatch across the study footprint is optimized based on resource economics. In this cycle, the model also co-optimizes ancillary service procurement for each area. The high hurdle rates for unit commitment are lowered to enable more bilateral trading between balancing areas.
- **Intra-day trading:** the model simulates market activity through one-hour optimization horizons. Trading is assumed to utilize unused transmission, represented as the difference between their day-ahead trading volume and the total contract path limits. No unit re-commitment is allowed due to the non-firm nature of the transactions. Changes to generation availability, such as forced outages, which were not "visible" during the day-ahead cycle become visible during this cycle.
- **Real-Time Cycle:** this cycle simulated the operation of the real-time imbalance markets, such as through WEIM transactions. In this cycle, the model can re-optimize dispatch levels and unit commitment decisions for fast-start thermal resources (based on the assumption that the real-time market design allows for unit re-commitment). Deviations from day-ahead forecasts (due to uncertainty) need to be balanced in real-time.

These cycles can take on different assumptions, depending on market structure. In a bilateral setting, all are set up to analyze utility-specific unit commitment and dispatch decisions, with each of them including hurdle rates and transmission fees that limit the amount of economic transactions that can take place between the utilities. In WEIM and EDAM+WEIM scenarios, all of the cycles are set up to simulate market-wide optimization of unit commitment and dispatch, including the EDAM "reference pass" cycle. In the EDAM case, there would be no hurdle rates between EDAM participants in any of the cycles, allowing the model to optimize both unit commitment and dispatch in the market footprint on both a day-ahead and real-time basis.

MODELING APPROACH

Physical Transmission

WECC-Defined Paths Modeled



Limits on the physical transmission system include all the paths defined in WECC Path Rating Catalogue

- We added CAISO and PAC constraints
- Can additional transmission paths to represent congestion internal to each BAA
- Limits on all paths reflect updates provided by the EDAM study participants
- We can implement hourly or seasonal derates on WECC paths or other constraints added to the model

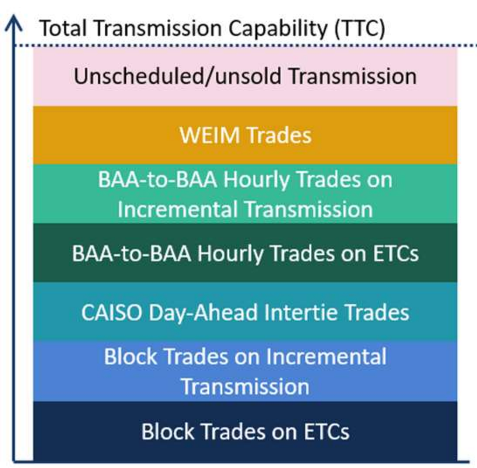
MODELING APPROACH

Types of Trades and Transmission Reservations Modelled

Our model simulates the use of different types of contract-path transmission reservations for bilateral trading across DA and RT

- Existing long-term transmission contracts (ETCs) and incrementally purchased transmission
- Total reservations on each contract path is limited by the total transfer capability (TTC)
- Trades are structured as blocks or hourly
- Bilateral trades between BAAs, at major hubs, or across CAISO interties
- Account for renewable diversity and day-ahead forecast uncertainty vs. real-time operations
- Unscheduled transfer capability released for WEIM trades in real-time

Types of Trades Modeled



MODELING APPROACH

ENELYTIX® powered by PSO

Power System Optimizer (PSO), developed by Polaris Systems Optimization, Inc. is a state-of-the-art market and production cost modeling tool that simulates least-cost security-constrained unit commitment and economic dispatch with a full nodal representation of the transmission system, similar to actual RTO and ISO market operations. Such nodal market modeling is a commonly used method for assessing the operational benefits of wholesale market reforms (e.g., JDAs, WEIMs, RTOs).

PSO can be used to test system operations under varying assumptions, including but not limited to: generation and transmission additions or retirements, de-pancaked transmission and scheduling charges, changes in fuel costs, novel environmental and clean energy regulations, alternative reliability criteria, and jointly-optimized generating unit commitment and dispatch. PSO can report hourly or sub-hourly energy prices at every bus, generation output for each unit, flows over all transmission facilities, and regional ancillary service prices, among other results. Comparing these results among multiple modeled scenarios reveals the impacts of the study assumptions on the relevant operational metrics (e.g. power production, emissions, fuel consumption, or production costs). Results can be aggregated on a unit, state, utility, or regional level.

PSO has important advantages over traditional production cost models, which are designed primarily to model dispatchable thermal generation and to focus on wholesale energy markets only. The model can capture the effects of increasing system variability due to large penetrations of non-dispatchable, intermittent renewable resources on thermal unit commitment, dispatch, and deployment of operating reserves. PSO simultaneously optimizes energy and multiple ancillary services markets on an hourly or sub-hourly timeframe.

Like other production cost models, PSO is designed to mimic ISO operations: it commits and dispatches individual generating units to meet load and other system requirements, subject to various operational and transmission constraints. The model is a mixed-integer program minimizing system-wide operating costs given a set of assumptions on system conditions (e.g., load, fuel prices, transmission availability, etc.). Unlike some production cost models, PSO simulates trading between balancing areas based on contract-path transmission rights to create a more realistic and accurate representation of actual trading opportunities and transactions costs. This feature is especially important for modeling non-RTO regions.

One of PSO's distinguishing features is its ability to evaluate system operations at different decision points, represented as "cycles," which occur at different times ahead of the operating hour and with different amounts of information about system conditions available. Under this sequential decision-making structure, PSO can simulate initial cycles to optimize unit commitment, calculate losses, and solve for day-ahead unit dispatch targets. Subsequent cycles can refine unit commitment decisions for fast-start resources and re-optimize unit dispatch based on the parameters of real-time energy imbalance markets. The market structure can be built into sequential cycles in the model to represent actual system operation for utilities that conduct utility-specific unit commitment in the day-ahead period but participate in real-time energy imbalance markets that allow for re-optimization of dispatch and some limited re-optimization of unit commitment. For example, PSO can simulate an initial cycle that determines day-ahead unit commitment decisions that reflects the constraints faced by, and decisions made by, individual utilities when committing their resources in the day-ahead timeframe. The initial day-ahead commitment cycle is followed by cycles that simulate day-ahead economic dispatch, including bilateral trading of power, and a real-time economic dispatch, reflecting trades in real time (whether bilateral or optimized through an WEIM or RTO). Explicit commitment and dispatch cycle modeling allows more accurate representation of individual utility preference to commit local resources for reliability, but share the provision of energy around a given commitment.

