

WECC Trends Analysis and Early Indicators Report

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EXECUTIVE SUMMARY

The Trends Analysis and Early Indicators Report (the Trends Report) by the Quantum Planning Group (QPG) covers events, studies, reports, and research from the Third Quarter of 2021 (3Q21). The report is produced for WECC and the Scenarios Work Group (SWG), and it is distributed widely to WECC staff and its Stakeholders. Trends Reports provide insight into current events and longer term trends and their implications for WECC and its stakeholders within the Western Interconnection. QPG utilizes WECC's EPS—Events, Pattern, and Structure—tracking system to prepare the Trends Reports. Our analysis also considers and builds on learnings from past Trends Reports, which are [here](#). The overall time frame for this report is the current day through 20 years in the future. Thus, it considers events that could lead to the emergence of industry-level impactful events and reliability risks at any point within the 0-20-year planning horizon. This report is organized around three sections:

1. WECC 2020 Reliability Risk Priorities - we look at each risk area, and note the short, medium, and long-term risk levels as of October 7, 2021. We discuss recent events and trends that may impact each risk area.
2. Challenges of Achieving a 100% Renewables Power System in the US – The National Renewables Laboratory (NREL) and the Department of Energy (DOE) of June 16, 2021
3. Broader Trends, Uncertainties, and Wild Cards - Other events in the first quarter that have a broader impact beyond the reliability risks fall into six areas.

Report Highlights

WECC Reliability Risk Priorities

By their very definitions, the four reliability risks will play out over a long time as they deal with ongoing structural changes in the Bulk Power System (BPS) and the Distributed Power System (DPS), changing consumer choices, and climate change-driven events. *Therefore, the long-term view plays a continuing critical role in WECC's planning processes.*

We cannot know whether any electric power system plans and actions will come to fruition—we fully expect them to change over time—or whether they will effectively eliminate, moderate, or mitigate reliability risks over the next 20 years. It is entirely in WECC's purview to test, analyze, and gauge the impacts to risks of those plans. *Therefore, we did not assume any medium or long term actions that will affect the risks one way or another.*

Resource Adequacy & Performance: Short-term Risk Level is **MODERATE** trending to **HIGH** and trending **Severe** in the **Medium to Long term**. While risk in this area is largely driven by the interplay of the other Risk Priorities as discussed below, there is an area that may provide a more direct threat and could drive increasing risk levels over the medium to long term: uncoordinated transmission planning and expansion in the 10-20 year timeframe. Cyberthreats remain a high risk to the electric power system.

Changing Resource Mix: Short-Term Risk Level is **MODERATE** trending to **HIGH** and elevated to **SEVERE** in the **long term**. We have elevated this priority's long term risk due to a continuing uncoordinated drive towards 100% renewables/clean energy futures, both nationally and within the Western Interconnection. Additionally, we are now seeing new analyses and study reports shedding light on the challenges associated with achieving a 100% clean energy future in the US.

Distribution System and Customer Load: Short-Term Risk Level is **LOW** trending to **MODERATE to HIGH** in the **Medium term**, and **SEVERE** in the **Long term**. As noted in recent study reports, the DPS will see significant changes in the next 20 years, seeing more renewable resources added. As it takes on roles previously served by the BPS, more distribution lines will be needed and existing lines upgraded. There are ongoing uncertainties in just how customer load will change with high levels of electrification, especially with high EV adoption, and how the changes affect the DPS and BPS. As these changes play out, the need to integrate the BPS and DPS will become acute.

Extreme Natural Events: Short-Term Risk Level is **HIGH** with a clear trend towards **SEVERE** in the Medium and Long term. This past summer saw the increasing effects of global warming and climate change as the Western Drought and wildfire events accelerated across the Western Interconnection, and hydropower has declined. In a stark new report, a team of National Oceanic and Atmospheric Administration (NOAA) and independent researchers found the drought across the Southwest is the worst in the instrumental record, which dates to 1895. Our updated Table of Reliability Risk Priorities and expanded discussion begins on page 6.

Challenges of Achieving a 100% Renewables Power System in the US

The Scenario Work Group of WECC is currently involved in assessing study cases to generate a greater understanding of the reliability risks and impacts of a 100% renewable BPS in the Western Interconnection.

Of particular interest to the SWG, WECC Staff, and stakeholders, new studies were completed by the National Renewable Energy Laboratory (NREL) on June 16, 2021. The studies offer essential insights into the technical and economic challenges that need to be overcome to achieve 100% renewable electric power across the United States. Of note: the studies are also finding the same issues as the SWG studies, namely, both reliability and market issues in balancing supply and demand and the need for a yet to be developed or even undiscovered flexible clean energy source. For more details, see page 11.

