WECC

Electric Reliability and Security for the West

State of the Interconnection

Insights and Takeaways

2022

Introduction

This document provides a high-level look at the State of the Interconnection (SOTI) over the last 18 months, with a focus on key risks. General historical system performance data for the Western Interconnection can be found in the State of the Interconnection Online Portal. In addition, WECC quarterly tracks system health through its Reliability and Security Indicator Dashboard.

During 2021 and the first half of 2022, the West continued to see challenges to reliability and security. The Northwest heat wave and worsening drought made 2021 a particularly challenging year. Cyber events continued to test system security through the first half of 2022. Also, prolonged higher-than-normal temperatures persisted throughout much of the West over the summer of 2022. Despite these challenges, the Western Interconnection remained reliable in 2021 and 2022, except for proactive outages in eastern Washington during the Northwest heat wave in late June 2021 (affecting approximately 340,000 customers). As was the case in 2020, the last 18 months continue to demonstrate the extent of change affecting the Western Interconnection.

WECC's Reliability Risk Priorities (RRP) form the backbone of this report. RRPs are matters with a unique impact and importance to the Western Interconnection—to which WECC can make material reliability and security contributions. WECC's staff and technical committees use the RRPs to help ensure that reliability and security risks are addressed through concentrated mitigation strategies.

WECC updates its list of RRPs every two years. In June 2022, the WECC Board of Directors (Board) approved the refreshed list of RRPs. Two 2020 risks remain on the list: resource adequacy and extreme natural events. The other 2020 risks (changing resource mix and effects of the distribution system and customer load on the bulk power system (BPS)) combined into the 2022 risk "impacts of changing resources and customer load impacts on the BPS." Cybersecurity was added in 2022 as the fourth reliability risk priority.

Throughout the year, WECC staff addresses a variety of topics and concerns impacting the reliability and security of the interconnection. The sections below provide information on the state of the interconnection in each RRP area and additional areas that have impacted the interconnection during the preceding 18 months.

Resource Adequacy and Performance

The severe cold weather in Texas and the Midwest in early 2021 served as a reminder that extreme weather can create resource adequacy challenges at any time and place. Faced with its own severe weather and a rapidly changing system, the West's resource adequacy concerns grew over the last 18 months. After the West-wide heat wave in 2020 demonstrated the West's vulnerability to resource shortfalls, WECC's work and the efforts of industry over the last year-and-a-half have shed light on the depth of the problem. For example:

- The August 2020 heat wave—during which the California Independent System Operator (CAISO) had to initiate rotating outages—ignited questions about the sufficiency of planning reserve margins in California. In early 2021, the California Public Utilities Commission (CPUC) effectively increased the Planning Reserve Margin (PRM) to 17.5% for three entities under its jurisdiction.[1]
- West-wide, the potential loss of significant hydro resources like Glen Canyon and Hoover dams due to sustained drought, announced in 2021, prompted WECC and the industry to confront the possibility of running a system without these historically dependable resources.[2]

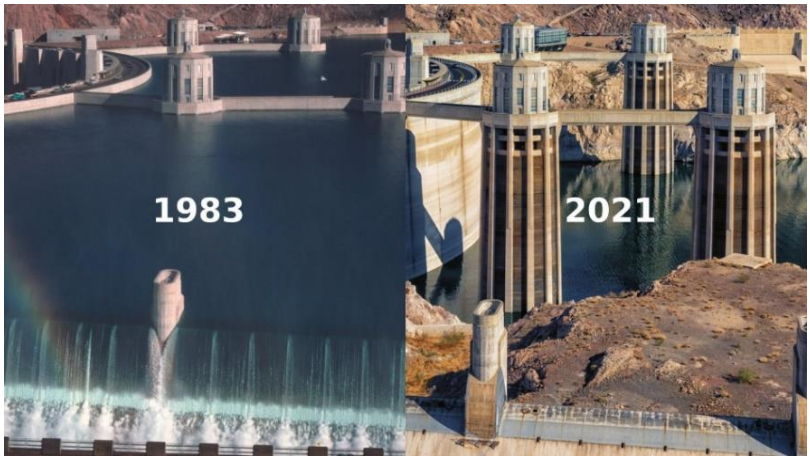

Figure 1: Comparison of Lake Mead in 1983 and 2021

- The planned retirement of nearly 30,000 megawatts of generation (mostly thermal resources) by 2039 only exacerbates the concerns.
- While resource adequacy is a significant challenge on its own, the ability of the existing transmission system to support future needs has also come under scrutiny, further complicating the resource adequacy conversation.

Going forward, the West must address concerns about whether the historical approach to analyzing and planning for resources is still sufficient. The sufficiency of existing PRMs, the reliance on historical data to predict and plan for the future, the inability to account for energy limitations (versus capacity planning) in planning methods, and the disjointed nature of resource planning are all issues the West

[1] These entities include Pacific Gas and Electric Company, Southern California Edison Company, and San Diego Gas and Electric Company. See https://docs.cpuc.ca.gov/publisheddocs/published/g000/m373/k745/373745051.pdf.

[2] Image: Lake Mead Water Shortage (lasvegasnevada.gov)

will continue to face. In addition, questions have emerged about the ability of the electricity sector to build at the scale and speed necessary to meet resource needs over the next decade. For example, global supply chain issues have caused delays in building planned solar resources, which are central to utility plans to reach clean energy targets while remaining resource sufficient.

Meeting the West's resource adequacy needs to ensure a reliable BPS will continue to be a top priority for WECC and the industry. WECC has responded to this concern by honing its analytical work and elevating the dialogue to better coordinate across the Western Interconnection.