Appendix B

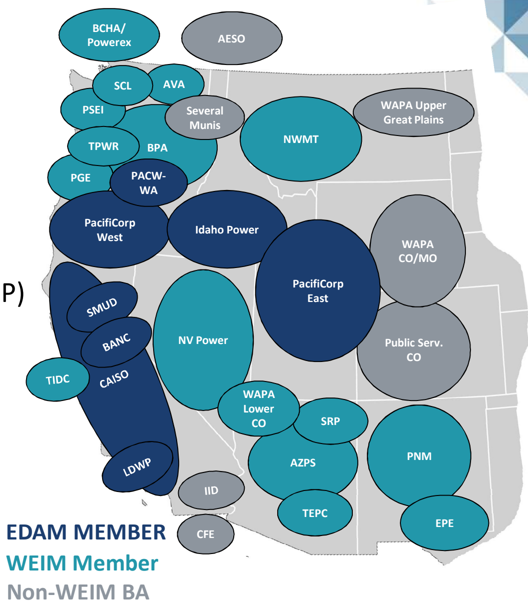
Model Inputs and Assumptions

EXECUTIVE SUMMARY

Assumed EDAM Footprint

The simulated EDAM footprint includes:

- **PacifiCorp**, broken into PAC-East (PACE), PAC-West (PACW), and PAC-West in Washington (PAWA)
- The **California ISO** (CAISO)
- **Idaho Power** (IPCO)
- **Los Angeles** Department of Water and Power (LDWP)
- The **Balancing Authority of Northern California**
  - Broken into BANC and SMUD (Sacramento)



EDAM Footprint and Capacity Mix: 2032

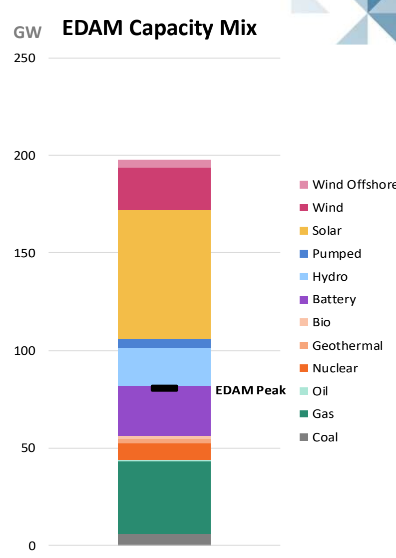
Assumed EDAM footprint: CAISO, BANC+SMUD, LADPW, IPC and PAC

Study year: 2032 (to reflect longer-term conditions with higher renewable generation and retired fossil units)

Total capacity in assumed EDAM footprint: nearly **200 GW**

- Dispatchable capacity (including battery and hydro) exceeds EDAM peak by ~40 GW
- Solar capacity by 2032 is nearly 100 GW, with a significant portion from CAISO

Study participant generation updated with latest IRPs (incl. planned transmission); CAISO mix updated to current 2032 projections, with around 90% of generation clean by 2032



Gas Price Forecasts

Study participants provided forecasted NG prices at various hubs

- We compared the data from multiple participants at SoCal, Kern, Malin, and Sumas, and are using the middle forecast of the group, which shows prices **between $4-5/MMBtu** (2022$)

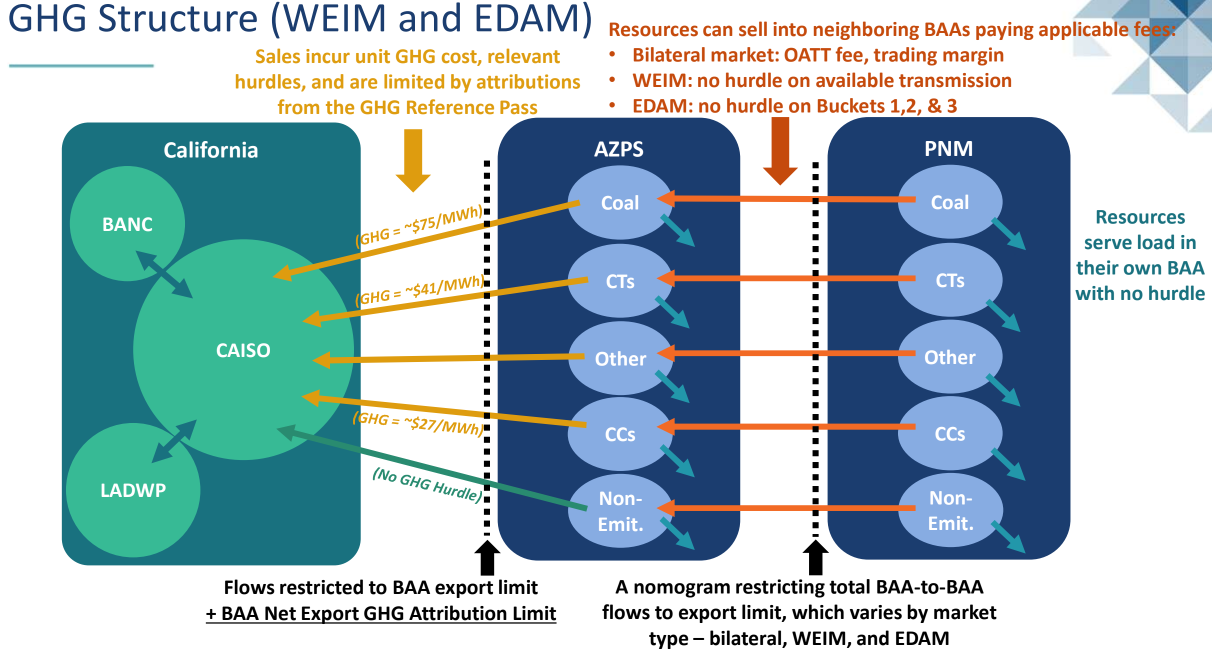
Modeled natural gas prices use a goal price of **about $4.50/MMBtu** at Malin and apply monthly basis differential at other hub from historic and participant-provided data