Broader Trends & Uncertainties

Pandemics, the economy, national policy, and sometimes state and provincial policies are influenced by global and international events, especially over the long term—the Trends Reports' focus. These issues can impact reliability issues in the Western Interconnection via their influence on economic growth, technology innovation and adoption, and policy formation at the national, state, and provincial levels. Those influences may play out over time, and thus readers need to be in a mode of learning, curiosity, and imagining. For more details on these events and how they may impact the Western Interconnection, the power system, and BPS reliability, please see the report section beginning on page 12.

The Coronavirus Pandemic - The Pandemic is a long way from being over. Despite the fast development of highly effective mRNA vaccines and governments' vaccination efforts, it's still a race between vaccination rates and infections, new Covid-19 variants, and new vaccines or booster shots. So far, we are losing that race. New confirmed cases of Covid-19 remain high in the US, and vaccination rates are still unequal across the states and well below what is needed to control the virus. Hospital ICU beds are full, and hospitals are turning away patients with other acute conditions. Some good news, as of October 4, 2021, new daily reported cases are down 9.6%, and deaths are down 4.5%. At least 43,639,012 cases and 701,988 deaths (more than the Spanish Flu pandemic in 1918-1919) have been reported in the US since February 29, 2020.

The Economy - On the economic front, North American and global economies continue to slow in the face of the surge of the Delta Covid-19 variant and supply chain breakdowns. Forecasters are downgrading their growth forecasts for 2021 and the first half of 2022. We see price spikes as pent-up demand still outpaces supply. Supply chains across the globe are broken due to a shortage of goods and shipping containers combined with new Covid restrictions at ports and in manufacturing. China has a new issue—electricity supplies are running low, and factories and cities have lost or have had power cut back—manufacturing has slowed dramatically. A significant amount of equipment used in the US power system is manufactured in Asia and Europe. Supply chain and manufacturing slowdowns may cause delayed BPS and DPS plant, equipment, transmission maintenance and repairs, and new projects.

Climate Change - Climate change accelerates and becomes more widespread, as detailed in a new report from the United Nations Intergovernmental Panel on Climate Change (IPCC). The report updates current data and validates findings of new and improved modeling techniques. The most critical finding is that climate scientists reached an "unequivocal" consensus on human-made warming. The report makes clear that the planet will warm by 1.5° Celsius in the next two decades without drastic moves to eliminate greenhouse gas pollution. It also notes that methane emissions are a leading contributor to global warming. Additional warming would be expected to accentuate extreme natural events, one of WECC's current Reliability Risk Priorities.

Wild Cards

For more details on these events and how they may impact the Western Interconnection, the power system, and BPS reliability, please see the report section beginning on page 16.

Financial Systems and Cryptocurrencies – Since our last report, additional developments in this space warrant a more heightened sense of awareness. The developments include a closing off of the entire Chinese economy from Bitcoin and cryptocurrency-related transactions by the Chinese central government, swings in cryptocurrency market values, and movement by the U.S. Treasury Department to consider speedier regulation of cryptocurrencies, including regulation of some forms as investment securities.

The Chinese Banking System - At the time of this report, the full extent of the financial crisis at the Evergrande Corporation in China is unfolding. The Company is defaulting on loan payments and payments to suppliers in its far-flung operations (reported to exceed \$300 billion). The Chinese national government and banking authorities seem to want to let the Company fail to some degree to warn against future debt-related corporate development in China. How these events may affect China’s and global economies is only speculation at this time, and we will continue to watch this unfolding situation.

The power industry is a capital-intensive industry and is thus sensitive to national and global developments in capital markets. In the past, China’s banking and financial system problems have rippled across the globe, causing tightening in capital markets and increased interest rates—which can limit funds available for power system infrastructure projects and slow economic growth. Cryptocurrencies and how they fit or do not fit into the traditional global financial system add another additional factor into the mix and increases uncertainty.

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INTRODUCTION

The Trends Analysis and Early Indicators Report (the Trends Report) by the Quantum Planning Group (QPG) covers events, studies, reports, and research from the Third Quarter of 2021 (3Q21). The report is produced for WECC and the Scenarios Work Group (SWG), and it is distributed widely to WECC staff and its Stakeholders. The report serves as a vehicle to create conversation and learning among SWG members and WECC staff that might guide future scenario work, study case analyses, and assessment of short and long term risks to BPS reliability in the Western Interconnection. How, why, and where factors emerge that may impact the power system's future cannot be predicted. As we have recently witnessed, a pandemic and the economic recession it caused, while generally acknowledged could happen in the future, could not have been predicted for 2019. Therefore, this report touches on many areas where future events may emerge with potential short and long term impacts.

Trends Reports provide insight into current events and trends and their implications for WECC and its stakeholders within the Western Interconnection. QPG utilizes WECC's EPS—Events, Pattern, and Structure—tracking system to prepare the Trends Reports. The EPS tracking system serves as a portal for WECC staff and stakeholders to submit and classify current events related to the Western Interconnection and WECC scenarios' energy futures. All EPS can be viewed and searched, and WECC members and WECC Staff can submit their EPS [here](#). Our analysis also considers and builds on learnings from past Trends Reports, which are [here](#). The overall time frame for this report is the current day through 20 years in the future. Thus, it considers events that could lead to industry-level impactful events and reliability risks at any point within the 0-20-year planning horizon.

