



The Impacts on California of Expanded Regional Cooperation to Operate the Western Grid (Final Report)

David Hurlbut, Mark Greenfogel, and Brittany Speetles

National Renewable Energy Laboratory

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Executive Summary

Changes inside and outside the power sector are making the potential benefits of regional cooperation in operating the electricity grid more compelling than ever before. To keep California policymakers abreast of the most current information, the California State Legislature asked the California Independent System Operator (CAISO) to work with other California balancing authorities (BAs)¹ to develop a knowledge base on regional cooperation and the possible effects on California’s energy and environmental goals. Assembly Concurrent Resolution (ACR) 188, approved by the California State Assembly and Senate in August 2022, requested a report synthesizing the studies, policies, and papers on the potential benefits of expanded regional cooperation in California, with a focus on key issues that will most effectively advance the state’s energy and environmental goals, including Senate Bill 100 (Chapter 312 of the Statutes of 2018).² This includes any available studies that reflect the impact of regionalization on transmission costs and reliability for California ratepayers.

CAISO and the BAs agreed on securing an independent third party—the National Renewable Energy Laboratory (NREL)—to conduct the review and synthesize the findings. As a national laboratory of the U.S. Department of Energy, NREL is independent of any stakeholder and state authority.³ NREL’s approach in conducting this review is to provide an objective synthesis of proposals, studies, and papers dealing with regional cooperation in California and the West.

Assembly Concurrent Resolution (ACR) 188, approved by the California State Assembly and Senate in August 2022, requested a report synthesizing the studies, policies, and papers on the potential benefits of expanded regional cooperation in California, with a focus on key issues that will most effectively advance the state’s energy and environmental goals under Senate Bill 100 (Chapter 312 of the Statutes of 2018). This includes any available studies that reflect the impact of regionalization on transmission costs and reliability for California ratepayers.

Aside from compiling studies, ACR 188 asked CAISO to provide updates on the transmission development and resource diversity estimates that were included in the *2021 SB 100 Joint Agency Report*. The next joint agency report will not be published until 2025, and the California Energy Commission confirms there are no updates at this time. Section 5 of this report examines the estimates most recently used and contrasts them with California’s increasing need for capacity in the near term and the long term.

Lastly, ACR 188 requested a discussion of “regional transmission organizations [RTOs] in Colorado, Nevada, and other regional states, collaboration between states on energy policies to maximize consumer savings while respecting state policy autonomy, and engagement between neighboring states on the future of regional transmission organizations in the west.” No RTO currently exists in other western states, but several states and a number of regional forums are

¹ Besides CAISO, other BAs involved in the preparation of this report included the Balancing Authority of Northern California, the Turlock Irrigation District, the Western Area Power Administration, the Los Angeles Department of Water and Power, NV Energy, PacifiCorp, and the Imperial Irrigation District.

² See Appendix A for the full text of ACR 188.

³ There is no endorsement by NREL, expressed or implied, of any position that any agency of the State of California may take in discussions with other western states on regional cooperation.

assessing key topics including governance, resource adequacy, resource sharing, and transmission development. For example, utilities in the Rocky Mountain region have been looking at cooperative arrangements with a neighboring RTO, Southwest Power Pool (SPP). Section 2 of this report summarizes these regional activities.

This report interprets the term “regional cooperation” broadly. Expanding CAISO to be a West-wide RTO is one option that has been studied, but regional cooperation can take many other forms. Some of these models have been or are being implemented already, demonstrating a general momentum towards greater regional cooperation.

- Some regional cooperation is already taking place through existing joint operating agreements, power pooling arrangements, and bilateral contracting platforms such as the Western Systems Power Pool and Intercontinental Exchange.
- Since 2014, CAISO has operated a voluntary real-time Western Energy Imbalance Market (WEIM), which has saved participants more than \$3 billion.⁴
- On Feb. 10, 2023, the Federal Energy Regulatory Commission (FERC) approved the Western Resource Adequacy Program, a cooperative arrangement for sharing reserves and reducing the cost of resource adequacy.
- Also in February 2023, the CAISO board approved measures to implement an Extended Day-Ahead Market (EDAM) that utilities may choose to join without becoming full CAISO members.

Though the focus of ACR 188 and this report is how regional cooperation might benefit and impact California achieving its energy policy and environmental goals, in a practical sense, achieving regional cooperation depends on finding mutual benefits for the rest of the West too. Joining a voluntary regional power market is a decision each potential participant will need to make based in its own analysis of benefits, costs, risks, and policy goals. Significantly, the preponderance of literature suggests regional cooperation will help California and other states realize cost savings and common energy policy goals. However, some of the technical studies included in this review suggest the benefits of more comprehensive forms of regional cooperation such as a West-wide RTO might not be spread evenly across participating states and their utilities. Reconciling the differences will likely be a matter of good-faith negotiation among the parties after each has assessed the magnitude of its own potential benefits and risks, and ultimately some may opt out.

Expanding CAISO to become a multistate regional transmission organization (RTO) is an option that ACR 188 calls out specifically.⁵ The literature affirms that such a scenario would not remove the jurisdiction of California (or any other state) over its retail rates, resource planning, resource siting, transmission siting, renewable energy policies, or emissions reduction policies.⁶ However, the literature also suggests strongly that such a move would require changes to

⁴ The WEIM began in 2014 and now includes 19 utilities across the Western United States and Canada. Three additional utilities will join the WEIM effective April 1, 2023.

⁵ An RTO is an entity of sufficient regional scope that maintains operational or functional control of facilities used for the transmission of electric energy in inter-state commerce, and ensures nondiscriminatory access to these facilities. Federal Power Act Section 3(27).

⁶ For a summary analysis, see Gardner (2019).

CAISO's governance.⁷ All other multi-state RTOs in the country have an independent governing board and a special advisory committee that includes energy officials from all states in the RTO's geographic footprint. Typically, the board is elected by RTO members from a slate prepared by a nominating committee, and members of the regional states committee are public utility commissioners, state energy officers, or other officials from affected states.⁸ CAISO's rules for operation would continue to be under federal jurisdiction through its open-access transmission tariff approved by the Federal Energy Regulatory Commission (FERC).

The studies and papers summarized in this report form a consistent narrative. The points frequently made include:

- The measurable benefits of regional cooperation include production cost savings, resource capacity savings, and emission reductions.
- Qualitative benefits include greater transparency, increased stakeholder participation, and more efficient use of the transmission system.
- Regional cooperation can enhance reliability, especially under stressful conditions that impact the availability of some generation and transmission assets.
- A geographically larger operational footprint tends to yield greater resource and load diversity.
- An RTO, because it is a more comprehensive structure for cooperation that optimizes a wider array of grid functions, tends to yield greater cost savings and grid flexibility than more limited forms of cooperation.
- Larger and more comprehensive structures also expand the types of issues that need to be addressed, such as governance and principles for allocating the cost of new transmission.
- More limited forms of cooperation also yield benefits such as cost savings, even though the benefits might not be as large as they would be with more comprehensive frameworks for cooperation.

The literature reviewed in this report shows there are many factors that policymakers in California and other states must balance in choosing regional cooperation solutions that are right for the time. However, experiences in other parts of the country suggest regional cooperation is not one single decision. Rather, it is an evolutionary progression. In the Western US, participant experience with the WEIM provided a foundation for CAISO's development of the EDAM, therefore it is reasonable to expect that participant experience with EDAM and WRAP might over time inform the next phase of expanded regional cooperation.

Modes of Regional Cooperation

The literature suggests expanded regional cooperation in the West could take any of the following forms:

- Regional RTO expansion, where transmission utilities outside of California elect to either join CAISO (or SPP) or form a new RTO

⁷ This view was also stated by several stakeholders who commented on a preliminary draft of this report.

⁸ The issue of CAISO's governance structure is discussed further in Section 1.3.

- Centrally dispatched energy markets operated by an RTO (for utilities not opting for full RTO membership)
- A regional resource adequacy and planning reserve sharing program.

Technical studies included in this review show that an expanded RTO or a centrally dispatched energy market operated by an RTO could provide significant savings in production costs, especially as states expand their use of renewable energy resources. An RTO or a regional resource adequacy program can provide significant savings in the cost of resource adequacy. Both categories of benefits tend to be even greater when energy markets, resource adequacy, and all other grid functions are integrated under an RTO with access to a wide diversity of resources and load across a broad geographic footprint.

Any of these modes of cooperation can advance California’s energy and environmental policies. Moreover, CAISO and the other California BAs are already leading or engaging in these opportunities. The degree to which state policies could be advanced depends on the mode of cooperation that is applied and on the number and location of utilities that elect to participate.

Improved Transmission Value, Reliability, and Grid Resilience

The technical studies reviewed for this report found that in addition to reducing production costs, regional cooperation also offered significant savings in the cost of resource adequacy. Whether under a full RTO or under more limited modes of cooperation, centralized regional operation can smooth out variability in demand and in the performance of renewable resources, and it can enable the sharing of operating reserves to manage variability at a lower cost.

Transmission planning across a region rather than by individual utilities separately can reduce transmission congestion costs and the cost of operating reserve required to maintain reliability. This leads to more efficient use of the transmission system and greater reliability for customers. Other benefits include:

- Less curtailment of solar and wind resources due to congested transmission paths
- The ability to move excess wind and solar power elsewhere in the region when local production is high and demand is low
- More operational flexibility to manage the variation in solar and wind output
- Better grid resilience (the ability to mitigate or recover from extreme weather events and other major outages).

Transmission expansion can also take advantage of load diversity for resource adequacy planning, thereby enabling lower reserve margins and lower resource adequacy costs.

An RTO consolidates transmission planning (along with other grid management functions) and has stakeholder processes for developing equitable cost allocation rules. Regional cooperation in transmission planning can also coincide with non-RTO regional energy markets and regional resource adequacy plans, however. FERC requires at a minimum that each public utility transmission provider participate in a regional transmission planning process that produces a

regional transmission plan.⁹ However, FERC itself has said actual engagement on transmission coordination has been insufficient in light of changes in the resource mix and demand.¹⁰

The literature contained no estimates of how regional cooperation might affect the distribution of transmission costs specific to customers in California. This question primarily concerns new transmission, because the practice in other multi-state RTOs is to preserve the historical assignment of legacy transmission costs. For new transmission, the assignment of costs generally follows the distribution of benefits, which are project-specific and highly dependent on why the new line is needed.¹¹

The literature reviewed suggests that larger market footprints and more comprehensive structures for cooperation could increase reliability benefits for western states. The growth in wind and solar power across the West is increasing the need for flexible operating reserves (including battery storage and demand response), and procuring and operating them across a larger geographic footprint tends to reduce the cost and increase competition.

Some studies suggest that cooperation across a larger geographic footprint also enhances the ability to protect the grid against unusual stresses, such as an extreme weather event, natural disaster, cyberattack or physical sabotage. However, the studies reviewed here link such improvement to better transmission coordination so that power can be moved into a distressed area quickly when it is needed. Though real-time situational awareness is also critical to managing emergencies, and an RTO has consistent situational awareness across its footprint as well as standard operating procedures for emergency conditions, no study analyzed the differences between RTOs and other cooperative arrangements in providing adequate situational awareness during an emergency.

Main Takeaway on Regional Cooperation

The studies reviewed, while varying in focus, are consistent and demonstrate that California's goals for renewable energy and greenhouse gas reduction can be achieved more quickly and with less cost to Californians through expanded regional cooperation. The magnitude of the benefits to California will vary based on the mode of cooperation and on the states and utilities that elect to participate. For example, the total benefits to California of a West-wide extended day-ahead energy market operated by CAISO (Energy Strategies 2022) were less than the benefits estimated for the state under a West-wide RTO (Energy Strategies 2021). For the rest of the West, an extended day-ahead market retained a slightly larger portion of the expected benefits of a full RTO (Energy Strategies 2022).

An important threshold question raised by the literature reviewed here is: *what are the grid functions that should be performed regionally to obtain the greatest benefit at the least cost*

⁹ FERC Order No. 1000, *Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities* (July 2011), <https://www.ferc.gov/sites/default/files/2020-04/OrderNo.1000.pdf>.

¹⁰ FERC Notice of Proposed Rulemaking, *Building for the Future Through Electric Regional Transmission Planning and Cost Allocation and Generator Interconnection* (April 2022), <https://www.ferc.gov/media/rm21-17-000>.

¹¹ Generally, a line can be needed for reliability, congestion relief and other sources of production cost savings, public policy directives, or a combination of these factors. See FERC Order No. 1000.

while simultaneously respecting state policy autonomy? A large multistate RTO is one of several options; it could provide the largest margin of benefit, including the greatest visibility into operational performance, efficient dispatch, and lower-cost reliability. It could also entail more complexity, especially for states not already in an RTO. Other less-comprehensive forms of enhanced regional cooperation, such as a regional energy market or a regional mechanism for resource adequacy, would also provide some measure of cost savings, reliability improvements, and reduced carbon emissions for the benefit of California and all other participants. These limited forms of cooperation would preserve state autonomy over policies and practices that are outside the scope of the cooperative arrangement.

Supply, demand, and resource adequacy trends suggest California will need:

- Continued commercial procurements from the rest of the West
- More exports in the middle of the day to minimize the need to curtail solar
- Reserve sharing (especially with the Southwest) as California works to improve its internal reserve margins for the future
- Improved reliability especially during times of extraordinary stress on the grid.

Stakeholder Comments

A preliminary draft of this report was posted to the CAISO public website and on January 13, 2023 and stakeholders were given several weeks to provide comments. The feedback reflected a wide variety of positions, interests, and aspirations for expanded regional cooperation. CAISO has responded to the comments received in a separate document posted on the CAISO website.¹²

In considering stakeholder comments for this final report, NREL was guided by its understanding of what the legislature requested: an objective review of existing literature that could serve as a knowledge base for use by California decisionmakers. We avoided elevating or rejecting any potential avenue of cooperation—that is best done through deliberation and consensus building by states and affected parties based on their interests as they evolve over time.

Some topics raised in comments are relatively new research fields and, consequently, did not have existing studies examining their intersection with regional grid cooperation. Though a significant amount of research is under way on topics such as interregional transmission planning, grid resilience against extreme weather events, energy justice, cybersecurity risks, and new metrics for resource adequacy that better account for the capacity value of wind and solar technologies, published studies of how expanded regional cooperation in the West might specifically affect these issues are limited at this time.

This does not imply that progress towards greater regional cooperation should stop until the research is complete. Expanded regional cooperation in the West achieved major breakthroughs in the past 12 months based on what is known about the potential benefits at stake. Markets will continue to evolve, just as the knowledge informing the path of evolution will continue to grow.

¹² <http://www.caiso.com/Documents/ISOResponses-Comments-AssemblyConcurrentResolution188-Jan20-23StakeholderMeeting.pdf>

Table of Contents

Executive Summary	v
1 Background	1
1.1 Regional Cooperation’s Value Propositions	3
1.1.1 The West’s Changing Resource Mix.....	3
1.1.2 Planning Reserve Margins	5
1.1.3 Legacy Practices Do Not Fit Well with the New Resource Mix.....	6
1.1.4 How California and the West Exchange Electricity.....	7
1.2 The Options.....	9
1.3 Reconciling Different State Policies in a Regional Framework.....	11
1.4 Summary	12
2 Regional Cooperation Efforts in the West	13
2.1 State Efforts.....	13
2.1.1 Western Interstate Energy Board	13
2.1.2 The Committee on Regional Electric Power Cooperation	13
2.1.3 Western Interconnection Regional Advisory Body.....	14
2.1.4 Multistate Study	14
2.1.5 Arizona.....	14
2.1.6 Colorado.....	15
2.1.7 Montana.....	15
2.1.8 Nevada.....	16
2.1.9 New Mexico	16
2.1.10 Oregon.....	17
2.1.11 Washington	17
2.2 Frameworks for Regional Cooperation	18
2.2.1 CAISO-Operated Western Energy Imbalance Market.....	19
2.2.2 CAISO-Operated Extended Day-Ahead Market (EDAM).....	20
2.2.3 SPP-Operated Western Energy Imbalance Service.....	21
2.2.4 SPP-Operated “Markets+”	22
2.2.5 Western Resource Adequacy Program.....	24
2.2.6 Western Markets Exploratory Group	25
3 Literature Included in the Review	27
3.1 Technical Studies	29
3.2 Policy Studies.....	47
3.3 Legal Assessments	54
3.4 Other Literature	58
4 Annotated Summary of the Literature	74
4.1 Types of Benefits	75
4.2 The Options.....	77
4.2.1 The RTO Model.....	77
4.2.2 Energy Imbalance Markets.....	79
4.2.3 Day-Ahead Markets	79
4.2.4 Coordination on Resource Adequacy.....	80
4.3 Impacts on California	80
5 SB 100 and Relevant Updates	83
Glossary	86
References	91
Appendix A. Text of Assembly Concurrent Resolution 188	97
Appendix B. Additional Background	100
B.1 Legal Framework for ISOs and RTOs	100
B.2 Energy Imbalance Markets: Regional Coordination in Action	107

List of Figures

Figure 1. Time series change in sources of generation in Western States	4
Figure 2. Prospective planning reserve margins in the West.....	6
Figure 3. California's electricity supply and demand.....	8
Figure 4. Using exports to reduce renewable energy curtailment.....	8
Figure 5. CAISO, SPP, and the U.S. portion of WECC not in CAISO	10
Figure 6. WEIM's actual economic benefits thanks to operational cost savings.....	73
Figure 7. Cumulative capacity additions for the 60% RPS, SB 100 Core, and Study scenarios	84
Figure 8. Clean energy, RPSs, and goals in the United States.....	106
Figure 9. CAISO-operated WEIM coverage as of 2022	108
Figure 10. SPP-operated WEIS coverage as of 2022.....	109

List of Tables

Table 1. Topics Included in ACR 188	2
Table 2. Major Retirements of Coal Generating Plants in the West.....	5
Table 3. Studies and Papers Included in the Review	27
Table 4. Capital Costs for Solar Photovoltaics and Wind (2022 \$/kW)	33
Table 5. Cost Savings Estimated for 2030 Relative to 2019 Market Structure (\$Million/Year).....	35
Table 6. Summary of Study Results.....	67
Table 7. California's Estimated Annual Savings in Production Costs in 2030.....	81
Table 8. 2045 Annual Cost Summary for the 60% RPS, SB 100 Core, and Study Scenario	85
Table B-1. RTO Multistate Participation Structures.....	104

List of Abbreviations and Acronyms

AC	alternating current
ACORE	American Council of Renewable Energy
ACR 188	Assembly Concurrent Resolution 188
ATC	available transfer capacity
AWEA	American Wind Energy Association
BA	balancing authority
BAA	balancing authority area
BANC	Balancing Authority of Northern California
C&I	commercial and industrial
CAISO	California Independent System Operator
CEBA	Clean Energy Buyers Association
CO ₂	carbon dioxide
d/b/a	doing business as
DC	direct current
DR	demand response
DOE	U.S. Department of Energy
EDAM	Extended Day-Ahead Market
EIM	[electricity/energy] imbalance market
EPS	emission performance standard
ERCOT	Electric Reliability Council of Texas
FERC	Federal Energy Regulatory Commission
GHG	greenhouse gas
GIS	Generation Information Systems
GW	gigawatts
ISO	independent system operator
ISO-NE	Independent System Operator of New England
LMP	locational marginal prices
LSE	load-serving entity
MISO	Midcontinent Independent System Operator
MW	megawatts
N/A	not applicable
NERC	North American Electric Reliability Corporation
NREL	National Renewable Energy Laboratory
OASIS	Open Access Same-Time Information System
OOS	offshore
OWM	organized wholesale market
PR	Puerto Rico
PUC	Public Utilities Commission
REBA	Renewable Energy Buyers Alliance
RPS	renewable portfolio standard
RTO	regional transmission organization
SPP	Southwest Power Pool
TWh	terawatt-hours
USVI	U.S. Virgin Islands
WAPA	Western Area Power Administration

WECC	Western Electricity Coordinating Council
WEIM	Western Energy Imbalance Market
WEIS	Western Energy Imbalance Service
WIRED	Western Interconnection Regional Electricity Dialogue
WPP	Western Power Pool
WRAP	Western Resource Adequacy Program

1 Background

Policymakers in California and other Western states (the West)¹³ are exploring options for greater regional cooperation to improve management of the Western power grid and to better achieve public policy goals.¹⁴ The resource mix is changing both in California and in the rest of the West, which in turn is increasing the degree of regional interdependence and could increase the value proposition for greater regional cooperation. In addition to a changing resource mix, the electric grid is experiencing increasingly frequent stresses to reliability induced by climate change. Meanwhile, state policies for shifting transportation, building heating, and other activities away from the use of fossil fuels and toward greater electrification are increasing the overall demand for electricity in California and the West. All these factors affect how regional cooperation can contribute to the achievement of California’s energy and environmental goals.

In accordance with Assembly Concurrent Resolution (ACR) 188, approved by the California State Assembly and Senate in August 2022, the California Independent System Operator (CAISO) coordinated closely with its partner balancing authorities (BAs) on the development of this report.¹⁵ CAISO and the BAs mutually agreed to engage an independent third party to author the report. Accordingly, CAISO secured the assistance of the National Renewable Energy Laboratory (NREL). As a national laboratory of the U.S. Department of Energy, NREL is independent of any particular stakeholders and state policies. The approach in conducting this review was to provide an unbiased synthesis of proposals, studies, and papers dealing with regional cooperation in the West and the potential impact on California’s energy and environmental goals. *There is no endorsement by NREL, expressed or implied, of any position that any agency of the State of California may take in discussions with other Western states on regional cooperation.*

Table 1 provides a thumbnail summary of the legislature’s guidance in ACR 188 and cross-references to the relevant sections in this report.

¹³ For this report, Western states include Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming.

¹⁴ Western power grid and similar general terms refer to the Western Interconnection, which covers the Western United States, the Northern part of Mexico’s Baja California, and the Canadian provinces of British Columbia and Alberta. Unless stated otherwise, the discussion in this review focuses on cooperation among U.S. states.

¹⁵ BAs involved in the preparation of this report include CAISO, the Balancing Authority of Northern California, the Turlock Irrigation District, the Western Area Power Administration, the Los Angeles Department of Water and Power, NV Energy, and the Imperial Irrigation District.

Table 1. Topics Included in ACR 188

ACR 188 Text	Topic	Section of this Report
<p><i>“...the Legislature requests that by February 28, 2023, the Independent System Operator, in consultation with the California balancing authorities, produce a report that summarizes recent relevant studies on the impacts of expanded regional cooperation on California and identifies key issues that will most effectively advance the state’s energy and environmental goals, including any available studies that reflect the impact of regionalization on transmission costs and reliability for California ratepayers...”</i></p>	Impacts of expanded regional cooperation on California	See Section 4.
	Issues that will most effectively advance the state’s energy and environmental goals	See Section 4.3, which includes implications specific to California policies.
	Impact of regionalization on transmission costs and reliability for California ratepayers	See Section 4.1, which summarizes West-wide impacts that include California.
<p><i>“...the report should include relevant updates to the transmission development and resource diversity estimates in the 2021 SB 100 Joint Agency Report ...”</i></p>	Updates to the 2021 SB 100 Joint Agency Report (CEC 2021)	See Section 5.
<p><i>“...the report should also discuss the regional transmission organizations in Colorado, Nevada, and other regional states, collaboration between states on energy policies to maximize consumer savings while respecting state policy autonomy, and engagement between neighboring states on the future of regional transmission organizations in the West...”</i></p>	RTOs in Colorado, Nevada, and other regional states	See Section 2.1 <i>To date, no entity has filed a petition with FERC to create an RTO in any Western state outside California.</i>
	Collaboration between states on energy policies to maximize consumer savings while respecting state policy autonomy	See Section 2.
	Engagement of neighboring states on the future of RTOs in the West	See Section 2. <i>RTOs are one of several modes of regional cooperation that neighboring states are studying.</i>

NREL, CAISO and the participating BAs developed an initial list of studies and papers for inclusion in this review. This list was then circulated to CAISO stakeholders, the California Energy Commission, and the California Public Utilities Commission for additions and recommended deletions. NREL used its judgment in deciding the literature ultimately included in Section 3 based on the guidance in ACR 188. This report reviews 38 studies and papers.

Appendix A of this report provides the full text of ACR 188. Appendix B provides background information regarding the operational benefits that can be enhanced by RTOs and other modes of regional cooperation, and the legal framework as defined by FERC rules, including how FERC-jurisdictional RTOs interact with their affected states.

The decision by any entity to participate in a regional cooperation regime involves an assessment of potential benefits, risks, and alternatives. The literature has abundant discussion of potential benefits and options but much less discussion of risks. Therefore, the summaries provided in this report aim to inform the first step of the decision process: whether the potential benefits of participating in a regional cooperation plan are compelling enough to begin an assessment of risks. It is also a reason why the authors make no recommendation about which options for regional cooperation are preferred.

1.1 Regional Cooperation's Value Propositions

Assessing how regionalization might further California's energy and environmental policies includes understanding market conditions in the rest of the West and how they might affect what California's partners bring to the table. Though the same sectoral transformations are in play everywhere, each state has a different history and policy environment that affect its current strengths and needs. In this section, we briefly summarize:

- How the West's resource mix is changing
- The challenges that this new resource mix poses for conventional grid management practices
- Trends in planning reserve margins
- Implications for how California and the rest of the West exchange power.

1.1.1 The West's Changing Resource Mix

Crucial changes are occurring in how electricity is generated in the West. The characteristics of this new mix pose challenges to grid management practices developed decades ago. This underlying transformation is an important driver of cooperation between California and other Western states. Figure 1 shows how the mix has changed since 2001.

Another important change not shown in Figure 1 is the growth of battery storage, which has increased significantly in California over the past several years and is supplying power and operational flexibility in the evening hours as solar-based generation declines.

The key trends in California include:

- Significant growth in solar power
- The addition of more than 4 GW of battery storage, with plans to add another 7.9 GW (EIA 2023b)
- Hydroelectric power's sensitivity to longer and more frequent drought conditions
- Reliance on in-state natural gas generation and increased imports to offset annual and multiyear shortfalls in hydroelectric power availability during drought conditions.

Intraday trends not shown in Figure 1 include more midday exports due to increased solar generation, and reliance on imports during the evening peak.

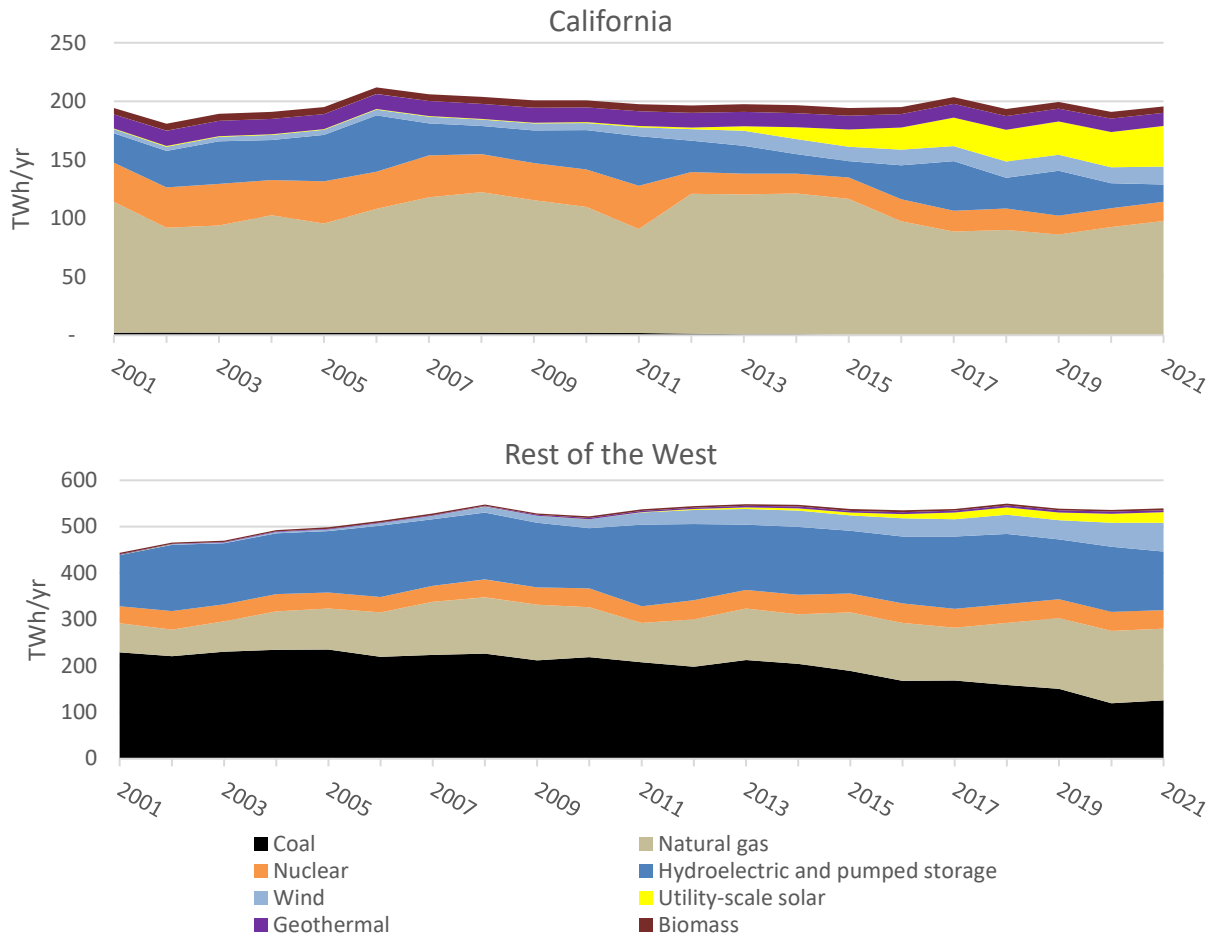


Figure 1. Time series change in sources of generation in Western States

Source: EIA 2023a

The figure does not include energy redispatch from battery storage: more than 4 GW of capacity in California and more than 200 MW in the rest of the West (EIA 2023b)

Key trends in the rest of the West include:

- A significant reduction in generation from coal
- Significant growth in wind power and solar power
- The addition of more than 200 MW of battery storage, with plans to add another 3 GW across the West (EIA 2023b)
- Greater use of natural gas generation.

Table 2 lists the largest coal plant retirements in the West over the past decade—9.4 GW total. Another 14 GW is scheduled for retirement over the next 15 years (WECC, 2022).

Table 2. Major Retirements of Coal Generating Plants in the West

Plant	State	Retired (Year or Years)	Capacity (MW)
Navajo	Arizona	2019	2,409
Mohave	Nevada	2012	1,636
San Juan	New Mexico	2017–2022	1,293
Centralia (Unit 1)	Washington	2020	730
Colstrip (Units 1 and 2)	Montana	2020	716
Cholla (Units 2 and 4)	Arizona	2015–2020	703
Boardman	Oregon	2020	642
Reid Gardner	Nevada	2014–2017	637
Four Corners (Units 1–3)	New Mexico	2013	633
Total			9,399

Source: EIA 2023b

1.1.2 Planning Reserve Margins

Although significant efforts are underway within California and across the West to strengthen resource adequacy programs and procure large amounts of new generating resources, the Western Electricity Coordinating Council (WECC) and the North American Electric Reliability Corporation (NERC) anticipate that planning reserve margins will fall throughout the West over the next decade (see Figure 2), resulting in more hours being at risk for lost load (WECC 2022; NERC 2022a).¹⁶ This has been driven in part by the retirement of large fossil fuel plants. Significant efforts are underway within California and across the West to strengthen resource adequacy and procure large amounts of new generating resources. Still, NERC forecasts that margins for California and the Northwest will fall below reference levels sometime after 2030.