- Prices follow historical seasonal pattern
- Daily pricing for the two extreme weeks, reflecting data from 2016 and 2019 actual events
- Prices are generally higher in the southwest and California and lower in the Rocky Mountain region and Northwest, fitting historic trends

Modeled Hub Natural Gas Prices
($ 2022 Real)

Hub	2032 Average Price	Basis to Malin
SoCal	$4.89	$0.43
PG&E	$5.66	$1.20
Cheyenne	$4.51	$0.06
Sumas	$4.41	-$0.05
Rocky Mountains	$4.28	-$0.17
Malin	$4.46	-

GHG Structure (WEIM and EDAM)



EDAM Reference Pass

The EDAM Reference Pass shuts off all transfer from the non-GHG region to the GHG region to determine dispatch levels without GHG region sales

The reference pass identifies what levels of dispatch would occur without non-GHG to GHG sales

The results set **hourly export limits** that are enforced in the actual EDAM case for WEIM and EDAM members for sales to GHG balancing authorities

- These export limits are based on reference pass hourly net exports and reference pass actual renewable generation

EDAM GHG Structure and "GHG Reference Pass"

Our GHG modeling structure accounts for two constraints specified in the EDAM design for GHG attributions relative to a baseline from EDAM's "reference pass" cycle, which we simulate as well

1. **Resource Specific GHG Attribution (resource-type attribution under proposed approach) =**

   max{0, min{GHG Bid, UEL – Reference Pass, Optimal Dispatch}}

   - GHG Bid: **Unless you tell us to treat certain resources differently, we will assume resource bid all their capacity into the GHG Region**
   - UEL – Reference Pass: **Calculated using results of our GHG Reference Pass run**
   - Optimal Dispatch: **GHG attribution cannot exceed final dispatch of resource**

2. **BAA Total GHG Attribution <= (Net TTC Difference - BAA Net Exports hourly in reference pass)**

Imbalance Reserve Requirement

EDAM hourly reserve requirement estimated to fall by about 2 GW on average in the EDAM Case (relative to the Status Quo Case) due to the diversity benefit achieved by the EDAM footprint

Imbalance Reserve is a new reserve product being implemented by the CAISO as part of their DA Market Enhancements (DAME) initiative, and will apply to EDAM

- The Imbalance Reserve requirement (up and down) will be set to meet the 97.5 percentile of each BAAs historical net load variability
- In EDAM, participants' Imbalance Reserve Requirement will be reduced by the diversity benefit created by pooling commitment and dispatch across the regional footprint
- Does not impact other operating reserve types – regulation, contingency, etc.
- We calculated each EDAM participants Imbalance Reserve Requirement and the EDAM diversity benefit to reduce each member's requirement

EDAM Transmission Availability

All three buckets of EDAM transmission are hurdle-free:

- **Bucket 1: Transmission to Support Resource Sufficiency**
  - Includes long term transmission contracts for energy used for sufficiency accounting purposes
- **Bucket 2: "Donated" Transmission Contracts**
  - Existing transmission contracts made available ("donated") to the EDAM by participants
- **Bucket 3: Unsold Firm Transmission**
  - Remaining transmission made available for EDAM *(participants might hold back from transmission for block trading)*

Study participants provided existing transmission contracts (ETCs) and total transfer capability (TTC)

- The study assumes Bucket 1 and 2 equals total ETCs and Bucket 3 equal TTC – ETC (i.e., remaining TTC)
  - This assumes EDAM members will make all of their transmission available to the market
  - If individual members plan to hold back some of their transmission rights, please let us know and we can carve them out

Resource Sufficiency Test

The EDAM Straw Proposal applies the Resource Sufficiency Test to each EDAM member the day prior to real-time, before begin day-ahead market operations

- EDAM members will be subject to fines for failing the test
- The 2019 EDAM Feasibility Study, included an hourly analysis of Resource Sufficiency for each proposed EDAM member at that time
  - In that analysis, failure of the test was extremely rare
- We undertook an ex-post check to confirm that members are resource sufficient in all hours

Generation > hourly load + imbalance reserves + other reserves

Generation = battery state of charge (up to max dispatch) + DA renewable forecast + max of thermal gen + hydro dispatch + max of hydro flex capability + transmission rights

WECC Transaction Types

The Brattle WECC model has several transactions types optimized in the bilateral market

- Where applicable, transmission paths between also have **economic transfer constraints (ETCs)** modeled, which represents ownership of specific transmission lines and long-term contracts
- We model all **total transmission constraints (TTCs),** or total contractual limits on WECC trading between BAs
- We also model **WECC trading hubs**, including Malin, Palo Verde, Mead, MidC, and NOB