This report is organized around three sections.

1. WECC 2020 Reliability Risk Priorities - we look at each risk area, and note the short, medium, and long term risk levels as of July 7, 2021. We discuss recent events and trends that may impact each risk area.
 - a. Resource Adequacy & Performance
 - b. Changing Resource Mix
 - c. Distribution System & Customer Load Impacts
 - d. Extreme Natural Events
2. Challenges of Achieving a 100% Renewables Power System in the US – The National Renewables Laboratory (NREL) and the Department of Energy (DOE) reports of June 16, 2021
3. Broader Trends, Uncertainties, and Wild Cards - Other events in the first quarter that have a broader impact beyond the reliability risks fall into five areas.
 - a. The Pandemic
 - b. The Economy
 - c. Climate Change
 - d. Wild Cards
 - i. Financial Systems and Cryptocurrencies Update
 - ii. The Chinese Banking System

We think direct reporting of the source articles is essential for the reader's learning from the Trends Reports. Therefore, the report text will include excerpts taken directly from the EPS or referenced article text, along with QPG's commentary—this is particularly important, as current events are moving quickly.

Because of the wide diversity and interests of the readership and how the reader elects to read the report—printed or screen viewed—we have erred on the side of more detail rather than less in the excerpted text.

WECC RELIABILITY RISK PRIORITIES

We described the [WECC Reliability Risk Priorities](#) and their impacts on the Bulk Power System (BPS) and the work that led to their creation in the [First Quarter Trends Report](#). We also noted that by their very definitions, the four reliability risks priorities (RRPs) would play out over a long time since they deal with ongoing structural changes in the BPS and DPS, changing consumer choices, and climate change-driven events. *Therefore, the long-term view plays a critical role in WECC's planning processes.*

We cannot know whether any plans and actions by states and provinces, utility IRPs, Balancing Areas projections, etc., will come to fruition—we fully expect them to change over time—or whether they will effectively eliminate, moderate, or mitigate reliability risks over the next 20 years. It is entirely in WECC's purview to test, analyze, and gauge the impacts to risks of those plans.

Therefore, we did not assume any medium- or long-term actions that will affect the risks one way or another. For that, we invite a continuing dialogue within WECC, its committees, subcommittees, working groups, and its stakeholders. In each Reliability Risk Priority discussed below, we note where WECC might consider establishing new Working Groups or Forums for better assessing and understanding potential medium and long term risks. We present our view of reliability risks as a way to stimulate such a dialogue.

In light of the risks playing out over time, we chose to consider the risk categories in three time periods: a Short term of now to 4 years out into the future, a Medium term of 5-10 years, and in the Long term, 10-20 years (2031-2041). While we report on them, analyzing the various plans and actions by states and provinces, utility IRPs, Balancing Area projections, etc., is beyond the scope of Quantum's brief in the Trends Report.

Six key developments drove this quarter's update to our view of the Reliability Risk Priorities since the last report:

1. New DOE/NREL and third party studies analyzing the challenges of achieving a 100% Renewable grid
2. Preliminary results from WECC 2021 Study Program in both Year 10 and Year 20 studies
3. Release and analysis of the UN IPCC Report: *Climate Change 2021 – the Physical Science Basis*
4. Impacts of the Western Drought
5. New studies on transmission planning and expansion needs for high renewables and electrification penetration in the medium and long term
6. Continuing issues of Cybersecurity and Cyberthreats

Considering these developments and others noted in this report, Table 1 below summarizes our updated high-level view from now until 2041 of the Reliability Risk Priorities.

Table 1, WECC Reliability Risk Priorities Trends and Summary Overview, *Source: Quantum Planning, October 7, 2021*

