State of the Interconnection

2023

WECC

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We are facing an exciting and challenging future in the power industry. Modern society relies on electricity in almost every aspect of daily life, and a reliable electric system can mean the difference between life and death. The generation mix continues to change. Load patterns are no longer predictable. Customers want more of a say in what choices their utilities make at a time when electricity use is increasing. The transmission system, now many decades old, must be expanded to accommodate the movement of power across the region. The backdrop for all of this is a changing climate and the aridification of the West, causing new and unpredictable weather patterns. Finally, cyber- and physical security have never been so threatened by foreign and domestic actors.

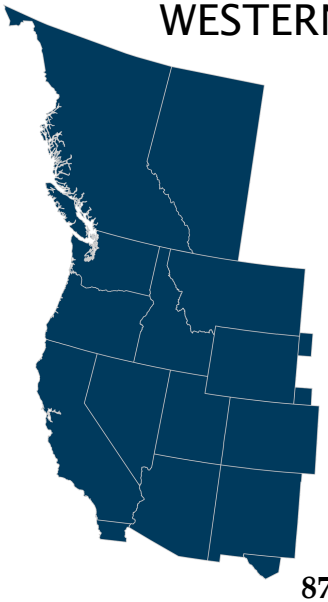
But knowledge is power. We seek, with this report on the state of the Western Interconnection, to inform conversations, provide clarity on important topics, illuminate areas of change, and elevate matters that have a substantial impact on reliability.

In previous iterations, WECC's State of the Interconnection (SOTI) included both a dashboard and a report. In response to stakeholder feedback, and in an effort to provide value across our spectrum of stakeholders, the dashboard and report have been bifurcated. The dashboard will continue as a performance analysis tool for subject matter experts and industry analysts on WECC.org.

"Changes to the grid are coming at us faster than we anticipated and at an unprecedented magnitude. Meanwhile, inverter-based resources are taking the place of historical baseload generation units, and the demand for electrification of other sectors, such as transportation and heating, continues to increase. To ensure the grid remains highly reliable during these changes, a regular focus on the health of the bulk power system must remain at the forefront of the discussion."

—Melanie M. Frye, President and CEO

WESTERN INTERCONNECTION AT A GLANCE

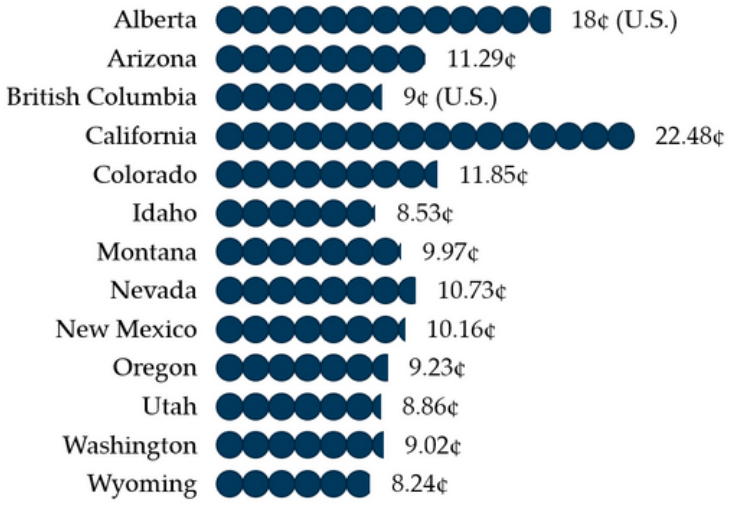


WESTERN INTERCONNECTION BY THE NUMBERS

4	Reliability Coordinators
34	Balancing Authorities
47	Transmission Operators
298	Generator Owners
407	Registered Entities
87%	Public or protected land
22,581	Wildfires in 2022
156,000	Miles of transmission
167,530	MW Peak Demand
1,800,000	Square miles
87,000,000+	People

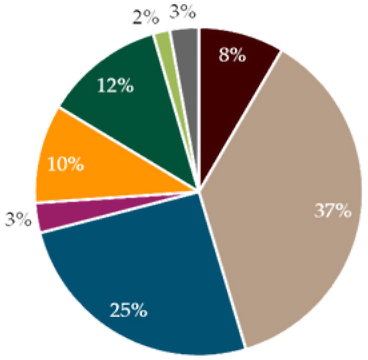
The national average price of electricity in 2022 was 12.49 cents per KWh. The West had both the lowest and second highest annual average state electricity prices in the country.

2022 Annual Average Cost of Electricity by State and Province (cents/KWh)



CAPACITY AND GENERATION

Western Interconnection Capacity 2021 (MW)

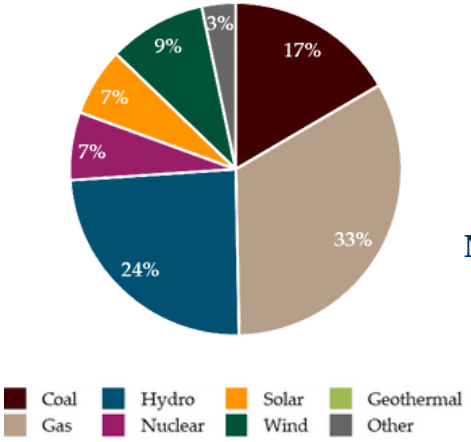


The total generation capacity in the Western Interconnection was almost 286 GW in 2021.

5-Year Lookback

	2017	2021	
Coal	37 GW	24 GW	-35%
Natural Gas	101 GW	106 GW	+5%
Wind	23 GW	34 GW	+48%
Solar	16 GW	28 GW	+75%
Hydro	72 GW	73 GW	+1%
Nuclear	8 GW	8 GW	-

Western Interconnection Net Generation 2021 (MWh)



Total net generation in the Western Interconnection in 2021 was 857,000 GWh.

5-Year Lookback

	2017	2021	
Coal	206,000 GWh	142,000 GWh	-31%
Natural Gas	221,000 GWh	283,000 GWh	+28%
Wind	55,000 GWh	82,000 GWh	+49%
Solar	38,000 GWh	57,000 GWh	+50%
Hydro	257,000 GWh	208,000 GWh	-19%
Nuclear	58,000 GWh	57,000 GWh	-2%

Sources: U.S. EIA, Government of Canada, Energy British Columbia

ANNUAL DEMAND

Annual demand in the Western Interconnection was over 892 million MWh in 2021, greater than all previous years except 2015, which had an all-time high annual demand of 895 million MWh.

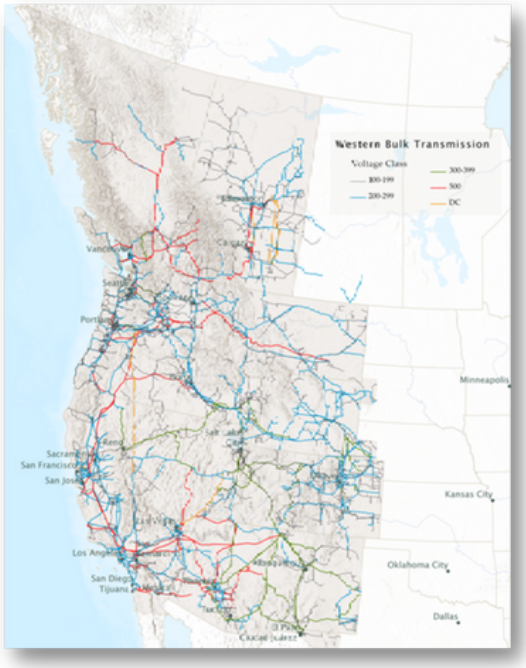
PEAK DEMAND

The 2022 interconnection-wide annual peak demand, and new all-time peak, was 167,530 MW, which occurred on September 6, 2022, during the August-September heat event. To date, the 2022/2023 interconnection-wide winter peak demand was 125,600 MW and occurred on December 21, 2022.