- In its Western Assessment of Resource Adequacy (Western Assessment), WECC examines the future impacts of increased variability on the system. This report examines how the availability of energy—in addition to capacity—contributes to ensuring there are sufficient resources to meet customer variable demand. The 2021 Western Assessment shows the likelihood of resource shortfalls for each subregion in the Western Interconnection.
- In response to stakeholder requests to provide a forum for discussion of resource adequacy issues, WECC started a Resource Adequacy Assessments Task Force. The Task Force's job is to review the 2022 Western Assessment; identify gaps in resource adequacy across the West; define WECC's continued future role in resource adequacy; build a list of resource adequacy needs; and select the best methods for assembling groups to fulfill the necessary tasks.
- In addition, WECC is holding a Resource Adequacy Webinar Series. This series, which started in July 2022, is in response to stakeholder requests that WECC provide a forum for West-wide discussion about resource adequacy. Each webinar in the series is intended to be responsive to stakeholder feedback and current dialogue surrounding the resource adequacy issue. Feedback obtained through the discussions will inform and help frame WECC's resource adequacy work, including the Western Assessment.

Change in Diversity

The Western Interconnection's varied generation types, peak load seasons, and climate zones have been a great strength and underpin the system's design, planning, and operation. Climate change, a changing resource mix, and widespread extreme weather are affecting the ability to capture this diversity. Historically, weather events were localized—when one area was experiencing high demand, there was enough transmission from other areas to deliver power to compensate. However, the weather and climate events in the West are lasting longer and are more expansive. Extreme weather is no longer rare. For example, wide-spread heat waves are causing coinciding demand spikes. These conditions reduce or eliminate the availability of power that more temperate areas like the Pacific Northwest have been able to provide to hotter areas like California and the Desert Southwest because the Pacific Northwest needs that power to serve native loads. Further, the resource mix is becoming more sensitive to extreme weather conditions. Solar and wind resources are affected by weather,

requiring the availability of dispatchable resources to balance the system when variable resources are not providing energy.

Energy Storage

The potential of energy storage continues to gain attention across the West and has implications for resource adequacy. However, the role of energy storage in the future is undetermined. While this resource has operational characteristics that can offset some challenges—such as filling gaps that variable energy resources create—the amount of storage needed to make a material difference in the Western Interconnection seems much higher than is achievable in the short term. Still, industry is planning to build an unprecedented amount of energy storage over the next 10 years.

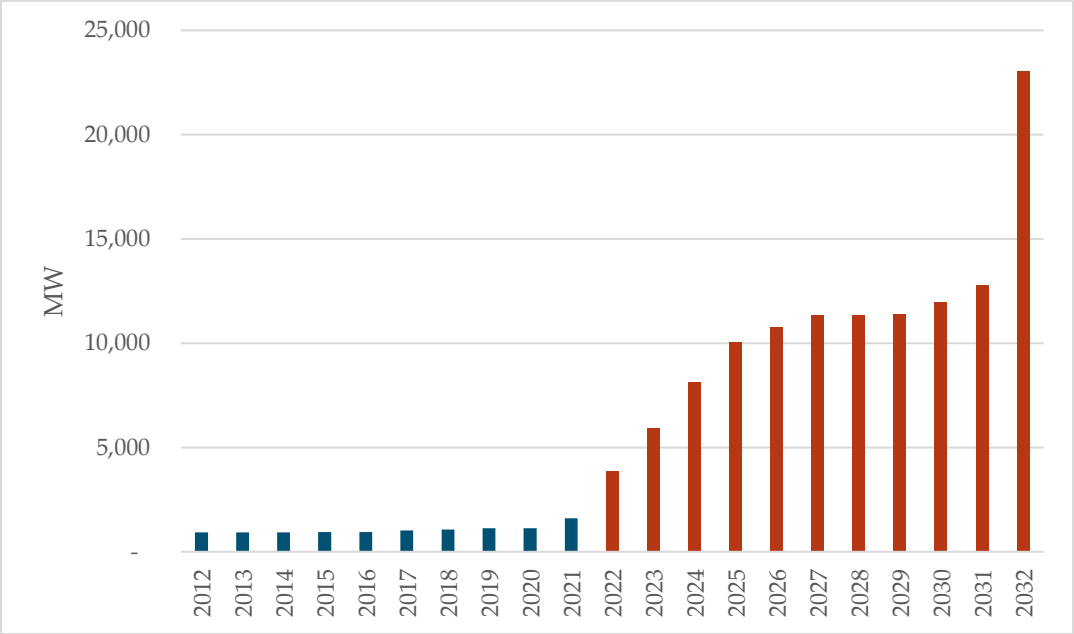

Figure 2: Cumulative actual and planned energy storage additions in the West 2012-2032

Electrification

Electrification presents an emerging challenge to the reliable planning and operation of the system, particularly because it contributes to load variability. Electrification primarily includes the transition of load to electricity—such as home heating or electric vehicles. The West is just beginning to understand the potential impacts of electrification on the BPS. Electrification could shift and reshape load, as well as change how the system responds to contingencies. Because load predictability is key to planning and operating the system, the ability to adjust to these shifts is critical.