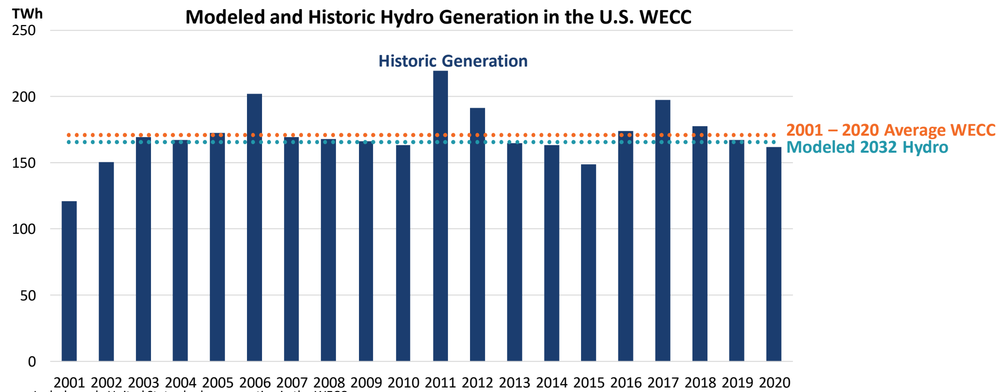
WECC Transaction Types Modeled

Transaction Type	Pays an Hourly OATT Rate?	Economic Dispatch Friction Charge	Unit Commitment Friction Charge
	per MWh	per MWh	per MWh
Block Trades on ETCs	No	$1.5	$1.5
Block Trades on Incremental TTC	Yes	$1.5	$1.5
Hourly Trades on ETCs	No	$6.0	$16.0
Hourly Trades on Incremental TTC	Yes	$6.0	$1.5
CAISO Intertie Trades on ETCs	No	$1.5	$16.0
EIM Transactions	No	EIM Only	EIM Only
EDAM Transactions	No	$0.0	$0.0

Hydro Generation

Modeled hydro generation reflects an “Average year” in the WECC, with **total generation at 165 TWh**

- Most hydro generation is “load following”

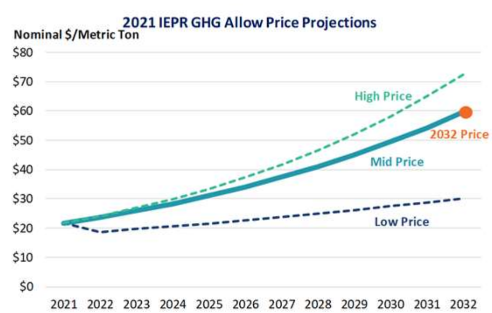


Includes only United States hydro generation in the WECC.

Greenhouse Gas Pricing

We modeled detailed GHG regulations, GHG trading, and GHG pricing for the WECC

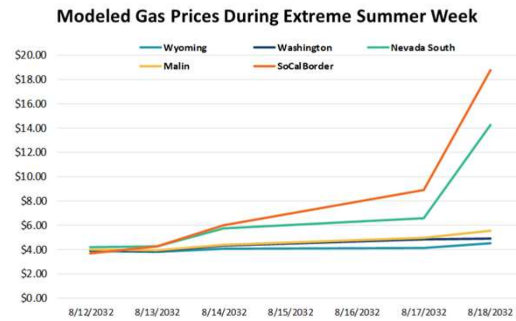
- We assume the California and Washington GHG pricing programs are linked by 2032, implying generators in both state pay the same price
  - We use the 2021 IEPR projected carbon price for 2032 *(using the mid price scenario)*
- Canada balancing authorities pay the Canadian national GHG price for 2032
  - *Assumed at $170 CAD per ton*
- Imports into GHG pricing BAs pay either generic GHG hurdles rates based on gas combined cycle emissions rates or resource type-specific rates depending on the market and trade type



Extreme Weeks

To help capture the increasing role weather emergencies are playing in the WECC, we modeled a cold snap and heat wave week

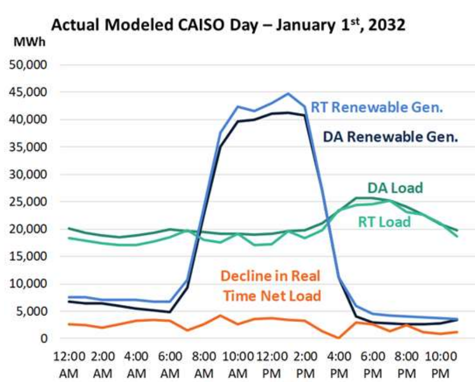
- The assumed heat wave week follows a similar load and gas price pattern as the August 2020 event in the Southwest and the cold snap week follows a similar pattern as the Pacific Northwest cold snap in February 2019
- Gas prices are scaled up to reflect actual daily spot prices observed during these events
- Energy and peak is scaled up to reflect higher actual observed demand during these events
  - For example, CAISO peak is 19% higher than its summer average during our heatwave



Renewable and Load Uncertainty

To better capture the value of markets, including WEIM, we model load and renewable uncertainty between day-ahead market closure and real-time operations for the EDAM footprint

- In the example CAISO day shown in the figure, renewable generation increases in real time while load falls, and the WEIM accounts for the change by exporting power out of CAISO
- The variance captures the value WEIM provides by balancing load and generation
- The study participants provided day-ahead forecast errors for load and renewables for their BAAs and we used CAISO and NREL data to implement day-ahead uncertainty in other BAAs



Appendix C

Summary of Results

EXECUTIVE SUMMARY

Overall EDAM Footprint-wide Results

Simulations of the assumed EDAM footprint (CAISO, PAC, LADWP, IPC, BANC) are based on 2032 as a proxy year to represent annual benefits for the first decade of EDAM operations

The results document significant benefits offered by the proposed EDAM design:

- **Over $800 million in annual cost savings to EDAM participants, with net benefits of over $430 million**
  - Savings associated with 50 TWh in EDAM transactions and a 27% increase in trade between EDAM participants
  - PacifiCorp and every one of the other assumed EDAM participants benefits (even after considering reduced bilateral trading gains and wheeling revenue losses, if any)
  - Results are net of reduced WEIM benefits (i.e, based on difference of “EDAM+WEIM” benefits and “WEIM” base-case benefits), reflecting that EDAM more efficiently takes on a portion of the role played by WEIM today
- **2.4 TWh in reduced renewable generation curtailments**
- **Reduced WECC-wide coal dispatch and reduced regional emissions**

Summary of 2032 EDAM Benefits

The Study Participants see gross customer benefits of $600 million/year, and a net benefits of $390 million due to EDAM participation.

- For the entire EDAM footprint (incl. CAISO), estimated gross customers benefits are $810 million/year, with net benefits estimated at $438 million.