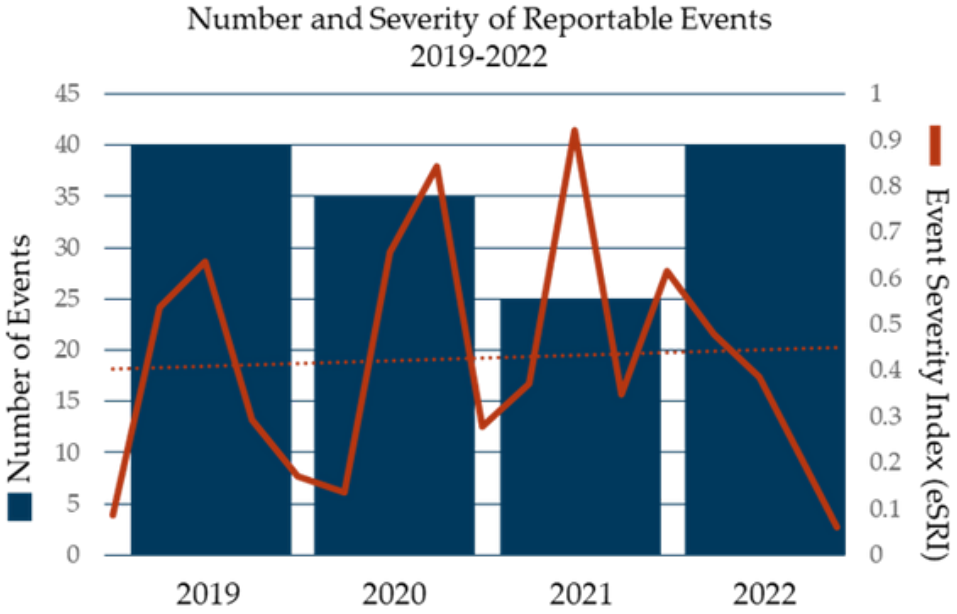
TRANSMISSION

There are 156,000 miles of transmission in the Western Interconnection.

Voltage Class	Miles
100-199 kV	51,000
200-299 kV	63,000
300-399 kV	14,000
400-599 kV	21,000



EVENTS AND OUTAGES



- There were 40 reportable events in 2022. The severity of events, as measured by the eSRI, has increased over the last four years.
- There were 10 Energy Emergency Level 3 Alerts (EEA-3) in 2022, nine of which occurred in Q3 and were associated with heat waves. The average duration of the EEA-3s in 2022 was more than 200 minutes, exceeding the average duration for EEA alerts in previous years by almost double.
- WECC tracks system performance on its Reliability and Security Indicator Dashboard.

The data included in this report reflect the most current validated data available at the time of publication.

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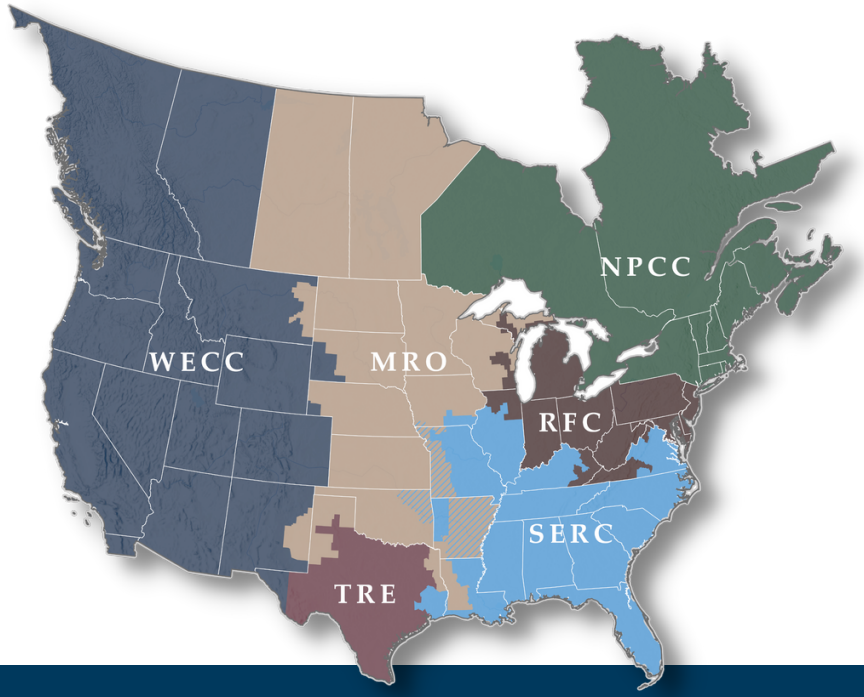
INTRODUCTION

WECC is the Regional Entity responsible for ensuring a reliable Bulk Power System (BPS) in the Western Interconnection. In this role, WECC promotes reliability and security through analysis and assessment of risks to the BPS, monitoring and enforcement of mandatory reliability and security standards, and strong engagement with a broad range of stakeholders.

WECC works with five other Regional Entities across the continent and the North American Electric Reliability Corporation (NERC) as part of the Electric Reliability Organization Enterprise (ERO Enterprise). Together, the ERO Enterprise works to ensure a highly reliable and secure bulk power system in North America.

The ERO Enterprise works as one synchronous machine—effectively, efficiently, and collaboratively.



The ERO Enterprise develops the ERO Enterprise Long-Term Strategy. From there, WECC develops the WECC Long-Term Strategy (LTS) to reflect the shared mission of the ERO Enterprise and consider the conditions, characteristics, and risks unique to or uniquely affecting the West. WECC's LTS directly links to our purpose, vision, and mission.

LONG-TERM STRATEGY

Five strategic focus areas:

1. Innovate and expand risk-based focus in all standards, compliance monitoring, and enforcement actions.

2. Assess and initiate action to mitigate known and emerging risks to reliability and security.

3. Strengthen engagement with the reliability and security community in the Western Interconnection.

4. Seize opportunities for effectiveness, efficiency, and continuous improvement.

5. Build the capability and culture that enable WECC to deliver on its critical reliability mission.

Vision

A reliable and secure bulk power system in the Western Interconnection.

Mission

To effectively and efficiently mitigate risks to the reliability and security of the Western Interconnection's bulk power system.

Our "Why"

Electricity is an integral part of the fabric of modern life. WECC strengthens that fabric to preserve and improve society's future.

RELIABILITY RISK PRIORITIES

WECC identifies and assesses a broad range of reliability and security risks. To help WECC and its technical committees focus their work, WECC works with stakeholders to develop Reliability Risk Priorities (RRP). In 2022, WECC and its stakeholders identified four RRPs.

Cybersecurity

Cyberattacks are increasing in volume and sophistication. Cyberattacks can cause a loss of control or damage to communications, data monitoring, protection and control systems, and operational tools. Attacks can cause loss of load and hinder resilience and recovery measures. The pervasiveness, increasing risk, and potential harm that can result from a cyberattack make this a priority risk for WECC.

Extreme Natural Events

Extreme natural events are becoming more common in the Western Interconnection due to wide-ranging changes in climate and weather patterns. Record-breaking temperatures, extended cold weather, prolonged drought, and increasing intensity of wildfires have forced entities to rethink how they plan and operate the system. The West also has several seismic zones, which represent a potential low-frequency, high-impact threat.