Impacts of Changing Resources & Customer Load Impacts on the BPS

Changing Resource Mix

The resource mix in the West has changed significantly in the last decade. Despite pandemic, political, and economic turbulence, wind and solar capacity have steadily grown. By the end of 2021, wind capacity had grown 15% from the previous year, and solar had grown 12%. The relative energy contribution of resources has also changed. Over the past five years, wind increased from 5.9 percent of total generation to 8.6 percent, while solar increased from 2.8% to 5.8%. Coal's proportion of total generation in the Western Interconnection continues to decline, amounting to less than 17% of all generation in megawatt-hours (MWh) in 2020 compared to 27% five years earlier.[3]

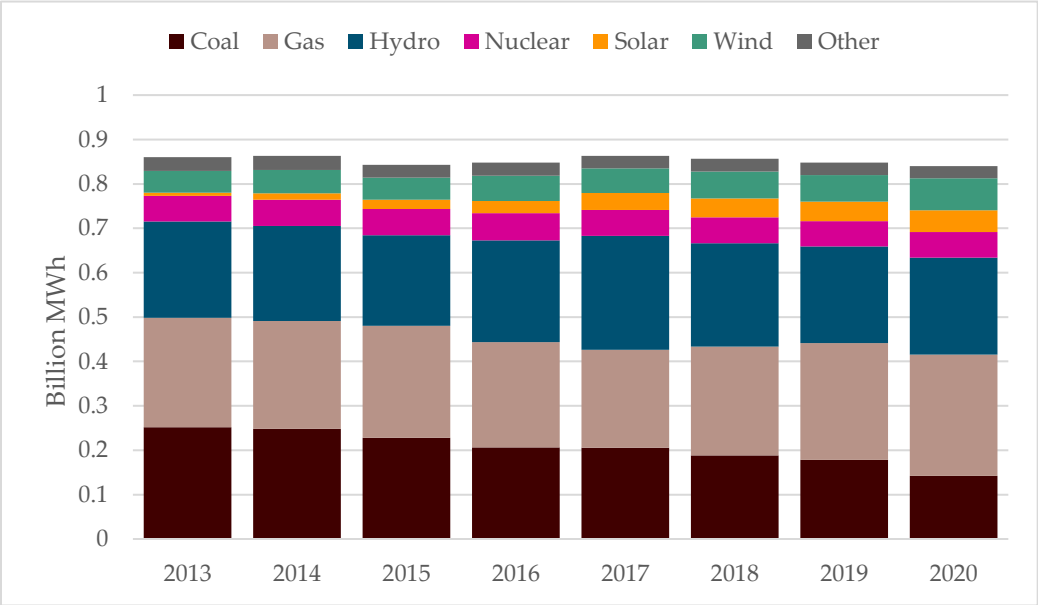

Figure 3: Western Interconnection Net Generation (MWh) by Fuel Type 2013-2020

The resource mix in the West will continue to change as federal and state governments set aggressive clean energy goals and entities in the West work to meet the established targets, respond to customer demands, and manage an aging system. The pace of change to the resource mix is likely to increase. The retirements that entities have planned through 2039 have increased over the last five years. In 2018, plans indicated a total of approximately 5,000 MW of generation would be retired by 2039. In the 2022 plans, that number increases six-fold, to around 30,000 MW.

[3] For more historical system data, visit the State of the Interconnection Online Data Dashboard.

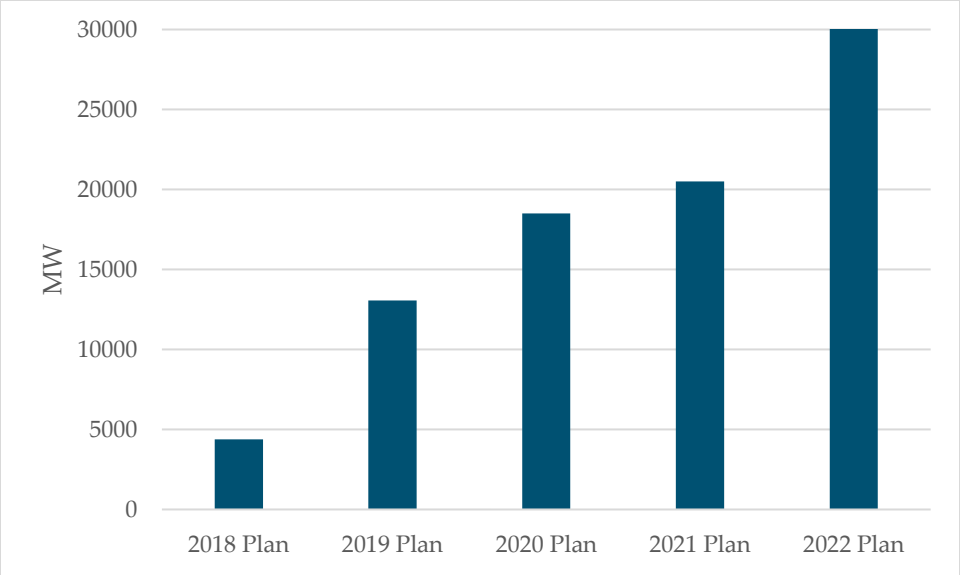

Figure 4: Total Nameplate Capacity of Planned Retirements in the Western Interconnection through 2039 by Plan Year

Based on 2022 plans, in the next 10 years, more than 80 GW of new resources will be built. If these plans hold and this generation is built, solar, energy storage, and wind will make up more than two-thirds of the new resources.