EDAM Benefits ($ millions/year)

Benefit Metric	Study Participants	CAISO	Total EDAM
EDAM Benefits			
Adjusted Production Cost Savings	$99	$36	$134
EDAM Congestion Revenues	$186	$83	$269
EDAM Transfer Revenues	$324	$85	$409
Total EDAM Benefits	**$609**	**$204**	**$813**
Other EDAM Related Impacts			
Impact on Wheeling Revenues *[1]*	$14	-$117	-$103
Impact on WEIM Congestion Revenues	-$31	$15	-$16
Reduced Bilateral Trading Profits *[2]*	-$207	-$49	-$256
Net EDAM Benefits	**$385**	**$53**	**$438**

Notes: [1]: Impact on wheeling revenue includes only short-term wheeling revenues. The TRR Settlement process in the EDAM tariff provides EDAM transmission providers a rebate for lost short-term wheeling revenue, which would offset the impact of lost short-term wheeling revenue. [2]: Reduced bilateral trading profits is the value of exports and imports from EDAM member BAAs, including third-party marketers.

Estimated EDAM Benefits are Conservatively Low

The estimated benefits are likely understated due to several factors:

- **Overstated base-case efficiency:** our simulation of the status quo is more efficient than reality.
  - The Base Case assumes that balancing authorities have optimal security-constrained unit-commitment and dispatch (SCED) in both DA and RT, making the simulated dispatch more optimal than in reality.
  - Inefficient utilization of transmission due to bilateral scheduling and trading is not fully modeled, understating the extent EDAM will be able to make better use of available transmission.
  - Transmission outages are not modeled, which would magnify the benefit of SCED-based congestion management in EDAM compared to the status quo
- **Normalized loads and fuel prices:** the model uses weather-normalized loads and averaged monthly natural gas prices without daily volatility (except for the two weeks to represent heat waves and cold snaps).
  - Challenging market conditions, such during as the 2022 gas price spikes, will magnify EDAM benefits. Illustrated by the WEIM experience in 3Q of 2021 and 3Q-4Q of 2022.
  - The Base Case does not reflect the limited liquidity of bilateral market during such challenging market conditions.
- **No capacity benefits quantified:** we have not quantified the extent to which EDAM may reduce investment costs associated with lower operating reserve requirements.
- **Limited EDAM footprint:** like in WEIM, EDAM benefits will increase as more parties join EDAM
- **Assumed in intertie bidding in EDAM:** as is the case in WEIM, we assume only CAISO has enabled intertie bidding in the EDAM, which reduces the efficiency gains from EDAM formation.

Benefit Metric: Adjusted Production Cost

Adjusted Production Cost (APC) is a standard metric used to capture the direct variable energy-related costs from a customer impact perspective

The APC is the sum of production costs and purchased power less off-system sales revenue:

(+) Production costs (fuel, startup, variable O&M, emissions costs) for generation owned or contracted by the load-serving entities

(+) Cost of bilateral and market purchases valued at the BAA's load-weighted energy price ("Load LMP")

(–) Revenues from bilateral and market sales valued at the BAA's generation-weighted energy price ("Gen LMP")

The APC is calculated for the Status Quo Case and the RTO case to determine the RTO-related reduction in APC

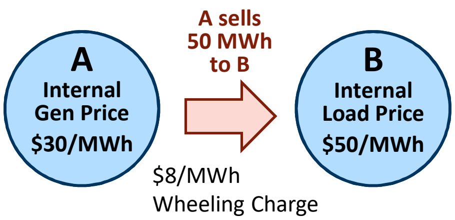
- By using the generation price of the exporter and load price of the importer for sales revenues and purchase costs, the APC metric does not capture wheeling revenues and the remaining portion of the value of the trade to the counterparties (see next slide)

Operational Benefit Metrics: Wheeling Revenues, Trading Gains

Based on the simulation results, we also estimate several additional impacts from increased trading facilitated by the market reforms, which is not fully captured in APC.

- **Wheeling Revenues:** collected by the exporting BAAs based on OATT rates
- **Trading Gains:** buyer and seller split 50/50 the trading margin (and congestion revenues in WEIS/RTO)

EXAMPLE:



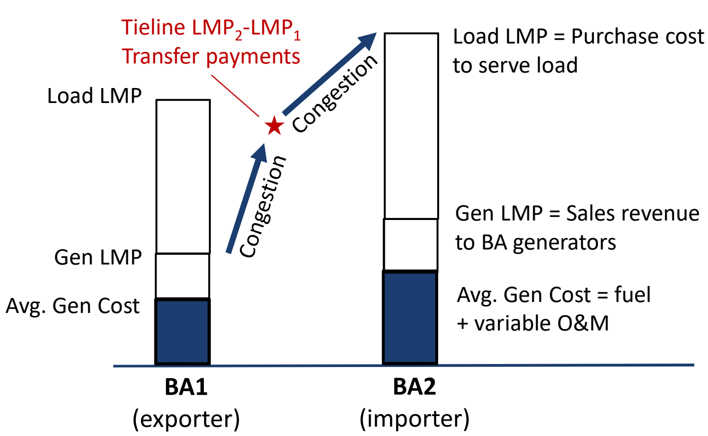
The APC metric only uses area-internal prices for purchase cost and sales revenues, which does not capture part of the value:

- A receives \$30×50MWh=\$1,500 in APC sales revenues
- B pays \$50×50MWh=\$2,500 in APC purchase costs
- ➔ \$1,000 of trading value not captured in APC metric

Trading value = \$20/MWh Δprice x 50 MWh = \$1000

- Exporter A receives wheeling revenues: \$8/MWh x 50MWh = \$400
- Remaining \$600 trading gain split 50/50: both A and B receive \$300