Resource Adequacy

Resource adequacy has grown more complex and intertwined with other important considerations such as transmission adequacy. Extreme events, clean energy policies, wide variance in state regulatory and policy actions, customer choice patterns (e.g., the move toward vehicle electrification), and other drivers are increasing variability and causing the generation and load patterns in the West to shift. Regional resource and transmission planning must be prepared to account for these changes. This is a critical risk for the Western Interconnection.

Impact of Changing Resources and Customer Loads on the BPS

New and emerging technologies such as inverter-based resources (IBR) and electric vehicles make grid planning and operations more complex. Emerging technologies must be integrated into the system in a way that does not degrade reliability. To do this, the behavior and operation of new technology must be understood in the context of bulk power system operations. To date, the West has experienced several system disturbances related to solar IBRs that demonstrate the need to address this risk.

Cybersecurity

CONTINENT-WIDE COOPERATION ON CYBERSECURITY

WECC works closely with other Regional Entities, NERC, and the Electricity Information Sharing and Analysis Center (E-ISAC) to identify, track, and analyze security threats to the BPS.

GridSecCon

The 11th annual GridSecCon security conference took place in October 2022. The conference brings together a cross-section of industry and government partners to discuss grid security threats and planning. GridSecCon 2023 will be held on October 17–20, 2023.

GRIDEX

NERC and the E-ISAC released the GridEx VI Lessons Learned Report, which highlights findings from the November 2021 GridEx exercise. In addition to WECC, participants from the West included electric entities and government representatives from 13 of the 14 states in the Western Interconnection, as well as British Columbia, Alberta, and Mexico. GridEx VII will be held on November 14–15, 2023.

CYBERSECURITY THREATS TO THE BPS

In 2022, five cyberattacks were reported through the DOE-417 form in the Western Interconnection, none affecting load.

Month	Description	BPS Impact
January	Malware	None. Detected and removed
March	Cyberattack on vendor	Interrupted vendor's access to SCADA data
June	Cyberattack on corporate email and telephone service	None. Backup system used
August	Cyberattack on vendor	Non-BPS. Disruption of vendor VER forecast delivery
September	Ransomware attack on corporate communications	None. Backup systems used

"SHIELDS UP"

The geopolitical situation in 2022 caused the Cybersecurity and Infrastructure Security Agency (CISA) and the Department of Homeland Security to take a "shields up" posture. The shields-up state reminds industry to increase vigilance, collaboration, and coordination.

SUPPLY CHAIN

In 2022, NERC released a security guideline on cybersecurity risk management lifecycle. The guideline addresses supply chain cybersecurity risk management for operational technology systems on the BPS. The guideline recommends that electric entities develop supply chain cybersecurity risk management plans and outlines the components that those plans should contain.

PHYSICAL SECURITY

Deliberate physical attacks to BPS facilities in the Western Interconnection increased by 83% in 2022. In the West, there were 73 physical security related incidents in 2022, affecting more than 44,000 customers. This was an increase over the 40 events logged in 2021. Notable events include:

- November 17–18, 2022: Substation break-ins and destruction of SCADA equipment and relays affecting 3,400 customers and 20 MW of load.
- November 24, 2022: Substation break-in and destruction of elements. No customers were affected.
- December 25, 2022: Substation break-ins affecting 30,000 customers and 62 MW of load.

CYBER- AND PHYSICAL SECURITY STANDARDS

Through its oversight function, WECC monitors and enforces registered entity compliance with over a dozen cyber- and physical security standards (CIP Standards). Two additional standards will go into effect in 2024. Through outreach such as the Reliability & Security Workshop, WECC helps educate entities on compliance with existing and upcoming CIP Standards.

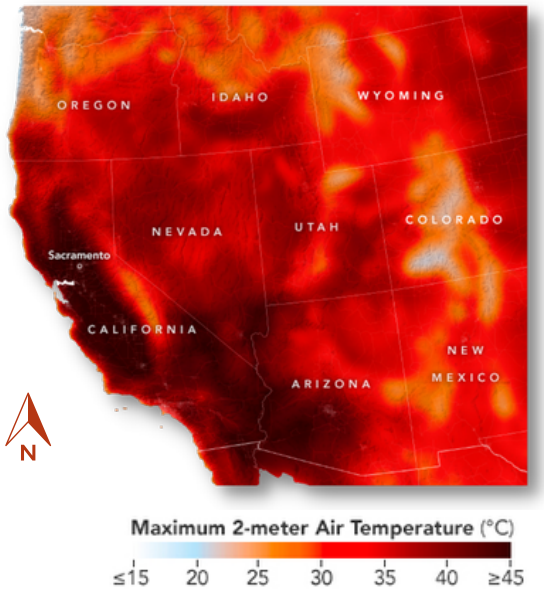
WECC POWER SYSTEM SECURITY CONFERENCE

In August, WECC will host a cyber- and physical security conference focused on power system infrastructure and considerations specific to the West.

Extreme Natural Events

EXTREME WEATHER

Last year, the West experienced extreme weather ranging from heat waves and dry spells to extreme winter storms and atmospheric rivers. The frequency, duration, and seasons of extreme events have increased over the last 40 years. WECC studies the potential effects of extreme weather on the BPS through its assessment and planning work.



Source: A Long-lasting Western Heatwave (nasa.gov)

AUGUST/SEPTEMBER HEAT WAVE

During the heat event from August 30 to September 10, 2022, the West set a new peak demand of 167,530 MW. The previous record was 162,017 MW, set on August 18, 2020. During the event, over 1,000 cities experienced record-breaking heat with afternoon temperatures 15 to 30 degrees higher than average.

DECEMBER COLD FRONT

In December 2022, a cold front caused new demand records for British Columbia Hydro and Power Authority (BC Hydro), Alberta Electric System Operations (AESO), and the Western Power Pool (WPP).

RELIABILITY STANDARDS

On April 2, 2023, new cold weather reliability standards will go into effect. These standards are meant to ensure facilities are prepared to operate under extreme cold weather conditions.

EOP-011-2: Emergency Preparedness and Operations
Requires Generator Owners to implement cold weather preparedness plans for generating units that consider location and configuration, and factors such as annual inspection and maintenance of freeze protection measures.

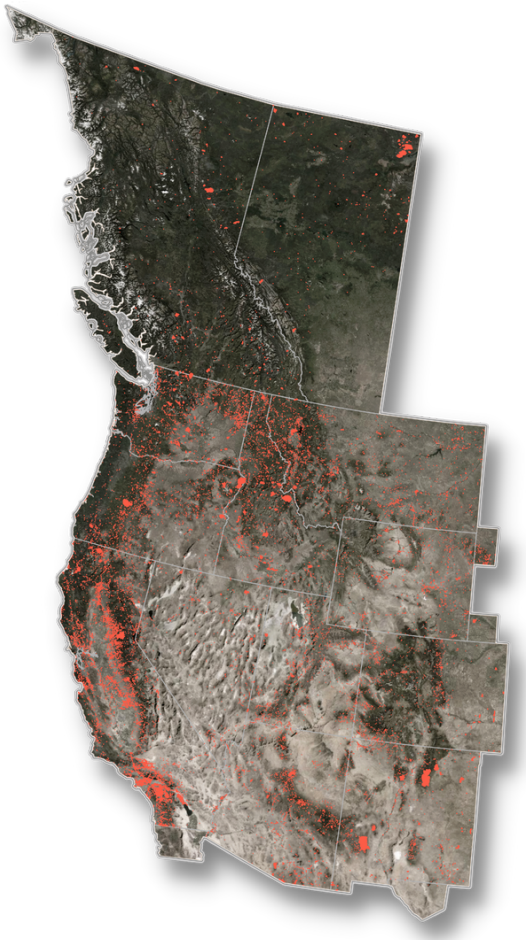
IRO-010-4: Reliability Coordinator Data Specification and Collection
Requires Reliability Coordinators (RC) to request specified data on BES generating units during locally forecast cold weather to allow the RC to perform operational analyses.