WECC Reliability Risk Priorities: Summary Overview				
RISK KEY: LOW MODERATE HIGH SEVERE				
Reliability Risk Priority	Short Term: Now-4 yrs.	Medium Term: 5-10 yrs.	Long Term: 10-20 yrs.	Comments *
Resource Adequacy & Performance	Risk is largely dependent on the interplay of the other risk priorities and will follow their trajectory	As more DPS/DER/BTM resources and transmission come online, missing and incomplete data will compromise modeling and planning Extreme natural events will have increasing impacts Uncoordinated transmission planning is an emerging risk The evolution of cyberthreats remains a high risk to the electric power system		<ul style="list-style-type: none"> • More long-term coordinated planning across the Interconnection may reduce, mitigate, or avoid risk • More complete and accurate data for DPS/DER/BTM resources can reduce risk but must be addressed in the short- term with integrated modeling tools • DER and BTM operating plans and data must be visible to each other, and modeling tools must include an integrated BPS/DPS power system • Extreme natural events are accelerating
Changing Resource Mix	The pace of change is increasing due to pressures to address climate change and the push towards renewables	The pace of uncoordinated change and mix begins to outpace planning and system adjustments The ability of system planning and system operating adjustments to keep pace with the rate of change and mix is critical in avoiding severe risk		<ul style="list-style-type: none"> • Pace of change is uncoordinated across the Interconnection, driven by economics, the push towards clean energy, and policy/regulation to address climate change • Risk is driven by slow actions to modernize the grid and optimize planning across the Interconnection
Distribution System & Customer Load Impacts	The pace of change is increasing, and new system modeling tools and data are needed to model a future integrated BPS/DPS power system	The pace of change and mix begins to outpace planning, operating adjustments, and system modeling tools	The pace of change and mix could overwhelm the pace of system planning, integration actions, and operating adjustments	<ul style="list-style-type: none"> • The distribution system will see the most diverse and significant changes due to push towards increased electrification, increased adoption of electric vehicles, state and local pushes to address climate change, and moves towards renewables, with corresponding load increases • The DPS could have more impacts on the BPS than any other risk factor other than Extreme Natural Events
Extreme Natural Events	Heat and droughts are intensifying, wildfire seasons beginning much earlier - Hydropower already being negatively impacted	Occurrence of events spread and intensify Clusters of mixed events within and across Interconnection state and provincial regions become more common	Extreme events-many clustered- are widespread across the Interconnection Impacts from events in adjacent northern and eastern interconnections are common	<ul style="list-style-type: none"> * Primary drivers: Climate change and warming accelerating * Increasing warming – both in temperature and number of areas affected - in the Western Interconnection * Widespread precipitation pattern changes * No short, medium, or long term actions can prevent significant increases in events and intensity in the 20-year timeframe

* This table summarizes observations, issues, and potential actions related to WECC’s Reliability Risk Priorities. Expanded discussions are in the report sections that follow.

Resource Adequacy & Performance: Short-term Risk Level is **MODERATE** trending to **HIGH** and trending **Severe** in the Medium to Long term. While risk in this area is largely driven by the interplay of the other Risk Priorities as discussed below, there is an area that may provide a more direct threat and could drive increasing risk levels over the medium to long-term: uncoordinated transmission planning and expansion. Cyberthreats remain a high risk to the electric power system.

Transmission - WECC does not provide transmission planning (including siting) for the Western Interconnection. However, we think that uncoordinated regional transmission planning and expansion—in the face of the changing resource mix, significant changes in the DPS, and the continuing push to clean energy futures by local, state, and provincial governments—is an emerging risk to the BPS. To date, most studies looking at clean energy futures have focused on resources and not on the infrastructure, transmission, and distribution needed to get the resulting electricity to where it is needed. We think that ongoing awareness and assessment—perhaps through a Work Group or Forum— of short, medium, and long-term transmission planning and expansion would provide WECC and its stakeholders a better understanding of this emerging risk. References and additional information:

- EPS: [\\$1 trillion infrastructure bill is a baby step toward the US grid we need](#)
- EPS: [Gridlock in transmission queues spotlights need for FERC action on planning](#)
- Study: Princeton University: [Net Zero America – Potential Pathways, Infrastructure, and Impacts](#)
- Study: National Academies of Science Study: [The Future of Electric Power in the United States \(2021\)](#), Chapters 2 and 3

Cybersecurity and Cyberthreats - While not part of the WECC Reliability Risk Priorities, cyberattacks are a known and significant risk to the BPS, the DPS, and Behind the Meter (BTM) resources and systems across the US electric power system and other critical infrastructure. WECC's understanding of cyber events and the associated issues and risks is critical to ensure BPS reliability. Therefore, WECC has programs that address the security of its internal systems and works with NERC to address the increasing threats of cyberattacks within the Western Interconnection.¹ A recent survey of industry executives shows that those in the energy and utility sectors consider those industry sectors the most exposed to cyberthreats. This view is echoed by FERC Chair Richard Glick, who noted in remarks to the US House Subcommittee on Energy that "*There's no doubt that ... the biggest threat facing the electric grid today is cybersecurity,*"

The US Department of Homeland Security Threat Assessment for 2021 notes that "*Cyber threats from nation-states and their surrogates will remain acute. Foreign states use cyber operations to steal information, influence populations, and damage industry, including physical and digital critical infrastructure. Although an increasing number of countries and non-state actors have these capabilities, we remain most concerned about Russia, China, Iran, and North Korea. Many skilled foreign cybercriminals targeting the United States maintain mutually beneficial relationships with these and other countries that offer them safe haven or benefit from their activity.*" In future Trends Reports, events related to cybersecurity and cyberthreats are noted in this report section. References and additional information:

- EPS: [FERC Chair Notes Cybersecurity the biggest threat facing the electric grid today](#)
- Report: US Department of Homeland Security 2021 [Annual Threat Assessment, April 9 2021](#), page 20
- Study Report: National Academies of Science Study: [The Future of Electric Power in the United States \(2021\)](#), Chapter 6
- EPS: [Energy, utility sectors feel 'most exposed' to cybersecurity threats](#)
- EPS: [Biden administration expands cybersecurity initiative](#)
- EPS: [Biden orders voluntary cybersecurity performance goals for electric utilities, other critical sectors](#)

¹ For WECC's work in the cyber security area, see the [Cyber Security Work Group](#) and [Situational Awareness and Security Monitoring Subcommittee](#)

- EPS: [China Breached Dozens of Pipeline Companies in Past Decade](#)

Changing Resource Mix: Short-Term Risk Level is MODERATE trending to HIGH and elevated to SEVERE in the Long term. We have elevated the long-term risk in this priority due to a continuing uncoordinated drive towards 100% renewables/clean energy futures, both nationally and within the Western Interconnection. Additionally, we are now seeing new analyses and study reports shedding light on the challenges associated with achieving a 100% clean energy future in the US. (A discussion of these challenges starts on page 11.)

Validating the preliminary findings of the Scenarios Work Group's Year 20 study (100% Renewable BPS by 2040), the new studies show a need for additional technology advances in flexible renewable resources for baseload resource replacement in the long term. For two of these potential resource types—hydrogen and advanced nuclear—new studies show they may not be developed to a point to fill baseload gaps by 2040.

New concerns are being raised more frequently about the costs of recycling and disposal of renewable resource components, including solar PV panels, battery storage, and wind turbines parts. In the next ten years, and certainly by 2040, many solar PV panels, batteries, and wind turbines will reach their effective life and need replacing. The recycling processes are new, complicated by the hazardous materials used in the components, and no understanding of the costs involved. We are unaware that renewable component recycling and disposal costs over time are included in capital and long-term lifecycle costs projections.

References and additional information:

- EPS: [The Biden administration announced a goal of producing 45% of US electricity from solar by 2050.](#)
- EPS: [LA approves 100% clean energy by 2035 target](#)
- EPS: [Oregon commits to 100 percent clean electricity by 2040](#)
- EPS: [California's curtailments of solar electricity generation continue to increase](#)
- EPS: [The BPS remains reliable, yet key metric suggests worrying trend](#)
- EPS: [California: Growing storage fleet beginning to impact energy markets as envisioned](#)
- EPS: [Nuclear reactors of the future have a fuel problem](#)
- EPS: [For Many, Hydrogen Is the Fuel of the Future. New Research Raises Doubts.](#)
- EPS: [Recycling Renewable Energy Component, An Impending Roadblock?](#)
- EPS: [U.S. begins detaining solar panel imports over concerns about forced labor in China](#)
- EPS: [The solar industry has a supply problem](#)

Distribution System and Customer Load: Short-Term Risk Level is LOW trending to MODERATE to HIGH in the Medium term, and SEVERE in the Long term. As noted in recent study reports, the DPS will see significant changes in the next 20 years, seeing more renewable resources added. As it takes on roles previously served by the BPS, more distribution lines will be needed and existing lines upgraded. There are ongoing uncertainties in just how customer load will change with high levels of electrification, especially with high EV adoption, how customers may manage BTM generation and storage systems individually and collectively, and how the changes may affect the DPS and BPS. As these changes play out, the need to integrate the BPS and DPS will become acute.

As we move toward 2040, one of the most pressing needs is the ability of BPS planners and operators to see and model the DPS integrated into the BPS. Currently, modeling tools used within the BPS cannot integrate DPS data and needed DPS data is missing, incomplete, or is not accurate. WECC Year 20 studies (and Year 10 studies to a lesser degree) have been significantly limited by these deficiencies, preventing an integrated power system model and a clear picture of potential reliability issues. While not responsible for DPS reliability or planning, WECC must understand the effects of future changes in the DPS on BPS reliability. We think that ongoing awareness and assessment—perhaps through a Work Group or Forum—of changes in the DPS and BTM would provide WECC and its stakeholders a better understanding of this emerging risk.