In California, greater electrification is expected to increase total consumption and peak demand, while declining availability of fossil fuel generation and conventional hydropower are expected to outpace the growth of renewables and battery storage. WECC notes that delaying the retirement of some fossil fuel plants and accelerating the installation of battery storage has provided near-term relief for the West overall, but it cautions that additional mitigation measures will be needed once the fossil fuel plants are retired.

¹⁶ Here we use planning reserve margin estimates from WECC and NERC for methodological consistency across planning regions. Methodologies used locally may yield results that differ from those estimated by WECC and NERC.

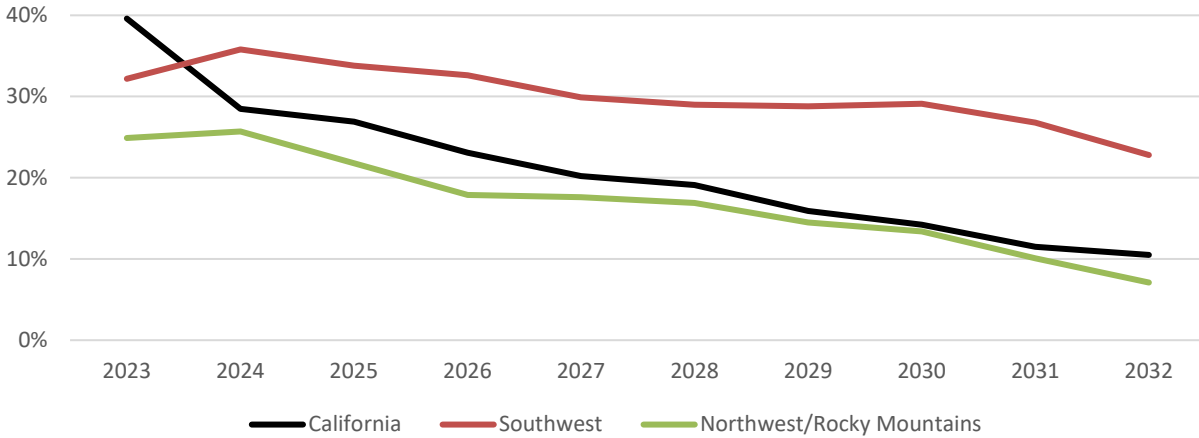


Figure 2. Prospective planning reserve margins in the West

Prospective resources include existing capacity, capacity under construction or pending approval, firm and nonfirm capacity transfers, minus plant retirements. Demand response is applied as an adjustment to total internal demand.

Source: NERC 2022a

In its recent assessment of resource adequacy in the West (WECC 2022), WECC recommends:

- Evaluating resource and transmission adequacy in a coordinated fashion through comprehensive wide-area system planning
- Ensuring resource plans include contingencies to manage slowdowns in planned resource additions
- Adapting planning practices to account for more uncertainty.

1.1.3 Legacy Practices Do Not Fit Well with the New Resource Mix

The changes in the resource mix shown in Figure 1 bring with them important changes to how the grid operates; for example:

- Wind power and solar power, the two fastest-growing sources of generation in the West, are less controllable than conventional thermal generation. As these resources increase, variability in the overall resource mix will also increase, creating a greater need for flexible response resources to keep generation and load in balance with one another in real time.
- Use of natural gas generation, which has more operational flexibility than coal or nuclear, has increased in the rest of the West.
- The decline of coal and nuclear has reduced the availability of traditional baseload resources. While resources with baseload characteristics such as geothermal, biomass, and nuclear will continue to be part of the resource mix, scheduling around baseload resources has decreased because total baseload capacity has decreased. At the same time, day-ahead wind and solar forecasts have become a critical component of scheduling.

As shown by the capacities of the retired coal plants listed in Table 2, it used to be possible to manage a large amount of generating capacity at a single point on the grid. Point-to-point exports from these plants could be managed without an organized regional market. These plants were also fully controllable and thus did not add unplanned variability to the grid.

Managing the variability of the emerging renewable resources involves two changes from previous management practices. First, if the wind and solar capacity is dispersed across a wide area, some of the variability at individual plants tends to offset variability at other plants, resulting in a smaller net variability that grid controllers need to manage. This is different from the management of large coal plants, where economies of scale came from maximizing the generating capacity built at a central station.

Another difference is the time scale of operation. Today the variability of wind and solar output can be forecasted day-ahead with reasonable accuracy, and these forecasts can inform the dispatch of flexible resources such as batteries, combined cycle generators, and gas turbines. Significant savings can be realized by first optimizing dispatch in the day-ahead market (where more than 90% of transactions are awarded), and then adjusting dispatch in the real-time market every five or fifteen minutes. In contrast, fast markets add little extra value to slow-responding coal units.

In summary, economies of scale for solar and wind are achieved through geographic dispersion and fast, flexible dispatch, which was not the case for central-station coal plants.¹⁷

Another critical challenge associated with conventional grid management practices is transmission planning. Wind power and solar power are expanding in part because their capital costs are falling. However, the ability of wind and solar to actually deliver low-cost energy to customers depends on where they are located (windier and sunnier locations produce more energy per dollar of capital investments) and on minimizing the need to curtail generation due to overproduction or transmission constraints. Solving these challenges most efficiently for renewable resources that are dispersed regionally depends on regional—and possibly interregional—transmission planning among states and utilities.

1.1.4 How California and the West Exchange Electricity

California's power trading relationship with the rest of the West has two supply-and-demand characteristics:

- Historically, California has generally been a net importer of bulk electricity from the rest of the West, as shown in Figure 3. The state's reliance on the rest of the region for a large percentage of its commercial needs has not changed appreciably over the past two decades.
- More recently, California has begun to dispose of surplus renewable energy generation by exporting some of it to other states. This happens most often during midday, when the production of solar plants is high and electricity demand is low. Figure 4 illustrates the phenomenon using May 8, 2022 as an example.

¹⁷ See, for example, Katz and Chernyakhovskiy (2020) and Miller et al. (2014).

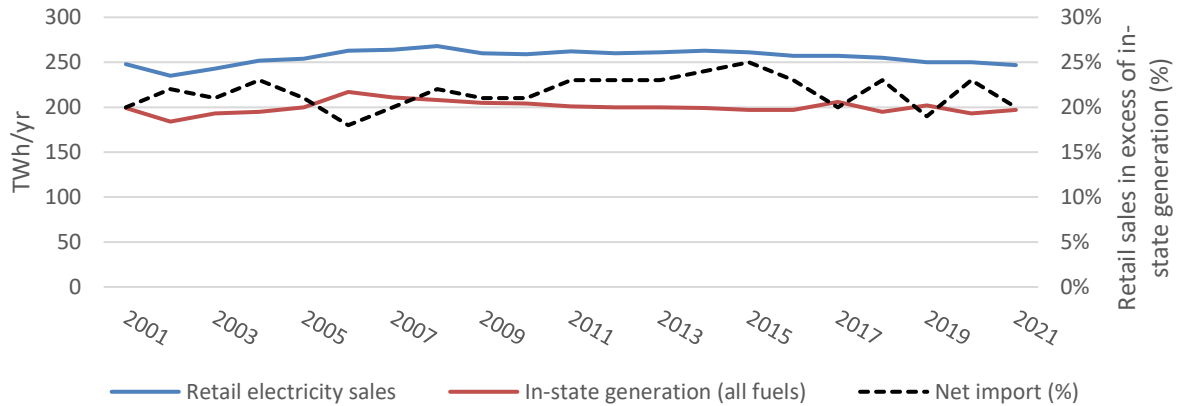


Figure 3. California's electricity supply and demand

Source: EIA 2023a, 2023c

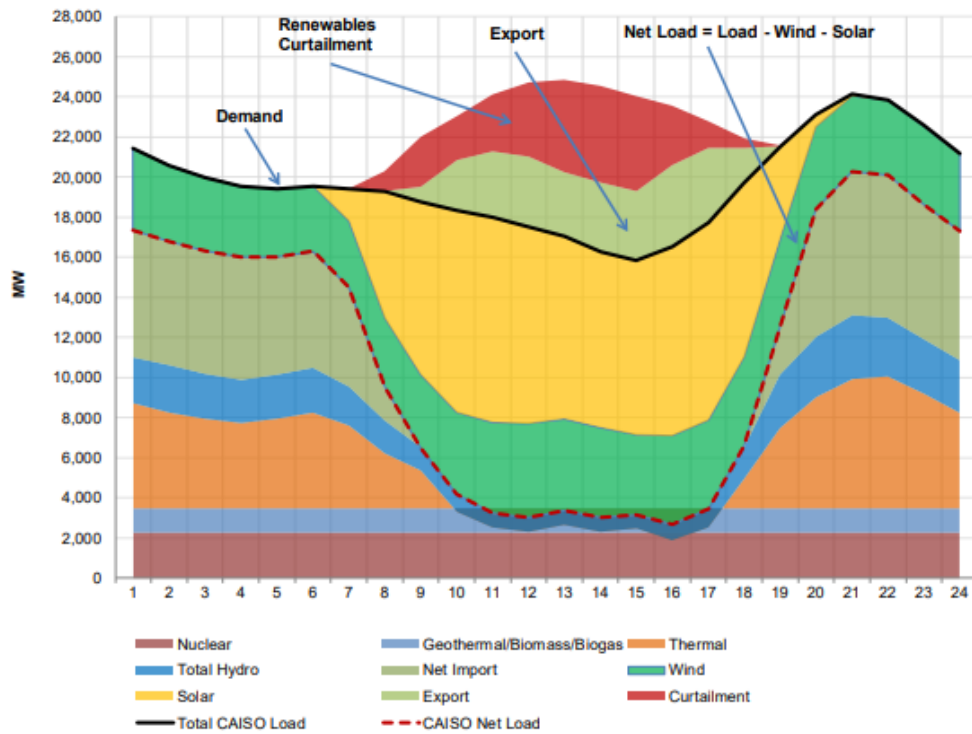


Figure 4. Using exports to reduce renewable energy curtailment

Source: CAISO, data for May 8, 2022

California has become more efficient in its use of electricity, but its consumption will increase in the near future as other sectors of the economy—most notably transportation and building heat—move away from fossil fuel combustion and toward electrification. Thus, trends in future demand could put additional pressure on supply, including electricity imports. At the same time, further growth in California's in-state solar and wind resources will increase its need to export generation that would otherwise be curtailed.

Reliability is a need that is attracting heightened interest with respect to regional cooperation. As the Western Power Pool (WPP) observed in its filing before FERC to create a Western Resource Adequacy Program (WRAP), the Western Interconnection is experiencing a “dramatic transformation” in the characteristics of generation resources on the grid, electricity demand (including state mandates and customer preferences for clean energy), and the operational challenges of extended drought and increasingly frequent extreme weather events. WPP also noted that “the western interconnection has significant regional diversity that can be tapped to bolster resource adequacy and reliability.”¹⁸ WPP’s petition to create WRAP culminated a multiyear, multistakeholder effort to formulate a cooperative approach to long-term reliability and resource adequacy.

These supply and demand trends suggest California will likely need:

- Commercial procurements from the rest of the West
- More exports in midday to minimize the need to curtail solar
- Reserve sharing (especially with the Southwest) as California works to improve its internal reserve margins for the future
- Improved reliability and access to additional supply especially during times of extraordinary stress on the grid.

In addition to supply and demand trends, related benefits could include optimization of the transmission system, and better visibility into overall system conditions.

1.2 The Options

A regional transmission organization (RTO) is the most comprehensive mode of regional cooperation. Many studies included in this review use the RTO model as a reference point for regional cooperation. CAISO is the only independent system operator in the Western United States.¹⁹ However, some utilities in the WECC Rocky Mountain region have explored joining the Southwest Power Pool (SPP), an RTO covering states in the Eastern Interconnection near its seam with the Western grid (see Figure 5).

¹⁸ Northwest Power Pool d/b/a Western Power Pool, *Submission of Tariff to Establish Western Resource Adequacy Program*, filing with the Federal Energy Regulatory Commission (August 31, 2021) at pp. 2–3.

¹⁹ The terms “independent system operator” and “regional transmission organization” are operationally the same. In this review we use RTO to describe an ISO that covers more than one state.

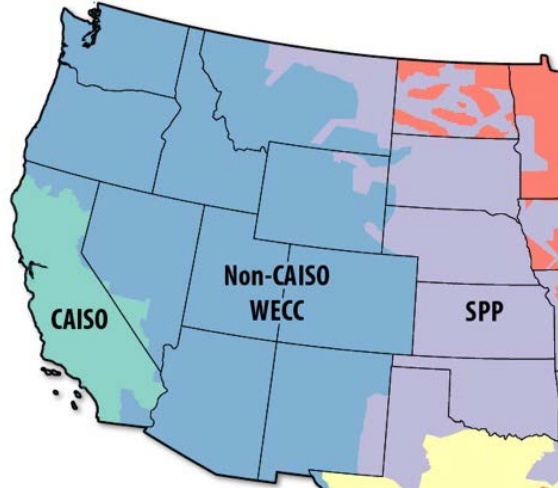


Figure 5. CAISO, SPP, and the U.S. portion of WECC not in CAISO

Map by Billy Roberts, NREL

Several studies included in this summary simulate markets in which all utilities in all Western states are part of an RTO. Such modeling scenarios are analytically useful for estimating the upper bound of possible benefits from a regional organized market. However, universal participation is not necessary. Joining an RTO is a decision initiated largely by individual utilities. Utilities for whom benefits are readily demonstrable will likely join first, while others may remain opt outs. State regulators may intervene, and state legislatures may affirm a state policy (initiatives by Nevada, Colorado, and Oregon are described in Section 3 of this report). Buying and selling power across the transmission system is interstate commerce and therefore exclusively under federal jurisdiction; accordingly, terms and conditions of market rules must be approved by the Federal Energy Regulatory Commission (FERC).

Over the past decade, Western states and stakeholders have experimented with more targeted modes of cooperation that focus on specific high-value grid functions: regional energy markets and mechanisms for resource adequacy. Both CAISO and SPP have proposed using their systems to operate day-ahead and real-time energy markets in parts of the West outside their footprints.

Resource adequacy—ensuring that generation resources continue to be sufficient to meet anticipated demand and reserve margin requirements—is another avenue of regional cooperation addressed by studies reviewed in this report. Regional cooperation on resource adequacy can expand the pool of resources available for managing extreme weather events, support lower and more efficient reserve margins, and reduce the long-term cost of acquiring new resources. Studies suggest these benefits can be substantial, apart from savings in operating costs. WRAP, a multistate approach to resource adequacy developed by the WPP (described in Section 2.2.5), was approved by FERC on Feb. 10, 2023.

Proposals solely focused on centralized energy markets or resource adequacy would not require full RTO membership and would likely preserve each participating BA’s other functions. A regional resource adequacy program may reduce the cost of resource adequacy in a utility’s integrated resource plan and allow states to continue overseeing the mix of resources selected to meet energy policy goals.

Studies also point to an increased need for regional transmission planning. According to planning studies prepared by California’s regulatory bodies and CAISO, California may need to build as much as 120,000 MW of new clean resources to meet its clean energy goals by 2040, with most of it coming from new in-state or off-shore projects (CAISO 2022a, p. 19). At the same time, these studies also indicate the need for additional out-of-state resources to reliably meet California’s goals. Many low-cost wind and solar zones in other parts of the West need new transmission to reach load centers, and the ability to move power from one part of the West to another is often critical to keeping service available during wildfires or extreme weather conditions. The most cost-effective options for new clean energy resources and for maintaining reliability include cooperation on the regional infrastructure needed for efficient interconnectivity.

1.3 Reconciling Different State Policies in a Regional Framework

Expanding CAISO into a multi-state RTO would create the need for changes in the governance structure, mechanisms for transmission cost allocation, alignment of resource adequacy programs to accommodate energy policies of participating states, and market rules that could accommodate varying state energy policies.

For example, SB 100 requires that by 2045 all retail sales of electricity to California end-use customers and all electricity serving state agencies be from eligible renewable energy and zero-carbon resources. The law also requires that achievement of this policy “shall not increase carbon emissions elsewhere in the western grid and shall not allow resource shuffling.”²⁰ However, an RTO is required by federal law to operate in a nondiscriminatory manner for all market participants regardless of where they do business.²¹ One tool it uses is security-constrained economic dispatch (SCED), which determines which units run and the prices at which they will be paid for each operating period. SCED optimizes unit dispatch based on demand, unit availability, and marginal cost. CAISO includes a greenhouse gas (GHG) pricing component in its SCED outcomes, but this feature is not commonly part of SCED in other markets. A version of this approach (combined with a system of energy tagging) is included in the EDAM recently approved by the CAISO board (McKenna 2023, see p. 11). But because the EDAM could eventually reach into states with different GHG policies, its market rules need to accommodate transactions that do not involve California or the GHG price adder applied to resources serving California customers. The approach in EDAM is to allow bids that specify resources available to serve California load, and the GHG price at which they are willing to do so. Careful monitoring of EDAM market outcomes over time will reveal whether this approach addresses the resource shuffling issue in a way that does not discriminate against any market participant. Nevertheless, this modification demonstrates the need to accommodate varying state policies in a multi-state organized market and how market rules might adapt.

It is important to note that all multistate RTOs work against a backdrop of differing state policies. No study included in this review specifically examined how an RTO (or the specific

²⁰ California Public Utilities Code Sec. 454.53(a)

²¹ See Appendix B for a description of federal laws and regulations governing RTOs and ISOs.

process included in the EDAM) might address resource shuffling, but many did refer to the need to reconcile different state policies within a multi-state RTO.

Successfully arbitrating such differences within the RTO itself would depend on a governance structure where all participating states have meaningful input. Many state documents reviewed in this report note that governance is a key issue with respect to a multistate RTO. As it currently exists, CAISO is largely a single-state independent system operator in which the governor and legislature have authority over who serves on the RTO's governing board. Governors and legislatures do not have as prominent a role in the governance of other multistate RTOs, but they are still involved. The common practice in multistate RTOs is to seat members of the governing board by a vote of RTO members or similar stakeholder process. Multistate RTOs have state advisory committees (usually comprising utility regulators from participating states) that provide input directly to the governing board and in some cases have direct filing authority to FERC on matters such as transmission cost allocation and resource adequacy.

In multistate RTOs, states retain authority over retail service issues, and these policies can differ from state to state on matters such as renewable energy content and customer participation in demand response programs.

A centrally dispatched energy market or a regional resource adequacy program would perform fewer grid functions. Generally speaking, the impacts on state policies that are outside the scope of a regional cooperation framework would be minimal.

1.4 Summary

Several papers included in this review discuss how technological advances and the need to address climate change are forcing significant adaptations in how the grid is managed. The regional resource mix is shifting away from coal and toward wind power, solar power, and battery storage. Though wind and solar power—the two fastest-growing components of the West's generation portfolio—have no carbon emissions, their fuel source is less controllable than conventional thermal generators (many of which have been retired over the past few years). Numerous studies demonstrate that variable renewables are easier and less costly to integrate if they are managed regionally, especially as wind and solar become a substantial portion of the region's resource mix.

These changes suggest the need for—and the benefit from—regional cooperation is greater today than ever before. Together, the topics discussed in the body of literature reviewed here suggest a key threshold question that NREL has used to organize the review: *what are the grid functions that should be performed regionally to obtain the greatest benefit at the least cost while simultaneously respecting state policy autonomy?*

2 Regional Cooperation Efforts in the West

[T]he report should also discuss the regional transmission organizations in Colorado, Nevada, and other regional states, collaboration between states on energy policies to maximize consumer savings while respecting state policy autonomy, and engagement between neighboring states on the future of regional transmission organizations in the West. (ACR 188)

It is important to note that some regional cooperation is already taking place through existing power pooling arrangements, bilateral contracting platforms and indices such as the Western Systems Power Pool and Intercontinental Exchange, and joint operating agreements. The authors were unable to find any analysis of whether these existing arrangements could address the changing grid characteristics described in Section 1. Moreover, NREL’s understanding is that the intent of ACR 188 is to understand the implications of RTO expansion and other *new* modes of regional cooperation, topics for which research is available and readily accessible.

The state efforts and modes of cooperation described in this section provide a context for understanding “the impacts of expanded regional cooperation on California,” ACR 188’s primary request. Section 4 discusses the impacts related to the modes of cooperation introduced in this section.

2.1 State Efforts

Several Western states have engaged in efforts to explore the benefits of regional collaboration, in the form of state regional groups, legislation, regulatory proceedings, studies, and other initiatives.

2.1.1 Western Interstate Energy Board

The Western Interstate Energy Board was created by Western state governors in 1970 and grew out of the Western Interstate Nuclear Compact to provide the tools and framework needed to support cooperative efforts in the energy field and to enhance the economy of the West. Today, the board is an organization of 11 Western states and two provinces in Western Canada that works to promote energy policy that is developed through the cooperative efforts of its member states and provinces and in collaboration with the federal government.

The Western Interstate Energy Board works with its partners across the region (i.e., state regulators, policymakers, regulated entities, consumer advocates, and industry experts) to support state engagement and collaboration on key energy policy issues affecting the West. Among other activities, the board supports work on energy projects—proposed by its members—that are determined to be regionally beneficial. It also provides staff support to the Western Energy Imbalance Market (WEIM) Body of State Regulators and to other state regional groups, such as the Committee on Regional Electric Power Cooperation and the Western Interconnection Regional Advisory Body.

2.1.2 The Committee on Regional Electric Power Cooperation

The Committee on Regional Electric Power Cooperation is a joint committee of the Western Interstate Energy Board and the Western Conference of Public Service Commissioners that serves to bring key western stakeholders together in a common forum to address Western electric

power system policy issues requiring regional cooperation. The committee comprises one energy office official and one regulatory utility commissioner from each of the 11 Western states and the two provinces in Western Canada. As set forth in the committee’s charter (November 3, 2022), committee efforts “may include engagement with the regional institutions in the West that seek to deliver functions typically provided by Regional Transmission Organizations (RTOs)” and may also “include efforts to improve interconnection-wide transmission planning, [and to] create and establish RTOs[.]”

The joint committee also works with its members to, among other tasks, monitor efforts to deliver centrally organized RTO functions in the West, to develop common positions on important policy issues, and to conduct meetings and teleconferences, providing educational opportunities for state and provincial policymakers, utility regulators, and other stakeholders across the West.

2.1.3 Western Interconnection Regional Advisory Body

The Western Interconnection Regional Advisory Body was created by FERC in 2006, in accordance with Section 215(j) of the Federal Power Act. As a Section 215(j) advisory body, the body has the authority to advise FERC, NERC, and WECC on matters pertaining to electric grid reliability in the Western Interconnection.

All states and provinces with load in the Western Interconnection are eligible to appoint a representative to the Western Interconnection Regional Advisory Body, which works to achieve consensus among its members and to speak with a common, regional voice on matters pertaining to electric system reliability. The body also works with the Committee on Regional Electric Power Cooperation to convene Western regulators, policymakers, industry experts, nongovernmental organizations, and other interested stakeholders in a common forum to discuss current and emerging electricity issues, challenges, and opportunities facing the West.

2.1.4 Multistate Study

Working in partnership with state energy offices in Idaho, Colorado, and Montana, and with funding from a U.S. Department of Energy (DOE) grant, the Utah Governor’s Office of Energy Development kicked off a state-led assessment of organized market options. Representatives of 11 Western states participated in the effort; representatives from Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming served as members of the project’s lead team. In 2021, WEIB and DOE announced the release of *The State-Led Market Study* (Energy Strategies 2021a), which explores options for a more coordinated approach to grid management in the West and shows how regional collaboration can support the delivery of power that is both clean and affordable. See [3], page 33, for a summary of *The State-Led Market Study*.

2.1.5 Arizona

In 2021, the Arizona Corporation Commission opened a docket to, among other things, investigate regional planning, markets, and collaboration in the Western Interconnection;

explore the possibility of mandatory or voluntary participation in an RTO; and consider the governance, costs, and benefits associated with participation.²²

The Arizona Corporation Commission has engaged its state utilities and other stakeholders in this investigation and is posing questions about the costs and benefits of joining an RTO and any relevant studies conducted to that end. The commission has also held open meetings and invited CAISO and SPP to brief the commission on their day-ahead market options and to offer their thoughts about a Western RTO.

For a summary of the Arizona Corporation Commission Chairwoman’s docket memorandum describing the investigation’s purpose and identifying next steps, see Section 4.

2.1.6 Colorado

In 2019, Colorado passed the Colorado Transmission Coordination Act, requiring the Colorado Public Utilities Commission (Colorado PUC) to investigate costs and benefits for Colorado utilities to participate in a wholesale energy market. The resulting investigation culminated in two reports: *Colorado Transmission Coordination Act Evaluation of Market Alternatives* and *Colorado Transmission Coordination Act: Investigation of Wholesale Market Alternatives for the State of Colorado*. Both reports are summarized in Section 3.

Building on the Colorado Transmission Coordination Act, in 2021, Colorado passed Senate Bill 21-072, requiring state utilities to join an organized wholesale market (OWM), or RTO, by 2030.²³ SB 21-072 also establishes provisions governing participation in wholesale electricity markets and requires the Colorado PUC to consider the ability of utilities’ proposed new transmission facilities to enable participation in an OWM.

In June 2022, the Colorado PUC issued a Notice of Proposed Rulemaking to amend the Rules Regulating Electric Utilities and, on October 11, 2022, held an evidentiary hearing to specify filing requirements for utilities seeking to join wholesale electricity markets and reporting requirements regarding utilities’ plans, commitments, and actual participation in such markets. Regulated utilities and other stakeholders submitted comments on the commission’s proposed rules and participated in the October 11 hearing.

Through this effort, the Colorado PUC aims to ensure it is sufficiently informed about the potential impacts of market participation to Colorado customers and the state’s ability to meet its emission-reduction requirements and clean energy goals. The commission will continue with this effort in the coming months.

2.1.7 Montana

Montana has not performed a state-specific study that explores regional cooperation in detail. In December 2022, the Montana Public Service Commission held its first Resource Adequacy and Risk Conference, in Helena, Montana. The Commission invited current and former public utility

²² “Docket Details: E-00000A-21-0271,” Arizona Corporation Commission, <https://edocket.azcc.gov/search/docket-search/item-detail/26018>.

²³ “Senate Bill 21-072,” Colorado General Assembly, https://leg.colorado.gov/sites/default/files/2021a_072_signed.pdf.

commissioners, state energy office representatives, and governors' advisors from Colorado, Idaho, Montana, Utah, and Wyoming, as well as other subject matter experts, to explore issues related to "ensuring safe, reliable, sustainable, and efficient regional supply of baseload electrical energy; the region's risk profile in the energy sector and how to mitigate those risks; and ensuring that regional customers' needs for energy are met in the future." This was the first in what is expected to be an ongoing series of Commission meetings on resource adequacy and risk.

2.1.8 Nevada

In 2021, Nevada passed Senate Bill 448, which included a requirement for the state's transmission providers to join an RTO by 2030 (unless the utility can demonstrate, and the Nevada PUC agrees, it would not be in its customers' best interest to do so or that more time is needed to develop a viable option).²⁴ SB 448 also created a Regional Transmission Coordination Task Force to advise the governor and the Nevada Legislature on topics and policies related to regional energy transmission in the West, including the costs and benefits of joining an RTO to provide access to a wholesale electricity market.

In a 2022 report, the task force noted it had examined energy issues and opportunities to better position Nevada for improved regional electricity transmission coordination and had received several presentations from a wide range of experts, including representatives of the renewable energy industry, utilities, environmental advocates, consumers, businesses, and state regulators.²⁵ The report also identified several issues related to transmission planning, coordination, and wholesale market development for the task force to consider going forward, as it continues its effort to develop policy recommendations for joining an RTO.

2.1.9 New Mexico

In 2020, the New Mexico Legislature adopted the Energy Grid Modernization Roadmap Act (House Bill 233), directing the New Mexico Energy, Minerals, and Natural Resources Department to develop a road map for energy grid modernization and empowering the New Mexico Public Regulation Commission to direct utility investments to that purpose.²⁶ The law includes a directive to the commission to consider whether a utility's proposed grid modernization investments are "designed to support connection of New Mexico's electrical grid into regional energy markets and increase New Mexico's capability to supply regional energy needs through export of clean and renewable electricity."

In fall 2020, the Energy, Minerals, and Natural Resources Department created the Grid Modernization Advisory Group to develop a series of whitepapers to inform the development of the grid modernization road map that will guide utilities, regulators, policymakers, and electricity consumers in the transition to 100% zero-carbon resources by 2050, as required by New

²⁴ "SB448," Nevada Electronic Legislative Information System, <https://www.leg.state.nv.us/App/NELIS/REL/81st2021/Bill/8201/Text>.

²⁵ Regional Transmission Coordination Task Force, letter to Governor Steve Sisolak and Legislative Council Bureau Director Brenda Erdoes, November 30, 2022, https://energy.nv.gov/uploadedFiles/energynv.gov/content/Programs/TaskForces/RTCTF_Report_FINAL_11.30.22.pdf.

²⁶ New Mexico Legislature, [https://www.nmlegis.gov/Sessions/20 Regular/final/HB0233.pdf](https://www.nmlegis.gov/Sessions/20%20Regular/final/HB0233.pdf).

Mexico’s 2019 Energy Transition Act. A draft version of the road map (GMAG 2021) recognizes that several regional discussions about the benefits of RTOs are already underway and recommends the creation of, and ongoing support for, a New Mexico RTO task force to actively participate in these discussions and to explore potential benefits to New Mexico that would come from regional electricity coordination.

Informed by a Grid Modernization Advisory Group recommendation, the Public Regulation Commission issued a Notice of Proposed Rulemaking to develop new regulations to address grid modernization. The commission engaged Gridworks to lead the stakeholder process, develop a series of Notice of Proposed Rulemaking workshops, and develop a report summarizing key takeaways and provide recommendations to the commission.

2.1.10 Oregon

In 2021, Oregon passed Senate Bill 589, requiring the Oregon Department of Energy to prepare a report that identifies the benefits, opportunities, and challenges posed by the development or expansion of an RTO in Oregon.²⁷

To kick off this effort, the Oregon Department of Energy appointed an Oregon RTO Advisory Committee that consists of representatives of the governor’s office, the state legislature, the state’s two investor-owned utilities, consumer-owned utilities, independent power producers, organized labor and environmental groups.