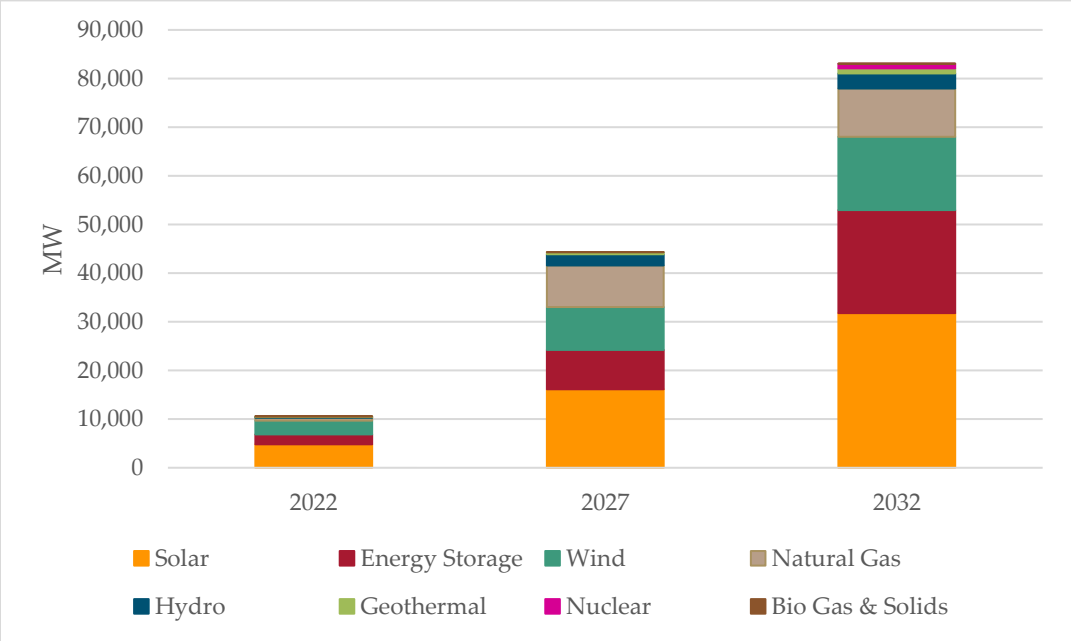

Figure 5: Cumulative Resource Additions in the Western Interconnection 2022-2032 (based on 2022 plan information)

WECC studies the reliability implications of the changing resource mix from historical and future perspectives to understand the implications for reliability. For example:

- In its Performance Analysis work, WECC examines historical resource changes and system performance, such as generator outages. This information then informs assumptions for studying potential future scenarios.
- WECC's Events Analysis team and associated stakeholder committees investigate events involving specific types of resources—e.g., inverter-based resources (IBR)—to better understand the challenges and best ways to integrate them into system planning and operations. WECC, partnering with industry and the rest of the Electric Reliability Organization (ERO) Enterprise, has shared several lessons learned and guidelines on integrating IBR technology into the BPS.
- WECC's system planning work regularly studies possible future resource mix scenarios to determine how various resource mix patterns may affect system adequacy and stability. Most recently, WECC conducted a Variability in Loads and Resources assessment, which studied the extent to which a combination of extreme weather events, lack of firm resources, and generation variability could cause unserved energy in the system. The assessment found that battery energy storage systems (BESS) positioned near load centers mitigated unserved energy in the system during the study period. The study results also indicate that BESS could provide valuable ancillary services and other benefits, such as ramping capability.
- Through probabilistic analysis, WECC has enhanced its ability to account for the changing resource mix in its resource adequacy work. Probabilistic analysis allows WECC to account for a wide range of future resource-mix scenarios and forms the core of the Western Assessment of Resource Adequacy. Based on this work, WECC recommends entities in the West re-examine their Planning Reserve Margins to ensure they fully account for increasing resource and load variability.

Effects of Distribution System and Customer Load on the BPS

Distributed generation continues to affect hourly, daily, and annual demand and demand patterns. Distributed Energy Resources (DER) represent an increasing portion of the total energy supply. Distributed solar generation has grown steadily in most of the Western Interconnection from around 6.5 million MWh in 2014 to around 27.2 million MWh in 2021. Distributed solar generation provides roughly half the amount of energy each year as utility-scale solar generation.

In its 2020-2021 study program, WECC assessed a set of 2032 scenarios, including a High Distributed Energy Scenario. The results from this analysis show that, without careful planning, there is a significant potential impact on grid-level generation from high levels of distributed generation—including economic impacts, increased ramping requirements, and difficulty maintaining voltages within reasonable levels. The analysis clarified that additional investigation of this issue is necessary. WECC continues to work with the rest of the ERO enterprise to help the industry address the impacts of distributed generation and customer load changes on the system's reliability.

Extreme Natural Events

The West continues to experience extreme natural events, including severe weather, wide-ranging changes in climate, and the lingering effects of the COVID-19 pandemic.

Changing Climate

Climate change is increasing the frequency of extreme weather events—such as heat waves, droughts, flooding, and wildfires. During the past 100 years, the world's surface air temperature has increased an average of 1.1°F each year.[4] Current predictions indicate that this trend will increase without aggressive action to reduce CO_2 levels over the next 75 years. This information has prompted many states, cities, utilities, and companies to act through mechanisms like clean energy commitments. It also affects the ability to plan because historical data is no longer a strong indicator of future weather and climate patterns.