References and additional information:

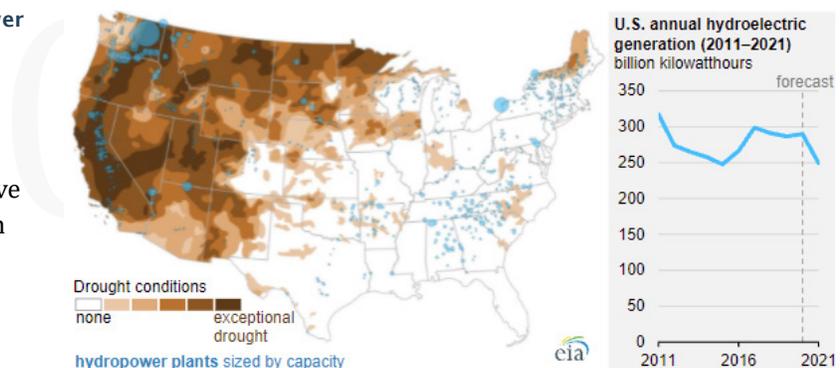
- EPS: [Reimagining the Distribution System](#)
- Article: [The Cost of Upgrading Electric Distribution - AAF \(americanactionforum.org\)](#)
- Article: [EV Impact: Rise of electric vehicles heightens grid-integration imperative](#), S&P Global, September 23, 2021
- EPS: [California PUC unveils draft plan for 'forward-thinking' distributed energy policy](#)
- EPS: [Residential electric panels represent a nearly \\$100B 'roadblock' to full electrification](#),
- EPS: [Biden Wants More EVs and Stronger Auto Emissions Rules](#)
- EPS: [Major Auto Manufacturers Make Long Term Commitment to EV Transition](#)

Extreme Natural Events: Short-Term Risk Level is HIGH with a clear trend towards SEVERE in the Medium and Long term. This past summer saw the increasing effects of global warming and climate change as the Western Drought and wildfire events accelerated across the Western Interconnection. In a stark new report, a team of NOAA and independent researchers found the drought across the Southwest is the worst in the instrumental record, which dates to 1895. NOAA also concluded that global warming is making it far more severe, primarily by increasing average temperatures, boosting evaporation. The drought is occurring in the context of the [first climate change-induced "megadrought,"](#) which research shows began in 2000 and is exceptional on millennial timescales. The drought is affecting hydropower production across the Western Interconnection.

On September 23, 2021, the US Energy Information Administration (EIA) forecast that electricity generation from US hydropower plants will be 14% lower in 2021 than in 2020. The report includes data on specific states in the Western Interconnection.

Figure 1, US Drought and Hydropower Capacity as of September 9, 2021,
Source: US EIA and US Drought Monitor

The report noted, “Extreme and exceptional drought conditions have been affecting much of the western United States, especially California and states in the Pacific Northwest, home to the majority of US hydropower capacity.”



There are no indicators so far that show the drought easing. Expect further decreases in hydropower across the region in 2022, wildfire seasons to start earlier and end later in the year.

Wildfires and other extreme natural events are no longer singular and isolated. Wildfires occurred and expanded across the region in 2021, with many occurring simultaneously (e.g., Oregon, California, Arizona, and Nevada). Expect more clustering of extreme natural events in the future, and more of them, as climate change continues to accelerate. In considering BPS reliability risk impacts, WECC might consider changing how it looks at extreme natural events.

Looking at clusters of events occurring simultaneously across more of the region should provide a better understanding of potential risk to the BPS than modeling singular past-based events. At the same time, shorter and intermediate time frames may be considered since nature doesn't follow WECC's 10 and 20-year planning timelines. Indeed, WECC may want to think about doing ongoing mixed event studies in the short term instead of singular event studies in Year 10. A focused Work Group or Forum to support both short and long-term study would be beneficial. A broader discussion on climate change and implications for WECC planning starts on page 14. References and additional information:

- EPS: [Western Drought Update: Worst on Record](#)
- EPS: [Drought shrinking California hydro, increasing reliance on thermal, imports](#)

- Article: [EIA expects U.S. hydropower generation to decline 14% in 2021 amid drought](#), Today in Energy, US Energy Information Administration (EIA),
- EPS: [Warmer Arctic led to killer cold in Texas, much of US](#)
- EPS: [First-ever water shortage declared on the Colorado River](#)
- EPS: [Western Drought Impact Colorado River and States that Depend on it](#)
- EPS: [NYPA Launches First Study to Assess Potential Impact of Climate Change on Its Operations](#)

CHALLENGES OF ACHIEVING A 100% RENEWABLE US POWER SYSTEM

The Scenario Work Group of WECC is currently involved in assessing study cases to generate a greater understanding of the reliability risks and impacts of a 100% renewable BPS in the Western Interconnection. The cases and analysis are aimed explicitly at Nine scenarios will be created and studied around variations to three primary themes within a 100% renewable bulk power system (BPS) future:

1. Will it be possible to assure the reliability of the BPS with the penetration of renewable resources reaching levels at or above 80% to 100%?
2. How might the distributed power system (DPS) evolve under these scenarios, how integrated might it be with the BPS, and what will be the impacts on BPS reliability?
3. How might market and regulatory forces evolve under these scenarios, and what will be the impacts on BPS reliability?

As the WECC work has progressed, other national entities and electric power-related labs and organizations have been pondering very similar questions, especially around how to replace all fossil-fueled generation (coal and natural gas generation) with cleaner and zero-emissions sources of power (renewables). Importantly, in May of this year, a team of 17 power systems experts from the US Department of Energy's (DOE's) National Renewable Energy Laboratory (NREL) and DOE's Office of Energy Efficiency and Renewable Energy (EERE) is chiming in with a fresh take on the issues involved.