In December 2021, the Oregon Department of Energy published its report, finding broad stakeholder agreement on the value of increased regional coordination and collaboration in reaching the state’s climate policy goals, recognizing a need to balance competing stakeholder interests both inside and outside Oregon, and observing that market design and governance structures will likely be the most consequential issue for such regional efforts. See item [20] in Section 3 for a summary of the Oregon Department of Energy’s *Regional Transmission Organization Study: Oregon Perspectives* report.

2.1.11 Washington

Washington has not undergone a state-specific study exploring regional cooperation. In 2019, Washington passed the Clean Energy Transformation Act (CETA), requiring that the state obtain 100% of its electricity from clean energy resources by 2045. Among other things, CETA directed the Washington Department of Commerce (Commerce) to review and revise the state’s energy strategy to align with requirements set forth in the Energy Independence Act, Clean Energy Transformation Act and the state’s greenhouse gas emission reduction limits. Commerce established a 27-member advisory committee comprised of legislators, government officials and civic organization, energy/utility business, and public interest representatives to guide this effort and, in December 2021, released the *Washington 2021 State Energy Strategy: Transitioning to an Equitable Clean Energy Future*.²⁸

²⁷ “Senate Bill 589,” Oregon State Legislature, <https://olis.oregonlegislature.gov/liz/2021R1/Downloads/MeasureDocument/SB589/Enrolled>.

²⁸ <https://www.commerce.wa.gov/growing-the-economy/energy/2021-state-energy-strategy/>

Considering potential paths to meet Washington’s 2030 and 2050 emissions limits, Commerce analyzed several scenarios to decarbonize the state’s energy sector. In its report, Commerce notes that, “[g]reater interconnection among the 11 Western states [was] a key part of all scenarios and points to the importance of expanded regional coordination and transmission to lower overall decarbonization costs.” Washington’s 2021 Energy Strategy notes that, to achieve a more dramatic decarbonization outcome and a more equitable transition, steps must be taken to coordinate and collaborate with local, Tribal, and state policymakers and in regional organizations.

2.2 Frameworks for Regional Cooperation

An RTO is the most comprehensive framework for regional cooperation. For states that are not already in an RTO, participation would change nearly every aspect of operating the transmission grid to a more centralized model. An expansion of existing RTOs—either CAISO, SPP, or both—is a scenario included in several studies of regional cooperation included in this review.²⁹

Three other conceptual frameworks for limited cooperation have also emerged in the West:³⁰

- Regional real-time energy imbalance markets
- Regional day-ahead energy markets (combined with a real-time energy imbalance market)
- Regional cooperation on resource adequacy.

The energy markets contemplate operation by an existing RTO (either CAISO or SPP).³¹ Two factors support this. First, an RTO can use its existing systems to operate a regional energy market outside its boundaries. This can avoid many of the start-up expenses involved with creating a new entity outside the RTO to operate the market.

Second, RTOs have ongoing stakeholder processes. Many stakeholders in an RTO bring institutional experience in solving the operational details of complex markets. These existing processes can provide a forum for utilities, generators, load-serving entities, and other diverse interests to identify critical issues early in the development of expanded energy markets.

The framework for regional resource adequacy cooperation does not contemplate operation by an RTO. Instead, it contemplates the creation of a new utility with the sole purpose of managing regional resource adequacy for participating utilities.

²⁹ Basin Electric Power Cooperative, Colorado Springs Utilities, Deseret Power Electric Cooperative, Municipal Energy Agency of Nebraska, Platte River Power Authority, Tri-State Generation and Transmission Association, Western Area Power Administration, and Wyoming Municipal Power Agency are investigating SPP membership.

³⁰ Other organized frameworks facilitate wholesale energy trading in the West, but we have not included them in this discussion as they are not part of any study. For example, the Western Systems Power Pool is an organization that has crafted common *pro forma* commercial agreements under which signatories can agree to trade power products. Conversely, the Intercontinental Commodity Exchange is a commonly used index tool to price bilateral-traded energy products. These two frameworks are noted here briefly for completeness.

³¹ All other functions would remain with the regulated utility, preserving a large degree of state oversight.

Energy markets and resource adequacy are two important functions that all RTOs perform. RTO functions that are *not* performed by an energy market or a regional resource adequacy plan include:

- Centralized reliability services
- Centralized congestion costs management
- Centralized transmission pricing and open access to the transmission system
- Centralized transmission planning.

2.2.1 CAISO-Operated Western Energy Imbalance Market

The ISO's WEIM began operating in 2014 as a real-time energy market. It automatically finds the lowest-cost energy to solve real-time imbalances between actual generation and actual demand. These real-time adjustments normally account for up to 10% of the energy delivered to customers at any given time.

Balancing can be a challenge with higher penetrations of wind and solar generation, due to the inherent variability in these resources' real-time output. By leveraging the resource diversity and transmission connectivity that exists between the major supply and demand regions of the West, the WEIM has improved the integration of renewable energy resources throughout the Western grid.

Since its launch in 2014, the WEIM has grown to include 19 participating entities, has enhanced grid reliability, and has generated estimated cost savings surpassing \$3.4 billion for its participants. In 2023, the WEIM is expected to grow to include 22 entities, representing 79% of demand across the Western Interconnection.³²

Market Design

The decision to join the WEIM is made by a BA, the utility entity responsible for always keeping metered generation and metered demand in balance within its control area. Any generator in a participating BA may choose to offer uncommitted capacity into the WEIM, although there is no requirement that *all* generators submit offers.

The WEIM combines real-time imbalances across all participating BAs (including CAISO) and selects the least-cost energy offers to solve the combined system-wide imbalance. For every 5- and 15-minute operating interval, the WEIM calculates locational marginal prices (LMPs) for each participating BA. CAISO uses these prices to settle payments for energy that is dispatched through the WEIM.

The WEIM allows participants to buy and sell power close to the time electricity is consumed. This is particularly useful in addressing real-time imbalances caused by fluctuations in output

³² Current and expected WEIM participants include Arizona Public Service, Avista, Balancing Authority of Northern California, Bonneville Power Administration, California ISO, Idaho Power Company, Los Angeles Department of Water & Power, NorthWestern Energy, NV Energy, PacifiCorp, Portland General Electric, Powerex, Public Service Company of New Mexico, Puget Sound, Salt River Project, Seattle City Light, Tacoma Power, Tucson Electric Power, Turlock Irrigation District, Avangrid (entry 2023), El Paso Electric (entry 2023), and the Western Area Power Administration Desert Southwest region (entry 2023)

from wind and solar plants. The use of least-cost WEIM resources reduces the cost of integrating large amounts of variable renewable energy resources.

Governance

A five-member Governing Body that is independent of any entity participating in the market governs the WEIM. The Governing Body provides oversight of WEIM market rules, stakeholder outreach, and strategic leadership. The Body of State Regulators provides a forum for state commissioners to give input about CAISO and WEIM operations of regional interest, and the Regional Issues Forum provides a venue for stakeholders to discuss a wide variety of market-related issues and give advice to the WEIM Governing Body. The Governing Body has joint authority with the CAISO Board of Governors to approve or reject proposals to change or establish tariff rules applicable to WEIM balancing authority areas, entities, and market participants.

2.2.2 CAISO-Operated Extended Day-Ahead Market (EDAM)

Utilities participating in the WEIM may also elect to participate in CAISO's proposed EDAM. However, unlike the WEIM, the EDAM has not yet begun operation. A detailed market proposal was published on December 7, 2022; PacifiCorp signed on to the EDAM the following day. The final EDAM market proposal and the Governance Review Committee's final proposal for joint authority over EDAM were approved by the CAISO Board of Governors and the WEIM Governing Body on February 1, 2023. PacifiCorp announced its intention to join EDAM on December 8, 2022. CAISO is now in the process of working with stakeholders to file EDAM tariff language with FERC in the spring of 2023.

A day-ahead market settles more energy than a real-time energy imbalance market—typically 90%–97% of the energy delivered to customers. Its LMPs tend to be more stable because price disturbances caused by unanticipated deviations in demand or renewable energy production happen in the real-time market. Generally, the day-ahead energy market represents expectations about the cost of all energy needed to serve customers. Hourly demand is the updated load forecasts for the next day, and offers are based on suppliers' knowledge about their units' availability for the next day. The Market Operator's economic dispatch software combines inputs for the next day into a globally optimized solution for each operating hour.

Market Design

BAs participating in the WEIM would not be required to participate in the EDAM, but all participating in the EDAM would be required to participate in the WEIM. If a BA elects to participate in the proposed EDAM, *all* generators in its control area would have to submit energy offers into the EDAM. This is different from the WEIM, which allows a BA's committed generators to abstain from participation. Applying a similar exemption to the EDAM could cause undue cost shifting to other market participants, due to the larger volume of energy that would be settled day-ahead. Rather than allowing generators to opt out of the market, the EDAM would allow generators to self-schedule as price takers; that is, they would tell their BA and CAISO the level at which the unit would generate, and they would accept whatever LMP might prevail in the generator's BA in the day-ahead market.

A BA participating in the EDAM may also function as an aggregator for all demand resources in its control area wishing to participate in the CAISO energy market.

Resource Adequacy

The Western Resource Adequacy Program (WRAP) discussed in Section 2.2.5 is evolving concurrently with the EDAM. (PacifiCorp announced its participation in WRAP at the same time it announced its participation in the EDAM.) The EDAM proposal does not require the participation in any specific resource adequacy program, including WRAP. It does anticipate the need for coordinating rules between the EDAM and the WRAP if, like PacifiCorp, more entities choose to participate in both. The approved EDAM proposal notes, “Entities that participate in both the WRAP and the EDAM will ultimately be responsible for managing their participation in each; however, harmonizing both designs on an ongoing basis to ensure the success of both programs in providing the intended value proposition is important.”

Governance

In the near term, the trajectory of EDAM development will likely involve joint oversight by the CAISO Board of Governors and the WEIM Governing Body. For the longer term, the WEIM Governance Review Committee—an advisory committee representing a broad range of stakeholders and perspectives from across the West—led a public stakeholder process to develop a governance proposal applicable to both the WEIM and EDAM. The governance framework provides that:

The WEIM/EDAM Governing Body will have joint authority with the Board of Governors to approve or reject a proposal to change or establish a tariff rule applicable to the WEIM/EDAM Entity balancing authority areas, WEIM/EDAM Entities, or other market participants within the WEIM/EDAM Entity balancing authority areas, in their capacity as participants in the WEIM/EDAM. The WEIM/EDAM Governing Body will also have joint authority with the Board of Governors to approve or reject a proposal to change or establish any tariff rule for the day-ahead or real-time markets that directly establishes or changes the formation of any locational marginal price(s) for a product that is common to the overall WEIM or EDAM market. The scope of this joint authority excludes, without limitation, any other proposals to change or establish tariff rule(s) applicable only to the CAISO balancing authority area or to the CAISO-controlled grid.³³

The WEIM Governing Body will also have advisory input on all rules that apply to the real-time market, and day-ahead market under EDAM. The proposal was approved by the WEIM Governing Body and CAISO Board of Governors at their joint session in February 2023.

2.2.3 SPP-Operated Western Energy Imbalance Service

In 2021, SPP launched the Western Energy Imbalance Service (WEIS) market. It is a real-time wholesale electricity market like WEIM that dispatches energy from participating regional

³³ For avoidance of doubt, the joint authority definition set forth above does not include measures, such as parameters or constraints, the CAISO may use to ensure reliable operation within its balancing authority area.

resources every 5 minutes to balance generation and demand and to reliably deliver affordable electricity to utility customers.

WEIS participants are generally located in Colorado, and there are small load pockets in Wyoming, Montana and New Mexico.³⁴ Together, they represent approximately 8% of the load in the WECC.

Market Design

WEIS participants must submit resource plans and ancillary service plans to SPP so that it can determine the system-wide adequacy of resources and ancillary services. Participants may submit energy offers from registered resources, which SPP includes in its security-constrained economic dispatch. Imbalances are solved against offers every 5 minutes, and resources that are dispatched are paid based on the prevailing LMPs at the time of dispatch.

Participants must provide SPP with information on unscheduled intra-hour nonfirm transmission. This residual transmission capacity is used in security-constrained economic dispatch to redispatch participating generators.

Governance

The WEIS is overseen by a Western Markets Executive Committee, which has authority to approve or reject amendments to the WEIS tariff and to adopt detailed market protocols to enact the tariff. Western states where the WEIS is active may appoint one regulatory commissioner as a state liaison with the committee.

2.2.4 SPP-Operated “Markets+”

In September 2022, the SPP circulated a draft document that described its “Markets+” proposal for areas of the Western Interconnection. SPP says that the purpose of the Markets+ proposal is to provide utilities and other market participants in the Western Interconnection with an incremental step toward regional coordination that provides most of the benefits of an RTO but does not involve full RTO membership. Markets+ includes the basic elements of an RTO: a day-ahead energy market, a real-time energy market for balancing, and processes for reliability unit commitment—key focus areas for most RTO simulations that have been conducted for the West.

An important difference between Markets+ and a full RTO is that transmission owners participating in Markets+ would maintain their own open-access transmission tariffs. Transmission owners would continue to sell firm and non-firm transmission capacity as before, but there would also be a new market transmission service that would use the unsold transmission capability the transmission owner makes available for Markets+. The transmission owner would continue to charge its FERC-approved rates for the firm and non-firm capability it

³⁴ Participants include Basin Electric Power Cooperative, Black Hills Energy (effective April 2023), Colorado Springs Utilities (effective April 2023), Deseret Power Electric Cooperative, Guzman Energy, Municipal Energy Agency of Nebraska, Platte River Power Authority (effective April 2023), Tri-State Generation and Transmission Association, and the Western Area Power Administration (Colorado River Storage Projects, Rocky Mountain Region, and Upper Great Plains West Region).

sells, and there would be a new market transmission service charge paid by generation and load settled in Markets+.

On November 30, 2022, SPP published its final Markets+ service offering, which outlines a two-phase process to continue the Markets+ development. Phase 1 is expected to take 21 months and have a fixed price of \$9.7 million; it includes drafting of Markets+ protocols and tariff language. Phase 2 will begin with FERC approval and will include SPP acquiring necessary software and hardware and integrating participating entities into the Markets+ system.

Because Markets+ is still under development, SPP has not yet submitted a proposed tariff to FERC. Task forces and working groups are still developing the details of several market elements.

Market Elements

Essentially, Markets+ would be a new category of energy transaction taking place on a participating transmission owner's network. The new transactions would resemble an RTO's day-ahead and real-time energy markets—centralized least-cost dispatch without violating market transmission service transmission limits. Centralized dispatch would result in LMPs, price points that are specific to nodes on the grid and that consider transmission congestion (which limits the ability to fully use the least-cost resources) and line losses.

The current proposal does not include a market for congestion revenue rights, unlike many RTOs. Instead, Markets+ anticipates reallocating congestion rents to holders of firm network and point-to-point transmission rights under the participating transmission owner's open-access transmission tariffs.³⁵

The Markets+ draft proposal includes a real-time energy imbalance market, which would replace the WEIS Market for Western BAs currently participating in that program.

Governance

Governance is proposed to be through an independent panel comprising five persons who have no affiliation with any market participant or stakeholder. Candidates to the panel are nominated by a committee of market participants and voted on by all market participants. State input comes from a regional state committee, to which each state may nominate one representative from its regulatory commission. This governance structure is similar to that of SPP itself.

Resource Adequacy

The Markets+ energy and reserve markets would not affect any participating entity's resource adequacy responsibilities. However, SPP is considering a requirement for load-responsible entities to participate in a common, FERC-approved resource adequacy program, or to meet the

³⁵ When a line is congested, LMPs on the load side of the constraint are higher than the system-wide marginal cost of energy and LMPs on the generation side are lower. Dispatch software breaks down LMPs into their system marginal cost and congestion cost components; the congestion component is the economic rent caused by congestion.

same resource adequacy standards as the FERC-approved program. SPP is also exploring coordination with the WRAP proposed by the Western Power Pool.

In addition, SPP proposes a must-offer requirement for its day-ahead energy market. Each entity would be required to include enough resources in its schedule to cover its own needs for load, interchange, and reserves.

Progress

As of December 2022, Bonneville Power Administration and six Northwest utilities had announced their interest in participating in Markets+. ³⁶ The utilities include Avista Corp., Chelan County Public Utility District, Grant County Public Utility District, Powerex Corp., Puget Sound Energy, and Tacoma Power. The Western Area Power Administration's upper Great Plains Region, which includes portions of Montana, the Dakotas, and parts of Nebraska, Iowa, and Minnesota, is already a full member of SPP. Western's Rocky Mountain region, which includes portions of Colorado and Wyoming, has joined SPP's WEIS. At this time, only Powerex Corp. has committed to full implementation in Markets+.

In November 2022, some entities in the Markets+ footprint expressed interest in participating in an energy imbalance only market design: a product similar to WEIS but under the Markets+ governance structure. SPP has committed to exploring the addition of a Markets+ real-time phase in the coming months: a service offering that would provide a foundation for entities to join Markets+ and potentially add day-ahead market features later.

2.2.5 Western Resource Adequacy Program

The Northwest Power Pool, doing business as the Western Power Pool (WPP), submitted a petition to FERC in August 2022 for the creation of a regional Western Resource Adequacy Program (WRAP). This program focuses on the efficient use of capacity to maintain reliability in the face of extreme events, such as unexpected outages or when load is more than what is forecasted. Resource adequacy is normally a function performed by RTOs and by individual utilities outside an RTO. However, participants in the Northwest Power Pool (NWPP) stakeholder process agreed resource adequacy was a pressing regional need that should not wait on the development of new regional energy markets.

The WRAP proposal is based on two design elements:

- A “forward-showing” program through which WPP forecasts participants’ peak load and establishes a planning reserve margin: the program includes regional metrics, common methodologies for estimating the qualified capacity contribution and effective load-carrying capability of various resources, deliverability expectations, and common periods for demonstrating adequacy.

³⁶ BPA is concurrently evaluating both SPP's Markets+ and CAISO's EDAM. John Hairston, letter to Public Power Council Executive Committee, August 11, 2022, <https://www.bpa.gov/-/media/Aep/projects/grid-modernization/bpa-letter-regarding-spp-markets.pdf>. Also see “Southwest Power Pool Announces New Western Energy Market Initiative Commitment,” August 16, 2022, at <https://spp.org/newsroom/press-releases/southwest-power-pool-announces-new-western-energy-market-initiative-commitment>.

- An “operational program” by which participants have prearranged access to capacity resources in the program footprint during times when a participant is experiencing an extreme event.

Governance

An independent board of directors would have ultimate authority over the WRAP. It would also have a Committee of State Representatives comprising one regulatory commissioner or state/provincial energy office delegate from each participating state or province.

Membership would be limited to load-responsible entities, which are defined as entities that own, control, or purchase capacity resources or are federal power marketing agencies and have an obligation to meet energy or system load at all hours.³⁷

Joint comments supporting WRAP were filed with FERC on September 30, 2022 by utility regulatory commissioners and state energy offices from Arizona, California, Colorado, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming. FERC approved the WRAP tariff filing on February 10, 2023.

WPP would become a new public utility (as defined by the Federal Power Act) under FERC jurisdiction for administering the WRAP. However, its utility function would be limited to resource adequacy and would not change bilateral contracting, dispatch, or energy balancing (including participation in the CAISO-operated Western Energy Imbalance Market or the SPP-operated Energy Imbalance Service). The WRAP would have little effect on a participating utility’s real-time operations generally, except for greater transparency and more efficient real-time access to reliability resources during extreme events.

2.2.6 Western Markets Exploratory Group

The Western Markets Exploratory Group is an industry-led effort formed in 2021 to explore “the potential for a staged approach to new market services—including day-ahead energy sales, transmission system expansion, power supply and grid solutions, and existing and emerging public policies—that can benefit customers and help participants meet carbon emission-reduction goals.”³⁸

³⁷ As of December 2022, the following utilities have formally committed to moving forward with the WRAP: Avista Utilities, Calpine Energy Solutions, Chelan Public Utility District, Clatskanie People’s Utility District, Eugene Water & Electric Board, PacifiCorp, Portland General Electric, Powerex Corp, Puget Sound Energy, Seattle City Light, and Tacoma Power. Other entities participating in the process include Avangrid Renewables, Arizona Public Service, Basin Electric Power Cooperative, Black Hills Energy, Clatskanie PUD, Salt River Project, Shell Energy, Bonneville Power Administration, Douglas County PUD, Grant County PUD, Idaho Power, NorthWestern Energy, NV Energy, Snohomish County PUD, Turlock Irrigation District, and the Energy Authority (representing Benton PUD, Clark Public Utilities, Cowlitz County PUD, Emerald PUD, Franklin PUD, Grays Harbor PUD, and Lewis County PUD).

³⁸ Western Markets Exploratory Group participants include Arizona Electric Power Cooperative, Arizona Public Service, Avista Corp, Balancing Authority of Northern California, Black Hills Energy, Bonneville Power Administration, Chelan County PUC No. 1, El Paso Electric Company, Idaho Power, Los Angeles Department of Water & Power, NorthWestern Energy, NV Energy, PacifiCorp, Platte River Power Authority, Portland General

The Western Markets Exploratory Group has hired Utilicast as a consultant to help develop a road map and timelines, but to date the group has published no material.³⁹ The Western Markets Exploratory Group and Utilicast have contracted with E3 to perform a production cost-benefit study that evaluates day-ahead and other markets services, which could potentially result in RTO services. The group anticipates the study will assist participants in future decisions with respect to market formation and market design.

Electric, Public Service New Mexico, PUD #2 of Grant County, Puget Sound Energy, Salt River Project, Seattle City Light, Tacoma Power, Tri-State Generation & Transmission Association, Tucson Electric Power, Western Area Power Administration, and Xcel Energy Colorado.

³⁹ “Energy Companies Exploring Regional Grid Solutions Engage Utilicast To Oversee Strategic Planning,” Western Markets Exploratory Group, March 24, 2022, <https://electricenergyonline.com/article/energy/category/t-d/56/951615/energy-companies-exploring-regional-grid-solutions-engage-utilicast-to-oversee-strategic-planning.html>.

3 Literature Included in the Review

NREL, CAISO, and other California BAs developed the list of studies using publicly available resources and provided the draft list for stakeholder review. Commenters recommended certain studies that were added to the scope of this report as a result. The final list of studies was posted to CAISO’s web page on regional solutions on November 8, 2022.⁴⁰ Documents included in this review are divided into the following categories:

- Technical analyses of various modes of coordination
- Policy statements and analyses by government agencies
- Analyses of legal issues
- Other relevant documents.

For the reader’s convenience, Table 3 lists the studies and papers by the four categories listed above. For each publication:

- The first column lists the citation number used to cross-reference the publication in Section 4.
- The second column includes the author and date, which is how publications are listed with their full references on page 91.
- The third column lists the page number on which the publication is reviewed in this section.

Table 3. Studies and Papers Included in the Review

Citation Number	Study Title (Source: Author and Date)	Page Number
Technical Studies		
[1]	<i>Extended Day-Ahead Market: Feasibility Assessment Update from EIM Entities</i> (CAISO 2019)	30
[2]	<i>Senate Bill 350 Study: The Impacts of a Regional ISO-Operated Power Market on California</i> (Casey et al. 2016)	31
[3]	<i>The State-Led Market Study: Technical Report</i> (Energy Strategies 2021a)	33
[4]	<i>CAISO EDAM Benefits Study: Estimating Savings for California and the West Under EDAM Market Scenarios</i> (Moyer and Ramirez 2022)	35
[5]	<i>The State-Led Market Study: Market and Regulatory Review Report</i> (2021b)	36
[6]	Colorado Transmission Coordination Act Evaluation of Market Alternatives (CO Rev Stat § 40-2.3-102 2021)	38
[7]	<i>Benefits of the SPP RTO Expansion into the WEIS Footprint</i> (Brattle 2022)	38
[8]	Reliability Implications of Expanding the EIM to Include Day-Ahead Market Service: A Qualitative Assessment (WECC MIC MEA 2020)	39
[9]	<i>2040 Clean Energy Sensitivities Study</i> , WECC (Bailey 2022)	40
[10]	<i>Sharing Power Among the Pacific States</i> (Florio 2018)	40

⁴⁰ “Exploring Regional Solutions,” CAISO, <http://www.caiso.com/informed/Pages/RegionalSolutions.aspx>.

Citation Number	Study Title (Source: Author and Date)	Page Number
[11]	<i>Root Cause Analysis: Mid-August 2020 Extreme Heat Wave</i> (CAISO, CPUC, CEC 2021)	41
[12]	<i>Resource Adequacy in the Pacific Northwest</i> (Ming et al. 2019)	42
[13]	<i>Implications of a Regional Resource Adequacy Program on Utility-Integrated Resource Planning</i> (Carvallo et al. 2020)	42
[14]	<i>WIRED Resource Adequacy Working Group Report</i> (CNEE 2020a)	43
[15]	<i>Western Flexibility Assessment: Investigating the West’s Changing Resource Mix and Implications for System Flexibility</i> (Brownlee et al. 2019)	44
[16]	<i>Empirical Estimates of Transmission Value Using Locational Marginal Prices</i> (Millstein et al. 2022)	45
[17]	<i>WECC EDT Phase 2 EIM Benefits Analysis and Results: October 2011 Revision:</i> (Orans, Olson, and Moore 2011)	46
[18]	<i>Examination of Potential Benefits of an Energy Imbalance Market in the Western Interconnection</i> (Milligan et al. 2013)	46
[19]	<i>Analysis of Benefits of an Energy Imbalance Market in the NWPP</i> (Samaan et al. 2013)	47
Policy Studies		
[20]	<i>Regional Transmission Organization Study: Oregon Perspectives</i> (Schultz 2021)	48
[21]	<i>Colorado Transmission Coordination Act: Investigation of Wholesale Market Alternatives for the State of Colorado</i> (Colorado PUC 2021)	49
[22]	Commission Decision Determining Market Participation is in the Public Interest (2021) ⁴¹	50
[23]	Arizona Corporation Commission docket memo from Office of Chairwoman Lea Marquez Peterson (2021) ⁴²	52
[24]	<i>Qualitative Assessment of Potential Reliability Benefits from a Western Energy Imbalance Market</i> (FERC 2013)	53
Legal Assessments		
[25]	<i>Evaluation of Jurisdictional and Constitutional Issues Arising from CAISO Expansion to include PacifiCorp Assets</i> (Carlson and Boyd 2016)	54
[26]	<i>Enhanced Western Grid Integration: A Legal and Policy Analysis of the Effects on California’s Clean Energy Laws</i> (Brint et al. 2017)	56
Other Literature		
[27]	“Transmission Benefits All Users of the Power Grid” (Goggin 2021)	58
[28]	“Prospect of a New Western Regional Transmission Organization” (Campbell 2021)	59

⁴¹ “Commission Decision Determining Market Participation is in the Public interest,” Decision No. C21-0755 before the Public Utilities Commission of the State of Colorado, Proceeding No. 19M-0495E, https://sustainableferc.org/wp-content/uploads/2022/01/C21-0755_19M-0495E-00000002.pdf.

⁴²

Citation Number	Study Title (Source: Author and Date)	Page Number
[29]	<i>Potential Customer Benefits of Interregional Transmission</i> (GE 2021)	59
[30]	<i>In Support of Western Regional Resource and Transmission Planning Coordination</i> (Gridworks and CNEE 2021)	60
[31]	<i>Pathways Toward Grid Decarbonization: Impacts and Opportunities for Energy Customers from Several U.S. Decarbonization Approaches</i> (Shawhan, Witkin, and Funke 2022)	61
[32]	Designing the 21st Century Electricity System: How Electricity Buyers Can Accelerate Change (Gramlich 2021)	62
[33]	<i>WIRED GHG Accounting Working Group Report</i> (2020b)	63
[34]	<i>Renewable Energy Policy Pathways Report</i> (REBA 2020)	65
[35]	<i>Grid Vision: The Electric Highway to a 21st Century Economy</i> (AWEA 2019)	68
[36]	<i>Improving Transmission Planning: Benefits, Risks, and Cost Allocation</i> (Brattle 2019)	68
[37]	<i>A Regional Power Market for the West: Risks and Benefits</i> (Paulos 2018)	70
[38]	WEIM Quarterly Reports: 2014–2022 (WEIM n.d.)	71

3.1 Technical Studies

The first seven technical studies in this section directly address RTO benefits and challenges. We begin with a 2019 feasibility assessment update (CAISO 2019) from WEIM entities participating in the EDAM. We next turn to the California Senate Bill 350 Study. Conducted in 2016, this comprehensive analysis provides a starting point for comparisons with more recent studies. Following that are two companion studies: one led by several Western states that simulated West-wide RTOs and other regional coordination options, and a survey of regulatory issues related to West-wide grid coordination. These are followed by an RTO analysis conducted for the State of Colorado, an analysis conducted for utilities currently participating in SPP’s WEIS, and two analyses by WECC: one examining how an extended day-ahead market—more limited and focused than an RTO—might affect grid reliability throughout the West, and one testing the ability of the system as it currently exists to accommodate very high levels of clean energy deployment.

Other studies deal with specific aspects of regional cooperation for which an RTO might be one of several options. Four address resource adequacy, one addresses grid flexibility, and one addresses regional transmission expansion. The section ends with two analyses of potential EIM benefits that predate the creation of the CAISO-operated WEIM. These are included as a retrospective glimpse into how forecasted benefits compared with actual benefits.

Definitions:

- *Capacity expansion analysis* examines future load growth and capacity retirements to identify the optimal mix of new generation investments over a long-term planning horizon. In some cases, capacity expansion analysis simultaneously optimizes new generation capacity with new transmission and new storage capacity. By changing the assumptions, capacity expansion analysis can identify portfolios of new generation,

transmission, and storage that are likely to be cost-effective across several future scenarios.

- *Production cost analysis* measures the operating cost of the grid for each hour (or shorter time interval) of the year. It finds the least-cost dispatch solution for all hours, considering transmission line limits and requirements for operating reserve. Unlike capacity expansion analysis, it does not account for capital costs nor does it automatically add new generation, transmission, or storage. Production cost analysis may be used in conjunction with capacity expansion analysis to examine how a portfolio of new investments might affect annual operating costs.
- *Resource adequacy* refers to whether the power system has enough capacity (generation, storage, and demand response) to reliably meet all demand for electricity over a long-term planning horizon.

All monetary amounts included in the following summaries have been adjusted from their originally reported values to 2022 dollar equivalents. This is to aid consistency and to facilitate comparisons of summary results for studies conducted in different years.

For the purposes of this review, “independent system operator” (ISO) is functionally the same as an RTO.

[1] [*Extended Day-Ahead Market: Feasibility Assessment Update from EIM Entities \(2019\)*](#)

Prepared by Brattle Group, Energy + Environmental Economics (E3)

Prepared for Utilities Participating in the CAISO-Operated Energy Imbalance Market

This assessment examined the potential benefits of an EDAM in the West. The EDAM would be a centralized energy market conducted one day before the actual operating day. Its results would form part of the schedule for generators and other resources going into the following operating day. Currently, the day-ahead schedule is based on bilateral contracts and a utility’s plan for the use of its own resources, with no regional least-cost optimization. In this assessment, the EDAM would be voluntary, meaning some day-ahead bilateral contracting and self-scheduling would continue.