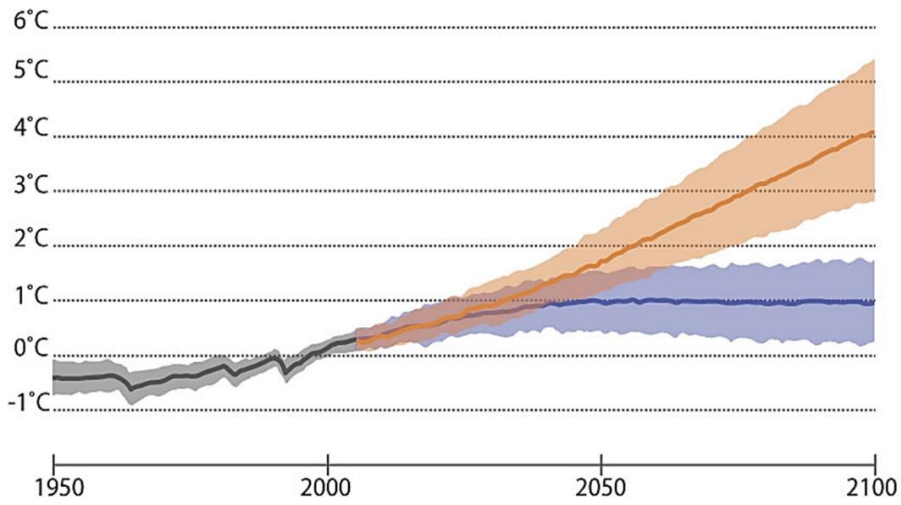

Figure 6: Global Average Surface Temperature Change Projections

Reduction in Predictability

The electric industry relies on historical loads, weather, and generation data to extrapolate future system behavior. This information is a critical input to models that help system planners identify potential reliability concerns. Until recently, predictability has been a leading characteristic of the power system in the West. However, meteorological studies show that historical weather data is no longer a reliable indicator of how the weather will behave in the future.[5] Load, and to an increasing extent, generation, are affected by the weather. Therefore, historical data is becoming less dependable as an indicator of future conditions. Adopting new techniques, like probabilistic modeling, will help

[4] According to global scientists from the Intergovernmental Panel on Climate Change (IPCC). On the chart, the orange shading indicates a future with more greenhouse gas emitted (1,313 pp CO2 by 2100). The blue shading indicates a future with 475 ppm CO_2 by 2100. For more information on the chart, see University Corporation for Atmospheric Research (UCAR).

[5] https://www.science.org/doi/10.1126/sciadv.aay2368 and https://www.popsci.com/story/environment/underestimating-extreme-weather-climate-change/

address the deteriorating predictability by evaluating and planning a broad range of potential scenarios.

Clean Energy Initiatives

In total, at least 90% of the population in the Western Interconnection's footprint is covered by a clean or renewable energy commitment or mandate. Utah and Arizona aim to have 15–20% renewable energy portfolios by 2025, while six other states plan to cut all carbon emissions by 2040 through 2050. Several cities in the West have also adopted clean or renewable energy targets. These cities include large metropolitan areas such as San Diego, Portland, Denver, Los Angeles, and Salt Lake City. In addition to states and cities, eight investor-owned utilities (IOU) in the West have adopted clean-energy targets from 2030 to 2050.

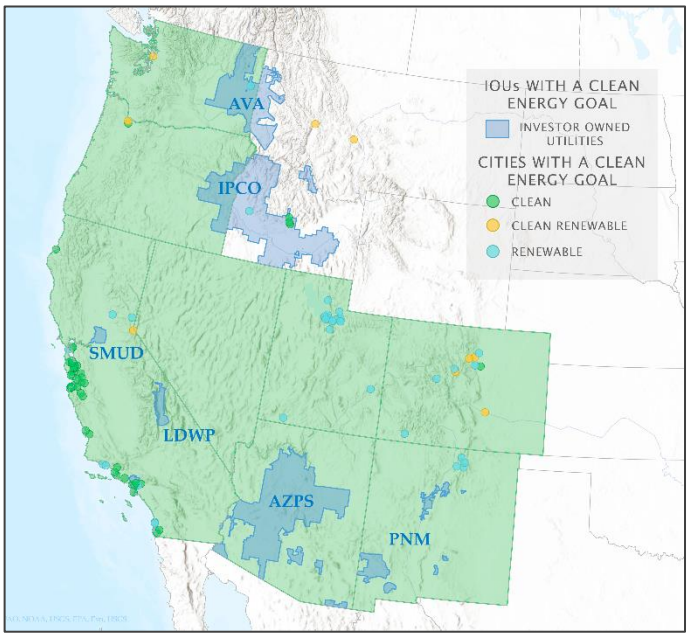

Figure 7: States, large utilities, and cities with renewable or clean energy targets

In its 2040 Clean Energy Sensitivities Assessment, WECC investigated the reliability impacts of increasing the contribution of zero-carbon-emission resources to 80%, 90%, or 100% of the total. The assessment found that, with clean energy levels at 90% or higher, the benefits of adding more clean energy resources greatly diminish. As a result, even with extensive battery storage systems, renewable energy curtailments would increase across all hours of a day.

Heat Waves

Heat waves in the U.S. have increased in frequency, duration, and intensity over the last 60 years. During that time, the length of heat wave seasons tripled from just over 20 days in the 1960s to over 70 days in the 2020s. The Pacific Northwest heat wave from late June to early July 2021 resulted in record-breaking temperatures and over 1,000 deaths. Temperatures as high as 108°F in Seattle and 116°F in Portland resulted in new all-time highs in summer peak demand. The heat caused outages of substation distribution transformers, resulting in some load loss. In July 2022, the Pacific Northwest experienced another heat wave, though not as extreme as 2021.