Illustration of APC and congestion/transfer based on CAISO tie-point approach



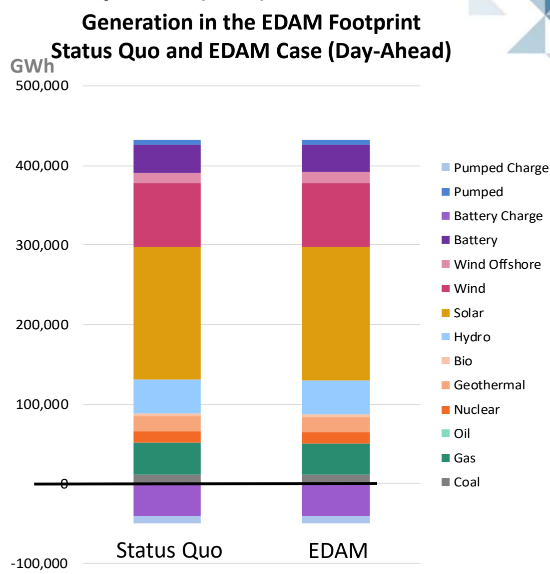
EDAM congestion and transfer revenues use individual tieline LMPs (to implement CAISO's suggestion)

- **Congestion Payment (to exporter)** **= MW x (Tie LMP_1 – Gen LMP_1)**
- **Congestion Payment (to importer)** **= MW x (Load LMP_2 – Tie LMP_2)**
- **Transfer Payment (split 50/50)** **= MW x (Tie LMP_2 – Tie LMP_1)**

2032 Generation Mix for the EDAM Footprint (DA)

EDAM generation mix is dominated by renewables by 2032

- Renewables account for 70% of generation (solar 46%, wind 24%)
- Thermal non-nuclear generation accounts for just 14% of EDAM generation
  - Gas is the majority of this at 10% of EDAM generation
- Batteries discharge 41 TWh in EDAM, mainly in CAISO
- Nuclear accounts for 4% of generation, provided by new projected nuclear units and Palo Verde shares

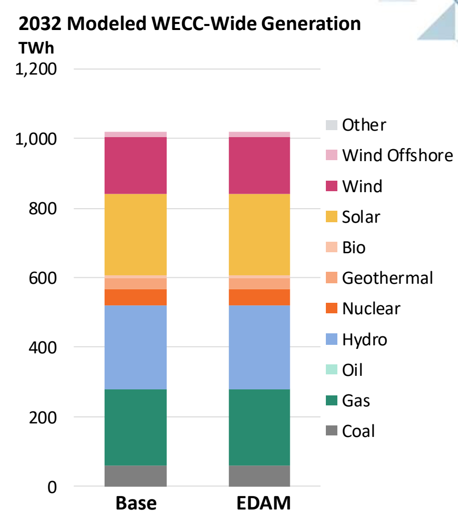


Total WECC-Wide Generation in 2032

WECC-wide generation capacity assumptions are based on **utility data** for the EDAM footprint and **integrated resource plans** for all other BAs

By 2032, WECC generation is **dominated by low or zero** marginal cost resources ***(73% of all generation)***

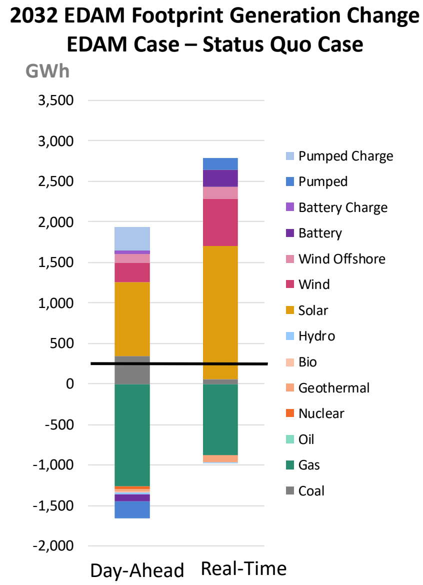
- **41% of generation is renewable**: 23% solar, 16% wind, 2% offshore wind
  - Renewables are aided heavily by ~46 GW of storage capacity
- Another **32% is low marginal cost:** 24% hydro, 3% geothermal, 5% nuclear
- **Thermal generation is a still significant share**, with gas at 22%, coal 6%, and biomass 1%



Change in Generation Dispatch (Status Quo Base to EDAM)

EDAM enables beneficial shifts in the generation dispatch to achieve production cost savings

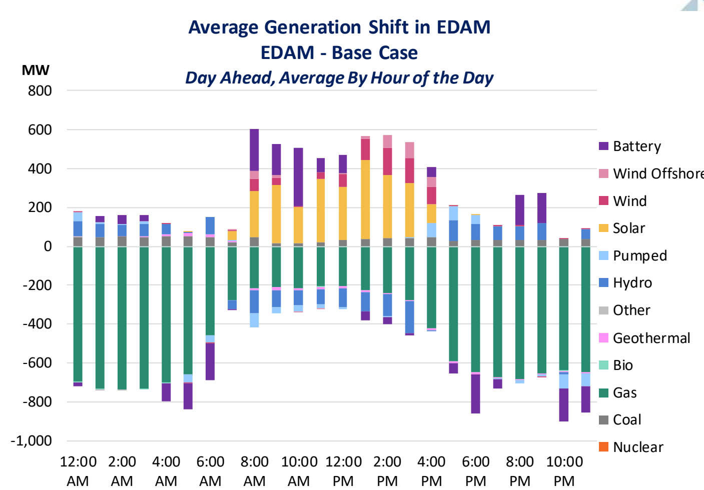
- Renewable curtailments fall ~1,200 GWh in day-ahead, ~2,400 GWh in real-time
- In day-ahead, reduced renewable curtailments displaces mostly gas
- In real-time, the simulated EDAM footprint exports more renewables (due to lower curtailments) and gas generation to the non-EDAM portion of the WEIM footprint
  - Overall, gas generation is lower due to implementation of EDAM



Average Hourly Change Generation Dispatch

EDAM reduces footprint-wide curtailments of solar and wind midday (mainly in CAISO) and displaces gas at night

- Storage charges and discharges more in EDAM, optimizing as an entire group
- Hydro flexes around system prices, producing less during the day and more at night
- Imports into the EDAM footprint (mostly from NVE) increase during the evening and night



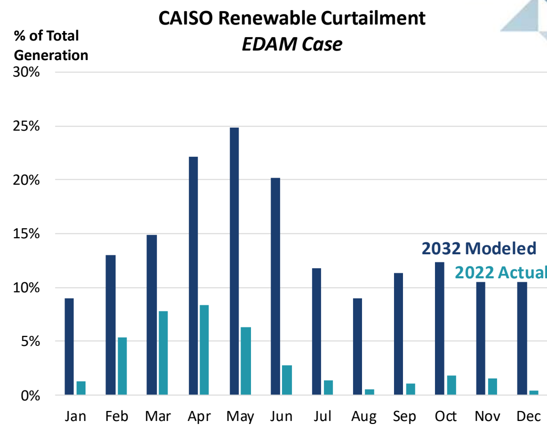
Note: Negative battery values reflect additional charging or a drop in discharging. Positive values reflect additional discharging.