The analysis did not propose details for how an EDAM should be designed or how costs and responsibilities should be allocated. Instead, it simulated generic elements of an EDAM to measure a plausible range of potential reductions in production cost. The aim was to illustrate the likely magnitude of benefits available from some kind of EDAM configuration.

The analysis envisioned EDAM as an additional voluntary market service on top of the existing WEIM. Utilities not participating in the WEIM (as of 2019) would continue to rely on self-scheduling, bilateral contracts, and other mechanisms currently available. The simulations looked at load conditions for 2028 and modeled dispatch for the entire WECC footprint.

Findings

Additional savings to WEIM entities participating in an EDAM ranged from \$143 million to \$273 million per year based on the assumptions that were tested (results adjusted for inflation from 2018 dollars to 2022 dollars). By comparison, actual WEIM-only benefits in 2020 reported

by CAISO were \$375 million (2022 dollars). Utilities participating in the WEIM in 2020 are also those simulated in the EDAM assessment.⁴³

The assessment included a resource sufficiency step that implied additional benefits. By calculating the effects of forecast error and the need for replacement reserve across the entire EDAM footprint rather than locally, both these inputs (and, by inference, their related costs) were smaller for EDAM participants.

Limitations

This assessment was conducted shortly after discussions about creating an EDAM began among WEIM entities. As the researchers note, “results are only indicative and based on assumptions that may not reflect the ultimate market design—this is only the beginning of a substantial and complex process.”

[2] [*Senate Bill 350 Study: The Impacts of a Regional ISO-Operated Power Market on California \(2016\)*](#)

Prepared by Brattle, E3, Bear, Aspen

Prepared for CAISO in Response to a Directive from the California Senate

This study examined how a theoretical RTO covering most of WECC might affect electricity customers in California.⁴⁴ The analysis relies primarily on a capacity expansion analysis and a production cost analysis, with results used to inform a renewable portfolio analysis, an environmental analysis, a rate impact analysis, an economic impact analysis (including impacts on disadvantaged communities), and a reliability analysis.

Some institutional issues involving the formation of an RTO are discussed as factors that could affect costs that would be passed on to customers in California. These issues include the allocation of costs for new transmission and resource-sharing arrangements to reduce the cost of resource adequacy.

The executive summary and findings focus almost exclusively on impacts to California, with little discussion of impacts on other states that might be included in the theoretical RTO. Background volumes that go into detail about the production cost analysis and capacity expansion analysis include results for regions of the West outside California.

Findings

The study found that the larger the area of expansion, the greater the savings to California customers. An RTO that added only PacifiCorp to the existing CAISO footprint could save California customers about \$70 million per year, or about 0.1% of retail costs; a West-wide RTO, on the other hand, could save \$1.3 billion to \$1.9 billion per year (original figures converted to 2022 dollars). This savings estimate considers overall benefits to California ratepayers including emission reduction; creation and retention of jobs; environmental impacts

⁴³ Study [38] addresses the quarterly benefits for 2021 and 2022.

⁴⁴ The study assumes the Bonneville Power Administration and most of the Western Area Power Administration would not be part of the theoretical RTO.

across the west; benefits to disadvantaged communities; and the increased reliability and integration of renewable resources.

The capacity expansion analysis scenarios required the addition of enough resources for California to get 50% of its energy requirements from renewables by 2030 (the state’s target at the time of the SB 350 study). The study tested two California procurement models under a West-wide RTO: one assuming procurement of in-state renewables and one that allowed more liberal procurement of out-of-state renewables if they were cost-effective (represented as up to 3 GW of wind from Wyoming and up to 3 GW of wind from New Mexico). The liberalized procurement model resulted in \$670 million of additional benefits to California customers, compared to the scenario that restricted renewable energy imports. Most of the savings came from reduced net costs related to wholesale production, purchases, and sales; and from reduced capital investments related to the state’s RPS portfolio.

The study also found that CO₂ emissions related to California load simulated for 2030 fell 6.7%–7.5% with a West-wide RTO, with greater reductions (9.3%–10.6%) if California were to import more out-of-state renewables. CO₂ emissions WECC-wide were projected to fall 3%–4% with a regional RTO.

The greatest job and economic impacts—including impacts on disadvantaged communities—were related to lower electricity costs. The study estimated California’s average disposable income would increase by between 0.1% and 0.2% with a regional RTO, leading to higher state gross domestic product, higher economic output, and gains in wages and state revenue. The study estimated a job gain of 9,900 to 19,300 but noted possible tradeoffs related to ratepayer benefits, local employment, economic impacts, and environmental impacts.

Environmental impacts depended on how California procured new renewable capacity. Allowing more out-of-state resources in the state mix resulted in less land use in California and more land use in the rest of WECC (including land needed for additional transmission). The study also found that more efficient dispatch reduced water consumption for power generation both in California and in the rest of WECC.

Limitations

The SB 350 capacity expansion analysis was conducted in 2016, when capital costs for new wind and solar technologies were higher than they are today. Table 4 compares costs used in the 2016 study with current capital cost estimates maintained by NREL in its Annual Technology Baseline.⁴⁵ Note that the costs projected by the SB 350 study for 2030 are higher than the actual costs observed in the sector for 2020. (For consistency, all figures are adjusted for inflation to 2022 dollars.)⁴⁶

⁴⁵ “Annual Technology Baseline,” National Renewable Energy Laboratory, <https://atb.nrel.gov/>.

⁴⁶ It is important to note that this study was conducted before the passage of SB 100. The demand for power within California to meet the higher renewable targets embedded in SB 100 along with the planning assumptions embedded in the CAISO’s 20-year outlook (CAISO 2022a) indicate as much as 100 GW of new resource development over the next 20 years within the State of California.

Table 4. Capital Costs for Solar Photovoltaics and Wind (2022 \$/kW)

		SB 350 Study (2016)		NREL Annual Technology Baseline (2022)	
		2015 Observed	2030 Projected	2020 Observed	2030 Projected ^a
Solar Photovoltaics	Arizona	\$2,552	\$2,182		
	California	\$2,722	\$2,328	\$1,540	\$961
Wind	Wyoming and New Mexico	\$2,216	\$2,151	\$1,689	\$1,219
	California (Carrizo)	\$2,441	\$2,368		

Capital costs exclude tax credits and other financial incentives.

^a Based on moderate assumptions for future cost reductions.

Lower capital costs would tend to improve net savings across all scenarios modeled in the SB 350 study. What is unclear is how lower wind and solar photovoltaics costs would affect comparisons of scenarios. For example, the study found that with a West-wide RTO, California customers would see more benefit by allowing more imports for renewable energy procurements. Lower capital costs would benefit imports and in-state resources both. However, sites with higher capacity factors for the same technology would tend to see greater benefits from lower capital costs, because every dollar of savings would be associated with more energy generated. For wind power, capacity factors in some of the best areas of Wyoming and New Mexico are near 50%, compared to a California statewide average of 28%.⁴⁷

[3] *The State-Led Market Study: Technical Analysis (2021)*

Prepared by Energy Strategies

Prepared for DOE, State Energy Offices of Utah, Idaho, Colorado, and Montana

This DOE-funded study used a production cost analysis to examine the relative cost savings of three market constructs applied to three regional configurations. The constructs included:

- A centralized real-time energy market (comparable to the WEIM currently operated by CAISO)
- A centralized day-ahead market operating in conjunction with a centralized real-time market
- An RTO.

The regional configurations included:

- A single market comprising all of WECC
- A two-market model including CAISO and the rest of WECC

⁴⁷ The California average was calculated from statewide data reported by the California Energy Commission for 2021. See https://ww2.energy.ca.gov/almanac/renewables_data/wind/index cms.php.

- A two-market model in which utilities in Colorado and Wyoming participated in SPP and the remainder of WECC (including CAISO) participated in a separate market.

The technical team that conducted the study held several review sessions with Western state energy officials throughout the project. Input from states helped to decide the key questions to be answered as well as which scenarios would be examined.

All cases were simulated for 2030. Status quo cases were based on 2020, taking into account announcements by utilities to join CAISO's WEIM or the energy imbalance service operated by SPP.

Findings

The State-Led Study Market Study estimated that a West-wide RTO would produce \$833 million in just the annual production cost savings by 2030 (in 2022 dollars), or about 6.4% of what the West's total cost of generation would be based on how the energy markets work currently. This is larger than the production cost savings estimated by the SB 350 study performed by CAISO in 2016. The study found that RTO markets provided significantly more benefits than a centralized day-ahead market alone. This trend held for the West as a whole and for each state individually.⁴⁸

However, in terms of production costs, individual state benefits diverged with respect to a single RTO versus two RTOs (see Table 5). For all Western states except Arizona, Washington, and California, the savings in production costs were slightly greater if the states participated in a second RTO rather than joining the CAISO RTO. On the other hand, the study said all states would gain greater capacity benefits under a single RTO, mostly because of greater load diversity.

⁴⁸ The only exception was Idaho, where simulated operating costs for 2030 under a single RTO increased by 1.5%. The study did not discuss why this exceptional outcome might have occurred. Nevertheless, Idaho's simulated savings in capacity costs more than offset the increase in production cost.

Table 5. Cost Savings Estimated for 2030 Relative to 2019 Market Structure (\$Million/Year)

State	Production Cost Savings		Capacity Savings	
	Single RTO	Dual RTOs	Single RTO	Dual RTOs
Arizona	\$71	\$50	\$141	\$36
California	\$346	\$203	\$228	\$176
Colorado	\$75	\$83	\$118	\$118
Idaho	-\$10	\$0	\$106	\$84
Montana	\$12	\$13	\$43	\$4
Nevada	-\$6	\$34	\$60	\$14
New Mexico	\$52	\$53	\$84	\$11
Oregon	\$96	\$100	\$153	\$93
Utah	\$52	\$54	\$67	\$11
Washington	\$123	\$107	\$540	\$441
Wyoming	\$23	\$24	\$28	\$11

Original values adjusted to 2022 dollars.

Limitations

The study took a simplified and classic approach to estimates of capacity value. Its methodology is not comparable to the earlier SB 350 study, which used a capacity expansion analysis to simulate the capacity additions needed by 2030.

The State-Led Market Study (Energy Strategies 2021a) simulated capacity expected to be available in 2030 against forecasted load, focusing on peak demand and the availability of resources. However, as more conventional resources retire and the power supply has more variable renewables in its mix, the critical time for resource availability is not necessarily the peak load hour. It may occur during shoulder times (the hours before or following the peak hour).

[4] [CAISO EDAM Benefits Study: Estimating Savings for California and the West Under EDAM Market Scenarios \(2022\)](#)

Prepared by Energy Strategies, LLC

Prepared for CAISO

This study builds on *The State-Led Market Study* (Energy Strategies 2021a), with a particular focus on the benefits associated with CAISO’s EDAM. The purpose of the study was to estimate the operational and capacity savings for California and other states in the Western Interconnection in the year 2030 assuming a West-wide EDAM footprint.

Operational cost savings are represented by adjusted production cost, the net costs for a defined area to serve load, accounting for generation cost, power purchase costs, and revenue from sales. A decrease in adjusted production cost across market scenarios represents operational savings.

Findings

The study found that a West-wide EDAM scenario would create \$214 million in operational savings (a 6.2% decrease from the status quo) and \$95 million in capacity savings for California each year, for total savings of \$309 million annually. Other Western states would save \$886 million annually in operational (\$329 million) and capacity (\$557 million) savings.

The study finds an annual incremental increase of approximately 3,400 GWh of gross energy exports out of California, and an annual incremental decrease of approximately 900 GWh of gross energy imports. The study also projects an increase of more than 1,400 GWh of solar and wind output in California as a result of the West-wide EDAM.

The authors project that the EDAM will achieve 74% of RTO operational savings for California and 81% of RTO operational savings for the other Western states compared to those estimated in *The State-Led Market Study* (Energy Strategies 2021a).

A sensitivity study suggests inclusion of an imbalance reserve product in EDAM is critical to the efficiency of the market. Removing the imbalance product results in lower operational savings at \$86 million per year in California (roughly 60% less than with an imbalance reserve product), and \$120 million per year in the other Western states (a 63.5% decrease).

Limitations

This study does not address benefits characterized as “other energy related savings” (e.g., more efficient transmission planning and environmental benefits of reduced emissions) and “non-energy savings” (e.g., downstream effects of lower energy prices including job and economic growth).

The capacity savings were not evaluated anew, but they were adopted from publicly available materials generated from *The State-Led Market Study* (Energy Strategies 2021a). This study assumes the high-end range of capacity savings; however, the authors note it is possible that EDAM would result in no direct capacity benefit depending on how resource adequacy constructs evolve.

The West-wide EDAM scenario assumes all Western BAs join EDAM, and that EDAM features a market-based imbalance reserve product, no transmission wheeling costs among market participants, and 100% transmission availability for market optimization. The sensitivity study assumes EDAM forms across the West, and BAs define and retain their own imbalance reserve.

[5] [The State-Led Market Study: Market and Regulatory Review Report \(2021\)](#)

Prepared by Energy Strategies, LLC

Prepared for DOE, State Energy Offices of Utah, Idaho, Colorado, and Montana

This report is a subjective evaluation of how well the market constructs examined in *The State-Led Market Study* (Energy Strategies 2021a)—an RTO, a day-ahead market, a real-time imbalance market, and a bilateral contract market—tend to achieve state energy policies. It rates each construct with respect to:

- Increased use of clean energy technologies

- Reliable and affordable provision of energy to consumers
- Impact on state jurisdiction.

The questions and the assessment were developed by a lead team comprising state representatives of Utah, Colorado, Idaho, Montana, Arizona, California, New Mexico, Nevada, Oregon, Washington, and Wyoming. Input from the lead team was compiled by Energy Strategies into three scorecards with specific elements for each state policy area.

Findings

The team agreed that RTOs are the superior construct for increasing the use of clean energy technologies. Specific strengths included efficient grid operations, lower barriers for accessing high-quality renewable energy locations, more opportunities for clean electricity resources to be added to the grid, financing opportunities, emission reductions induced by economic efficiency, clear market signals, and transparency with respect to prices, operations, and emissions. Bilateral and real-time imbalance markets were rated poor with respect to accessing high-quality renewable energy locations.

RTOs were also rated as the superior construct for delivering reliable and affordable energy to customers. Specific strengths included efficient grid operation, efficient use of existing generation, efficient use of transmission, support for reliable operations (including better visibility into system conditions), transparency of information, support for resource adequacy, and more opportunities for demand-side participation. Bilateral markets were judged poor with respect to unlocking the full potential of existing generation and decreasing the cost of new generation investments.

On the other hand, RTOs were rated weaker than the other three market constructs on several measures related to state regulatory authority: state control over resource adequacy, state control over the resource mix of regulated utilities, state control over transmission planning and investment, and state control over retail electric rates. The team said state engagement would be important particularly around RTO formation, specifically:

- Informed engagement by a state commission in the planning, decisions, and governance of an organized market
- Careful state PUC consideration of conditions of approval requests by jurisdictional utilities to join an organized market
- Comprehensive review of the impacts of proposals to unbundle state PUC regulated rates.

Limitations

The report was a summary of state perceptions regarding generic market constructs and was not an analysis of how the three topic areas might be addressed within a market construct. It also did not empirically evaluate perceptions against actual practices and outcomes with respect to critical areas such as resource adequacy and transmission planning, both of which can vary significantly under each market construct.

[6] *Colorado Transmission Coordination Act Evaluation of Market Alternatives (2021)*

Prepared by Siemens Power Technologies International

Prepared for Colorado Public Utilities Commission in Response to State Legislation (Colorado Transmission Coordination Act of 2019, C.R.S. 40-2.3-101 and 102)

This study examined several models of regional transmission coordination and their possible effects on Colorado electricity customers. One model was an RTO encompassing all of WECC, including CAISO, BPA, and the Western Area Power Administration. Another model contemplated Colorado utilities, along with some utilities in Wyoming, joining the SPP.⁴⁹

Besides the two RTO models, the study tested limited coordination through a real-time energy imbalance market (CAISO's WEIM and SPP's WEIS), and through a joint transmission tariff among regional utilities combined with a day-ahead power pool. The area covered by the study's joint tariff power pool model included utilities served by the BAs for Public Service Company of Colorado and the Western Area Power Administration's Rocky Mountain region, which includes all of Colorado and most of Wyoming.

Findings

This study found significant cost savings to Colorado if its utilities were to join a regional RTO. The benefits were slightly greater for joining SPP: a 9% savings in total system costs over the status quo reference case, compared to 8% for a WECC RTO and 7% splitting Colorado between SPP and a WECC RTO. The report noted that when Colorado participates in the WECC RTO, "higher power prices in the West (California) lead to slightly higher prices in Colorado." The marginal cost of serving demand in Colorado under a WECC RTO was about 16% higher than it would be if Colorado utilities were in SPP. Colorado also retired more coal capacity under the SPP RTO.

Total benefits under the joint tariff/power pool model were comparable to benefits under either of the energy imbalance markets. Variable costs were about the same, as were fixed costs and the cost of capital recovery. Day-ahead costs under the joint tariff were slightly lower than under either EIM, while real-time costs were slightly higher.

[7] *Benefits of SPP RTO Expansion into the WEIS Footprint*

Prepared by Brattle

Prepared for Basin Electric Power Cooperative, Colorado Springs Utilities, Tri-State Generation & Transmission Association, Western Area Power Administration

This study examined the benefits utilities currently participating in SPP's WEIS might see if they were to join SPP as full RTO members. The utilities included the Western Area Power Administration (Loveland Area Projects, Colorado River Storage Project, and the portion of the Upper Great Plains Region in the Western Interconnection), Colorado Springs Utilities, Deseret Electric Power Cooperative, Tri-State Generation and Transmission, Municipal Energy Agency

⁴⁹ The study used the Mountain West Transmission Group to represent utilities joining SPP. This included all utilities in Colorado and the Western Area Power Administration's Rocky Mountain region, which covers a large part of Wyoming.

of Nebraska, and the portion of Basin Electric Power Cooperative in the Western Interconnection. The analysis simulated these utilities as the “Westside” of an expanded SPP.

The analysis assumed a single optimization across the entire expanded RTO. Due to the limited ability to transfer power across the seam between the Western Interconnection and the Eastern Interconnection, the results were disaggregated between the Westside utilities and the rest of SPP, which is in the Eastern Interconnection.

Findings

The study found that full RTO participation could reduce production costs for the Westside utilities by 18%–26%. The lower value of that range represents operations during a low-hydro year. The estimates accounted for basic production costs, the cost of bilateral and market purchases, and revenues from bilateral and market sales. The utilities lost some wheeling revenue under the RTO scenarios due to “de-pancaking” of wheeling fees, but this lost revenue was less than one-quarter of the savings in production costs.

Limitations

Estimation of impacts on Western utilities outside the Westside group were not analyzed. The study also did not estimate benefits related to improvements in flexibility, reliability, or resilience.

[8] *Reliability Implications of Expanding the EIM to Include Day-Ahead Market Service: A Qualitative Assessment (2020)*

Prepared by Western Electricity Coordinating Council

WECC launched this study to “explore the potential reliability impacts of extending day-ahead market services to EIM participants.” It convened a group of experts to identify reliability considerations likely to occur with an EDAM and other possible market expansions.

Because this study was conducted before CAISO stakeholders had identified specific attributes of EDAM market design, the experts formulated their own general assumptions.

Findings

The study concluded that an EDAM would improve coordination across a broader footprint, with cost savings resulting from access to a broader resource pool and automated processes, the uniform application of tools and processes, and better management of system variability. On the other hand, potential risks included increased operational complexity, reduced bilateral market liquidity, difficulties in gas-electric coordination, and “seams” issues (energy transfers from one regional market to another).

Critical areas in EDAM market development included how transmission operations would be coordinated, evaluation of resource sufficiency, and how day-ahead market timelines could affect gas scheduling. It also recommended monitoring the development of reserve requirements and how those requirements would be met under new market constructs.

Limitations

The study did not specifically consider a Western day-ahead market operated by SPP (as contemplated in SPP's Markets+ proposal), or how an SPP market might differ from one operated by CAISO. Many of the study's observations and conclusions were general to a day-ahead market and did not refer to a specific operator.

[9] [2040 Clean Energy Sensitivities Study \(2022\)](#)

Prepared by WECC

WECC studied some of the operational considerations involved with achieving high levels of clean energy penetration.

Findings

Battery storage will be an important part of the decarbonized portfolio, but it reaches a point of diminishing returns at a West-wide system decarbonization level of around 90%.

Higher levels of variable renewable energy resources, which will be needed to reach 100% decarbonization, could create transmission challenges. Interregional flows could change, resulting in some paths being used constantly at 90%–100% of their rated capacities.

Limitations

The study relies on a production cost analysis that was adapted to existing market structures and operational practices in WECC. This includes CAISO as it exists today, utilities that have joined either the CAISO-operated WEIM or the SPP-operated EIS, and the RTO in Alberta. It did not test alternative market structures such as a West-wide RTO. WECC notes that because of this, the study's findings might be overly conservative.

[10] [Sharing Power Among the Pacific States \(2018\)](#)

Prepared by Gridworks

This paper by former California PUC Commissioner Mike Florio examines how resource adequacy policies are currently structured and how they might be modified to increase benefits for customers in all states.

Findings

The paper offers no specific proposals for multistate resource adequacy mechanisms, but it does suggest guiding principles based on prior efforts. In addition to the traditional balance between cost and reliability, principles include:

- The preservation of state authority over resource planning and procurement
- Progress toward a low-carbon electricity system
- Ensuring the ability of new technologies to enter the market.

The paper notes additionally that system flexibility to accommodate higher penetrations of intermittent renewables could become a major consideration in any new resource adequacy mechanisms. The issue of preservation of state authority over resource planning and procurement continues to be an important design principle within California and other Western states.

[11] *Root Cause Analysis: Mid-August 2020 Extreme Heat Wave (2021)*

Prepared by CAISO, the California Public Utilities Commission, and the California Energy Commission

Prepared for California Governor Gavin Newsom

This report examined factors that contributed to rotating outages in CAISO during an extreme heat event in August 2020. The event was an example of extreme stresses on the bulk power system exacerbated by an increasingly volatile climate, and which pose a challenge for conventional resource adequacy planning.

This study is included in this literature review because several of the issues it identifies involve resource adequacy, and this summary focuses on those findings. Several other studies included in this literature examined whether regional approaches to resource adequacy might help the bulk power system operate more reliably and with greater resilience during climate-induced extreme events. It also demonstrates an increased collaboration between BAs in recent years.

Findings

The report identified three closely related factors that led to the 2020 outages:

- A regional heat wave that caused electricity demand to outstrip what existing resource adequacy planning had anticipated.
- Resource planning targets that failed to ensure that enough dependable resources were on hand during the early evening hours, when load is increasing and the instantaneous output of wind and solar is falling.
- Practices in the day-ahead energy market that made the first two effects harder to manage.

The event itself was estimated to be a once-in-30-year event for August weather conditions, and it was followed a month later by another heat wave that was estimated to be a once-in-70-year event for September conditions. Moreover, energy markets were limited in their ability to provide supplemental resources during these events because the heat wave affected nearly all of the West. The report found that with such events happening more frequently than in the past, “it is unlikely that the current resource adequacy planning levels would have avoided rotating outages for the demand forecasted for August 17 through August 19” without the use of extraordinary interventions.

The report observes that the construct for resource adequacy currently used for California “was developed around peak demand, which until recently has been the most challenging and expensive moment to meet demand.” It notes further that “[w]ith the increase of use-limited resources such as solar generation in recent years, however, this is no longer the case. Today, the single critical period of peak demand is giving way to multiple critical periods during the day, including the net demand peak, which is the peak of load net of solar and wind generation resources.”

The report noted that regional energy transfers into CAISO via the WEIM provided some additional resources during critical operating hours, but not enough to avert the blackouts entirely.

[12] *Resource Adequacy in the Pacific Northwest (2019)*

Prepared by E3

Prepared for Puget Sound Energy, Avista, NorthWestern Energy, and the Public Generating Pool

This study focuses on the Pacific Northwest and its resource adequacy needs with high penetrations of renewable energy and an increasing number of coal retirements. It examines the amount of effective capacity that can be provided by wind, solar, storage, and demand response. It also looks at requirements for firm capacity under different carbon reduction scenarios.

Findings

A key conclusion was that the Pacific Northwest was at risk of underinvesting in the new capacity that would be needed to ensure resource adequacy. Deep decarbonization is possible, the study found, but only if the region retained a sufficient amount of firm capacity such as natural gas generators. Complete decarbonization—that is, replacing all carbon-emitting units with wind, solar, and storage—would be extremely costly and impractical, the study concluded.

The report also pointed to the relationship between resource adequacy and security of fuel delivery. Even under a deep decarbonization trajectory, the report said, the ability of resources such as natural gas units to deliver capacity that is truly firm will depend on a firm supply of fuel. This could require investments in fuel delivery infrastructure.

The creation of a formal regional mechanism could help ensure sufficient firm capacity and reduce the total amount of capacity that would be required. The study identified two sources of cost savings: those resulting from resource adequacy planning based on a regional peak rather than individual utility peaks, and those resulting from a planning reserve margin target that would be lower for the region. These insights subsequently became key design principles for the WRAP.

[13] *Implications of a Regional Resource Adequacy Program on Utility-Integrated Resource Planning (2020)*

Prepared by Lawrence Berkeley National Laboratory, University of Texas at Austin, Western Interstate Energy Board

Prepared for DOE

This study explores how a regional resource adequacy scheme might affect participating local utilities and the states that regulate them. It does not presume that an RTO is necessary for regional resource adequacy coordination; one model it examines is a voluntary resource adequacy mechanism under discussion by members of the Northwest Power Pool.

Key questions include how a utility’s integrated resource planning process might change, the local and regional division of resource adequacy elements, and the degree of control that the utility and its regulator would have over the utility’s resource mix after considering the influence of a regional resource adequacy mechanism.

Findings

The report concluded that while integrated resource planning proceedings are not likely to change fundamentally, the existence of a regional resource adequacy program could change some of the assumptions informing the integrated resource plan. The composition of the utility's resource mix would still be a local decision, but quantities procured and capacity accreditation would be governed by the resource adequacy program rules and managed by the resource adequacy utility. Key inputs and parameters that are common to all utilities participating in the program in the region might need to be reconciled when analyzing the characteristics of a preferred portfolio locally.

Two important inputs are:

- Capacity credit, which refers to how much of a technology's nameplate capacity may be counted toward the resource adequacy target quantity
- The planning reserve margin, which with forecasted load determines the total amount of capacity that the utility needs to hold to serve demand reliably.

The report notes a nexus between resource adequacy and transmission, which can affect the deliverability of power from a resource. A regional resource adequacy program would need to include studies of the transmission system's ability to deliver power, similar to what is done in an RTO. Such studies could also improve coordination between utilities on transmission planning, which can also inform a utility's integrated resource planning process.

[14] [Resource Adequacy Working Group Report \(2020\)](#)

Prepared by the Western Interconnection Regional Electricity Dialogue (WIRED)

Prepared for Center for the New Energy Economy

Colorado State University's Center for the New Energy Economy convened a group of experts to make recommendations to Western governors on policies for resource adequacy. The group included governors' energy advisors, utilities (including PMAs), renewable energy developers, and clean energy advocates.

Findings

The working group identified seven principles that should guide resource adequacy mechanisms in the West. They should:

- Be compatible with state policy objectives/state policy objectives should seek to be compatible or be able to be harmonized with regional resource adequacy programs
- Provide flexibility to participants to acquire resources that achieve cost savings for customers and meet state policy objectives
- Allow participating entities to have operational access to the shared set of resources
- Be administered in an independent manner and should equitably allocate resource requirements to participants to ensure that all participants fairly contribute to reliability
- Provide data and information to inform decision-making in utility-integrated resource plans
- Encompass as many states as possible to ensure a robust and diverse resource portfolio

- Include transparent transmission, market, and emissions assumptions, including ensuring transmission policy is consistent with open-access principles.

[15] *Western Flexibility Assessment: Investigating the West's Changing Resource Mix and Implications for System Flexibility (2019)*

Prepared by Energy Strategies

Prepared for Western Interstate Energy Board

This study examined regional cooperation limited to strategies to increase grid flexibility. It examined aggregated benefits in two increments: first, additional benefits attributable solely to a West-wide real-time and day-ahead energy dispatch market; and second, the additional benefit resulting from several regional strategies. These additional actions included new transmission to help deliver renewable power to loads, the addition of storage, managed charging of electric vehicle loads and (in the Northwest region) a more diverse resource mix. None of the actions were contingent on technological breakthroughs.

The deployment of renewable resources tested in the study was consistent with enacted and foreseeable state public policies as of 2019. For the West overall, the benchmark portfolio was 23% wind, 22% solar, 18% hydro and pumped storage, 7% distributed generation, and 2% from biofuels and geothermal. Natural gas contributed 21% of the benchmark portfolio.

Findings

The study's baseline scenario incorporated only the addition of integrated day-ahead and real-time energy markets throughout the West. Production costs fell 8% for 2025 and 12% for 2035 with just these changes. The additional flexibility strategies reduced production costs by another 4% for 2025 and 22% for 2035.

With the additional flexibility strategies and their resulting cost savings, the study said the West could reach a clean energy penetration of 69%. That would exceed 2019 policy targets.

The study noted that flexibility needs will tend to increase with diminished resource adequacy.

Coordinated wholesale markets can be effective vehicles for increasing system flexibility, the report noted, adding that "the West will operate with a less flexible system with higher operational costs and emissions should coordinated markets not materialize in the next several years." Near-term state goals were achievable without further market coordination, the report said.

Though the study did not break down its results by state, it nevertheless concluded that "interregional power transfers are likely to increase in the coming years and such economic transfers are one of the most effective tools for increasing system flexibility."

[16] *Empirical Estimates of Transmission Value Using Locational Marginal Prices (2022)*

Prepared by Lawrence Berkeley National Laboratory

Prepared for DOE

This study examines one particular benefit associated with RTOs: savings related to strategic expansion of regional and interregional transmission, measured by reductions in LMPs. The study's premise is that existing transmission planning approaches tend to understate the economic value of new transmission, particularly the value of congestion relief. This would have implications for how a Western RTO or a non-RTO regional transmission cooperation agreement might approach evaluation of new transmission.

Though the study considers only RTOs, it does treat the Western EIM as an extension of the CAISO footprint that contains real-time LMPs. This provides a large cross-sectional regional data set for analysis. (This review focuses on study findings for the Western Interconnection.)

Findings

LMPs in CAISO's real-time energy market and in the EIM indicate that the West's highest-price areas are California's northern and southern coastal areas, and its lowest-price regions are eastern Wyoming and California's Mojave Desert. Transmission connections from a low LMP region into a high LMP region would tend to reduce LMPs in the high price region to the extent that the prices are the result of transmission congestion (i.e., the inability to move a sufficient quantity of low-cost resources into the high-cost area).

The study also found that the California coastal areas are also marked by extreme variations in high prices. That is, real-time LMPs were high relative to the system average more frequently than in other parts of the West. Real-time LMPs can increase due to unforeseen outages, unforecasted variations in wind or solar output, extreme weather events, or a coincidence of these factors. Insufficient transmission capability at the wholesale level can exacerbate the impacts on congestion, which in turn can cause real-time LMPs to spike.