TOP-003-5: Operational Reliability Data
Requires Balancing Authorities (BA) and Transmission Operators (TOP) to request data on BES generating units during forecast cold weather to enable them to perform analyses.

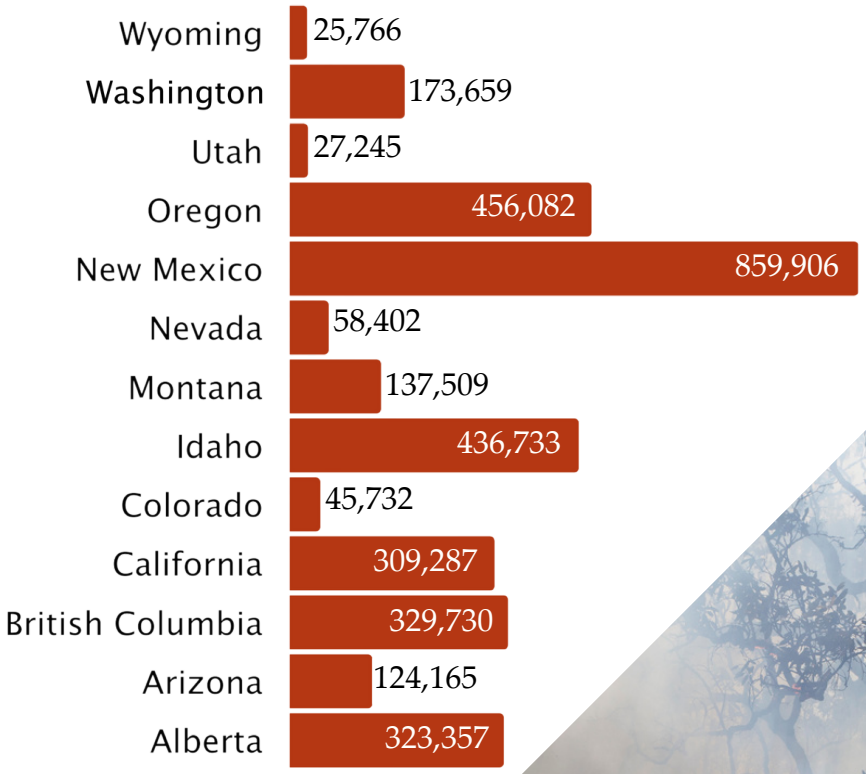
Additionally, in February 2023, FERC approved new Reliability Standards EOP-011-3 (Emergency Operations) and EOP-012-1 (Extreme Cold Weather Preparedness) to help implement recommendations from the joint inquiry into Winter Storm Uri in 2021.

WILDFIRE

In 2022, 22,581 wildfires burned 3.3 million acres of land in the Western Interconnection. Thirty-one fires affected the BPS between January and July 2022, resulting in 35 outages. This was a decrease from 70 fires in 2021 that affected the BPS. There is no strong correlation between wildfire number or severity and risk to the BPS. This is largely because fire location is the dominant driver of risk to BPS elements.

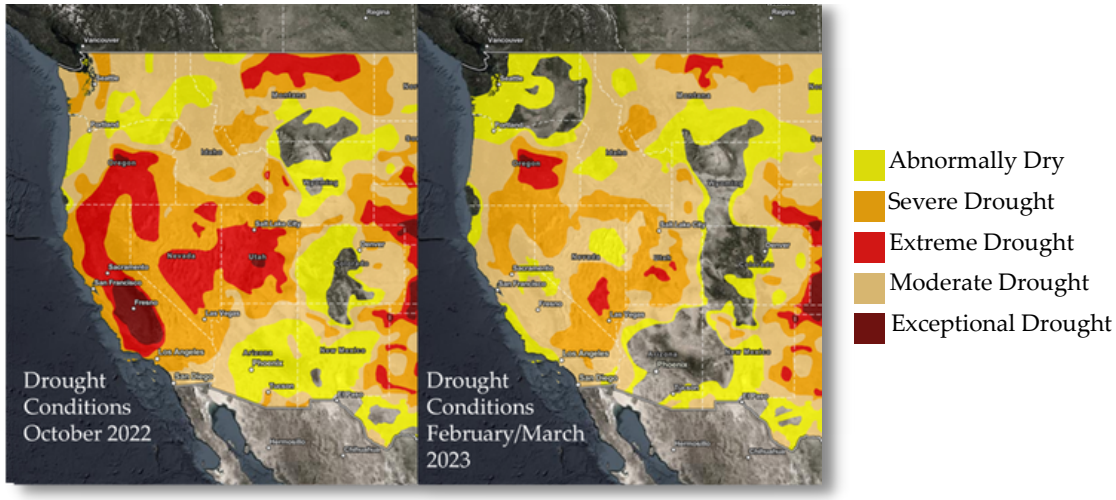


WECC's Situational Awareness function monitors and shares information on extreme events that affect the BPS. WECC's Wildfire Dashboard provides up-to-date information on wildfire activity and proximity to BPS elements.



ARIDIFICATION AND DROUGHT

Aridification is the long-term, gradual change of an area's climate from wetter to drier. Drought is a matter of moisture balance on a smaller scale, e.g., month-to-month.



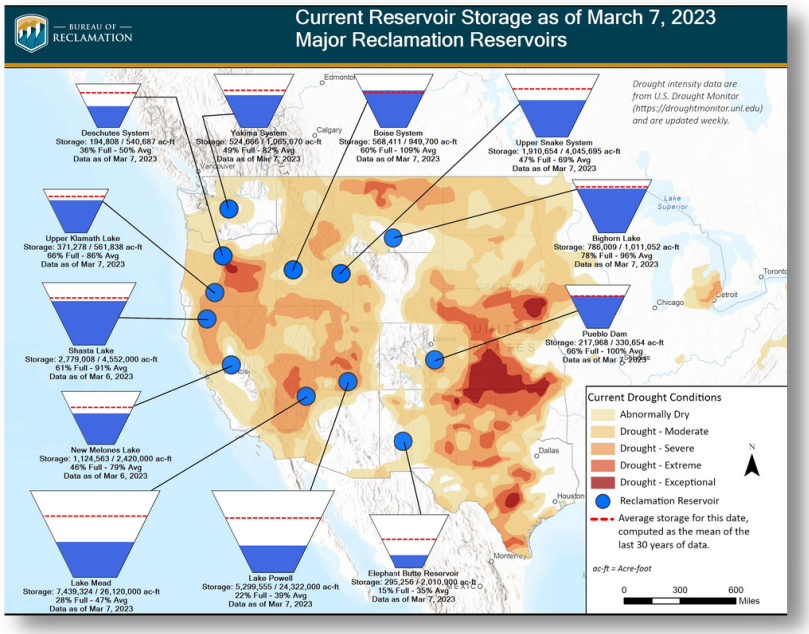
Source: Bureau of Reclamation

Despite record precipitation over the 2022-23 winter, much of the West remained in a state of drought; although conditions have improved compared to a year ago.