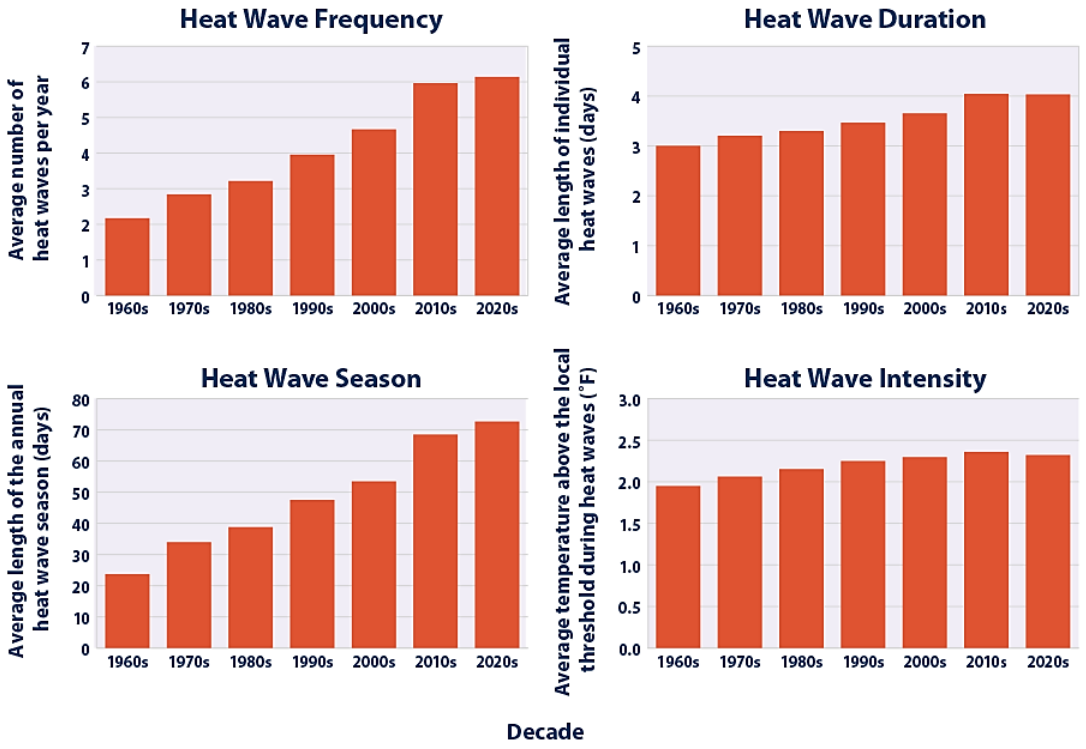

Figure 8: Heat Wave Characteristics by decade 1961-2021 (Source U.S. EPA)[6]

Wildfires

Wildfire activity has increased across most of the West over the last 20 years; however, 2021 was slightly milder than 2020 in terms of the number of fires and acreage burned. In 2021, 25,820 wildfires burned approximately 8.1 million acres in the Western United States, compared to 26,723 wildfires and 9.5 million acres of land in 2020. The number of BES transmission outages initiated by fire in 2021 was comparable to the annual number each year since 2015.

[6] https://www.epa.gov/climate-indicators/climate-change-indicators-heat-waves

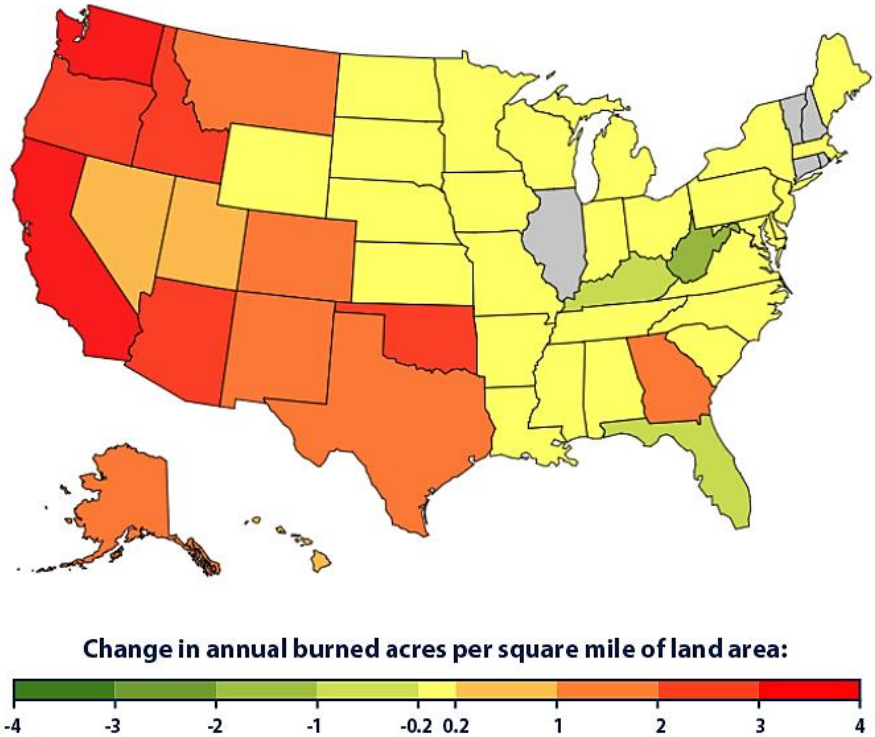

Figure 9: Change in Annual Burn Acreage by State Between 1984-2001 and 2002-2020 (Source U.S. EPA)[7]

In 2021, WECC requested wildfire data from nine WECC entities. The purpose of the request was to collect information on how wildfires affect the reliable operation of the BPS in the Western Interconnection. WECC used the information it collected to map wildfire activity in the West to determine future wildfire risk to the system. The analysis indicates that a wildfire's potential impact on the BPS depends more on its location than its size or severity.[8] In 2022, WECC expanded the data request to an additional 35 transmission operators. WECC shared the information from the survey in its Summer Readiness Workshop. WECC also tracks and shares close-to-real-time wildfire information and potential impacts to the BPS in its Wildfire Dashboard.

Drought

Worsening drought has been a concern for many years. However, in 2021, it crystalized with the announcement that Glen Canyon and Hoover dams, cornerstones of their respective generation fleets, were dangerously close to shutting down due to low water levels. In August 2021, the Bureau of Reclamation declared a water shortage for the lower Colorado River Basin feeding into Lake Mead, the first-ever announcement of its kind.[9] At the end of July 2022, the lake was only 27% full, its lowest since

[7] https://www.epa.gov/climate-indicators/climate-change-indicators-wildfires

[8] See https://www.wecc.org/_layouts/15/WopiFrame.aspx?sourcedoc=/Administrative/Ashbaker-WF%20DR%20Analysis_RRC_June2022.pdf&action=default&DefaultItemOpen=1.