Limitations

The study's methodology focused on regional LMP differences especially during periods when prices were exceptionally high. Though extreme price differences between regions could be construed as a value metric for new transmission, in many RTOs they are also construed as price signals for building new resources—either new generation, storage, or demand response capability in locations where prices are often high due to systematic transmission congestion. Therefore, the value metric used in the study does not exclusively apply to transmission, especially if strategically located new resources are a more cost-effective solution.

Real-time energy markets in RTOs are more prone to price excursions than day-ahead energy markets where most of an RTO's energy transactions are settled. Consequently, conclusions based on volatility in real-time price behavior alone could be different if the analysis also tested day-ahead price patterns.

[17] [WECC EDT Phase 2 EIM Benefits Analysis and Results: October 2011 Revision \(2011\)](#)

Prepared by E3

Prepared for WECC

This study of EIM benefits predates the launch of the CAISO-operated EIM by three years. WECC commissioned the study to better understand the production cost benefits and other societal benefits of having a centralized EIM in the Western Interconnection.

The EIM simulated in this study excluded CAISO and the Alberta Electric System Operator. Sensitivities tested the effect of reduced transactional barriers between CAISO and the then-conceptual Western EIM.

Findings

The study estimated \$191 million in cost savings for 2020 (original estimates converted to 2022 dollars) for utilities participating in the conceptual EIM. About 30% of the savings were related to more efficient dispatch, while the remainder was due to meeting flexibility reserve requirements at a lower cost (a lower total requirement after combining reserve areas, and more efficient procurement of the reserves that were still needed).

However, the study's sensitivity analyses suggested benefits were sensitive to assumptions about participating BAs. The study also found that reducing economic barriers between CAISO and the theoretical rest-of-WECC EIM would produce additional cost savings.

Comparison of Study Findings to Actual EIM Savings

Actual benefits to non-CAISO participants in the CAISO-operated EIM amounted to about \$304 million for 2020 (in 2022 dollars). Additional factors included in CAISO's benefit methodology include the value of reduced curtailment of wind and solar resources.

[18] [Examination of Potential Benefits of an Energy Imbalance Market in the Western Interconnection \(2013\)](#)

Prepared by NREL

Prepared for DOE, Western Public Utility Commissions Energy Imbalance Market Group

This early study of the EIM construct was requested by several Western states at a time when many of them were beginning to explore alternatives for greater regional cooperation. As with E3's 2011 study, the EIM footprint was assumed to be nonmarket utilities in the West (that is, CAISO and the Alberta Energy System Operator were treated as nonparticipants).

Findings

Simulated production costs fell by about 1.4% in the standard scenario with full EIM participation (or about 2% in sensitivities assuming high natural gas prices). Benefits did not fall significantly in the study's limited participation scenario.

The full participation scenario indicated LMP reductions of up to \$5 per MWh in parts of California and up to \$10 per MWh in Colorado and the Northwest. Simulated LMPs increased by up to \$5 in parts of Montana.

[19] *Analysis of Benefits of an Energy Imbalance Market in the NWPP (2013)*

Prepared by Pacific Northwest National Laboratory

Prepared for Northwest Power Pool

This study was conducted one year before CAISO and PacifiCorp launched the first phase of the CAISO-operated EIM. It examined a conceptual EIM comprising only the BAs in the NWPP. Because hydropower is a large component of the Northwest resource mix, the study included several sensitivities related to water availability and management practices.

Findings

The study estimated the baseline minimum achievable benefits in 2020 from a NWPP EIM would be \$49 million to \$71 million (adjusted to 2022 dollars), or between 1.2% and 2.1% of the total production costs simulated by the study. The benefits tended to be higher for years with more abundant hydropower supplies. When including reduced flexibility reserve due to sharing resources across the EIM, benefits increased to between \$154 million and \$187 million (2022 dollars). The calculation of benefits did not include reductions in wind or solar curtailment.

Comparison of Study Findings to Actual EIM Savings

The NWPP entities participating in the CAISO-operated EIM in 2020 included the Balancing Authority of Northern California, Idaho Power, PacifiCorp, Portland General, Puget Sound, and Seattle City Light. The sum of actual benefits to these entities in 2020 was about \$173 million (2022 dollars). CAISO's estimation of benefits includes the value of reduced wind and solar curtailments and the value of reduced flexibility reserve.

3.2 Policy Studies

The five policy studies collected by NREL and CAISO analyze the costs and benefits associated with increased regional coordination in the Western Interconnection. Four of the five items in this group of studies are analyses conducted in 2021 by or for a specific state public utility commission to investigate the benefits and risks of expanded regional coordination, including RTO entry. The inclusion of the state-specific studies in this report helps address the requirement stated in ACR 188 to explore how other states besides California have engaged with the question of increased regional cooperation; in particular, the studies explore “engagement between neighboring states on the future of regional transmission organizations in the West.”⁵⁰ The fifth study is a 2013 FERC staff paper that weighs the costs and benefits of a Western Electricity Imbalance Market, and its inclusion is useful in response to ACR 188's language around other forms of regional cooperation besides RTOs (i.e., “collaboration between states on energy policies to maximize consumer savings while respecting state policy autonomy”). It also helps illuminate how both reliability assessments and the Western regional cooperation conversation have changed since 2013.

⁵⁰ “Assembly Concurrent Resolution No. 188: Chapter 138,” California Legislative Information, https://leginfo.ca.gov/faces/billNavClient.xhtml?bill_id=202120220ACR188.

[20] *Regional Transmission Organization Study: Oregon Perspectives (2021)*

*Prepared by the Oregon Department of Energy and the Oregon Public Utility Commission
Prepared for the Oregon Legislature*

This study is in keeping with Senate Bill 589, which requires the state of Oregon to investigate the state-specific risks, costs, benefits, opportunities, and challenges of RTO entry. To meet these requirements, the Department of Energy identifies key findings from recent technical studies about RTO formation (listed in Appendix A), and develops scoping questions based on the findings (listed in Appendix B). Additionally, the department forms a stakeholder advisory committee and gathers written feedback from the committee on the scoping questions. The scoping questions address key topics related to joining an RTO such as legal barriers, state-specific costs and benefits, state-specific retail customer impacts, transmission rates and planning, renewables, environmental impacts, governance, climate resilience, and market design options. The Oregon Perspectives study qualitatively assesses what benefits RTO entry has for Oregon in terms of questions pertinent to ACR 188, such as transmission and reliability improvements, and what challenges may arise.

The study is qualitative and does not contain a technical analysis. The Oregon DOE determined that a technical analysis would not be necessary unless a specific market design and governance of an RTO is under consideration.

There is widespread agreement (short of a consensus) within the Oregon Department of Energy that RTO entry would result in system-wide benefits. The drivers of expected retail benefits include least-cost dispatch, access to a diverse pool of resources, less overbuilding, wheeling charges to move power across transmission, optimized use of existing transmission, diversified risk exposure, cost of regional transmission development, less imbalances, and lower costs in integrating renewables.

The study acknowledges the challenges that RTO entry would not solve, including increased complexity of the electricity system, more regional engagement of siting and permitting over time, the “missing money problem” associated with capacity procurement, and long interconnection queue waits that are currently curbing renewable growth in RTOs across the United States.

Findings

There is a general expectation that joining an RTO will result in economic benefits to Oregon retail customers, but this depends on how substantive challenges about governance and market design are addressed, as Oregon, like other states, will want equal standing with the other RTO members on market decisions. Other barriers to realizing the full scale of retail benefits include high administration costs, a potential increase in transmission costs compared to Oregon’s relatively low transmission costs, and barriers to ensuring a benefit flow-through to customers.

The key elements identified for development of RTO market design and governance are (1) diverse representation of communities that could benefit from RTO entry, (2) ensuring market nonparticipants have some influence in RTO governance, (3) transparent, inclusive, and accessible decision-making for a diverse group of stakeholders, and (4) ensuring RTO governing board members are independent from market participants and state policymakers.

Regarding market structure design, the study board postulates that Oregon should maintain some authority when deciding on resource adequacy issues and other state policy decisions. The authors also point out that Oregon has several medium- and long-term emissions reduction goals and emphasize that the achievement of these goals should be reinforced rather than inhibited by RTO entry.

The study also identifies areas where RTO entry could improve on a process that is already taking place. For example, renewable energy development will occur with or without an RTO in Oregon, but an RTO could promote additional low-cost opportunities.

Limitations

In this study, Oregon did not consider any regional expansion short of joining an RTO.

Additionally, the study states that equity and environmental justice should be considered in RTO development and that input from tribal communities and underserved communities should be considered but does not provide much surrounding detail about this. The study board should collect input from underserved communities and should perform an additional analysis that specifically addresses how RTO entry would affect underserved communities in the state of Oregon.

[\[21\] Colorado Transmission Coordination Act: Investigation of Wholesale Market Alternatives for the State of Colorado \(2021\)](#)

Prepared by the Colorado Public Utilities Commission

Prepared for the Colorado Legislature

This study is in keeping with the Colorado Transmission Coordination Act and Senate Bill 21-072. The Colorado Transmission Coordination Act directs the Colorado PUC to investigate costs and benefits to Colorado utilities' participation in a wholesale market, which can take several forms; in this paper, an energy imbalance market, joint tariff, power pool and RTO are investigated. Senate Bill 21-072 requires Colorado transmission utilities to join an OWM by 2030.

Colorado is required to reduce its economy-wide greenhouse gas emissions relative to a 2005 baseline by 26% by 2025, 50% by 2030, and 90% by 2050. Additionally, Colorado utilities are required to reduce their GHG emissions relative to 2005 baseline by 80% by 2030 and 100% by 2050. The study assumed compliance with Colorado's statewide goals.

The executive summary and findings focus on the current environment in the Western Interconnection and in Colorado, and on the benefits that a Western wholesale market could provide to Colorado. This is useful to the study and the requirements of ACR 188 because it involves a discussion of how states have engaged in regional market expansion. The paper includes a quantitative analysis, which finds that benefits such as cost savings for utilities can accompany increased regional coordination.

Findings

Greater regional coordination in the form of an RTO could reduce total annual utility costs for Colorado utilities by 4%–5% and could aid in achieving the state’s clean energy goals. A day-ahead market could also provide cost reductions of 2%–3%. Potential concerns about Western regional expansion are also identified and are especially relevant for full RTO entry. Although an EIM provides the lowest monetary benefits, it also provides the least potential complications in terms of governance. A day-ahead market similarly may provide less statewide benefits than an RTO but may be easier to incorporate in terms of governance structure.

The findings in the executive summary are organized into Colorado joining with CAISO, SPP and identifying an overall approach for utilities looking forward.

CAISO has experience with increased expansion as it has an EIM market that optimizes real-time imbalance energy for about 80% of the West and has received approval for a final proposal for a day-ahead market as well. At the time of the Colorado Transmission Coordination Act study’s writing, significant concerns about the day-ahead market including governance, resource adequacy and resource diversity and specific utility coordination issues were still being addressed.

Broadly speaking, the report recommends that Colorado utilities and the Colorado PUC should work with other Western Interconnection areas to explore options for market expansion.

Limitations

The study’s quantitative analysis is conducted by Siemens and uses a capacity expansion model. The study states that the following were not included in modeling:

- Coordinated ancillary services or a competitive procurement mechanism for utilities (could result in further cost reductions if included)
- Optimized expansion of transmission infrastructure (although the impact of some transmission upgrades was studied and could result in further cost reductions)
- The administration costs of creating the OWM.

The study does not include discussion of how greater regionalization would impact underserved communities in Colorado.

[22] [*Commission Decision Determining Market Participation is in the Public Interest \(2021\)*](#)

Prepared by the Colorado Public Utilities Commission

This proceeding is in keeping with the Colorado Transmission Coordination Act, which requested that the Colorado PUC perform a cost-benefit analysis of electric utility participation in regional wholesale markets.

The proceeding investigation consists of comments and feedback from utility stakeholders, regional thought leaders and the Colorado public, a research review and summary, and a techno-economic study performed by Siemens. It also identifies a timeline of developments since the Colorado Transmission Coordination Act was opened in 2019, including:

- Developments within the SPP’s WEIS and CAISO’s WEIM.
- The proposed SPP Markets+ bundle and CAISO EDAM, which would both allow for day-ahead commitment and dispatch without RTO membership.
- Identification and discussion of research exploratory groups.
- FERC’s planned investigations on transmission planning.

The proceeding finds that Colorado entry into a wholesale market is within the public interest but leaves specific market recommendations as a potential further analysis.

The findings of the proceeding predominately rely on a modeling exercise conducted by Siemens, which may have associated modeling limitations and estimates. These are discussed in detail in the review for the *Colorado Transmission Coordination Act: Investigation of Wholesale Market Alternatives for the State of Colorado 2021* study. The motivation of this proceeding is in part to summarize that more detailed study.

Findings

If certain concerns are adequately addressed, then the proceeding finds Colorado entry into a wholesale market to be within the public interest. The proceeding finds that generally, savings from cost and infrastructure efficiency associated with joining a regional market would likely translate to significant customer benefits. The expected savings are greatest for RTOs, then day-ahead markets, followed by EIMs, and finally joint tariffs.

The proceeding’s identified concerns include:

- Potential adverse impacts associated with state resource planning and interconnection queue processes
- Market participation administration fees as barriers to entry and exit
- The fact that RTOs are not immune to resource adequacy risks⁵¹
- Potential for reduced efficiency of transmission interconnection queues management compared to Colorado’s
- The mandate-adjacent language of the 2021 Senate Bill 72 as opposed to the status quo of voluntary entry⁵²
- The lack of accounting metrics for emissions tracking in organized markets and the need for a comprehensive GHG accounting approach for imports and exports to prevent emissions leakage
- The wide variance of state-level GHG policies
- Issues around transmission planning and cost allocation
- Governance decisions and a decreased or unclear role of the Colorado PUC in planning.

These concerns are greatest for RTOs and are less for EIMs and day-ahead markets.

⁵¹ The most recent NERC summer reliability assessment (NERC 2022b) showed elevated or high risk of insufficient operating reserves in CAISO, MISO and ERCOT, and SPP issued a resource alert in summer 2021 (SPP 2021).

⁵² SB72 states that “transmission utilities” (excluding municipally owned and power authorities) must join an organized wholesale market by 2030 unless (1) the utility has tried but there is no viable option or (2) the state PUC has determined that this is not in the public interest.

[23] *Arizona Corporation Commission Docket Memo from Office of Chairwoman Lea Marquez Peterson (2021)*

Prepared by Chairwoman Lea Marquez Peterson

Prepared for the Arizona Corporation Commission

In 2021, commissioners from the Arizona Corporation Commission (Arizona’s Public Utility Commission) opened a docket for investigation of Arizona’s entry into a regional market. This letter, from the Office of Chairwoman Lea Marquez Peterson, describes why the docket was opened and outlines next steps and needs for a more detailed Arizona Corporation Commission investigation. The letter presents a qualitative argument for a detailed investigation and notes that a quantitative analysis of benefits would provide increased insights.

Arizona has struggled with overbuilding and resource adequacy issues in the past and the commissioners believe that increased utility collaboration can help with these issues and stabilize customer rates. They cite the Cactus power pool as one example of utility collaboration. However, they also lay out concerns regarding full RTO/ISO entry.

If Arizona joined a regional market, it could take several forms. Each is a different level of commitment that comes with its own associated implications, requirements, and governance issues. The most involved form of entry is for Arizona to join an RTO, but regional market participation could also take the form of an energy imbalance market or joint tariff.

Tangentially to an ISO, the Arizona Independent Scheduling Administrator was established in 1990 by the public utility commission and utilities in the state to facilitate nondiscriminatory transmission access to the grid. The commissioners argue that the utilities within the state have not utilized its benefits, although they still pay dues and tariffs to the Arizona Independent Scheduling Administrator each year.

The paper also discusses the current state of regional expansion, and how it has gained momentum over past years. Several BAs in Arizona have joined—or plan to join—the Western EIM. For example, APS joined in 2016, SRP followed in 2020, and Tucson Electric Power joined in 2022.

Findings

With all this in mind and considering that regional markets are becoming an increasing part of the conversation, the commissioners addressed the need for a detailed investigation into potential benefits and risks for the Arizona grid, ratepayers, utility shareholders and the state. The investigation would ideally address consideration of needs, goals, objectives, and purposes and would consider issues related to cost allocation, resource adequacy and governance.

The potential benefits of joining a regional market outlined by the commissioner include increased collaboration, a wider market for diverse sets of resources, easier planning processes for interstate transmission lines, and more efficient use of resources such as transmission. However, the commissioners also outline several issues that the investigation should address with proposed solutions. These include:

- Transmission cost allocation

- Establishing the proper market incentives for reliability and resource adequacy
- Governance and the roles of states.

[24] *Qualitative Assessment of Potential Reliability Benefits from a Western Energy Imbalance Market (2013)*

Prepared by FERC Staff

Prepared for FERC

This study is a qualitative assessment that examines the reliability benefits of an electricity imbalance market (EIM). The reliability discussion is split up into issues surrounding (1) adequacy and (2) security. The staff paper was released one year before the launch of CAISO's WEIM.

The motivation for this paper is to qualitatively identify how an EIM could improve reliability in the Western Interconnection. It describes how loss of load events could be avoided by dispatching a wider variety of resources and through the effective management of flows.

The paper assumes an EIM would not include centralized unit commitment, day-ahead markets, ancillary service markets, or capacity markets. The consolidation of BAs is also not assumed (i.e., the paper assumes bilateral markets remain intact).

Findings

Broadly, reliability benefits of an EIM include better management of energy imbalances and transmission flows, opportunities to deliver from a diverse set of resources or to incorporate demand response and streamlining reliability coordinator issues.

The report breaks up benefits into several categories:

- Security-constrained economic dispatch
- Enhanced situational awareness
- Lessening of emergency alerts
- Contingency response improvements.

Security-constrained economic dispatch automates resources and transmission to balance load, and dispatches resources based on their real-time availability rather than reservations that are decided ahead of time. This can be helpful in preventing congestion and creating enhanced coordination to assist with reliable operations. With security-constrained economic dispatch, price signals become more consistent with reliable operations, and it is also associated with less unscheduled flows and better management of system imbalances.

Enhanced situational awareness and lessening of emergency alerts both have to do with the more rapid and automated response time of the system under an EIM versus bilateral contracting. Both could be associated with the tools used for security-constrained economic dispatch and are associated with more real-time data becoming available and providing the system with increased visibility.

Contingency response improvements refer to improvements associated with how quickly the system responds to unexpected events. An EIM could bring contingency response improvements

by increasing the pool of resources, increasing the visibility of the system and of transmission loads, improving ramping capability and improving renewable energy integration.

Limitations

The staff paper was written in 2013, and reliability and resource adequacy issues and debates have evolved over the past decade. Reliability models have improved significantly and can measure events at a higher time granularity. Modeling reliability and resilience inside versus outside an EIM could be important for future studies as utilities contemplate whether they should join the WEIS or WEIM, for example.

No quantitative assessment or discussion of reliability is included.

3.3 Legal Assessments

The following two studies evaluate potential jurisdictional and constitutionality implications of expanded regional markets. The discussion that follows summarizes authors' conclusions of studies, and it does not purport to present an independent evaluation of the conclusions or analysis of the merit of jurisdictional or constitutional challenges. As with any legal matter, the authors' conclusions summarized herein are subject to judicial interpretation.

- Evaluation of Jurisdictional and Constitutional Issues Arising from CAISO Expansion to include PacifiCorp Assets (2016)
- Enhanced Western Grid Integration: A Legal and Policy Analysis of the Effects on California's Clean Energy Laws (May 2017)

[25] [*Evaluation of Jurisdictional and Constitutional Issues Arising from CAISO Expansion to Include PacifiCorp Assets \(2016\)*](#)

Prepared by Ann E. Carlson, Shapiro Professor of Environmental Law, UCLA School of Law and William Boyd, Professor of Law and John H. Schultz Energy Law Fellow, University of Colorado Law School, in consultation with Ethan Elkind, Director, Climate Change and Business Program, UC Berkeley and UCLA Schools of Law and Daniel Farber, Sho Sato Professor of Law, UC Berkeley School of Law

Prepared for CAISO

This study examines whether the expansion of CAISO to include PacifiCorp assets would affect FERC's jurisdiction over CAISO in connection with California's environmental, generation facility, and load-serving entity regulatory authority. The study also examines whether such an expansion would increase the vulnerability of California's environmental and clean energy laws to Commerce Clause challenges.

In 2015, CAISO and PacifiCorp explored adding PacifiCorp as a full participating transmission owner in CAISO, resulting in the addition of PacifiCorp's transmission facilities to the CAISO-controlled grid and expanding CAISO's transmission territory to an additional five states.

Because electric power in the wholesale markets run by CAISO is already subject to federal regulation, an expansion to include PacifiCorp would not change CAISO's character as a participant in interstate commerce. The authors opined that because CAISO is already subject to FERC jurisdiction, inclusion of PacifiCorp assets in CAISO would not expand FERC's

jurisdiction or subvert California’s authority to regulate environmental matters. Similarly, such inclusion would not further expose California’s environmental and clean energy laws to Commerce Clause scrutiny.

Preemption Issues

Inclusion of PacifiCorp would not displace California’s authority over environmental matters, and would not preclude California from doing anything it otherwise could with respect to environmental matters. That preexisting limit prohibits California from implementing state laws that “intrude upon or seek to establish FERC jurisdictional rates.”

FERC v. EPSA, 577 U.S. 260 (2016) upheld FERC regulations on the basis that they were within FERC’s authority to regulate matters affecting FERC-jurisdictional rates. Any challenge to a California environmental law alleging an infringement of FERC’s “affecting” jurisdiction is independent of the geographic footprint of CAISO.

The authors note that the expansion of CAISO would not affect California’s rights to adopt policies regarding generation facilities or the procurement of particular types of resource by load-serving entities, rights the Federal Power Act expressly reserves to the states. The broad powers of the states to direct the planning and resource decisions of utilities within their borders (*e.g.*, promoting a particular type of resource, RPSs, incentives for particular types of generation, and future capacity bilateral contracting, among others) are not compromised by the expansion of an ISO or RTO encompassing a multistate region. Such policies are only limited by FERC’s jurisdiction insofar as they intrude on a FERC-jurisdictional rate. In rejecting a challenge to California’s feed-in tariff for combined heat and power facilities, FERC’s order explained that FERC’s jurisdiction over wholesale rates does not replace the states’ authority to dictate utilities’ purchase decisions. Such analysis is unaffected by the expansion of CAISO to include PacifiCorp.

In sum, regarding the preemption of California policies regarding generation facilities or the procurement of particular resources by load-serving entities, so long as California laws do not attempt to interfere with a FERC-jurisdictional rate, “it will continue to enjoy broad authority to direct the planning and resource decisions of utilities within its jurisdiction.”

Commerce Clause Challenges

Expansion of CAISO does not alter the constitutional framework applicable to California’s clean energy and environmental policies. “Electricity that flows across the CAISO system has and will continue to be traveling in interstate commerce over the Western Interconnect, regardless of whether CAISO operates wholly within the state of California or expands to include transmission facilities in other states.”

California regulates electricity imports through a performance standard and cap-and-trade program. The authors concluded that such California policies are defensible on Commerce Clause grounds, and that the expansion of CAISO does not affect the constitutionality of such electricity import regimes. Any Commerce Clause arguments exist notwithstanding any territorial footprint expansion. This includes any arguments based on the Eighth Circuit’s opinion in *North Dakota v. Heydinger*, 825 F.3d 912 (8th Cir. 2016) striking down a Minnesota statute that prohibited “any person” from importing power that would contribute to statewide

power sector carbon emissions. Importantly, the element of Minnesota’s law that only one judge on the panel held violated the Commerce Clause (a conclusion the authors contend is based on an erroneous understanding of how the electric grid functions) is not part of California’s performance standard statute.

The authors conclude that California’s RPS, together with most states’ RPS, is likely to withstand a constitutional challenge. Similarly, the expansion of CAISO would not subject California’s RPS to additional Commerce Clause risk.

In sum, Federal courts that have heard Commerce Clause-based challenges to state climate policies have generally upheld such policies. The policy at issue in one key exception, the *Heydinger* case, is distinguishable from any California policy. The expansion of CAISO to include PacifiCorp does not alter this conclusion.

Limitations

This legal assessment was conducted in 2016 and thus does not include consideration of intervening case law. However, a survey of federal case law since that time—including *FERC v. EPSA*, 577 U.S. 260 (2016) and *Hughes v. Talen Energy Marketing LLC*, 578 U.S. 150 (2016)—did not reveal any jurisprudence that would alter the analysis.

The analysis in this study is limited to evaluating the constitutional consequences of CAISO expansion to include PacifiCorp assets, rather than a large scale transition to an RTO. This distinction is of little import in this instance; the authors suggest their analysis of the expansion of CAISO to include PacifiCorp assets is similarly applicable to a larger scale expansion.

This study does not consider the implications of multiple state clean energy policies interacting in a single market, or the extent to which such interaction would affect the states’ ability to meet environmental goals. The study also does not consider any changes to California clean energy policy that might be desirable or otherwise emerge from regionalization.

[26] [*Enhanced Western Grid Integration: A Legal and Policy Analysis of the Effects on California’s Clean Energy Laws \(2017\)*](#)

Prepared by Juliana Brint, Josh Constanti, Franz Hochstrasser, and Lucy Kessler, graduate students at the Yale Law School and Yale School of Forestry & Environmental Studies

Prepared for Yale Environmental Protection Clinic

This study evaluates the practical, jurisdictional, and constitutional impacts of an integrated Western electricity market on California’s RPS, greenhouse gas emissions performance standard, and cap-and-trade clean energy policies.

Wholesale sales of electricity in California are already considered interstate commerce because of California’s participation in the Western Interconnection. Thus a California law that impacts wholesale electricity transactions affects interstate commerce regardless of whether CAISO becomes an RTO.

The authors conclude that enhanced Western grid integration would not interfere with state clean energy policies from both an operational and constitutional perspective, nor would it expand

FERC’s authority over California’s electricity system beyond its current jurisdictional scope. Moreover, the transition would not increase the vulnerability of California’s clean energy programs to Supremacy Clause or Commerce Clause challenges because power transactions on the California grid are already considered to be part of interstate commerce.

FERC Jurisdiction

FERC already has jurisdiction over wholesale sales of electricity, even such sales where both the generator and purchaser of the power are in California, because California’s grid is part of the Western Interconnection. Expanding the footprint of the grid that is being managed will not trigger a jurisdictional change because the California grid is already FERC-jurisdictional.

Under the Federal Power Act, states retain authority with respect to retail electricity sale and generation resources. Clean energy policies (*e.g.*, generation mix and retail rates) are valid exercises of state power, and states retain these powers regardless of the footprint of the RTO.

Preemption

Under the Supremacy Clause of the U.S. Constitution, a state law is “preempted” if it conflicts with Federal law. The traditional bright line between FERC’s exclusive jurisdiction over wholesale markets, and states’ jurisdiction over retail sales, has been blurred by electricity industry restructuring and technological advancement. The authors cite as examples regional transmission planning, the treatment of demand response resources in wholesale markets, and the relationship between state subsidies for new generation and wholesale capacity markets.⁵³ For example, in *Oneok v. Learjet*, 575 U.S. 373 (2015), the U.S. Supreme Court emphasized, “the importance of considering the target at which the state law aims in determining whether that law is preempted.” In other words, state laws that *target retail* rates are a proper exercise of state power, while those that *target wholesale* rates are likely preempted. The authors note that challenges alleging state clean energy policies are preempted by the Federal Power Act have largely been unsuccessful, and an integrated Western electricity market would not strengthen preemption arguments against California’s clean energy policies.

Dormant Commerce Clause

The focus of a dormant Commerce Clause analysis is the impact of law or regulation on interstate commerce. Courts evaluate dormant Commerce Clause cases with varying degrees of scrutiny depending on the nature of the state law subject to challenge. The focus of a dormant Commerce Clause analysis is the impact of the law or regulation on interstate commerce.

The authors evaluate whether participation in a multistate wholesale market impacts the strength of constitutional challenges to California’s clean energy policies on dormant Commerce Clause and Supremacy Clause grounds. The authors’ conclude that while California’s RPS, greenhouse gas Emission Performance Standard (EPS), and cap-and-trade program may be expected to face legal challenge, a transition to a regional wholesale transmission model would not create any

⁵³ Wholesale capacity markets exist in RTOs in the eastern United States but not in CAISO or ERCOT. None of the papers included in this review suggested a capacity market for the West.

additional legal risk beyond those dormant Commerce Clause and Supremacy Clause arguments already cognizable.

In conclusion, the authors state:

Transitioning from a single-state to a multi-state wholesale electricity market will not increase the risk that California’s clean energy policies face from challenges under the Supremacy Clause and dormant Commerce Clause. Making the necessary changes to allow CAISO to add out-of-state balancing authorities as full-scale members will improve the reliability of the Western grid and will help facilitate cost-effective renewables integration without jeopardizing California’s existing clean energy policies.

Limitations

This study assumes a Western RTO would be formed through the expansion of CAISO, as opposed to, for example, the creation of a new entity. The authors briefly mention that such expansion would require changes to CAISO’s governance structure requiring approval of the California State Legislature and FERC; the study does not address the scope of such changes.

This assessment was conducted in 2017 and thus does not include consideration of intervening developments or case law; however, we have found no intervening case law since that time that would materially alter the conclusions set forth in this study.

The study refers to the entity that would exist under an expanded Western grid as “a regional ISO,” which is referred to as an RTO for purposes of this review.

3.4 Other Literature

[27] [*Transmission Benefits All Users of the Power Grid \(2021\)*](#)

Prepared by Michael Goggin, Grid Strategies LLC

This study contends the benefits from transmission expansion conferred on renewable energy generation are less than the load diversity benefit. Therefore, cost allocation methods in which interconnecting generators pay for a large share of transmission expansion are inefficient and not just and reasonable.

Findings

The author’s primary message is that more of the value of transmission investment is realized through load diversity than renewable diversity. Transmission expansion promoting load diversity allows peak demand to be met with surplus generation from areas not concurrently experiencing peak demand; therefore, less capacity is needed. Transmission benefits all grid users and dispels the notion that the need for transmission investment is mainly driven by renewable growth. Therefore, “current transmission planning and cost allocation methods, in which interconnecting generators pay for a large share of transmission expansion, are inefficient and not just and reasonable.”

The Midcontinent Independent System Operator (MISO) estimated its Multi-Value Projects portfolio will reduce required planning reserve margins by up to 1%. SPP found its transmission investment permits a 2% reduction in SPP’s planning reserve margin, resulting in 40-year net present value savings of \$1.34 billion in reduced capacity costs. The author concludes sufficient transmission capacity could reduce the need for peak capacity by approximately 100,000 MW within both the Eastern Interconnection and the Western Interconnections, for a total of 200,000 MW of capacity savings totaling \$158 billion in benefits (including \$67 billion in savings within the Western Interconnection).