COLORADO RIVER MANAGEMENT

In 2022, to prevent catastrophic reduction in water levels, the Bureau of Reclamation reduced the water available for use by the seven states served by the Colorado River watershed. The Department of the Interior asked the states to come to an agreement on water use reductions, which they have not been able to do. This means the Department of the Interior may have to impose reductions.

Drought conditions are affecting reservoirs and hydro resources across the West. Lake Mead and Lake Powell are two of the most affected reservoirs. Lake Powell's water level is at its lowest since the lake was filled. The heavy precipitation across the West will help fill western reservoirs; however, dry soil and vegetation, and increased temperatures in spring and summer, will likely limit the amount of snowpack melt that will make it to the reservoirs.



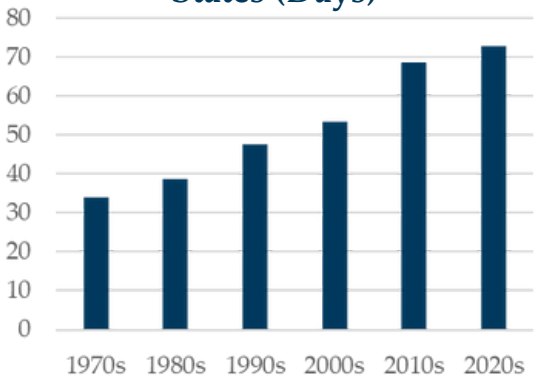
Source:
https://experience.arcgis.com/experience/512cef7647fe42698dc05dd4e75d4343/page/Current-Conditions/

Resource Adequacy

CHANGING PEAK DEMAND

The new interconnection-wide peak demand record of 167,530 MW set on September 6, 2022, exceeded the expected 2022 peak demand of 164,650 MW, calculated as part of WECC's Western Assessment of Resource Adequacy (Western Assessment).

Average Length of the Annual Heat Wave Season in the United States (Days)



Source: https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves

The June 2021 heat wave event in the Pacific Northwest occurred much earlier in the year than expected for heat waves. Over the last 50 years, the average length of the heat wave season in the United States has more than doubled—from 34 days in the 1970s, to over 73 days currently.

While the Western Interconnection's peak demand occurs in the summer, many entities are winter-peaking. As temperatures and extreme weather increase, some of these entities are becoming dual-peaking. This presents resource planning challenges for entities that have historically experienced one predominant peak.

SPOTLIGHT: BRITISH COLUMBIA DEMAND PEAKS

In some cases, entities have set new summer and winter peak demands in a relatively short range of time. During the extreme cold in late December 2022, BC Hydro set a new peak demand record of almost 11 GW, breaking a record set a year earlier in December 2021. In 2021, BC Hydro also experienced its all-time high summer peak demand during the June heat event, when cities across the Pacific Northwest and western Canada broke temperature records. BC Hydro anticipates its expansive hydro system will be able to meet continued increases in demand throughout the year caused by increasing temperatures and extreme weather events.

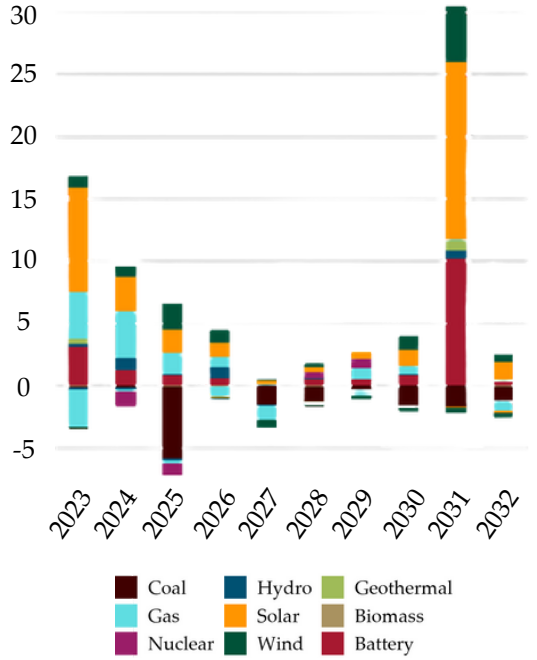
CHANGING RESOURCE MIX

The resource mix in the Western Interconnection will continue to change over the next decade.

Net Change in Resources 2023-2032

Coal	-13.4 GW
Nuclear	-1 GW
Natural Gas	4.7 GW
Hydro	2.3 GW
Solar	31.9 GW
Wind	9.2 GW
Battery Storage	18.3 GW

Planned Resource Additions and Retirements 2023–2032 (GW)



Resource Adequacy challenges will grow over the next decade.

- Variability is a primary driver of resource adequacy challenges, and, based on data provided by entities for WECC's Western Assessment, variability will increase.
- Projections for maintaining resource adequacy depend on new resources coming online as planned, with little margin for delay. Factors such as supply chain disruption or siting delays can pose serious risks.
- Most entities in the West rely to some extent on imports to remain resource adequate. Weather events and transmission availability play a critical role as to whether imports can be relied upon.

REGIONAL COOPERATION

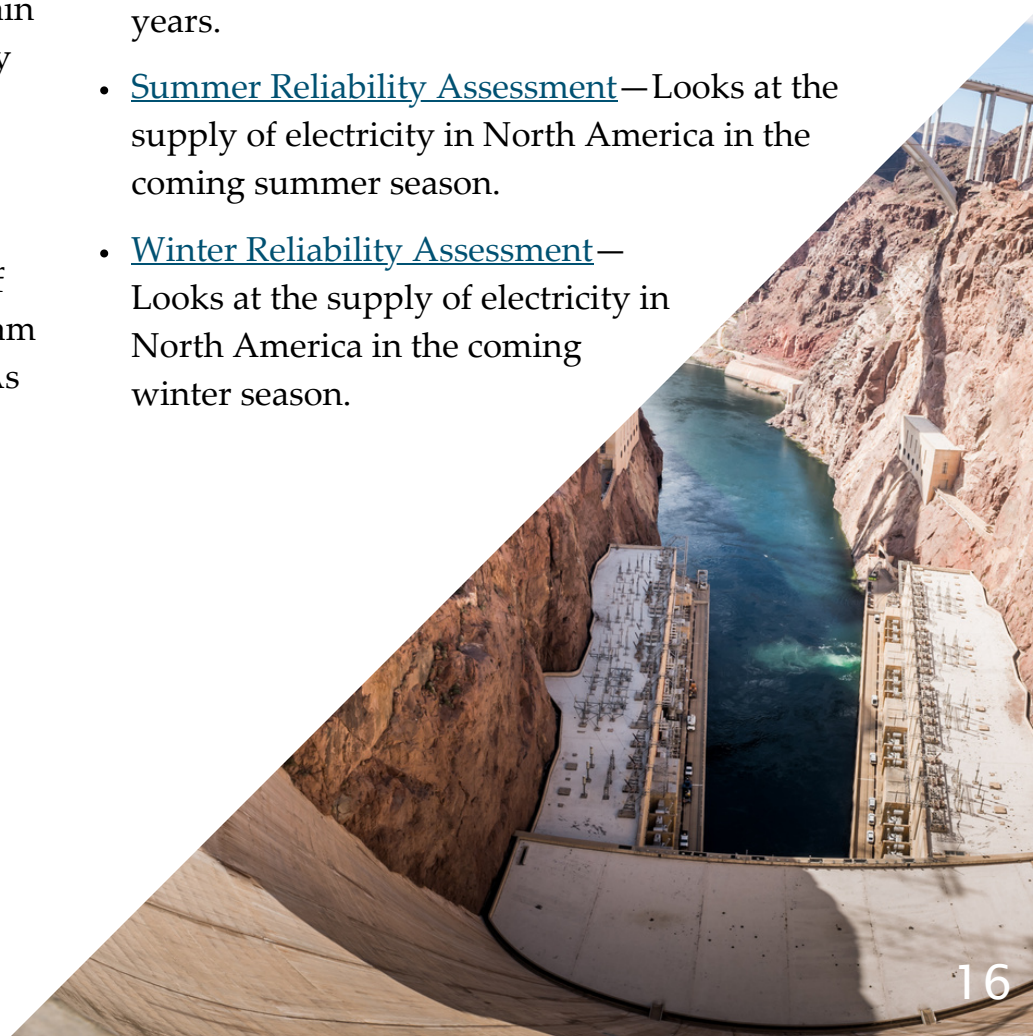
In February 2023, FERC approved the tariff for the Western Resource Adequacy Program (WRAP). The WRAP includes 19 entities. As the first regional program of its type in the West, the WRAP was developed to address growing resource adequacy challenges.