The two studies, "[The Challenges of Achieving a 100% Renewable Electricity System in the United States](#)" and "[Quantifying the challenge of reaching a 100% renewable energy power system for the United States](#)," were published in the journal *Joule*. The studies offer essential insights into the technical and economic challenges that would need to be overcome to achieve 100% renewable electric power across the United States. EERE's Office of Strategic Analysis funded the research.

The studies evaluate pathways and technical challenges and quantify the costs of transitioning to a 100% renewable energy (RE) power system for the contiguous United States. That cost depends on future system conditions (e.g., low versus high RE costs), the definition of the 100% requirement (e.g., whether the requirement applies to end-use demand or total generation), and the time frame for reaching 100%. Under base case conditions, the least-cost buildout has RE penetration reaching 57% in 2050 with average levelized costs of \$30/MWh. Requiring penetration of 100% by 2050 raises these costs by an additional \$10/MWh (29%). Incremental costs increase nonlinearly for the last few percent to 100% RE. The scenarios examined improve the understanding of the implications of transitioning to higher penetrations of renewable energy.

The US power sector's significant reduction of greenhouse gas emissions from electricity generation over the past 15 years is an indication of what bolder efforts can be achieved by other economic sectors. Researchers, power system analysts, utilities, and the business sector agree that achieving economy-wide net-zero carbon emissions come with costs, challenges, and uncertainties.

[According to a Department of Energy \(DOE\), April 2021 study](#): CO2 emissions from electricity generation in 2020 were about half the projections made in 2005 and 40% below actual 2005 levels. Other studies and private sector observers say that reaching economy-wide net-zero emissions (NZE) by 2050 will also require a transition to electrification in other industry sectors. Transportation, buildings, and other industrial sectors will require clean energy, developed and applied at unprecedented scale and speed, with support from still-unproven or even undiscovered technologies to eliminate or offset all CO2,

The report summary below puts forth the two key issues that the early work of the WECC Scenario study cases is also finding: market issues in balancing supply and demand and the need for a yet to be discovered flexible clean energy source.²

Understanding the technical and economic challenges of achieving a 100% renewable energy (RE) electric power system is critical, given the increasing number of United States regional and state commitments toward this goal. Although no detailed study of a major utility of large interconnection under 100% RE system has been published, considerable literature explores the potential to greatly increase RE penetration. This literature, combined with real-world experience with increased RE deployment, points to two main challenges associated with achieving 100% RE across all timescales: (1) economically maintaining a balance of supply and demand and (2) designing technically reliable grids using largely inverter-based resources. The first challenge results in a highly nonlinear increase in costs as the system approaches 100% RE, in large part because of seasonal mismatches. The second challenge might require new inverter designs, depending on the mix of RE technologies. Analysis and experience to date point to no fundamental technical reasons why a 100% RE electric power system cannot be achieved, but the economic challenges indicate the need for advancements in several technologies and careful consideration of the suite of options that could be used to achieve equivalent carbon-reduction goals. Previous work also points to the need for analytic tool development, and techno-economic feasibility analysis must also consider the host of regulatory, market, and policy issues that might limit the ability to deploy mixes of resources that are suggested by least-cost modeling exercises.

In the final quarter of this year, and likely followed by a more detailed report in the first quarter of 2022, WECC Year 20 scenario analyses will weigh in on these issues. The analyses will allow for specific and targeted assessments of what is involved in getting to a 100% renewables power system in the Western Interconnection. At this early stage of the WECC scenario analysis, it appears that many of the issues identified in the NREL/DOE reports discussed here will also exist in the Western Interconnection. However, they will come with manifestations related to policies, market structures, and historical developments specific to the power industry in the Western US. References and additional information:

- EPS: [New Series of Reports on the Challenges of a 100% Renewable Power System](#): NOTE: This EPS has links to numerous articles with discussions and analysis of these studies and links to the DOE/NREL studies
- Article: [What We Know—and Do Not Know—About Achieving a National-Scale 100% Renewable Electric Grid](#), NREL, May 19, 2021

BROADER TRENDS, UNCERTAINTIES, AND WILD CARDS

Pandemics, the economy, national policy, and sometimes state policies are influenced by global and international events, especially over the long term (the Trends Reports' focus). These issues can impact reliability issues in the Western Interconnection via their influence on economic growth, technology innovation and adoption, and policy formation at the national, state, and provincial levels. Those influences may play out over time, and thus readers need to be in a mode of learning, curiosity, and imagining.