[28] [*Prospect of a New Western Regional Transmission Organization \(2021\)*](#)

Prepared by Richard J. Campbell, Specialist in Energy Policy, Congressional Research Service

Prepared for Members and Committees of Congress

This report provides background information for members of Congress to consider whether furthering RTO formation in the West requires federal guidance (discussing, for example, the Climate Leadership and Environmental Action for our Nation’s Future Act (H.R. 1512), which would compel each public utility to place its transmission facilities under control of an RTO within two years of enactment). The report identifies the positions of those supporting and not supporting a formal federal policy of promoting RTO expansion in the West. Those in support cite planning and competitive savings of a full RTO. Those not supporting a formal federal policy prefer to “leave the ‘emergent’ WEIM to evolve to meet the needs of the Western states.”

[29] [*Potential Customer Benefits of Interregional Transmission \(2021\)*](#)

Prepared by General Electric International, Inc.

Prepared for American Council on Renewable Energy (ACORE)

This memorandum was prepared by General Electric International, Inc.’s Energy Consulting group in support of ACORE’s comments to FERC’s Advance Notice of Proposed Rulemaking titled, “Building for the Future Through Electric Regional Transmission Planning and Cost Allocation and Generator Interconnection.”

Findings

The authors acknowledge how increased reliance on carbon-free generation and extreme weather event challenges are impacting grid reliability. In this context, grid reliability is attainable with a high penetration of renewable energy in three ways:

- **Adequacy:** long-term supply-demand balance resilient to grid uncertainties
- **Operational Reliability:** day-to-day supply-demand balance for all periods
- **Stability:** system strength to sustain voltage and frequency.

GE Energy Consulting promotes incremental interregional transmission to enable lower wind and solar curtailment, higher generation diversity and flexibility in the face of uncertainty (e.g., generation, transmission and fuel outages or extreme weather), and greater system strength to avoid system tripping due to fluctuations in voltage, frequency, or unwanted oscillations. Implementing several forms of reliability enhancements (e.g., forecasting, regional

coordination/visibility, geographic diversity, and flexible demand, among others) provides benefits to consumers and promotes renewable penetration.

In the authors' view, CAISO (through the WEIM), SPP (through continued expansion since 2015), and Denmark (via the European Network of Transmission System Operators for Electricity) are three examples of jurisdictions effectively using an array of reliability enhancements to promote renewables expansion. To achieve target renewable energy penetration by 2035, the United States will benefit from higher diversity, flexibility, and grid strength enabled by regionalization. The authors call on FERC to provide national-level guidance to establish the framework for greater regionalization.

[30] [*In Support of Western Regional Resource and Transmission Planning Coordination \(2021\)*](#)

Prepared by Gridworks and Center for the New Energy Economy (Colorado State University)

Prepared for Western Interconnection Regional Electricity Dialogue (WIRED) Transmission Planning and Development Working Group

This report summarizes discussions held during the summer of 2021 by a group of stakeholders collaborating to address transmission planning in the West through the WIRED Transmission Planning and Development Working Group. Participants include Balancing Authorities of Northern California, CAISO, and PacifiCorp, among several others.

Findings

Participants recognize that to meet state clean energy and environmental policies, and satisfy customer demand, the Western Interconnection will need to plan for extensive new renewable energy generation and transmission resources. The stakeholders who participated in the discussions identified a vision for coordinated regional resource and transmission planning that would facilitate achieving states' environmental and energy goals, developing safe, reliable, and efficient transmission and generation resources, and allocating transmission development costs consistent with cost causation principles.

To better coordinate resource and transmission planning to help states achieve their energy and policy objectives, the participants recommend exploring the sufficiency of current resource planning, the costs and benefits of synchronizing resource and regional transmission planning cycles, and other steps that can be taken to improve interstate resource and transmission planning. The participants propose a paradigm shift where “future collaboration in times of unparalleled fleet transition to renewable energy calls for coordination of resource planning and transmission planning to achieve potential shared interstate benefits.”

The participants identified several potential benefits and challenges of coordination. Such benefits include more strategic identification of resource development areas; the ability of the current grid to connect those resources with loads depending on the season and time of day, and optimization of the current electric grid; improved model quality and better understanding of regional needs; and more efficient transmission expansion (*e.g.*, through identification of economies of scale). Challenges identified include present dispersed resource planning;

individual state goals (e.g., clean energy goals and resource mix requirements); and longer timelines for transmission development than development of generation.

To participate in the process, the participants identified three fundamental questions on which states must have developed a position:

1. To what extent will transmission development help achieve economic efficiencies and benefits from the existing resource fleet and the fleet planned for the future?
2. Will the state support in-state resource development for export purposes to help neighboring states meet their economic and environmental goals in exchange for the in-state economic development and employment benefits?
3. Is the state willing to achieve lower capital costs through higher interdependence with neighboring states?

Finally, the participants proposed a transmission planning exercise to assess the capabilities and congestion points of the existing transmission system considering the resource needs to achieve state goals. To assist with the exercise, participants encourage compiling information about the status of proposed transmission projects.

[31] [*Pathways Toward Grid Decarbonization: Impacts and Opportunities for Energy Customers from Several U.S. Decarbonization Approaches \(2022\)*](#)

Prepared by Resources for the Future

Prepared for Clean Energy Buyers Institute

This study examines the effects of five methods of decarbonizing the U.S. power sector:

- National clean energy standard
- Utility-led decarbonization
- National transmission macrogrid consisting of nearly 8,000 miles of high-capacity, direct current transmission lines
- Expansion of competition among generators via expansion of OWMs
- Expansion of supply choice to commercial and industrial customers, combined with OWM expansion.

The authors model the effects, costs, and benefits of each method as of 2035 and 2050 (except for a clean energy standard that targets 80% clean electricity by 2030, the effects are projected for 2025 and 2030).

Conducting an original estimate of the effects of OWM expansion was beyond the scope of the study; the authors instead apply the results of prior studies that have estimated the effects of OWM expansion. It is this discussion that is most salient for purposes of this overview.

Findings

The study examines the effects of expanding OWMs to parts of the United States that are not currently in them, including much of the West. OWMs permit planning over larger geographic

areas and generation diversity, which allows resources to be sited in more efficient areas and reduced capacity reserve margins. The authors identify five categories of benefits from OWMs:

1. More efficient use of existing resources through incentivized use of least-cost generating units, reducing use of those with higher operating costs
2. More efficient planning for future investment through efficient integration of renewable resources and increased load diversity and generation
3. Increased grid reliability and decreased congestion through the promotion of optimal investments made on a larger regional scale
4. Economies of scale through reduced redundancies of smaller BAs
5. Climate benefits from reduced fossil fuel generation and more efficient utilization of renewables.

Expanding OWMs to parts of the United States that do not have them is estimated to provide \$11 billion in annual cost savings as of 2035 and \$14 billion per year as of 2050 through more efficient investment, operation, and retirement decisions. The resultant emissions reductions are estimated to decrease annual emissions by 8% and damages by an additional \$8 billion in 2035 and \$10 billion in 2050.

Though the authors conclude that a clean energy standard produces the single largest benefit, combining the clean energy standard with OWM expansion can result in even lower electricity supply costs than clean energy standard alone, thereby offsetting some of the cost of the clean energy standard. When OWM expansion is added to the clean energy standard, the projected annual electricity supply cost savings is estimated to be \$11 billion. In addition, expanding OWM increases commercial and industrial voluntary clean power access, with even greater benefits when combined with expanded commercial and industrial supply choice.

Limitations

This study relies on a conservative quantitative value of damage per short ton of carbon dioxide of \$61 if emitted in 2035 and \$77 if emitted in 2050. This study also assumes no future tax credits for renewable generation.

[32] [*Designing the 21st Century Electricity System: How Electricity Buyers Can Accelerate Change \(2021\)*](#)

Prepared by Rob Gramlich, Grid Strategies LLC

Prepared for REBA Institute, an affiliate of the Renewable Energy Buyers Alliance

In 2021 the Renewable Energy Buyers Alliance changed its name to the Clean Energy Buyers Alliance. The REBA Institute is now the Clean Energy Buyers Institute.

This study examines the key changes to the electric power system needed to meet emissions reductions targets reliably and efficiently, with a focus on those changes that most significantly impact customers. The intended audience is policymakers, energy market stakeholders, and large electricity customers.

Findings

Among the fundamental changes to the power system the author identifies are large RTOs to facilitate movement of electricity across large areas and provide nondiscriminatory access to the transmission system, and transmission planning and cost allocation to expand regional and interregional capacity.

Because wind and solar resources generate power intermittently, and frequently some distance away from load centers, variability can be reduced through aggregation made possible by larger balancing areas with fewer transmission constraints.

To enable large spatial movement of power, the author identifies a need for consolidation of BAs in the Western United States. This benefits large electricity customers seeking a steady supply of renewably generated power because they can access generation at different times based on the regional markets. The author concludes, “To achieve large regional operation, there must be a single regional grid operator. RTOs are the institutions that can operate large regional spot markets in the United States. They can efficiently coordinate congestion management and flexibility service procurement in real time across large geographies with their dispatch system.” The system of many smaller BAs “places a ceiling on the ability [to] aggregate a large and diverse set of renewable power sources and inefficiently limits otherwise feasible power flows.”

The RTO market design best practices for which the author advocates include system flexibility based on fast scheduling and dispatch; scarcity-based pricing while supporting long-term contracting and hedging; market monitoring to prevent the exercise of market power; nondiscriminatory operations reliability services; bilateral contracting; integration of distributed energy resources; forecasting; optimizing energy-limited resources; hierarchical control; and compatible environmental attribute and electricity market products.

[33] [WIRED GHG Accounting Working Group Report \(2020\)](#)

Prepared by Center for the New Energy Economy

Prepared for WIRED

This report focuses on methods of greenhouse gas (GHG) accounting for different types of policies and provides recommendations for accounting across regional boundaries. Its purpose is to help states and other entities to identify and develop GHG accounting frameworks that can address emissions accounting complications. Complications in accounting processes are usually due to several factors, including:

- Inconsistencies in accounting because of different methodologies across states
- Difficulties in identifying resources that serve load across regional boundaries
- The “cross-jurisdictional issue” (i.e., the fact that many resources are not produced where they are consumed).

The report first identifies the two main categories of policies that are used to reduce emissions: (1) policies that incentivize clean energy resource development, such as an RPS or a clean energy standard and (2) policies that directly limit emissions, such as carbon cap-and-trade programs or setting a carbon price. These types of policies have different characteristics, and an accounting framework for one may not be appropriate for the other.

The report categorizes GHG accounting into four different general methodologies:

- **Attribute-Based Accounting:** This is a simple and flexible accounting system which reflects widespread regional benefits without specifically accounting by jurisdiction or individual loads. In this method, the attribute of a resource is separated from the accounting transaction (i.e., the renewable energy certificate, which includes subattributes of fuel type, and region) is separated from the energy transaction, load service, or acquisition of attribute). Attribute systems are used in voluntary markets, which means customers can purchase attributes without a supply agreement with their local utility. Many RPS and clean energy standard programs use attribute-based accounting.
- **Attribute-Based Accounting with Eligibility Criteria:** This method addresses a common critique of attribute-based accounting, which is that it does not include individual state preferences for a renewable attribute, and that purely attribute-based accounting can hide a lack of actual renewable procurement or lack of emissions reductions with its broad and simplified nature. Therefore, in certain programs increased eligibility such as geographical restrictions of procurement, and time frame restrictions on eligible vintages, are added.
- **Source-Based Accounting:** This method looks only at the source of electricity production and does not separately consider non-energy attributes. It is how utilities report to FERC Form 1, or to the U.S. Energy Information Administration. Another example is the Regional Greenhouse Gas Initiative, which looks at the power plant level and uses allowances as a form of compliance. Electricity transactions or deliveries to load are left out of this accounting method.
- **Source-Based Accounting for Electricity Imports:** This reshapes the source accounting method to look at imports specifically. The California Air Resource Board developed a methodology for this type of accounting, and it is used in the California Cap-and-Trade Program. Because imports are difficult to track and there are complications in matching resources to specific loads, no clean energy standard or RPS program has used an import-based approach to date. The study notes that complications associated with this approach can actually grow and make results more imprecise with increased time granularity, because of all the assumptions that accumulate.

Additionally, the report discusses the potential for double-counting (counting a single attribute for compliance twice), and carbon leakage (a phenomenon that occurs when, for example, a carbon-pricing region imports fossil fuels from other areas, increasing overall emissions). The report notes that these should be avoided, that their risk increases with inconsistent methodologies, and that a reporting program does not create events such as double-counting or leakage but can highlight where they might be happening.

Findings

The report outlines several potential market impacts associated with improper greenhouse gas accounting. For wholesale markets, the authors note that accounting does not need to take place on a resource-specific basis, and that inconsistencies across states can disincentivize efficient wholesale markets.

The report states that standardizing accounting methods across regions will be increasingly important as renewable penetration increases and policies become increasingly focused on decarbonization, and as regional expansion takes place to create more “efficient electricity markets.” With these shifts to the electricity system, the risks associated with inconsistent accounting, such as double-counting and leakage, also increase. The authors’ recommendations include the following:

- Governors and states should align accounting methodologies wherever possible, so that consistency across states can be achieved. Standardized definitions of important concepts such as double-counting and leakage should also be sought.
- For policies that focus on development of clean energy resources, an attribute-based approach is recommended. States can work with the Western Regional Energy Information System to develop attribute-based frameworks at the regional level for organized markets.
- Market designs and accounting metrics should support state policy rather than undermining it.
- Approaches should be simplified wherever possible and should consider legal, contractual and policy limitations during their design.

[34] [*Renewable Energy Policy Pathways Report \(2020\)*](#)

Prepared by the Brattle Group

Prepared for Clean Energy Buyers Association (CEBA)

This study focuses on determining pathways, including policy and market structure reforms, to increase renewable energy access for commercial and industrial (C&I) customers. In 2018, corporate buyers made up a fifth of all U.S. PPA agreements, and many wish to buy RECs from facilities that are not yet built to help drive transformation. The study argues that the market structures and policies within a state are sometimes barriers to progress for C&I entities, which include, for example, medical complexes, corporations, and universities. The goal of the study is to determine which state-level policies and market designs reinforce—and which ones impede—C&I renewable development, offer insights on impacts, and discuss a path forward for C&I customer renewable procurement.

The study uses eight representative U.S. states with varying climate policies and market structures as a case study. The eight states are Arizona, California, Colorado, Georgia, Massachusetts, Minnesota, North Carolina, and Virginia. The three policy pathway reforms studied are:

- Advancing RPSs in each state
- Expanding utility subscription program options
- Expanding supply choices and implement RTOs for non-wholesale market states.

The study evaluates the effectiveness of the reforms that it proposes through an analytical framework that considers three impacts relative to a status quo of renewable development: (1) the percentage of C&I customers that can reach 100% renewable energy supply in 2030, (2) the capacity (GW) deployed to meet demand in each policy pathway, and (3) the cost of procurement (cents per kW) in each pathway.

Findings

The report finds that the amount of build-out to meet C&I demand depends on several factors. These include the starting point of regulatory and market structure in the state, whether the state participates in an RTO, the local availability of renewable resources, the cost of renewables, and the amount of capacity that retiring fossil fuels leave open for renewable expansion.

For all eight states, supply choice works best for technical potential of up to 100% and reduced costs of up to 11% compared to the status quo. The study notes that RTO membership provides cost reductions and increased renewable access, and that RTOs also are good vehicles for maintaining long-term reliability. Further, the study states that participation in centrally organized wholesale markets will likely make the examined policy pathways cheaper, increase customer options, reduce production and operational costs, and facilitate more renewable energy integration over a broader geographical base.

The study also finds that expanding utility subscription programs are a great option for the near term to improve access for C&I customers and can expand access by 60%–63% or 52 GW by 2030. They can also result in a cost increase or up to 5% cost savings.

Finally, the study finds that identifying potential stranded asset costs and how to handle them is key for adopting the policies outlined, as these costs present a large uncertainty in results.

A summary of findings for the eight states is presented in Table 6 in the present report (page 67). It was adapted from Table 1 of the study, which also provides a summary of results by policy pathway.

Limitations

The study was published in 2020, and cost assumptions may be somewhat dated. It presents future renewable energy costs and stranded asset costs as points of uncertainties.

One policy pathway that was not analyzed and is noted by the authors is to decarbonize the electricity sector with a national commitment through carbon pricing or emissions limits. This would represent the lowest-cost policy pathway on average and could be analyzed in future studies.

Although this study uses eight states with different and representative U.S. policies and market structures, it does not represent options for every state in the United States. The variation in the study's results is enough that similar studies could be repeated for other U.S. states.

Table 6. Summary of Study Results

Policy Pathway	States Without a Centrally Organized Wholesale Market: Arizona, Colorado, Georgia, and North Carolina	States With a Centrally Organized Wholesale Market: California, Minnesota, and Virginia	States with Retail Choice: Massachusetts
Status quo	5 GW of new renewable energy for all	20 GW of new renewable energy for all	7 GW of new RE
Moderate RPS expansion above status quo	<ul style="list-style-type: none"> • Technical potential of new renewable energy capacity: Up to 19 GW • Technical potential of C&I with renewable energy supply: up to 33% of demand • Cost ranges relative to status quo: -3% to 0% change 	<ul style="list-style-type: none"> • <i>Only Minnesota and Virginia</i> • Technical potential of new renewable energy capacity: Up to 6 GW • Technical potential of C&I with renewable energy supply: up to 46% of demand • Cost ranges relative to status quo: -1% to +1% change 	<ul style="list-style-type: none"> • Technical potential of new renewable energy capacity: up to 3 GW • Technical potential of C&I with renewable energy supply: up to 59% of demand • Cost ranges relative to status quo: -0.3% to +1% change
Utility subscription expansion	<ul style="list-style-type: none"> • Technical potential of new renewable energy capacity: Up to 46 GW • Technical potential of C&I with renewable energy supply: up to 60% of demand • Cost ranges relative to status quo: -5% to +1% change 	<ul style="list-style-type: none"> • <i>Only California and Minnesota</i> • Technical potential of new renewable energy capacity: Up to 6 GW • Technical potential of C&I with renewable energy supply: up to 63% of demand • Cost ranges relative to status quo: 0% to +2% change 	N/A
Supply choice introduction	<ul style="list-style-type: none"> • Technical potential of new renewable energy capacity: 29–92 GW • Technical potential of C&I with renewable energy supply: 43%–100% of demand • Cost ranges relative to status quo: -11% to -1% change 	<ul style="list-style-type: none"> • Technical potential of new renewable energy capacity: 19–45 GW • Technical potential of C&I with renewable energy supply: 66%–100% of demand • Cost ranges relative to status quo: -5% to -1% change 	N/A

Adapted from *Renewable Energy Policy Pathways Report (2020)* Table 1

[35] *Grid Vision: The Electric Highway to a 2^{1st} Century Economy (2019)*

Prepared by the American Wind Energy Association (AWEA)

Prepared for the American Wind Energy Association (AWEA)

The goal of this study is to determine how updates to electric grid infrastructure can decrease outage frequency and congestion. A literature review is conducted to understand the history and future expectations associated with transmission expansion.

Findings

The study finds that expansion of the transmission system could save consumers up to \$47 billion per year. This would translate to a 10% reduction in electric bills driven mostly by decreased costs of congestion. Additionally, the long-term benefits for regional power providers usually exceed costs of transmission expansion by 2–4 times.

Benefits of transmission expansion on system performance are identified and include:

- Improved resilience (i.e., less damage to system infrastructure in the event of disasters and quicker recovery after unexpected events): Some of this is due to less system congestion which can make the system more vulnerable to attacks.
- Reduced threat of cyberattacks
- More support of renewable expansion, whether the expansion is utility-scale or distributed
- Support of new loads and electrification.

The paper also makes several recommendations for policies related to transmission expansion:

- States should look for interregional transmission solutions across state boundaries and should consider the long-term improvements that transmission expansion will bring during the planning process.
- Cost allocation should be spread out, especially for high-capacity and interregional transmission. This is usually a divisive topic for interregional transmission planning.
- The permitting process and siting should be simplified wherever possible, and federal authority should be used where possible when projects support national interests.

[36] *Improving Transmission Planning: Benefits, Risks, and Cost Allocation (2019)*

Prepared by Johannes Pfeifenberger, the Brattle Group

Prepared for Midwestern Governors Association & Organization of MISO States

The report is organized by (1) providing background on transmission trends and their drivers and (2) stating why planning must be improved to support a transitioning electric grid. Key challenges preventing optimal growth in transmission are presented, and transmission planning recommendations are outlined.

Transmission investment in the United States increased over the past decade and was around \$20 billion annually from 2015 to 2019. Traditional drivers of transmission growth include serving a growing load, interconnecting generation, supporting local and short-term reliability, and

replacing aging infrastructure. Focusing only on these needs misses some opportunities for focused transmission growth that adds optimal value.

The author recommends focusing on new drivers for transmission development, which include preventing and relieving congestion, expanding access to clean energy, increasing load diversity, realizing the full value of resources, addressing future uncertainties, and supporting cost reduction of interregional planning.

Current planning processes have not yielded the most value that transmission can provide, and barriers to doing so include:

- Failing to realize transmission's full range of benefits
- Failing to fully recognize the value that new transmission adds, and its fluctuations over time
- Failing to account for both short- and long-term risk mitigation
- The divisive nature of project-by-project shared regional cost recovery (as opposed to cost recovery on a grid-wide basis, for example)
- Ineffective interregional planning processes that are unable to identify projects that add the most value
- A focus on short sighted reliability and local needs that make certain transmission projects difficult to justify.

Findings

The author notes that transmission expansion has historically been suboptimal because transmission planning has not focused on the wide variety of benefits and long-term outcomes of new transmission. To improve long-term outlooks, planners can consider examples and past projects that have shown continued success and improvements to grid stability.

Better planning for uncertainties also must be included in transmission development. Uncertainty analysis relates to taking a long-term outlook so that high-cost potential benefits such as risk mitigation and flexibility are realized. There should be less of a focus on near-term reliability, and more of an emphasis of the long-term value that transmission can provide with relatively low cost over time.

Additionally, the divisiveness associated with interregional transmission should be reduced by fairly allocating regional costs based on the distribution of benefits that new transmission provides. Concerns with cost allocation are a large barrier to interregional growth even though interregional transmission projects are widely found to result in significant system cost savings. The author states that more interregional projects are needed to support a transitioning electric power grid and sites the importance of incorporating these into regional plans.

[37] *A Regional Power Market for the West: Risks and Benefits (2018)*

Prepared by PaulosAnalysis

Prepared for Next 10

This study presents risks and benefits of Western RTO expansion of CAISO. To frame its discussion, it first offers a brief background on where the conversation is currently, as well as some information about how electricity markets operate.

Proponents of expansion include clean energy industry groups and environmental groups. The benefits they identify include:

- Fewer barriers for integration of renewables because renewables could be exported instead of curtailed, and expansion would unlock more potential build locations for resources (Wyoming, Montana, and New Mexico).
- Better management of transmission: Transmission planning would be associated with more transparency and competition, and dispatch decisions would become more automated. There would hopefully be less duplications of costs and fees, less congestion, and more efficiency in transmission expansion decisions such that decisions would be focused across an entire region, and possibly less would need to be built overall to support the more regionalized system.
- Reduced operating costs of the grid: WEIM had saved the system \$330 million at the time of writing. With a Western RTO, utilities could share reserves and smooth out variability in demand over a large area.
- Improved competition, choice, customer savings, and increased available jobs spurred by lower power costs
- Pressured the least dispatch competitive plants to go offline, likely including coal and nuclear capacity.

At the time of writing, opponents of regional expansion included labor groups, the Sierra Club, and The Utility Reform Network. The reasons for their opposition included:

- Opponents feared that CAISO would have less power and that regional expansion could possibly threaten climate policies in the state because the RTO board would need to consider all Western states for policy decisions.
- There is potential to increase regional coal plants sales by possibly helping to enable, for example, coal prop-ups and subsidies to keep coal relevant.
- Some construction jobs would shift to out-of-state areas because these would be eligible for meeting California's climate goals.
- The opponents note other ways to integrate renewables in addition to Western expansion, such as relying more on California's potential for distributed energy resources and focusing on that potential more than regionalization.

Findings

Most studies suggest regionalization could lead to job growth in California, as cheaper electricity would lower costs for businesses. Growth would not be limited just to California, but to projects in the region that represent the best resources which might not currently have the adequate demand to be developed.

In terms of governance, the study notes that CAISO is not a state agency. CAISO must operate under a FERC framework of federal laws, and a regional RTO would operate similarly. An RTO would require a board and staff of non-stakeholders, which would encourage isolation of the regional market from political and market interferences. This might give California less power over an RTO board, but states are still mostly responsible for policy decisions.

In terms of threats to policy, the study notes that many of the current challenges to policy come from interstate commerce rules, which occur regardless of whether CAISO regionally expands. Regardless of regional expansion, states play a more prominent role than the RTO in drafting policies.

The study notes that many see regional expansion as a pathway toward easier integration of renewables. Distributed solutions such as solar and demand response are also involved but are less developed and still a little more expensive currently. More stringent policies will require more of both types of solutions, and the present study sees areas where they can work together to create a less carbon intensive future.

Finally, the study notes that it is unlikely for coal to do well in a large regional market, absent policy actions to promote its use. There are many locations to expand renewable resources, and these will likely take priority over coal.

Limitations

The study does not include a scenario that focuses specifically on distributed resources and how they interact with regional expansion. The study points out that this is an understudied area which has not been adequately studied by the SB 350 studies or other entities. It highlights the need for a detailed study to investigate how distributed resources can help decarbonize the Western Interconnection, and how distributed energy resources interact with RTO expansion.

The authors note that the benefits and risks of RTO expansion use different criteria and metrics, as the proponents site technical qualitative issues such as integrating renewables, reducing emissions, and opponents site more policy risks, such as uncertainties around how governance structures will affect outcomes. It states that future studies should decide how to place weight on these pros and cons before deciding how to move forward.

The study was published in 2018 and the risks and benefits may be slightly dated compared to the conversations currently taking place.

[38] *WEIM Quarterly Reports (2014–2022)*

Prepared by CAISO Staff

The Western Energy Imbalance Market (WEIM) quarterly reports outline the benefits that WEIM has provided in terms of (1) gross economic benefits achieved by operational cost savings, (2) CO₂ emissions avoided, and (3) the reduction in flexibility reserve across WEIM membership. Information on interregional transfers is also provided.

When the WEIM was launched by CAISO and PacifiCorp in 2014, it included only the balancing authority areas associated with CAISO and PacifiCorp. To date by the end of 2022, the WEIM has 19 participants across the West:

1. California ISO (CISO), 2014;
2. PacifiCorp (PAC), 2014;
3. NV Energy, (NEVP) 2015;
4. Arizona Public Service (APS), 2016;
5. Puget Sound Energy (PSEI), 2016;
6. Portland General Electric (PGE), 2017;
7. Idaho Power (IPCO), 2018;
8. Powerex (PWRX), 2018;
9. Balancing Authority of Northern California (BANC), 2019, 2021;
10. Seattle City Light (SCL), 2020;
11. Salt River Project (SRP), 2020;
12. Turlock Irrigation District (TID), 2021;
13. Los Angeles Department of Water and Power (LADWP), 2021;
14. Public Service Company of New Mexico (PNM), 2021;
15. Northwestern Energy (NWMT), 2021;
16. Avista Utilities (AVA), 2022;
17. Tacoma Power (TPWR), 2022;
18. Bonneville Power Administration (BPA); 2022; and
19. Tucson Electric Power (TEP), 2022.

The Western EIM footprint now includes portions of Arizona, California, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming, and extends to the border with Canada.

Since its launch in 2014 until 2022, WEIM has achieved an accumulated \$3.4 billion in benefits. The benefits are operational cost savings thanks to a regional real-time dispatch beyond California borders across the West. In 2022 Q3 alone, the WEIM achieved a gross \$485.29 million in economic benefits, avoided 10,960 metric tons of CO₂ because of avoided renewable curtailment, and had a 58% average reduction in flexibility reserve across its dispatch footprint.

Transforming the quarterly benefits into annual and accumulated benefits, and aggregating the BAA benefits into California and other-states' benefits, the WEIM's economic benefits are shown in Figure 6.

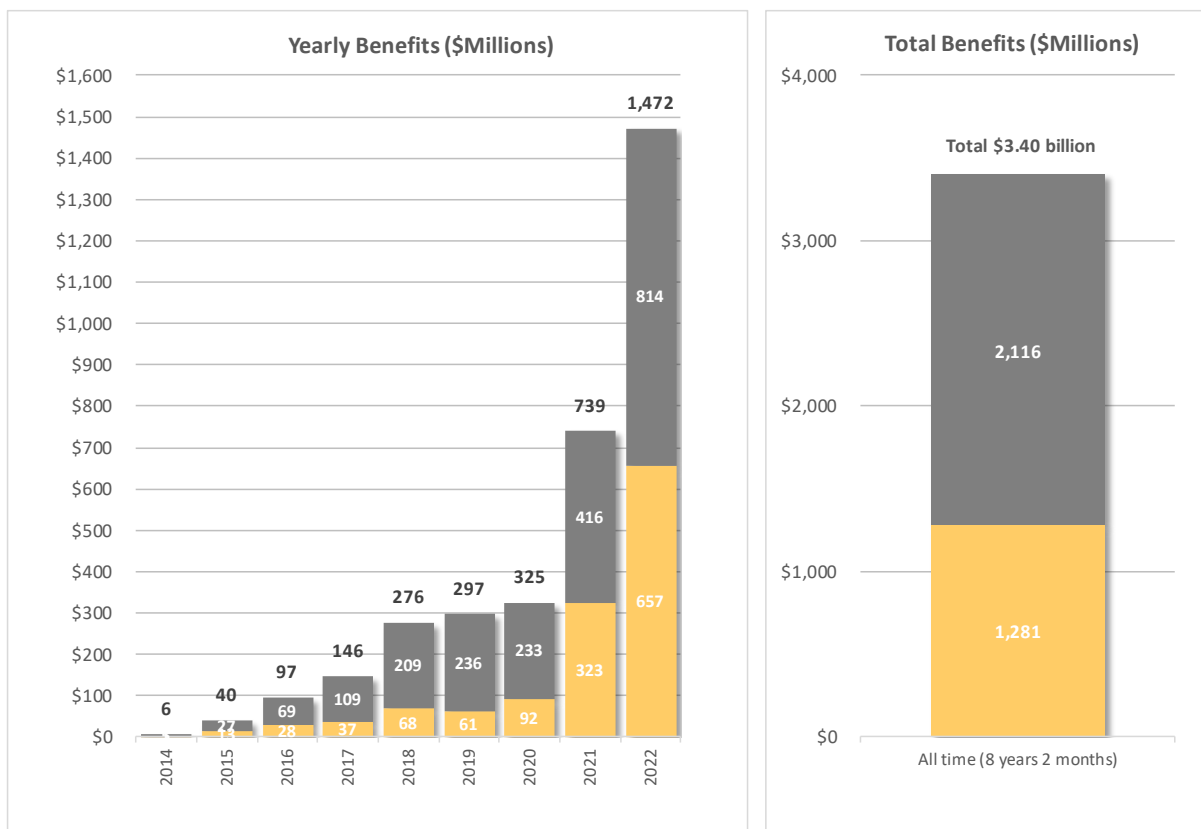


Figure 6. WEIM's actual economic benefits thanks to operational cost savings

As seen from the above figure, the total accumulated benefit is \$3.4 billion, where the portion is \$1.28 billion (38%).⁵⁴ Annual benefits have grown quickly as more participants joined. In the most recent three years, 2020, 2021 and 2022, WEIM's annual benefits are \$325, \$739 and \$1,472 million, respectively. In those annual benefits, the California portions are \$92 (28%), \$323 (44%) and \$657 million (45%), respectively.