[9] https://abcnews.go.com/US/water-shortage-declared-lake-mead-countrys-largest-reservoir/story?id=79487881

it was filled in 1937. From July 2021 to July of this year, the water level at Hoover Dam has dropped 100 feet to 1,041 feet, which is only 41 feet above the minimum level necessary to continue operating the hydropower turbines.[10]

Upstream from Lake Mead, Lake Powell has also seen reductions in water levels. Lake Powell has declined from approximately 3,554 feet in elevation at the Glen Canyon Dam in July 2021 to its lowest point of 3,522 feet in April 2022.[11] The water level at Glen Canyon Dam must stay above 3,490 feet to operate the turbines. In May, the Bureau of Reclamation announced it would reduce the amount of water released and increase the amount of water feeding into Lake Powell to ensure there is enough water to continue operating the Glen Canyon hydro plant.[12] While less water will flow downstream to Lake Mead, as of July 2022, these measures helped water levels rise at Glen Canyon Dam by around 15 feet.

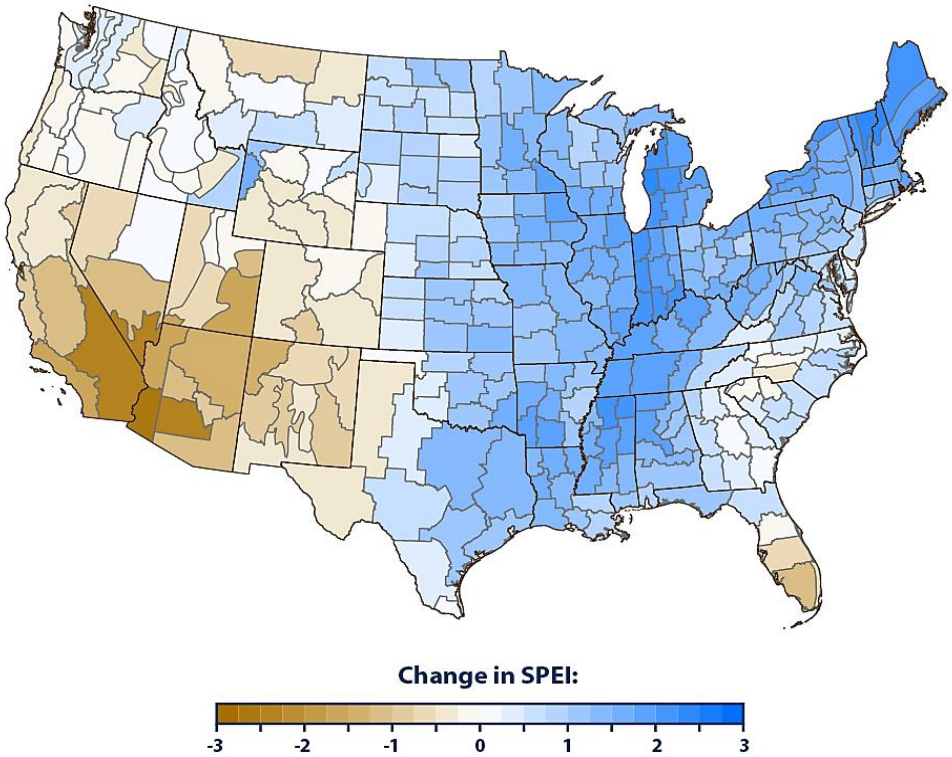

Figure 10: Average Change in Drought (5-Year SPEI) in the U.S. 1900-2020 (Source U.S. EPA)[13]

WECC examined the reliability impacts of a simultaneous drought, heat wave, and wildfire in the Western Interconnection through its Extreme Natural Event Study. The assessment found that the

[10] https://www.nytimes.com/2022/07/22/climate/lake-mead-level-pictures.html
[11] http://lakepowell.water-data.com/index2.php?as_of=2022-07-28
[12] https://www.usbr.gov/uc/water/crsp/cs/gcd.html
[13] This map shows the change in Standardized Precipitation Evapotranspiration Index (SPEI) https://www.epa.gov/climate-indicators/climate-change-indicators-drought.

system frequency did not drop below the standard underfrequency load shedding (UFLS) thresholds during the simulated extreme event and the system remained stable. Further, although many regions experienced unserved energy in the simulated event, unserved energy was minimal for the loads modeled in WECC's 2030 Anchor Data Set. However, it was more extreme when loads increased to lower probability but higher demand levels.

COVID-19

During the pandemic, the West learned how to mitigate the impacts of a reduced and largely remote workforce on the industry. Entities have successfully implemented measures to protect critical operations. However, the industry must now deal with the pandemic's economic, workforce, supply chain, and other indirect impacts. The pre-existing concerns over workforce retirements have been exacerbated as the electric industry, like other sectors, learns to deal with the "great resignation." In addition, lingering supply chain issues threaten the critical build-out of resources, particularly the solar resources that some entities are relying on to meet clean energy targets. The COVID-19 pandemic also showed that these kinds of outbreaks threaten our ability to operate the system because they create altered load characteristics.

Seismic Activity

Over the last 18 months, no seismic activity in the West has disrupted power system operations. However, the West has two major seismic zones capable of producing potentially catastrophic, high-impact, low-frequency events. The seismic activity impact on the BPS in these areas could put system reliability at risk.