The California Independent System Operator (CAISO) operates a resource adequacy program within its footprint in California.

CONTINENT-WIDE COORDINATION

In addition to the Western Assessment, WECC works with its ERO partners every year to produce three assessments of resource adequacy. Together, these assessments help the continent identify, understand, and prepare for potential resource adequacy challenges.

- Long-Term Reliability Assessment—Looks at supply and demand on the BPS in North America over the next 10 years.
- Summer Reliability Assessment—Looks at the supply of electricity in North America in the coming summer season.
- Winter Reliability Assessment—Looks at the supply of electricity in North America in the coming winter season.



Impacts of Changing Resources and Customer Loads

INVERTER-BASED RESOURCES

IBRs are resources that are asynchronously connected to the grid using a power convertor. IBRs include solar and wind resources, as well as battery energy storage systems (BESS). In 2022, there were three IBR-related events. Two of the events involved BESS.

In 2022, the Western Interconnection added over 3,000 MW of new solar resources. As the largest category of IBRs on the system today, solar resources have drawn attention due to events in recent years. In April 2022, NERC released the disturbance report for several solar events in 2021.

WECC and the ERO Enterprise have focused heavily on this emerging risk over the last several years. While solar-related IBR events decreased in 2022, battery storage—also inverter-based—is increasing, expanding the potential for increased IBR-related events.

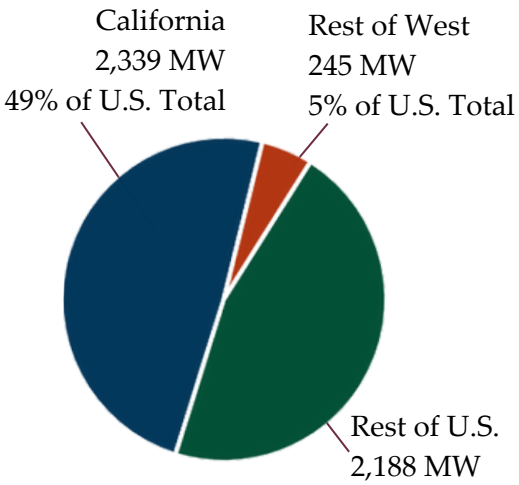
FERC ACTION

In November 2022, FERC acted on IBR-related items:

- RD22-4-000: Order directing NERC to develop a work plan to register certain IBRs to bring them under mandatory reliability standards.
- RM22-19-000; RM21-3-000: NOPR directing NERC to address data sharing, model validation, planning and operations studies, and performance requirements through the reliability tandards.
- Approval of standards FAC-001-4 (regarding availability of interconnection requirements information) and FAC-002-4 (regarding studying the impact of interconnecting facilities on the BES).

BATTERY ENERGY STORAGE SYSTEMS

U.S. Battery Storage in 2021 (MW)

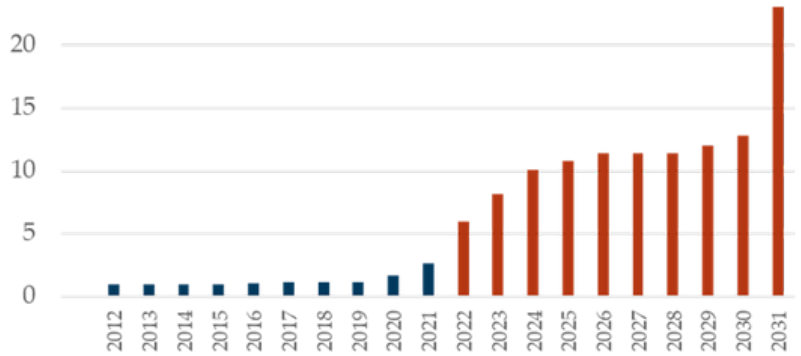


Source: EIA

In 2021, the West accounted for more than half of the total BESS capacity in the United States. In 2022, the West almost doubled the amount of BESS on the system due to 1,932 MW added in California.

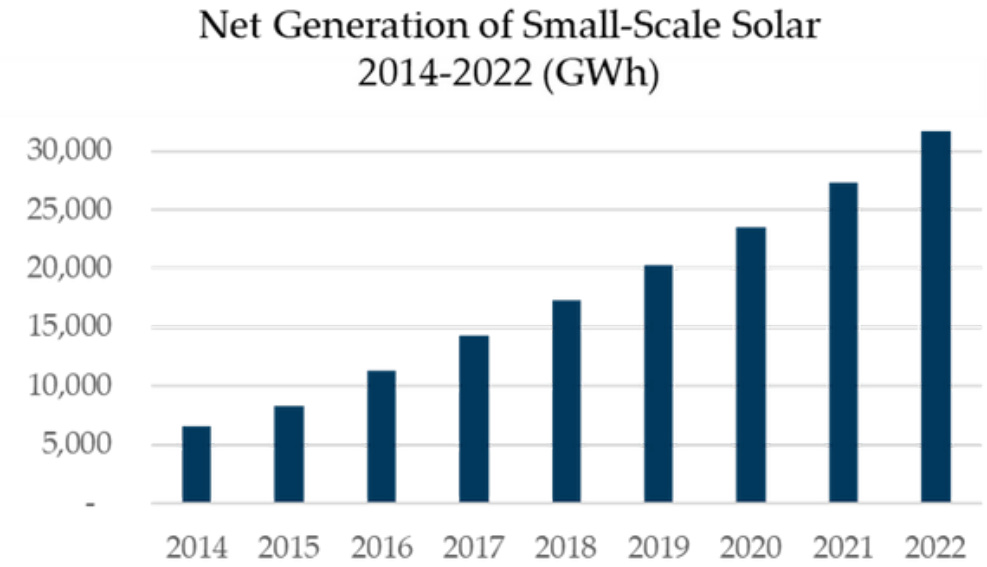
BESS capacity will continue to grow over the next decade, with more than 20 GW planned by 2031.

Cumulative Actual and Planned BESS Capacity in the West 2012–2031 (GW)



DISTRIBUTED ENERGY RESOURCES

Distributed energy resources (DER) are resources on the distribution system that are not included in the definition of the BPS, but produce electricity. DERs have grown substantially over the last nine years. In 2022, there were 31,728 GWh generated by small-scale solar in the interconnection. This is an almost five-fold increase over the output of small-scale solar a decade ago.