On details of the most recent year in 2022, the WEIM achieved \$1.47 billion in annual benefits, where the California portion is \$657 million, i.e. 45%. In addition, the WEIM avoided 120,095 metric tons of CO₂ in 2022 as environmental benefits, thanks to avoided renewable curtailment.

Going forward into future years, it is reasonable to expect that WEIM's annual economic benefit would go above \$1.5 billion.

⁵⁴ The California figure combines benefits for CAISO and for three participating California BAs that are not part of CAISO: Balancing Authority of Northern California, Los Angeles Department of Water and Power, and Turlock Irrigation District.

4 Annotated Summary of the Literature

[T]he Legislature requests that ... the Independent System Operator, in consultation with the California balancing authorities, produce a report that summarizes recent relevant studies on the impacts of expanded regional cooperation on California and identifies key issues that will most effectively advance the state's energy and environmental goals, including any available studies that reflect the impact of regionalization on transmission costs and reliability for California ratepayers. (ACR 188)

Taken together, the studies and papers included in Section 3 form a narrative on expanded regional cooperation. This section summarizes the narrative with annotated references to the literature in Section 3, where studies are identified by [numbers in brackets].⁵⁵

We apply a regional perspective to the narrative and then extract from that the implications for California's energy and environmental goals. Many of the impacts and benefits for California parallel the impacts and benefits for other participating states; if this were not the case, regional consensus on the cooperative frameworks described in Section 2 could be problematic as benefits vary by utility and region. As previously discussed, each entity will need to determine if the benefits are sufficient for their participation in the new forms of regional cooperation. Section 4.3 provides a focused discussion of the impacts and benefits that are unique to California's energy and environmental goals.

To synthesize this diverse body of literature into a single framework that responds to ACR 188, we pose the following questions:

- Section 4.1: What do California and every other Western state stand to gain from greater regional cooperation in operating the West's bulk power system?
- Section 4.2: How well do the modes of regional cooperation described in Section 2 achieve these benefits for the West overall and for each participating state?
- With respect to the RTO model, which ACR 188 calls out specifically, how would the distribution of benefits among states change with:
 - A single West-wide RTO that included CAISO or
 - Two sub-regional RTOs: CAISO and a second RTO that included other Western states?
- Section 4.3: What does the literature suggest about how options for regional cooperation might uniquely affect California, including impacts on costs and reliability and on the state's energy and environmental policies?

⁵⁵ For this narrative, we draw on findings in the cited literature that might not be called out specifically in the Section 3 summaries.

4.1 Types of Benefits

What do California and every other Western state stand to gain from greater regional cooperation in operating the bulk power system?

The technical studies and most policy statements and state analyses reviewed in this report focus on these benefits:

- Reduced production costs, including the cost of operating reserve for reliability
- Reduced resource adequacy costs
- Efficient transmission planning
- Reliability benefits.

In the literature reviewed, the magnitude of benefits depended on the market paradigm being modeled, the geography where the paradigm was applied, and detailed assumptions the study made regarding capital costs, fuel costs, and other basic inputs.

An important caveat about the technical modeling of benefits is that the scenarios generally assume universal participation by all BAs in the general market footprint; this is a simplifying assumption to make the analysis more tractable. Today's CAISO does not include every California BA, and even a so-called West-wide RTO may have opt-outs. It is reasonable, therefore, to regard the modeling results as estimates of the upper bounds of possible benefits.

Reduced Production Costs: *Production costs* are the cost of fuel, starting a generator, managing transmission congestion, holding operating reserve for reliability, system losses, and all other operating and maintenance costs that vary based on the amount of electricity generated.⁵⁶ Generally, RTOs provide for more-efficient use of existing resources; they incentivize greater use of least-cost generating units and reduce the use of resources with higher operating costs [30],[31]. Every study that simulated market outcomes found that an RTO would reduce production costs [2],[3],[6],[7]. Two state policy reports—for Oregon and Colorado—relied on these and other technical studies to support expectations for reduced production costs [20],[21]. These studies and others also identified across-the-board production cost savings with a West-wide day-ahead energy market [7]. The CAISO-operated WEIM has reduced real-time production costs with respect to balancing energy [38], and in fact, the benefits are larger than what was predicted by studies conducted before the WEIM was launched in 2014 [17],[18],[19].

Fast-balancing energy markets, run every 5–15 minutes in real time, help reduce the cost of maintaining reliability with high penetrations of wind and solar [3],[6],[15],[17],[18],[19]. Day-ahead energy markets include the efficient procurement of operating reserves [1],[2],[6],[8]. Operating either market over a larger geospatial footprint increases the available resources, and the studies suggest this enables further cost reductions.

Reduced Resource Adequacy Costs: *Resource adequacy* refers to having enough megawatts of generation capacity on hand to meet the year's highest demand while maintaining an appropriate

⁵⁶ It does not include capital costs, fixed costs, or other costs that remain fixed regardless of how often the generator runs.

reserve margin. *Capacity savings* refers to a reduction of the total megawatts of capacity needed for resource adequacy, and the estimated value of that avoided capacity. The technical studies found that in addition to reducing production costs, RTOs and day-ahead markets also offered significant savings in the cost of resource adequacy [2],[3],[6]. Other technical studies that focused on resource adequacy also found the potential for capacity savings [8],[10],[12],[13][14]. Generally, an RTO's centralized regional operation can smooth out variability in demand and in the performance of renewable resources and enable the sharing of reserves to manage variability at a lower cost [29],[37].

Efficient Transmission Planning: New transmission is economically efficient if the benefits that it enables—such as annual savings in the cost of generation, reliability, and resource adequacy—are greater than the annualized cost of the new lines. A benchmark used by FERC in its Order 1000 is a benefit-to-cost ratio of 1.25 to one.⁵⁷

Transmission planning across a region rather than by individual utilities separately can reduce transmission congestion and the cost of operating reserve required to maintain reliability [16], [27],[36]. Other identified benefits include:

- Better grid resilience (i.e., the ability to mitigate or recover from extreme climate events and other major outages)
- Less curtailment of solar and wind resources, and more operational flexibility to manage the variation in solar and wind output
- Better and cheaper access to renewable energy for customers
- Faster and more efficient decarbonization, including economic signals for retiring fossil fuel plants and efficient regional siting of wind and solar plants [29],[31],[32],[34],[35],[36].

Transmission expansion can also improve the diversity of load that is included in resource adequacy planning, thereby enabling lower reserve margins and lower resource adequacy costs [27].

The State-Led Market Study (Energy Strategies 2021a) included a sensitivity that manually added several generic high-voltage transmission upgrades to three of its scenarios (status quo, a single West-wide RTO, and a dual RTO scenario). In all three cases tested, there was a slight increase in West-wide benefits with the additional transmission [3]. However, the authors cautioned that the sensitivities did not constitute a comprehensive assessment of costs and benefits from the extra transmission.

DOE is conducting a study that, when published in late 2023, could be directly responsive to the transmission question posed in ACR 188.⁵⁸ The multiyear DOE study will estimate how different transmission build-out models might affect the cost of decarbonizing the power sector

⁵⁷ FERC Order No. 1000, *Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities*, July 2011, <https://www.ferc.gov/sites/default/files/2020-04/OrderNo.1000.pdf>, at p. 461.

⁵⁸ The National Transmission Planning Study is part of DOE's Building a Better Grid Initiative. See <https://www.energy.gov/gdo/national-transmission-planning-study>.

nationwide. The transmission models reflect increasing degrees of interregional cooperation, including:

- Local network additions only
- Local additions and new interregional AC connections
- New AC lines and point-to-point DC connections between regions
- A multi-region DC macrogrid.

The analysis includes long-term capacity expansion simulations that co-optimize new generation, new transmission, new storage, and the repurposing of existing transmission due to generator retirements. The study will include an analysis of how transmission-related benefits might be distributed among California and other transmission planning regions such as NorthernGrid and WestConnect.

Reliability: Several documents cited the increasing need for system flexibility to ensure reliability with high penetrations of wind and solar [10], [14], [15], [29], [32], [36], [38]. Combining real-time load across a larger area reduces variations in net load that need to be managed, and aggregating a larger number of wind and solar plants reduces their variation in net output. It also provides a deeper pool of resources to manage variability. Some papers focused on the role of regional cooperation in transmission planning [29], [36] and others discussed savings in resource adequacy costs [10], [14].

One area that merits additional study is the impact of regional cooperation on mitigating the impact of extreme weather events, extended drought, and cyberattacks. Some documents refer to the benefit potential [30], [35], [36]. However, few if any technical analyses are available that are specific to the West, and none of the reports reviewed in this study compare how different modes of cooperation affect the response to extreme stress. For example, an RTO has real-time situational awareness across its entire footprint, along with standard operating procedures for emergency and pre-emergency conditions that guide coordinated responses. We found no study comparing RTO emergency response procedures with peer-to-peer emergency response used by non-RTO utilities.

4.2 The Options

How well do the modes of regional cooperation described in Section 2 achieve these benefits for the West overall and for each participating state?

4.2.1 The RTO Model

An RTO is the most comprehensive mode of regional cooperation. Many studies included in this review use the RTO model as a reference point for regional cooperation. An RTO centralizes the following functions:

- Conducting centrally operated, bid-based energy markets to determine least-cost generation dispatch
- Centralized planning of transmission
- Setting and monitoring standards for resource adequacy
- Procuring and deploying operating reserves to maintain reliability
- Keeping total generation levels in balance with real-time electricity demand

- Ensuring enough generation resources are committed and available for the next day's operation
- Managing financial settlement among market participants (i.e., paying resources for providing energy, charging load-serving entities for energy used and for other services).

The State-Led Market Study (Energy Strategies 2021a) estimated a West-wide RTO would produce \$833 million in annual production cost savings by 2030 (in 2022 dollars), or about 6.4% of what the West's total cost of generation would be based on how the energy markets work currently [3]. This is more than the savings estimated by the SB 350 study in 2016 [2]. One technical analysis focusing on Colorado estimated the state could see an 8% savings in production costs with a West-wide RTO [6].

The technical studies also identified resource adequacy benefits as estimated by imputed capacity value savings. *The State-Led Market Study* (Energy Strategies 2021a) estimated capacity savings of about \$1.6 billion per year under a West-wide RTO (in 2022 dollars) [3].

Within an RTO, regional planning enables more transparency into how generators and load-serving entities are using the transmission network. It also supports more competition and efficient automated dispatch decisions [37]. CAISO and SPP currently have robust transmission planning processes for their territories; expanding the footprint or increasing cooperation with other parts of WECC could enable greater efficiencies [2]. An RTO systematizes regional transmission planning, supporting efficient use of the grid. These efficiencies could reduce the need for new local transmission that otherwise would be required if the utility were planning solely for its own area [4]. However, one analysis prepared for MISO cautions that in a multistate context cost allocation for interregional transmission can be contentious [36].

Though an RTO is the most comprehensive vehicle for increased regional cooperation, it is also the most complicated operationally and legally. For some authors, expanding CAISO to a regional RTO raises concerns that California would have less autonomy over many policies [37]. However, because California's grid is part of the Western Interconnection, it is considered a participant in interstate commerce for electricity and is thus already subject to FERC jurisdiction [24],[25]. Some legal analyses conclude that an expanded West-wide RTO would not expose California's clean energy policies to additional constitutional risk [25],[26]. Other concerns expressed by states besides California are how an RTO would be governed and whether all participating states would have input into how RTO market decisions are made [20],[21],[22].

*How would the distribution of benefits among states change if there were a single West-wide RTO that included CAISO—as compared to two sub-regional RTOs: CAISO and a second RTO that included other Western states?*⁵⁹

The State-Led Market Study (Energy Strategies 2021a) estimated a single West-wide RTO would have more production cost savings (16%–18% more) and more savings in capacity value (57%

⁵⁹ Having two Western RTOs does not necessarily mean *all* states and utilities that are not in CAISO would form a second RTO. The decision to join an RTO would be made by each utility (or possibly each state), with some joining CAISO, some joining SPP or a new RTO, and others joining neither. No study included in this review simulated all possible configurations of a dual RTO market.

more) than would two RTOs [3]. However, this and other studies suggest the distribution of production cost savings and savings in resource adequacy costs could vary among individual states [3],[6]. The type of technical modeling used in these studies accounts for detailed differences in generation cost between areas within the market being simulated. It also accounts for transmission congestion between areas; prices on the load side of a constraint tend to be higher and prices on the generation side tend to be lower. As a result, shifting from several segregated markets to one integrated market could simultaneously (1) exert downward pressure on market prices in high-cost areas, (2) exert upward pressure on market prices in low-cost areas, and (3) affect local imports, exports, and the associated flow of revenue between areas. These factors would drive local differences in benefits from regionalization even if the region-wide sum of benefits increased. A closely related matter also discussed in the literature is how to allocate and recover the cost of new transmission that would increase power flows from low-cost areas to high-cost areas.

Consequently, it would be reasonable for California to anticipate a range of economic expectations from states with whom it might engage in discussions regarding an RTO.

4.2.2 Energy Imbalance Markets

Several RTOs in the United States began as energy imbalance markets, where real-time imbalances between scheduled generation and actual load are filled through a centrally operated energy market. CAISO has operated a voluntary WEIM since 2014, and 19 utilities were participating as of 2022 [38]. SPP recently launched its WEIS, joined by parts of the Western Area Power Administration and five public power entities and cooperatives in the eastern portion of WECC [7].

WEIM benefits have exceeded what had been predicted by analyses before 2014 [17],[18],[38]. This is partly because CAISO is operating the WEIM using its existing dispatch systems, whereas the earlier studies had presumed a new operator with its own start-up and operating costs. The WEIM has achieved total benefits of more than \$3.4 billion since it began [38].

Nevertheless, the scope of regional cooperation in the WEIM does not go beyond the purpose of real-time energy balancing. For example, its operating rules discourage participants from leaning on the WEIM in lieu of maintaining their own flexibility reserve for reliability [11]

4.2.3 Day-Ahead Markets

A centralized day-ahead market is one important function performed by an RTO, and one that technical studies suggest constitutes a significant portion of an RTO's total benefits [3],[6]. If performed regionally without an RTO, the day-ahead market would meet some or all of a utility's load forecasted for the next day.

Two proposals—CAISO's EDAM and SPP's Markets+ proposal—are frameworks for a centrally run day-ahead market that do not require participants to become full RTO members. Studies suggest a West-wide day-ahead market would reduce total production costs relative to current practices [3],[6]. Nevertheless, the production cost savings are not as much as they would be with a full RTO. *The State-Led Market Study* (Energy Strategies 2021a) found that production cost savings with a single West-wide RTO were nearly eight times greater than they were under a West-wide day-ahead market [3]. The Colorado study found that just for that state, the

production cost savings of a West-wide RTO were more than three times greater than those of a day-ahead market [6].

4.2.4 Coordination on Resource Adequacy

Many writers argued—and some of the technical studies demonstrated—that pooling load and pooling the stock of generation across a larger region could reduce the cost of resource adequacy [2],[3],[10],[12],[13],[14]. Pooling load reduces the total amount of resources needed to serve load with a sufficient reserve margin, and pooling resources allows more access to lower-cost generation.

The creation of the WRAP culminates a period of discussion by participating utilities. The WRAP would focus solely on pooled resource adequacy, without fundamentally changing how a utility schedules or dispatches its resources. It requires minimum target levels for resource adequacy in future planning years, but does not direct the mix of resources, which are still exclusively a matter of state authority. The WRAP will be governed by an independent board of directors, with a participants committee and an advisory committee comprising regulators and energy officials from all states in the WRAP footprint.

4.3 Impacts on California

What does the literature suggest about how options for regional cooperation might uniquely affect California, including impacts on costs and reliability and on the state's energy and environmental policies?

The literature reviewed here suggests several pathways to greater regional cooperation. Consequently, the potential impacts on California are both varied and complex, as they depend on the mode of cooperation and the states and utilities that elect to participate.

In considering how California might be affected by the development of two Western markets rather than one, the literature taken as a whole suggests two extremely important caveats to keep in mind. The first is geography. Only one state—Colorado—has formally simulated the impact of an RTO or other forms of regional cooperation specific to its constituency [6]. Colorado is on the opposite side of the Western Interconnection from California and adjacent to SPP. Therefore, limits on transmission paths westward from Colorado will uniquely affect its assessment of options, benefits, and risks in comparing markets operated by CAISO and SPP.

The second important caveat is that all of the technical studies of an RTO assumed universal participation by all BAs. In reality, joining an RTO (CAISO or SPP) is voluntary. There could be many opt-outs, and the first opt-ins are likely to be those for whom the benefits are most demonstrable. There was no published simulation of expanding CAISO to a limited number of transmission utilities adjacent to CAISO where energy transfers are already occurring. It may be hypothesized that the benefits for California and this limited roster of neighboring utilities might be robust compared to the West-wide regimes simulated, but unless it is simulated it will remain a hypothesis.

Therefore, the quantitative outcomes of the studies included in this review are best interpreted as an upper bound of potential benefits under ideal conditions and universal participation. The

trends revealed in differences between scenarios are more important than the dollar value of the results.

Operating Costs: Two studies included in this review compared a single West-wide RTO with a dual RTO model [3],[6]. *The State-Led Market Study* (Energy Strategies 2021a) found that for either an RTO or day-ahead market, the savings to California would be less with two regional markets rather than one, as detailed in Table 7 [3].

Table 7. California’s Estimated Annual Savings in Production Costs in 2030

	One Market	Two Markets
Full RTO	8.3%	4.9%–7.9%
Day-ahead market	2.1%	1.5%

Savings are relative to current market arrangements (including current participation in the WEIM) projected to 2030.

Source: [3]

Resource Adequacy: Improved resource adequacy planning could help California avoid or mitigate the effect of disruptions caused by climate change [11]. Joining (or coordinating with) a regional resource adequacy program could reduce California’s cost of resource adequacy [12],[13],[14].

The State-Led Market Study (Energy Strategies 2021a) found that a single RTO would provide California and all other states greater capacity savings than two Western RTOs. For a day-ahead market, all states except Colorado would see greater capacity savings with one market rather than two [3].

Impacts on California’s Energy and Environmental Policies:

- **Increased Use of Clean Energy Resources:** *The State-Led Market Study* (Energy Strategies 2021a) assumed 60% of the West’s generation would come from wind, solar, hydropower, nuclear, and other zero-emission resources by 2030, based on policies in all Western states at the time of the study. Therefore, the scenarios tested in the study provide insight into the cost of integrating renewables at a level consistent with California goals. All regional day-ahead market scenarios provided savings in operating costs and capacity relative to today’s market configuration, and all RTO scenarios provided even more savings.
- **Decarbonization:** The WEIM has reduced curtailment of wind and solar resources by more than 1.85 TWh cumulatively since 2015, providing a 792,061-ton reduction in CO₂ emissions [38]. However, California’s CO₂ reduction benefits could diminish if some entities elect to exit the WEIM and join a separate RTO or SPP’s day-ahead market. More generally, all RTO configurations in *The State-Led Market Study* (Energy Strategies 2021a) resulted in WECC-wide carbon emissions that were lower than what today’s market structures would provide, and all configurations were comparably responsive to the inclusion of a price on carbon emissions [3].

None of the technical studies directly addressed the impact of regionalization on transmission costs specific to California. This may in part be because (1) the need for new transmission—and the allocation of its costs—are defined by how the new infrastructure will be used, (2) in the case

of regional transmission, use depends in part on the anticipated flow of imports and exports between regions, and (3) the flow of imports into California would likely depend on the type of regional coordination in place. However, one paper cautions that in a multistate context, cost allocation for interregional transmission can be contentious [35]. Assumptions would need to be made as to the multistate allocation of benefits and costs, but many simulations report only total costs and benefits without disaggregating results to the state level.

The literature generally notes that expanded regional cooperation would help California meet its clean energy goals more effectively than without expanded regional cooperation. One report concludes that enhanced Western grid integration would not interfere with state clean energy policies from both an operational and constitutional perspective, nor would it expand FERC's authority over California's electricity system beyond its current jurisdictional scope [25]. Moreover, it and another legal analysis concludes that the transition would not increase the vulnerability of California's clean energy programs to Supremacy Clause or Commerce Clause challenges since power transactions on the California grid are already considered to be part of interstate commerce [25][26].

The interdependence and uncertainties of these factors complicate modeling the impacts of regional coordination on transmission planning and investment for specific states. California and each of its neighboring states would need to clarify their willingness to (1) use transmission to maximize the economic efficiency of their own current and planned resource mix, (2) allow power purchase agreements to supply load in neighboring states, and (3) accept higher interdependence with neighboring states in exchange for lower costs [30].

5 SB 100 and Relevant Updates⁶⁰

[T]he report should include relevant updates to the transmission development and resource diversity estimates in the 2021 SB 100 Joint Agency Report. (ACR 188)

In 2018, the California State Legislature passed Senate Bill (SB) 100, titled The 100% Clean Energy Act of 2018. Motivated by the climate realities California was dealing with, policymakers developed legislation to diversify the state's resource portfolio. SB 100 established the goal that (1) by 2030 at least 60% of the state's electricity be renewably generated and (2) by 2045 all retail electricity sales be supplied by renewable energy and zero-carbon resources. CAISO reached out to the California Energy Commission on updates for the publication of this report and learned that there have been no relevant updates to the estimates and assumptions used in its 2021 report. The following section provides background on SB 100's current goals, the most recent joint agency report, and an overview of the most recent efforts related to SB 100, pursuant to the directives of ACR 188.

SB 100 tasked the California Energy Commission, the California Public Utilities Commission, and the California Air Resources Board with publishing a report, in collaboration with the other California BAs, on achieving SB 100's goals. These joint agencies published their first report in 2021, with SB 100 mandating that they publish a subsequent report every 4 years thereafter.

In 2021, the joint agencies published their first report on the progress made toward the goals set forth in SB 100 since its passage (CEC, CPUC, and CARB 2021). The report includes models that show what California's portfolio make-up could look like in 2045 consistent with SB 100 goals. It also considers what California will need to do before 2045 to ensure the state fulfills SB 100's goals on time. To build their models, the joint agencies defined zero-carbon resources as resources that either qualify under the RPS or generate zero greenhouse gas emissions.

The joint report examines three core scenarios that could unfold under SB 100's mandates. The first includes current load estimates assuming high electrification demand and all the candidate resources become available immediately. The second core scenario examines the same factors under different amounts of energy demand, and the third examines the same factors under different amounts of energy supply. In addition to the primary models, the joint agencies also built models that consider potential future legislation that could alter California's energy outlook. These models examine scenarios under which the legislature expands load forecasts to align with current demand assumptions, retires combustion resources, adds zero-carbon firm resources as eligible to fulfill the goals of SB 100, or accelerates SB 100's timeline via additional target dates.

Figure 7 shows the capacity additions and demand forecast predicted by the SB100 report. The SB 100 resource portfolios include only 10 GW of offshore wind because the SB 100 model capped offshore wind at 10 GW. However, the California Energy Commission has since adopted a 25-GW planning goal for offshore wind. To date, no regional coordination benefits studies are based on the SB 100 core scenario portfolio or portfolios with higher levels of offshore wind.

⁶⁰ This section was written by CAISO staff.

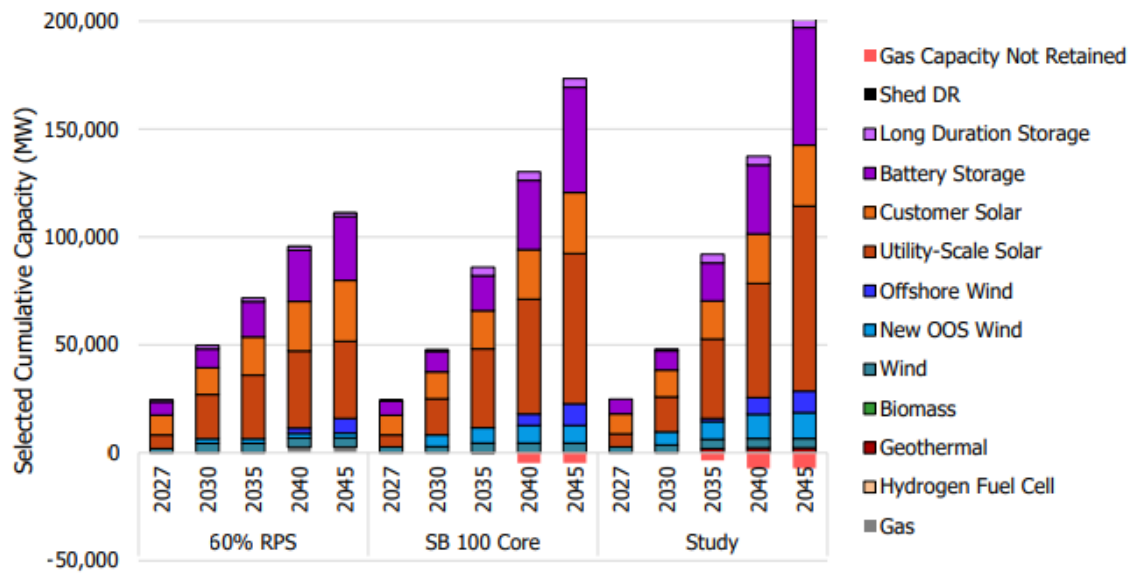


Figure 7. Cumulative capacity additions for the 60% RPS, SB 100 Core, and Study scenarios

Source: CEC 2021 (Figure 28)

DR = demand response, OOS = offshore

A key highlight of the report that continues to arise during workgroup discussions is the dramatic increase in demand that is driven by increased electrification across industry sectors. Some of this demand will need to be met by imports, and the report notes that retaining existing gas fleets could be a viable way to address the increase in demand.

In all three scenarios, capacity must increase significantly. Even in a 60% RPS scenario, California would still need approximately 110 GW of additional capacity; in the scenario that assumes high electrification, the estimate is nearly double that.

Another important aspect of the studies is California’s increasing reliance on out-of-state imports. In conservative estimates, California could procure a minimum of 2.2 GW of out-of-state wind just to meet the 60% threshold; this figure is closer to 12 GW in the expanded load study. Furthermore, since the publishing of this report, the California Energy Commission and the California Public Utilities Commission have updated their forecasting models and have called for thousands of MW of new procurement annually over the next decade. The following figure shows the costs reflected in the original SB 100 report, which are expected to rise.

New transmission costs are included under the Scenario Fixed Costs row in Table 12 of the SB 100 report (CEC 2021), which is reproduced here as Table 8, but those costs are likely to be conservative estimates given the increased demand in California Energy Commission forecasts since the SB 100 report was published.

Table 8. 2045 Annual Cost Summary for the 60% RPS, SB 100 Core, and Study Scenario

\$ Billions (2016)	60% RPS	SB 100	Core Study
Nonmodeled Costs	\$38	\$38	\$38
Scenario Fixed Costs ^a	\$9.8	\$18.8	\$25.0
Total Operating Costs	\$7.0	\$2.5	\$0.5
Total Revenue Requirement	\$55	\$60	\$64
Customer Costs	\$6.7	\$6.7	\$6.7
Total Resource Costs	\$62	\$66	\$70
Retail Sales (TWh)	372	372	372
Average Cost (¢/kWh)	14.8	16.0	17.1

^a Scenario fixed costs include baseline thermal fixed costs, new thermal fixed costs, new renewables fixed costs, new storage fixed costs, new demand response fixed costs, and new transmission fixed costs.

Source: CEC 2021 (Table 12)

The capacity estimates used in the SB 100 RESOLVE modeling demonstrate the importance of preparing for a significant increase in capacity needs over the next decade. These estimates came before the increased demand forecasts from the California energy organizations, making the information partially outdated and in need of further adjustments. These estimates will increase in future reports, given many states across the West are also aggressively seeking enhanced RPS goals and further decarbonization of their grids. As all assumptions used in each model result in the need for “significant capacity additions” to California’s grid, the likelihood that the demand is greater than being reflected in the most recent report is evident.

As noted above, the next joint agency report, with data sets potentially from 2024 inputs, is slated for 2025.

Glossary

Term	Definition
Ancillary service	Those services that are necessary to support the transmission of capacity and energy from resources to loads while maintaining reliable operation of the Transmission Service Provider’s transmission system in accordance with good utility practice (NERC 2022c).
Balancing authority	The responsible entity that integrates resource plans ahead of time, maintains Demand and resource balance within a Balancing Authority Area, and supports Interconnection frequency in real time (NERC 2022c).
Balancing authority area	The collection of generation, transmission and loads within the metered boundaries of the Balancing Authority. The Balancing Authority maintains load-resource balance within this area (NERC 2022c).
Bulk power transactions	The wholesale sale, purchase, and interchange of electricity among electric utilities. Bulk power transactions are used by electric utilities for many different aspects of electric utility operations, from maintaining load to reducing costs (EIA 2023d).
Contingency	The unexpected failure or outage of a system component, such as a generator, transmission line, circuit breaker, switch, or another electrical element (NERC 2022c).
Cross-border electricity trade	Trading in electricity between two states sharing a common border through an inter-connector power line, or between more than two states not sharing common border, but linked through a power pool which involves export or import of electric energy between the states (Law Insider n.d.).
Curtailement	A reduction in the scheduled capacity or energy delivery of an Interchange Transaction (NERC 2022c).
Day-ahead markets and hour-ahead markets	Forward markets where electricity quantities and market clearing prices are calculated individually for each hour of the day based on participant bids for energy sales and purchases (EIA 2023d).
Day-ahead schedule	A schedule prepared by a scheduling coordinator or the independent system operator before the beginning of a trading day. This schedule indicates the levels of generation and demand scheduled for each settlement period that trading day (EIA 2023d).