CAISO Renewable Curtailments: 2032 model vs. 2022 actual

While EDAM reduces curtailments by ~2.4 TWh, curtailed renewable energy in CAISO still amounts to over 10% of all renewable generation in the BAA

- In spring shoulder months, over 20% of renewable energy is curtailed in the CAISO BAA
- There remains over 20 TWh of curtailments in CAISO in our 2032 EDAM Case

This result highlights the potential for increased benefits as more BAAs join EDAM, particularly BAAs with additional transmission rights into CAISO/California



Note: Includes solar, wind, and offshore wind for CAISO.

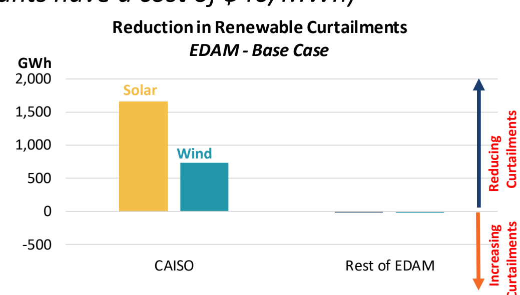
Renewable Generation Curtailments (2032)

EDAM reduces renewable curtailments in day-ahead and real-time by more than 2,300 GWh in the EDAM footprint, worth over $110 million

- Solar curtailments fall 900 GWh in DA and 1,600 GWh in RT, 0.5% and 0.8% of total production
- Wind curtailments fall 300 GWh in DA and 700 GWh in RT, 0.4% and 0.8% of total production
- At the assumed curtailment cost of $30/MWh (proxy for lost REC/PTC value), curtailment reductions are worth $70 million *(EDAM study participants have a cost of $40/MWh)*

EDAM Reduction in Curtailments (GWh)

	Solar		Wind	
	Day-Ahead	Real-Time	Day-Ahead	Real-Time
Total Maximum Generation	194,977	194,243	97,270	95,244
Total Base Curtailment	27,741	25,896	3,903	2,990
Total EDAM Curtailment	26,833	24,249	3,556	2,262
Reduction in Curtailments	**908**	**1,648**	**348**	**728**
% of Maximum Generation	**0.5%**	**0.8%**	**0.4%**	**0.8%**



GHG Emission Reductions: EDAM vs. Base Case

EDAM reduces emissions: both within the GHG-regions of EDAM and the remaining EDAM footprint, as well as within WEIM and WECC-wide

Simulations show that EDAM's GHG design (incl. its reference pass methodology) successfully prevents significant resource reshuffling, resulting in:

- Reduced renewable generation curtailments, particularly in high-renewable areas such as CAISO
- Switching from less efficient gas units to more efficient gas units within the EDAM footprint
- WECC-wide, coal generation falls by 200 GWh
- PacifiCorp-, EDAM-, WEIM-, and WECC-wide decreases of GHG emissions

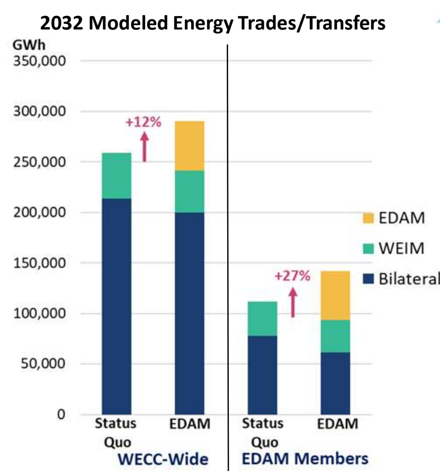
Total Emissions in Million Metric Tons (2032)

	EDAM			WECC	
Case	**EDAM GHG Region**	**EDAM Non-GHG**	**Total EDAM**	**Total EIM**	**Total WECC**
Base Case	16.31	19.31	35.62	125.37	170.70
EDAM Case	15.78	19.20	34.98	125.13	170.42
EDAM - Base	***-0.54***	***-0.11***	***-0.65***	***-0.24***	***-0.29***

Total BA-to-BA Transfers by Trade Type

The EDAM market **enables a 12% increase in overall WECC transfers/trades**, and a 27% increase directly for the EDAM members

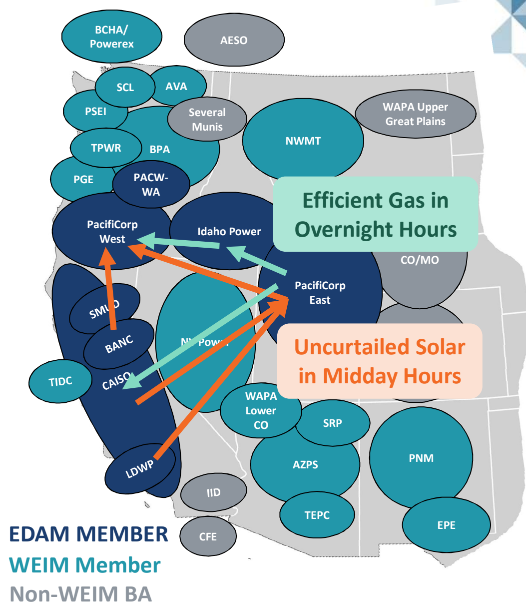
- Total WECC trading increases ~30 TWh due to the EDAM market
- New WECC trading comes from block trades (+11%), and hourly bilateral trading (+7%)
- Trading volumes decrease in WEIM (-9%), for CAISO intertie trades (-39%), and hourly trades on long-term ETCs (-23%)
- **Total EDAM transactions: 51 TWh**