Source: EIA

ERO STRATEGIES

In 2022, the ERO Enterprise developed strategies for addressing the challenges and risks associated with IBRs and DERs. In addition to reports on the Panhandle and Odessa wind disturbances in Texas, NERC released an Inverter-Based Resource Strategy and a Distributed Energy Resource Strategy. Additional information on the work on these issues can be found in the NERC quick reference guides for IBR and DER activities.

MONITORING AND ANALYSIS

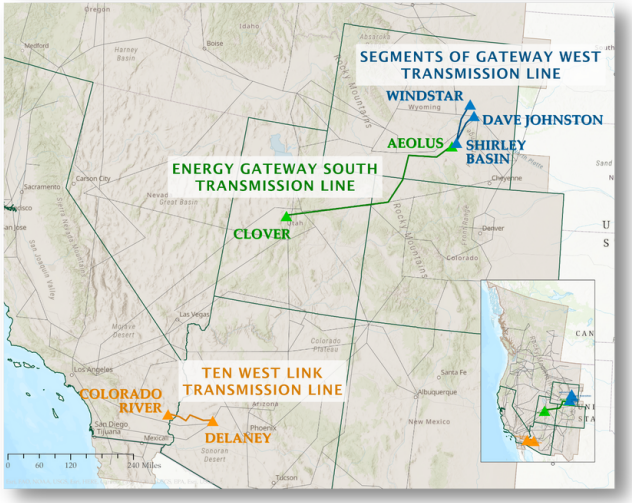
WECC's Event Analysis team tracks and analyzes IBR and BESS events and shares information on lessons learned and best practices. WECC Event Analysis is working with NERC and CAISO to develop a disturbance report of the two reported BESS reduction events that occurred in 2022. WECC also participates in continent-wide efforts to better understand and manage risks associated with IBRs, DERs, and BESS. WECC's Assessments team analyzes how these elements may affect the stability and adequacy of the grid. Together with stakeholders in its Technical Committees, WECC studies present and future scenarios to determine potential areas of risk to the stability of the BPS in the West.

Transmission

NEW TRANSMISSION

In 2022, three major transmission projects received final approvals for construction from the Department of the Interior:

- The Energy Gateway South Transmission Line across Wyoming, Colorado, and Utah.
- The Ten West Link Transmission Line from Arizona to California.
- Two segments of the Gateway West Transmission Line Project from Wyoming to Idaho.



A number of other transmission projects are in the late phases of review, siting, and approval, including the Boardman-to-Hemingway, Greenlink, and SunZia transmission projects. While these projects reflect progress, WECC studies show a growing risk associated with transmission availability, particularly regarding growing resource adequacy risks.

In December, FERC issued a Notice of Proposed Rulemaking (NOPR) to revise its governance of interstate transmission line siting. Pursuant to the Infrastructure Investment and Jobs Act, the NOPR proposes to use FERC's authority to permit a transmission line denied by a state when the line is in a National Corridor.

RELIABILITY MODELING

WECC's Reliability Modeling team produces and distributes information and planning data that is used by WECC members in their reliability and planning studies. Model data for the transmission system, including stability analysis, is part of this information. Through products like base cases and the Anchor Data Set, WECC helps to create state-of-the-art models of the electric system in the West.

Regional Transmission Planning

In April 2022, FERC issued a NOPR that, among other items, proposes to require transmission providers to conduct regional, long-term transmission planning in a time frame that addresses the future needs created by changes in resource mix and demand.

FEDERAL–STATE COOPERATION

Throughout 2022, the FERC Joint Federal–State Task Force on Electric Transmission met to discuss transmission issues, including transmission planning and generation interconnection concerns.

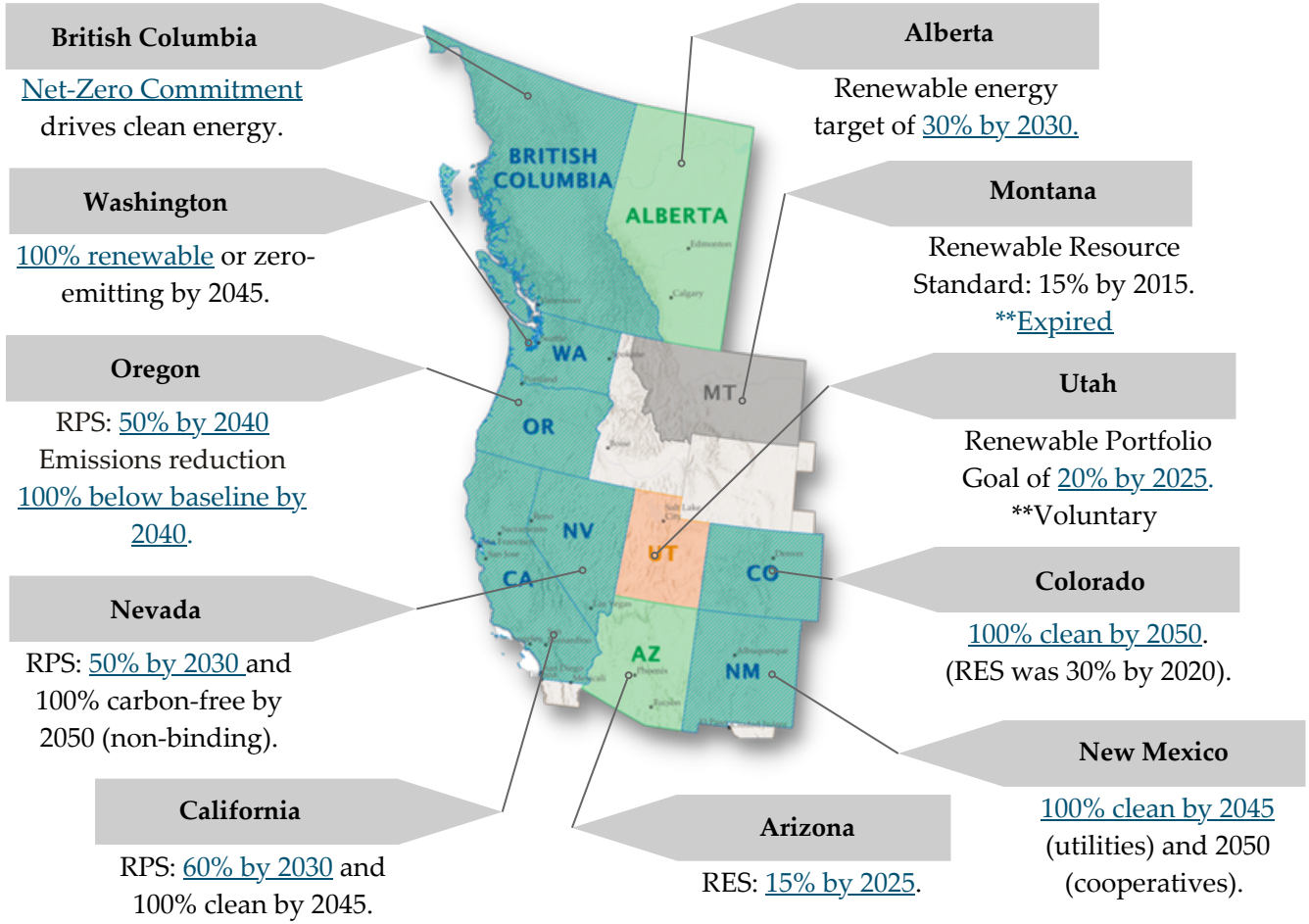
Fixing the Queue

In 2021, the generator interconnection queue backlog grew to over 1,400 GW nationwide. In June 2022, FERC issued a NOPR with proposals to help expedite the interconnection process.