Term	Definition
Energy imbalance market	A means of supplying and dispatching electricity to balance fluctuations in generation and load. It aggregates the variability of generation and load over multiple BAAs (NREL 2012).
Independent system operator	An independent, federally regulated entity established to coordinate regional transmission in a nondiscriminatory manner and ensure the safety and reliability of the electric system (FERC n.d.).
Independent power producer	A corporation, person, agency, authority, or other legal entity or instrumentality that owns or operates facilities for the generation of electricity for use primarily by the public, and that is not an electric utility (FERC n.d.).
Interstate	Sales where transportation of natural gas, oil, or electricity crosses state boundaries. Interstate sales are subject to FERC jurisdiction (FERC n.d.).
Interconnection queue	A list of transmission and generation projects that are currently proposed and seeking to join the grid (NYISO 2021).
Intrastate	Sales where transportation of natural gas, oil, or electricity occur within a single state and do not cross state boundaries. Intrastate sales are not subject to FERC jurisdiction (FERC n.d.).
Joint tariff	A tariff that contains only joint rates, which are rates that apply for transmission service over the lines or routes of two or more transmission providers, made by an agreement between the transmission providers (Law Insider n.d.).
Public utility commission	A state governmental body that regulates a utility.
Real-time assessment	An evaluation of system conditions using real-time data to assess existing (pre-Contingency) and potential (post-Contingency) operating conditions. The assessment shall reflect applicable inputs including, but not limited to load; generation output levels; known Protection System and Remedial Action Scheme status or degradation, functions, and limitations; Transmission outages; generator outages; Interchange; Facility Ratings; and identified phase angle and equipment limitations. (Real-time Assessment may be provided through internal systems or through third-party services) (NERC 2022c).

Term	Definition
Renewable energy credits	Represent the environmental attributes of electricity generated through a qualifying renewable energy resource. One REC [renewable energy certificate] is issued for every 1 megawatt-hour (MWh) of electricity produced by the qualifying source. Since renewable electricity fed into the electric grid is distributed according to physical laws rather than contractual agreements, RECs account for who can claim the use of renewable electricity. A State Renewable Portfolio Standard (RPS) typically requires the utilities to procure a certain amount of RECs to demonstrate compliance with their renewable energy requirement. RECs can be bought and sold as commodities in the market, and are issued and tracked by various Generation Information Systems (GIS) that operate within the U.S. electric grid (DSIRE n.d.).
Renewable portfolio standard	Require utilities to use or procure renewable energy or renewable energy credits (RECs) to account for a certain percentage of their retail electricity sales — or a certain amount of generating capacity — according to a specified schedule. (Renewable portfolio goals are similar to RPS policies, but goals are not legally binding.) Most U.S. states have established an RPS. The term “set-aside” or “carve-out” refers to a provision within an RPS that requires utilities to use a specific renewable resource (usually solar energy) to account for a certain percentage of their retail electricity sales (or a certain amount of generating capacity) according to a set schedule (DSIRE n.d.).
Reserve sharing group	A group whose members consist of two or more Balancing Authorities that collectively maintain, allocate, and supply operating reserves required for each balancing authority’s use in recovering from contingencies within the group. Scheduling energy from an adjacent balancing authority to aid recovery need not constitute reserve sharing provided the transaction is ramped in over a period the supplying party could reasonably be expected to load generation in (e.g., 10 minutes). If the transaction is ramped in quicker (e.g., between zero and ten minutes) then, for the purposes of disturbance control performance, the areas become a Reserve Sharing Group (NERC n.d.).
Resource adequacy	The ability of the electric system to supply the aggregate electrical demand and energy requirements of the end-use customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements (NERC 2022c).
Retail sales	Sales made directly to the customer that consumes the energy product (FERC n.d.).

Term	Definition
Right of first refusal	A contractual right to enter into a business transaction with a person or company before anyone else can (Chen 2022).
Security-constrained economic dispatch	The operation of generation facilities to produce energy at the lowest cost to reliably serve customers, recognizing any operational limits of generation and transmission facilities (FERC 2006).
Tariff	A compilation of all effective rate schedules of a particular company or utility. Tariffs include General Terms and Conditions along with a copy of each form of service agreement (FERC n.d.).
Transfer capability	The overall capacity of interregional or international power lines, together with the associated electrical system facilities, to transfer power and energy from one electrical system to another (EIA 2023d).
Transmission constraint	A limitation on one or more transmission elements that may be reached during normal or contingency system operations (NERC 2022c).
Transmission customer	<ol style="list-style-type: none"> 1. Any eligible customer (or its designated agent) that can or does execute a Transmission Service agreement or can or does receive Transmission Service (NERC 2022c). 2. Any of the following entities: Generator Owner, Load-Serving Entity, or Purchasing-Selling Entity (NERC 2022c).
Transmission operator	The entity responsible for the reliability of its “local” transmission system, and that operates or directs the operations of the transmission Facilities (NERC 2022c).
Transmission operator area	The collection of Transmission assets over which the Transmission Operator is responsible for operating (NERC 2022c).
Transmission owner	The entity that owns and maintains transmission Facilities (NERC 2022c).
Transmission planner	The entity that develops a long-term (generally one year and beyond) plan for the reliability (adequacy) of the interconnected bulk electric transmission systems within its portion of the Planning Authority area (NERC 2022c).
Transmission reliability margin (TRM)	The amount of transmission transfer capability necessary to provide reasonable assurance that the interconnected transmission network will be secure. TRM accounts for the inherent uncertainty in system conditions and the need for operating flexibility to ensure reliable system operation as system conditions change (NERC 2022c).

Term	Definition
Transmission service	Services provided to the Transmission Customer by the Transmission Service Provider to move energy from a Point of Receipt to a Point of Delivery (NERC 2022c).
Wholesale sales	Sales for resale in bulk power markets, natural gas, and oil (FERC n.d.).

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Appendix A. Text of Assembly Concurrent Resolution 188

(Filed with the Secretary of State August 19, 2022)

WHEREAS, It is the policy of the state that renewable energy and zero-carbon resources supply 100 percent of electric retail sales to end-use customers by 2045, Executive Order N-79-20 requires sales of all new passenger vehicles to be zero-emission by 2035, and the 2021 SB 100 Joint Agency Report, prepared pursuant to Senate Bill 100 (Chapter 312 of the Statutes of 2018), identifies 120 to 150 gigawatts of additional renewable resource development may be needed by 2040, much of it for intermittent resources, to meet California's zero-carbon targets; and

WHEREAS, The continued electrification of the transportation sector and other industries, growing customer demand for access to clean energy, and the goals codified in SB 100 require modernization of the electricity sector and grid system, including significant investments in upgrading existing and new transmission infrastructure to meet the goals listed above; and

WHEREAS, Since California's passage of SB 100 in 2018, many western states and utilities have adopted their own policies to achieve a clean resource mix and reduce the emissions of greenhouse gases, which are generally consistent with the policy direction of California; and

WHEREAS, As tens of thousands of megawatts of renewable resources are slated for development in the west and thousands of megawatts of coal-fired resources are retired and continue to be shut down, momentum is building across the western states for greater regional coordination to ensure that electricity is available at all hours of the day, including during peak and net-peak periods to replace retired and retiring generating facilities and meet future electrification reliability needs of a carbon-neutral economy with affordable costs; and

WHEREAS, As these transformations accelerate across the west, reliability challenges are also mounting. California has already experienced the effects of these challenges with grid-scale firm outages in August 2020 and several instances of declared energy emergency conditions occurring across the western interconnection; and

WHEREAS, The Western Electric Coordinating Council found in its 2021 Western Assessment of Resource Adequacy that by 2025 each of the studied subregions in the west would not be able to meet established reliability metrics without significant additions of capacity; and

WHEREAS, California is already dependent on its neighbors, historically importing approximately one-third of its total energy requirements and routinely importing significantly more resources from its neighboring states during the most critical summer days; and

WHEREAS, In 2021, the State Air Resources Board, the State Energy Resources Conservation and Development Commission, and the Public Utilities Commission jointly released the 2021 SB 100 Joint Agency Report to evaluate the opportunities and challenges of achieving the SB 100 goal of 100 percent clean electricity by 2045, which found that increased multistate coordination "offers significant potential to ease importation and integration of additional renewable energy facilities in regions where resource attributes match or complement California's seasonal and daily operational needs. Much of this coordination follows naturally from peak load

diversification; the Northwest peaks in winter, and the rest of the West in summer, allowing each region to rely on the other for a share of its seasonal peak capacity needs. Regional coordination also provides for geographic diversification in renewable energy, allowing for more consistent supply”; and

WHEREAS, The Independent System Operator is a nonprofit corporation that operates a competitive wholesale electricity market and manages the reliability of the transmission grid for 80 percent of the ratepayers in California and a small part of Nevada, while being interconnected to neighboring states as part of a larger, synchronized, and interdependent energy system within the western interconnection; and

WHEREAS, Since 2014, the Independent System Operator has operated the real-time energy market, called Western Energy Imbalance Market, which has grown to include portions of nine states in addition to California and, by 2023, active participants are expected to represent approximately 80 percent of the west’s demand for electricity; and

WHEREAS, The Western Energy Imbalance Market has resulted in over \$2,000,000,000 in cumulative benefits to ratepayers of the participating balancing authorities, enabled the participating balancing authorities to integrate renewables across the west more cost-effectively and reliably, and has resulted in reduced curtailments of renewable, zero-carbon resources, and avoided carbon emissions; and

WHEREAS, Planning is underway to expand the Independent System Operator’s day-ahead market across the western states to more readily and effectively use clean energy resources, reducing the need for renewable generation curtailments in periods of excess production. The extended day-ahead market is expected to achieve cost savings through a more efficient day-ahead commitment of generating units, including the displacement of resource commitments within one balancing authority area when more economic resources can be committed in other balancing authority areas instead; and

WHEREAS, In 2016, the Independent System Operator released a study, Senate Bill 350 Study: The Impacts of a Regional ISO-Operated Power Market on California, as mandated by Senate Bill 350 (Chapter 547 of the Statutes of 2015), that found that the expansion of the Independent System Operator had annual net benefits to the ratepayers of California-based balancing authorities who are members of the Independent System Operator and led to the deployment of more efficient renewable resources to meet the state’s renewable portfolio standard; and

WHEREAS, There is considerable potential for additional benefits for California consumers through further regional collaboration; and

WHEREAS, For example, in 2021, a multistate and United States Department of Energy-funded study, which California energy policy leaders helped guide, found that consumers saved annually up to \$2,000,000,000 and emissions of 191,000,000 metric tons of carbon dioxide were reduced as a result of certain market options in the west, demonstrating that a state like California sees significantly more benefits by achieving full load diversity across a larger footprint; and

WHEREAS, For the reasons stated above, it is in the public interest of the State of California to collaborate, coordinate on policy, and share systems and resources with our neighboring western states when opportunities for mutual benefit exist; and

WHEREAS, The Legislature should have current and comprehensive information on the impacts to California of expanding the existing Independent System Operator into a regional organization that manages wholesale electricity markets, transmission planning, and other services across a broader western region; now, therefore, be it

Resolved by the Assembly of the State of California, the Senate thereof concurring, That the Legislature requests that by February 28, 2023, the Independent System Operator, in consultation with the California balancing authorities, produce a report that summarizes recent relevant studies on the impacts of expanded regional cooperation on California and identifies key issues that will most effectively advance the state's energy and environmental goals, including any available studies that reflect the impact of regionalization on transmission costs and reliability for California ratepayers; and be it further

Resolved, That the report should include relevant updates to the transmission development and resource diversity estimates in the 2021 SB 100 Joint Agency Report, prepared pursuant to Senate Bill 100 (Chapter 312 of the Statutes of 2018); and be it further

Resolved, That the report should also discuss the regional transmission organizations in Colorado, Nevada, and other regional states, collaboration between states on energy policies to maximize consumer savings while respecting state policy autonomy, and engagement between neighboring states on the future of regional transmission organizations in the west; and be it further

Resolved, That the Chief Clerk of the Assembly transmit copies of this resolution to the Independent System Operator.

Appendix B. Additional Background

In 1998, due to state legislation (AB 1890) and FERC Order 888, the California ISO was incorporated as a nonprofit public benefit corporation.⁶¹ Like all other RTOs in the country, CAISO evolved out of previous regional power pooling arrangements and other modes of operational coordination among neighboring utilities that had frequent exchanges of power.

An RTO does not own any generation or transmission assets. However, it does have operational control of its participating transmission utilities' networks, and its market rules govern the dispatch of all generation. An RTO's basic functions include:

- Balancing generation levels with electricity demand in real time
- Ensuring enough resources are committed and available for the next day's operation
- Procuring and deploying operating reserve to maintain reliability
- Conducting centrally operated, bid-based energy markets to determine least-cost generation dispatch
- Centralized transmission planning
- Monitoring resource adequacy
- Managing financial settlement among market participants (i.e., paying resources for providing energy, charging load-serving entities for energy used and for other services).

Approaches to regional cooperation—short of an RTO that perform some of what an RTO does—include:

- An *energy imbalance market* (EIM) can provide participating utilities with a common mechanism for buying and selling energy for the limited purpose of balancing generation and load in real time. Operating an EIM over a larger area can reduce the cost of energy balancing for all participating entities.
- A *day-ahead energy market* can provide participating load-serving entities with low-cost, competitively procured resources to meet a portion of their next day's forecasted demand.
- *Regional transmission planning* can identify when transmission upgrades can serve multiple purposes. This can defer or eliminate new transmission that would otherwise be required if a utility were planning solely for its own needs. It does not require significant changes to real-time operations.
- Regional utilities and states can cooperate on *resource adequacy*. By adopting a common plan for sharing reserves, participating utilities can reduce their reserve margin requirements, use existing capacity more efficiently, and defer investment in additional resources while introducing minimal changes to real-time operations.

B.1 Legal Framework for ISOs and RTOs

RTOs are the most comprehensive mode of regional cooperation, and consequently they entail many layers of legal and regulatory requirements. The legal framework—especially the role of

⁶¹ CAISO and the Electric Reliability Council of Texas (ERCOT) are the only two RTOs in the country that were created by state legislation.

FERC—is fundamental to the creation or expansion of an RTO and could weigh on the minds of Western state officials as they consider options for regional cooperation.

The creation and evolution of CAISO has been largely state-driven, but within the legal guardrails of the federal government’s regulation of interstate commerce in the wholesale delivery of electricity. This section summarizes the key FERC actions that have spurred development of interstate wholesale electricity markets.

Federal Power Act, FERC Landmark Orders

Sections 205 and 206 of the Federal Power Act direct FERC “to ensure that the rates, charges, classification, and service of public utilities (and any rule, regulation, practice, or contract affecting any of these) are just and reasonable and not unduly discriminatory.” The commission is required to address—and has the authority to remedy—undue discrimination and anticompetitive effects. FERC’s statutory mandate is to ensure transmission used in interstate commerce and the rates, contracts, and practices affecting transmission services do not unduly advantage or disadvantage any party and are not unduly discriminatory or preferential.⁶²

This statutory authority, along with changes in the power sector that the commission observed in up through the late 1990s, led FERC to promote the development of ISOs and, subsequently, RTOs through a progression of rulemaking proceedings. FERC issued its first landmark rules on organized regional transmission markets in 1996. It adopted its pro forma model for RTOs at the end of 1999, and in 2011 promulgated a landmark rule for regional transmission planning.

FERC Order Nos. 888, 889, and 890: The Foundation for Competitive Wholesale Power Markets

In April 1996, FERC issued Orders Nos. 888 and 889 which provided a pathway for nondiscriminatory access to transmission.

The goal of Order No. 888 was to “facilitate the development of competitively priced generation supply options, and to ensure that wholesale purchasers of electric energy can reach alternative power suppliers and vice versa.”⁶³ FERC’s order required public utility owners or operators of transmission facilities used in interstate commerce to adopt business practices by which their power generation and transmission divisions operate at arm’s length from one another, a process known as functional unbundling.

FERC Order 889 established the basis for the development of an Open Access Same-Time Information System (OASIS) to provide information to transmission customers about transmission capacity availability, prices, and “other information that will enable them to obtain open-access nondiscriminatory transmission service.”⁶⁴

⁶² FERC Order No. 2000, *Regional Transmission Organizations* (Dec. 1999), <https://ferc.gov/sites/default/files/2020-06/OrderNo.2000.pdf> (hereinafter FERC Order 2000) at p. 143.

⁶³ *Id.* at p. 32.

⁶⁴ FERC Order No. 889, *Open Access Same-Time Information System (formerly Real-Time Information Networks) and Standards of Conduct* (April 1996), <https://www.ferc.gov/sites/default/files/2020-04/rm95-9-00k.txt> at p. i.

Order No. 890 introduced three additional developments:

- It increased nondiscriminatory access to the transmission grid by eliminating the wide discretion that transmission providers have in calculating available transfer capacity (ATC).
- It increased the ability of customers to access new generating resources and promote efficient utilization of transmission by requiring an open, transparent, and coordinated transmission planning process.
- It increased efficient utilization of transmission by eliminating artificial barriers to the use of the grid.⁶⁵

FERC Order No. 2000: Rules for the Formation of RTOs

FERC issued Order No. 2000 in December 1999—less than four years after Orders 888 and 889—to facilitate the formation of RTOs. The commission said its goal was to “promote efficiency in wholesale electricity markets and to ensure that electricity consumers pay the lowest price possible for reliable service.”⁶⁶ The order requires RTOs to be independent from market participants, possess an appropriate scope and regional configuration, possess operational authority for all transmission facilities under the RTO’s control, and to have exclusive authority to maintain short-term reliability.⁶⁷

The order requires RTOs to perform the following functions:

- Administer its own open-access transmission tariff and employ a transmission pricing system that will promote efficient use and expansion of transmission and generation facilities
- Create market mechanisms to manage transmission congestion
- Develop and implement procedures to address parallel path flow issues
- Serve as a supplier of last resort for all ancillary services required in Order No. 888 and subsequent orders
- Operate a single OASIS site for all transmission facilities under its control with responsibility for independently calculating ATC and total transmission capability
- Monitor markets to identify design flaws and market power
- Plan and coordinate necessary transmission additions and upgrades
- Undergo interregional coordination.

⁶⁵ FERC Order No. 890, *Preventing Undue Discrimination and Preference in Transmission Service* (Feb. 2007), <https://www.ferc.gov/sites/default/files/2020-06/OrderNo.890.pdf> at pp. 2-4.

⁶⁶ FERC Order 2000 at p. 1.

⁶⁷ Several RTOs have retained “independent system operator” in their corporate names even though their OATTs are in accordance with Order 2000.

FERC Order No. 1000: The Foundation for Regional Transmission Planning

In 2011, FERC further laid the foundation for regional transmission planning and regional cooperating with Order No. 1000. The order requires:

- Each public utility transmission provider participate in development of a regional transmission plan in accordance with the principles of FERC Order No. 890;
- Each public utility transmission provider amend its open-access transmission tariff to provide for consideration of transmission needs in local and regional transmission planning processes;
- Removal of a federal right of first refusal for incumbent utilities for certain new transmission facilities;
- Improved coordination between neighboring transmission planning regions for new interregional transmission facilities; and
- Participation of each public utility transmission provider in a regional transmission planning process that includes regional and interregional cost allocation methods for the cost of new transmission facilities.⁶⁸

On April 21, 2022, FERC issued a Notice of Proposed Rulemaking to improve regional transmission planning and cost allocation. The proposed rules would require transmission providers to conduct regional transmission planning on a longer-term basis in consideration of the changes in resource mix and demand, taking into account regulations and technology trends.⁶⁹

Role of States in an RTO and Historical Conflicts Between States Within an RTO

Some RTOs cover multiple states. In these cases, managing several states' roles in the RTO governance structure is important. States within an RTO retain jurisdiction over retail rates, resource planning, siting decisions for new capacity and transmission lines, renewable energy and emissions reductions policies, and, in some cases, policies that affect resource adequacy (Gardner 2019). The RTO's rules for operation, however, are under federal jurisdiction through the RTO's FERC-approved open-access transmission tariff.⁷⁰

Table describes the governance structures of state committee regulators in four multistate RTOs in the eastern United States.

⁶⁸ FERC Order No. 1000, *Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities* (July 2011), <https://www.ferc.gov/sites/default/files/2020-04/OrderNo.1000.pdf>.

⁶⁹ Notice of Proposed Rulemaking, *Building for the Future Through Electric Regional Transmission Planning and Cost Allocation and Generator Interconnection*, Docket No. RM21-17-000 (April 2022), <https://www.ferc.gov/news-events/news/ferc-issues-transmission-nopr-addressing-planning-cost-allocation>.

⁷⁰ The exception is ERCOT, which is under Texas jurisdiction. The ERCOT grid is not synchronously connected with any other state, resulting in minimal interstate power flows and minimal interstate commerce in the delivery of electricity.

Table B-1. RTO Multistate Participation Structures

RTO	State Organizational Structure	Relationship to RTO	Membership	Voting	Complementary Section 205 Filing Rights^a	Resource Adequacy
SPP	Regional State Committee: formal; no independent staff	Committee within SPP committee structure. Advises SPP board, and receives funding from SPP by submitting a budget approved by SPP	One state commission representative per state within SPP	One per state	Yes: transmission cost allocation, and resource adequacy	Collective approval for resource adequacy approach through a state committee vote
MISO	Organization of MISO States: formal; several independent staff	Exists outside MISO but receives funding from MISO	One state commission representative per MISO state plus select consumer advocates	One per state	Yes: transmission cost allocation	Individual states set target, can be different from regional reserve margin
PJM	Organization of PJM States: formal; nonprofit organization	“Liaison group” to PJM and directly advises PJM board; receives funding from PJM	One state commission representative per state (plus DC) within PJM	One per state	No	Provide collective comments on regional proposals
Independent System Operator of New England (ISO-NE)	New England States Committee on Electricity: formal; nonprofit	Participates on ISO-NE planning advisory committee, liaisons serve between state commissions and RTO	Governed by board of managers selected by six New England state governors	One per state	No	Has a collective vote to approve the regional reserve margin

^a Section 205 filing rights require transmission-owning utilities to request FERC approval before charging certain rates. These rights are sometimes shared with RTOs over lines they operate and with states. “Complementary” Section 205 filing rights mean RTOs retain their Section 205 rights and states can have influence over rights in certain ways to protect their own interests.

Adapted from Gardner 2019; Chen and Murnan 2019 (Table 1), and Parent et al. 2021.

When an RTO includes more than a single state, the RTO's operating protocols might need to accommodate differences in state policies. This can be more or less contentious depending on the policies, how the RTO's market is designed, and whether there are already venues for interstate dialogue on energy issues.

One difference between Western states⁷¹ and Eastern states that are in a multistate RTO is the existence in the West of long-standing region-wide institutions where state energy policies are discussed. These include the Western Governors' Association, the Committee on Regional Electric Power Cooperation, and other entities. West-wide regional transmission planning occurs under the WECC. Work by these entities has narrowed the policy issues of concern to Western states and provides a venue for addressing future issues that might arise.

State Climate Policies and Renewable Energy Mandates

Western states have a variety of climate and renewable energy policies (see Figure 8). A regional market operating across several states raises the question of whether a wind or solar plant built in one state can count toward the renewable energy goal in another, and therefore not count toward the goal of the state where the plant is physically located.

One common approach to tracking state renewable energy mandates has been to create regional clean energy credit accounting systems such as the Western Renewable Energy Generation Information System and the Generation Attribute Tracking System found in the PJM interconnection. These accounting systems enable the accurate tracking of renewable energy generation and the state mandates to which they are credited. For example, in the Western Renewable Energy Generation Information System, each state provides its criteria for resource eligibility, and the system tags each megawatt-hour of generation with the information needed to determine ownership, eligibility, and application.

⁷¹ For this report, Western states include Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming.

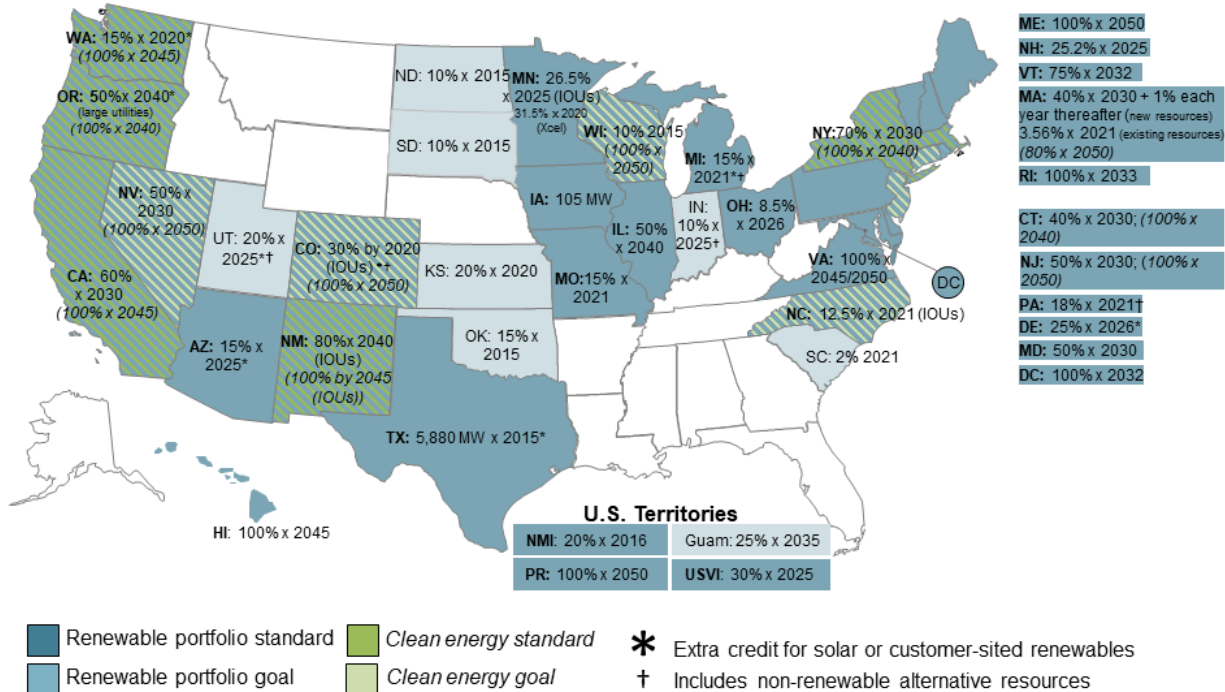


Figure 8. Clean energy, RPSs, and goals in the United States

Source: DSIRE, November 2022

PR = Puerto Rico, USVI = U.S. Virgin Islands

Resource Adequacy

Resource adequacy programs ensure the grid will have enough resources on hand to meet the highest level of demand for each year in the planning horizon. For state-regulated investor-owned utilities, prudent resource adequacy is undertaken by the states in which utilities serve retail customers. Similarly, publicly owned utilities design and administer their respective programs. Some RTOs, however, have created special markets to incentivize resource adequacy. A forward capacity market conducts an auction for fixed payments to generators, storage, and demand resources. Resources with the lowest-priced capacity offers are awarded the payments, which supplement the revenues that the resources receive from the RTO’s energy and ancillary service markets. Payments are intended to signal the long-term need for new capacity, with the capacity price higher or lower each year based on the peak load forecast, the total carrying capacity of existing resources, and the willingness of new resources to enter the market.

For a capacity market to work, rules must be applied equally across all states in the RTO. However, states might not agree on how their preferred resources ought to be treated in the RTO’s rules. One might have state incentives for nuclear, another might have special programs for battery storage. From the RTO’s perspective, price outcomes can be distorted for all participants if some of them have special subsidies that allow them to submit bids that are artificially low.

CAISO does not operate a capacity market for resource adequacy, and capacity markets for resource adequacy generally have not been supported in the West. Consequently, the specific

state conflicts seen in eastern RTOs over their capacity market design might not arise in the West. Nevertheless, states accustomed to a regulatory role in their utilities' resource adequacy planning could bring different expectations and priorities to a common resource adequacy policy applied by an expanded RTO. There could be other conflicts that the RTO would have to reconcile.

B.2 Energy Imbalance Markets: Regional Coordination in Action

CAISO launched the WEIM in 2014, allowing participation by Western balancing authorities (BAs) outside CAISO into a real-time electricity market. Benefits since the launch of the WEIM have included increased efficiency of each area's resource dispatch, energy flows, through a real-time market, reduced customer costs, and improved use of renewable resources across a larger footprint.

An energy imbalance market (EIM) is a real-time market that balances actual load and generator dispatch (load updated every 15 minutes, and generators dispatched every 5 minutes). Member BAs retain authority over their transmission and generation, but they may use the market to reduce the cost of their balancing function.⁷² Participation in an EIM is fundamentally different from becoming a member of an RTO because (CAISO n.d.):

- Transmission control, planning and rates remain within the control of EIM/EDAM member utilities and their regulators
- Resource adequacy and planning also remain with the state or local jurisdiction, outside an RTO structure (within utility structures)
- State regulatory authorities do not have any changes in governance.

The CAISO WEIM was launched in 2014 through a partnership between CAISO and PacifiCorp. The goal of the partnership was to take advantage of resource and geographic diversity across a more expansive wholesale electricity market structure, which would increase the pool of low-cost resources available for real-time balancing. Currently, there are 19 active participants and several planned entrants, including El Paso Electric Company, the Western Area Power Administration - Desert Southwest Region and Avangrid who will formally join the WEIM in the Spring of 2023. Figure 9 shows WEIM members and planned entrants as of 2022.

⁷² There are two types of balancing authorities: (1) traditional utilities responsible for some generation and transmission assets and (2) generation-only BAs. Usually, generation-only BAs have only a few assets, such as one or two generators.



Figure 9. CAISO-operated WEIM coverage as of 2022

Source: CAISO 2022b

BANC = Balancing Authority of Northern California, WAPA = Western Area Power Administration

CAISO estimates the WEIM has produced more than \$3.4 billion in benefits since it began, with about one-fifth accruing to the CAISO BAs and the remainder to member BAs outside CAISO, including participating public power utilities in California (WEIM n.d.). Wind and solar curtailments have also been reduced because of the ability to transfer surplus energy across regions through the WEIM.

In June 2019, SPP proposed a WEIS. In September of the same year, a Western Joint Dispatch Agreement signed by several utilities in two Western Area Power Administration BAs comprised the first participants. In 2020, FERC approved the SPP’s WEIS tariff, and since then, the WEIS membership has continued to grow.

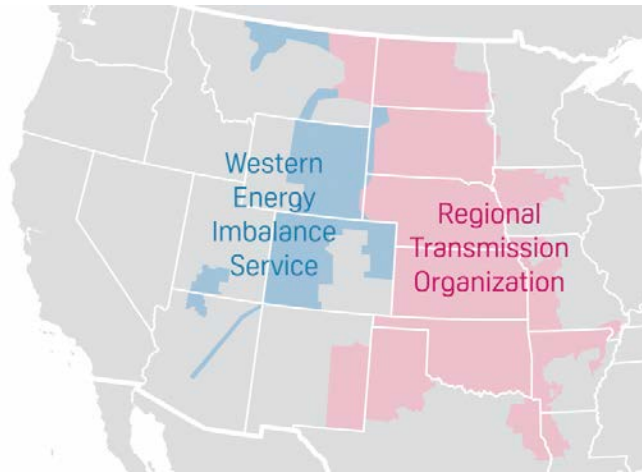


Figure 10. SPP-operated WEIS coverage as of 2022

Source: S&P Global Platts. SPP's RTO coverage is shown in red. WEIM coverage is shown in blue.

As they currently exist, the two energy imbalance markets in the West provide only short-term balancing through a real-time market, which averages about 5% of the electricity delivered to customers. In CAISO, 95% of transactions are settled in the day-ahead market. Both SPP and CAISO have proposed plans to extend their regional coordination to a day-ahead market, which could potentially result in further benefits associated with regional coordination.