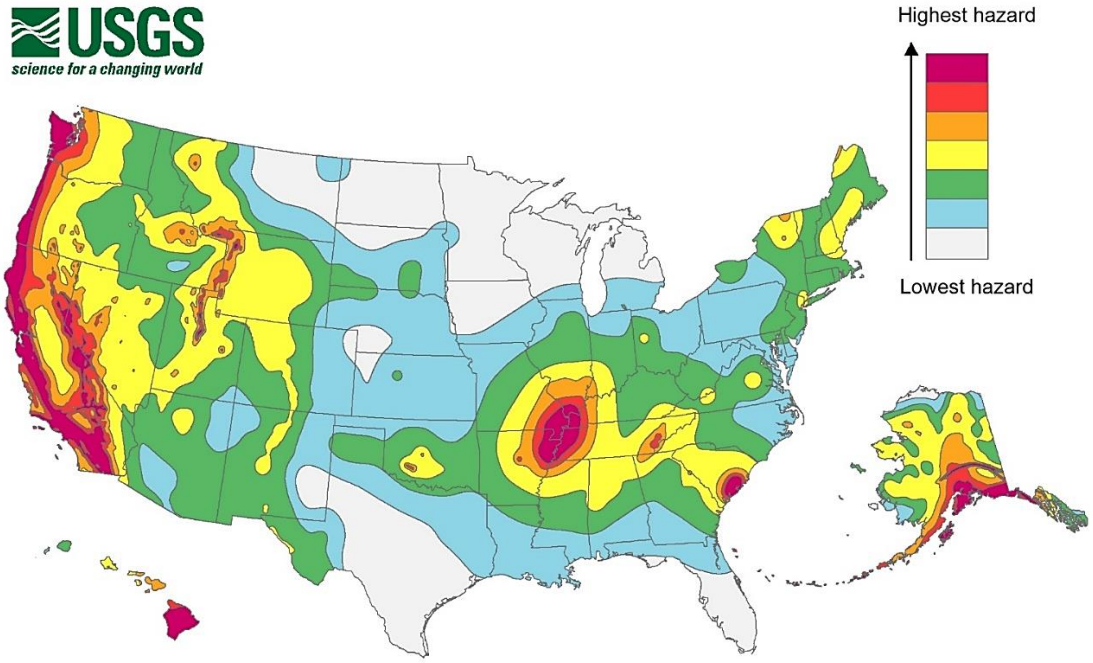

Figure 11: 2018 Long-Term National Seismic Hazard Map[14]

WECC works to study the potential short-term and long-term impacts of extreme weather and drought. Through its outreach efforts, WECC works with stakeholders to share information and best practices on various issues—including wildfires, summer and winter preparedness, and resource adequacy.

Cybersecurity

Cyberattacks are difficult to record and track, due in part to the clandestine nature of an attack and in part to the sensitivity of releasing information about attacks. While the numbers vary depending on the source, the number of cyberattacks has increased across all sectors over recent years. One source estimates that, from 2020 to 2021, weekly attacks on North American companies across all sectors increased 61% to around 500 attacks per week.[15]

In 2021, the Western Interconnection had no reportable cybersecurity incidents (incidents that directly affect reliability). However, WECC did receive three reports of cybersecurity events in 2021 that did not directly affect reliability. The events were isolated to each organization's corporate networks, and none of the events disrupted the BPS's reliability.

[14] https://www.usgs.gov/media/images/2018-long-term-national-seismic-hazard-map
[15] See https://blog.checkpoint.com/2022/01/10/check-point-research-cyber-attacks-increased-50-year-over-year/.

The actual reliability impacts of cybersecurity events in the West have been negligible; however, the nature of cybersecurity threats means that the potential impact of a cyberattack is still a significant concern. Therefore, cybersecurity continues to be a top-priority risk for WECC's stakeholders and Board of Directors, demonstrated by its inclusion in the 2022 Reliability Risk Priorities. WECC investigates and tracks cyber events in the West—in partnership with national efforts coordinated by the Electricity Information Sharing and Analysis Center (E-ISAC). WECC follows up with the industry on cyber events to identify and develop lessons learned. In addition, WECC participates in and supports two E-ISAC preparation and training initiatives. In November 2021, WECC participated in GridEx VI, a grid security exercise to test response and recovery plans in the face of simulated, coordinated cyber and physical attacks to the North American BPS.[16] WECC also supports and participates in E-ISAC's Annual Security Conference, GridSecCon.

Going forward, WECC will continue to focus on several activities to help strengthen cybersecurity, including:

- Focusing WECC's compliance monitoring strategy on how well entity controls mitigate risk;
- Holding assurance visits with entities to discuss cybersecurity practices;
- Hosting a Security Conference and Training; and
- Promoting and supporting the resources and work of the E-ISAC.

Conclusion

During 2021 and the first half of 2022, the West continued to confront risks to reliability and security—including heat waves, worsening droughts, and cyber events. Despite these challenges, the Western Interconnection has remained largely reliable. However, trends indicate that the occurrence and potential effects of these heightened risks will continue and, in some cases, worsen. If these challenges are not aggressively addressed now, they may erode the system's reliability, security, and resiliency in the future.

WECC is seeking your input on the State of the Interconnection (SOTI) report. Currently, the SOTI comprises two parts: an online historical data portal and a written report that shares the high-level takeaways of historical information contained in the online portal. WECC is reimagining the SOTI to help make the report and dashboard more useful and relevant to stakeholders. To that end, WECC is reinventing the SOTI report, expanding it to cover current events, reliability and security risks, and key performance indicators. The goal is to create an annual digest highlighting the previous year and outlining challenges and opportunities ahead. We would appreciate further input in scoping the new report. Please take a few minutes to complete this online survey.

[16] See https://www.nerc.com/pa/CI/ESISAC/Pages/GridEx.aspx.