Energy Policy

CLEAN AND RENEWABLE ENERGY POLICIES

Over 95% of the population in the Western Interconnection lives in a state or city or is served by a utility that has a clean or renewable energy commitment. Nine western states have renewable energy standards, and six of those have also adopted clean energy targets. In addition, a number of cities in the West have adopted renewable or clean energy targets.



FEDERAL POLICY HIGHLIGHTS

Infrastructure Investment and Jobs Act (2021)

- Amends the Federal Power Act to expand FERC's transmission line siting authority
- $65 billion for transmission and other power system upgrades
- $7.5 billion to build national EV charger network

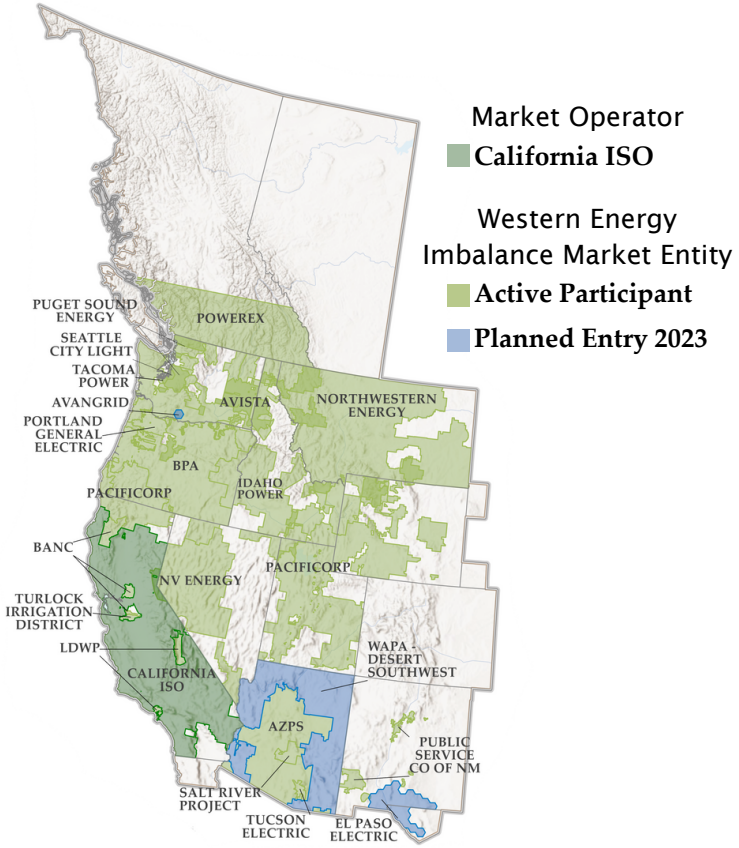
Inflation Reduction Act

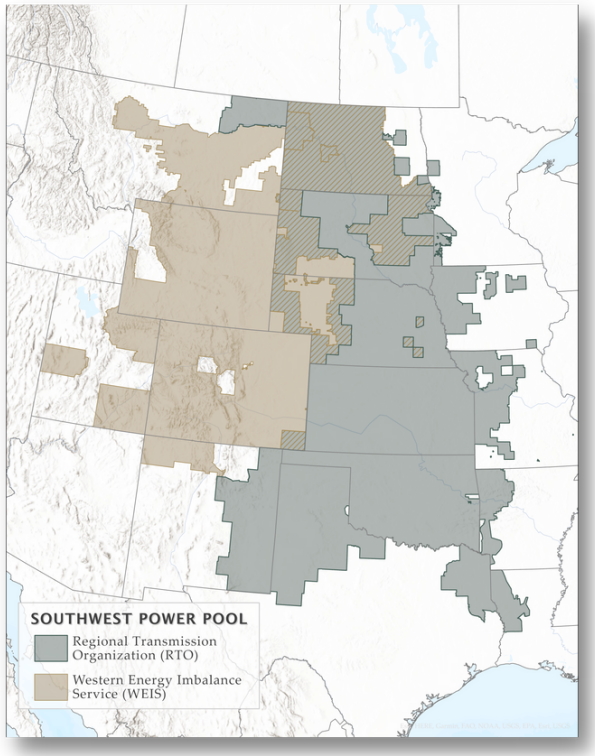
- $2 billion for transmission financing
- $760 million funding for siting authorities
- Clean vehicle tax credit
- Creates the DOE Energy Infrastructure Reinvestment Program for loans for revitalization of energy infrastructure
- $1.5 billion to national labs for critical infrastructure
- $9 billion to states and tribes for home energy rebate programs

Markets

In 2022, Avista Utilities, Bonneville Power Administration, Tacoma Power, and Tucson Electric Power joined the Western Energy Imbalance Market (WEIM), increasing the number of participants to 19. The WEIM reported over $1.47 billion in participant benefits in 2022 alone.

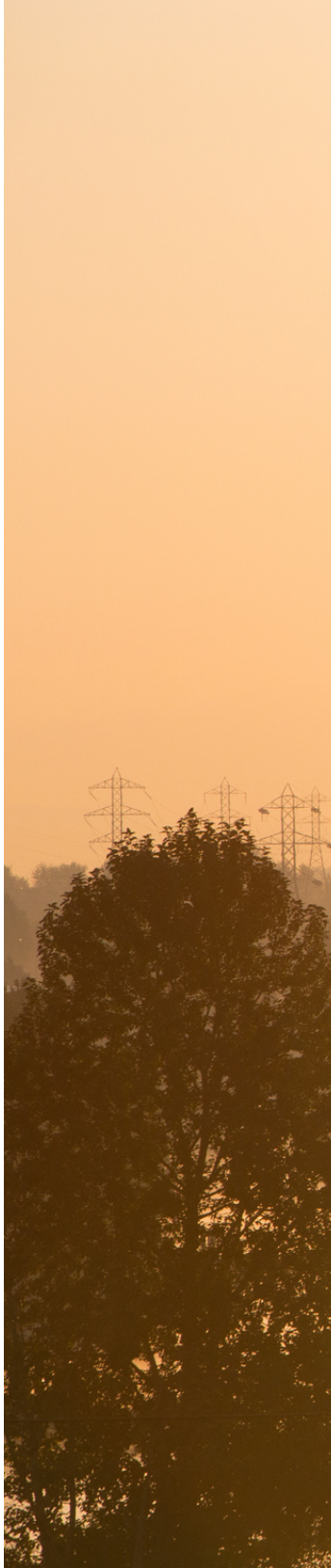
CAISO and its stakeholders have worked to develop an extended day-ahead market (EDAM), which could expand the CAISO day-ahead market to the rest of the WEIM footprint. In February 2023, the CAISO board of governors and the WEIM governing body approved the initiative. In 2023, they will file a tariff with FERC with an anticipated go-live date in 2024.





The Southwest Power Pool's (SPP) Western Energy Imbalance Service (WEIS) added Colorado Springs Utilities in 2022 and will add Black Hills Energy, Platte River Power Authority, and Xcel Energy in April 2023, bringing the total number of participants to 10.

In 2022, SPP worked with stakeholders to develop the Markets+ proposal for a day-ahead market plus real-time commitment and dispatch service. In addition, SPP is offering RTO services as part of an expansion of the SPP Regional Transmission Organization into the Western Interconnection (RTO WEST).



WECC

engage@wecc.org