Trading Patterns in EDAM

We observe two key patterns the simulated in EDAM transactions:

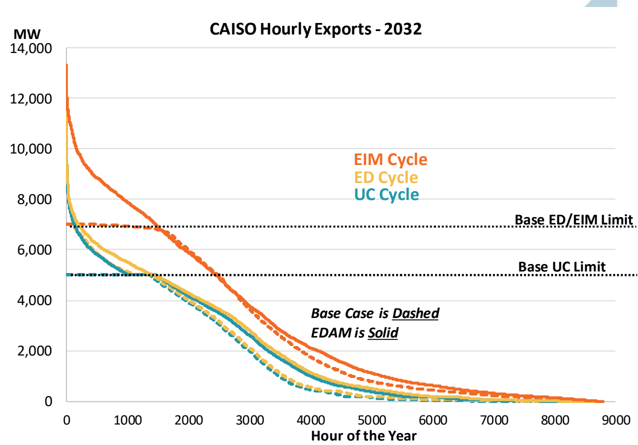
- During midday hours, the market uses excess solar in CAISO, which would get curtailed without EDAM, to back down thermal generation in PACE, PACW, and IPCO
- In the overnight hours, the most efficient gas-fired generation (usually in PACE) displaces less efficient (i.e., higher cost and higher emitting) gas generation in CA, OR, and WA
- Trading patterns would likely become more efficient as new members join the footprint
  - Our EDAM footprint has little PNW hydro and no AZ/NV solar with a different profile than CA solar



CAISO Export Curve

CAISO exports increase 21% even in the EDAM Unit-Commitment (UC) cycle due to the new market and removal of hourly export limits

- The base case has a CAISO export limit of 5 GW per hour in the UC cycle, and 7 GW per hour in the economic dispatch and WEIM cycles
  - Limits are widely-used modeling assumptions to capture the limited liquidity of bilateral markets
- The EDAM case keeps the 5 GW limit on day-ahead bilateral transactions, but **allows EDAM and WEIM transactions to exceed this limit**

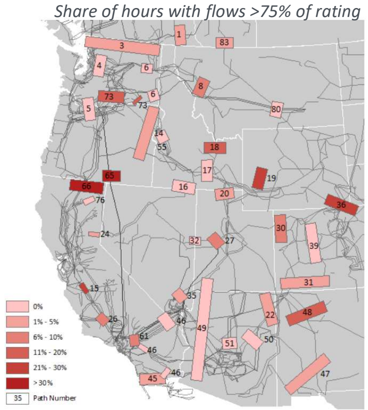


WECC Path Utilization

We simulated the WECC paths based on the most recent rating catalog

2017 WECC Path Utilization

Share of hours with flows >75% of rating



Source: WECC State of the Interconnection Report (Summer 2017)

2032 Modeled WECC Path Utilization

Top 25 Utilized Paths in Base Case

Path	Total Energy *GWh*	Utilization *% of Limit*
P15 Midway-LosBanos	29,317	98.80%
P76 Alturas Project	2,506	95.34%
P52 Silver Peak-Control 55 kV	141	94.66%
P24 PG&E-Sierra	1,287	91.79%
P77 Crystal-Allen	7,320	87.96%
P60 Inyo-Control 115 kV Tie	411	83.68%
P35 TOT 2C	4,007	76.23%
P26 Northern-Southern California	25,688	73.31%
P03East Side NW-BC	2,421	69.10%
P47 Southern New Mexico (NM1)	5,709	62.19%
P28 Intermountain-Mona 345 kV	6,557	53.47%
P18 Montana-Idaho	1,727	51.47%
P41 Sylmar to SCE	7,191	51.30%
P29 Intermountain-Gonder 230 kV	876	49.99%
P36 TOT 3	7,192	48.87%
P62 Eldorado-McCullough 500 kV Line	10,836	47.61%
P25 PacifiCorp/PG&E 115 kV Interconnection	333	47.58%
P81 Southern Nevada Transmission Interface (SNTI)	17,134	43.15%
P27 Intermountain Power Project DC Line	9,056	43.08%
P05 West of Cascades-South	27,105	42.98%
P66 COI	18,067	42.97%
P83 Montana Alberta Tie Line	1,197	42.06%
P42 IID-SCE	2,130	40.52%
P46 West of Colorado River (WOR)	37,827	38.55%
P61 Lugo-Victorville 500 kV Line	7,750	36.86%

Physical Congestion on WECC Paths (2032)

Congestion increases by over $100 million in EDAM for the listed WECC paths (5% higher than in Base Case)

- Congestion increase mostly on COI, CAISO-LADWP (P26), and P61
- Some congestion increases in PNW around P75, P15

Congestion increased this round in the base case (and some in the EDAM case) **due to higher renewable curtailment costs**, with the modeling trying to avoid curtailments via more base case and EDAM case trading

Day-Ahead Congestion on Paths with Largest Changes ($ Millions)

Path	Base Congestion	EDAM Congestion	Change	% Change
P61 Lugo-Victorville 500 kV Line	$436	$473	$37	8.6%
P66 COI	$219	$248	$30	13.7%
P26 Northern-Southern California	$618	$642	$23	3.8%
P28 Intermountain-Mona 345 kV	$121	$135	$15	12.3%
P15 Midway-LosBanos	$115	$127	$13	11.2%
P75 Hemingway-Summer Lake	$96	$107	$11	11.7%
P46 West of Colorado River (WOR)	$24	$31	$6	25.5%
P20 Path C	$10	$14	$3	31.8%
P16 Idaho-Sierra	$9	$11	$2	22.7%
P30 TOT 1A	$20	$13	-$7	-35.5%
P36 TOT 3	$22	$14	-$8	-35.6%
P47 Southern New Mexico (NM1)	$118	$92	-$26	-22.0%
Total Change (All Paths)	**$2,041**	**$2,150**	**$109**	**5%**

Note: Total includes all WECC paths, but only paths with changes in congestion of $10 million or more are shown.