The Coronavirus Pandemic

The Pandemic is a long way from being over. Despite the fast development of highly effective mRNA vaccines and governments' vaccination efforts—it's still a race between vaccination rates and infections, new Covid-19 variants, and new vaccines or boosters if needed. So far, we are losing that race. New confirmed cases of Covid-19 remain high in the US, and vaccination rates are still unequal across the states and well below what is needed to control the virus. New cases and deaths declined dramatically in the spring and early summer of 2021 as vaccines became available. But as the more contagious [delta variant](#) took hold in July, the virus surged again, particularly in states with low vaccination rates. Across the US, ICU beds are full, other healthcare problems are not treated, and new Covid-19 cases cannot be handled locally. Some good news: As of October 4, 2021, new daily reported cases are down 9.6%, and deaths are down 4.5% from the prior week.

² DOE/NREL: [The Challenges of Achieving a 100% Renewable Electricity System in the United States](#), June 16, 2021

At least 43,639,012 cases and 701,988 deaths (more than the Spanish Flu pandemic in 1918-1919) have been reported in the US since February 29, 2020. The current situation is so dire the US health agencies have approved booster shots for the Pfizer and Moderna vaccines and new vaccinations and test requirements. The Pandemic's impacts on power system reliability exist in at least two ways: its impact on economic growth and thus power demand and supply, and the ability to staff and manage electric power systems operations.

Globally, the situation is just as dire. The world also struggles with unequal vaccine rollouts and new threats posed by fast-spreading variants. Some countries find the spread of the virus outpacing their vaccination plans in the face of proliferating variants. Many countries still have not received vaccine doses, and many are significantly undersupplied. As of October 4, 2021, at least 235,141,203 cases and 4,806,444 deaths have been reported worldwide since Feb. 29, 2020. References and additional information:

- The Washington Post, [Guide to the Pandemic](#), updated hourly.
- Article: Biden vaccine executive order: Businesses with 100-plus workers must require Covid vaccines or tests, The Washington Post, September 9, 2021
- Article: [Child Covid-19 hospitalizations reach a new high as schools reopen. That's not the only reason to protect kids from Delta, doctors say](#), CNN, September 9, 2021

The Economy

North American economies continue to slow in the face of the surge of the Delta Covid-19 variant and supply chain breakdowns. In a survey released on Monday, September 27, 2021, The National Association for Business Economists (NABE) is marking down its forecasts for US growth this year as the Delta variant [takes a toll on the recovery](#). The panel now expects US GDP growth of 5.6%. Although that's still strong, it marks a downgrade from May when business economists anticipated 6.7% growth. At the same time, economists are bracing for [price spikes](#) to continue through 2021. Consumer prices are expected to surge by 5.1% during the fourth quarter on a year-over-year basis. That's up sharply from a forecast for 2.8% inflation as of May and underscores the sticker shock Americans are experiencing in everything from used cars and gasoline to meat. The good news is that business economists share the Federal Reserve's view that high inflation will prove to be temporary as the economy continues to adjust to Covid. Consumer prices inflation is expected to moderate to 2.4% by the fourth quarter of next year. Higher interest rates also impact general levels of economic growth and can thereby impact electric power demand and thus power prices.

The US Federal Reserve Chairman Jerome Powell noted that the COVID pandemic has permanently changed the U.S. economy, and it is important that the central bank adapts to those changes. "We're not simply going back to the economy that we had before the pandemic," Powell said at a Fed virtual town hall for educators and students. "We need to watch carefully as the economy continues to get through the pandemic and try to understand the ways that the economy has changed and what the implications are for our policy." He noted that those changes range from increased remote work to restaurants offering more take-out meals to real estate agents learning to show homes virtually. Many companies have already made large investments in technology to adapt to the pandemic's challenges. Powell said the heavy investment by companies in new technology means there will be more jobs in the future associated with maintaining that technology but also potential job losses in industries focused on in-person contact. He said some of those industries may be moving to an "automated, no-contact model."

This trend is already showing up in the jobs data, with the recovery slower in industries that rely on public interaction, such as travel, leisure, and hospitality. Those are jobs disproportionately held by women and people of color and typically pay lower wages. These changing work models and the current high levels of unemployed workers affect the power system will play out over the short and long term. Any guesses as outcomes and effects are unknown and speculative at this time. But there will be effects, and we will continue to watch and report on this area. References and additional information:

- Article: Inside [America's Broken Supply Chain](#), Washington Post, September 30, 2021
- Article: [Economists slash their forecasts for America's growth](#), CNN, September 27, 2021
- EPS: [Fed's Powell: There's no returning to pre-pandemic economy](#)

- EPS: [Child-care workers are quitting rapidly, a red flag for the economy](#)
- Article: [The Great Resignation Is Going to Be a Shock--Hitting Some Industries Harder Than Others | Inc.com](#)

As in North America, economies worldwide are experiencing struggles compounded by supply chain blockages due to Asia's renewed surge in Covid-19 infections. Asia—the world's biggest source of manufactured goods—is experiencing turmoil in factories and ports in countries that were once among the most successful at containing the virus. The snarls in Asia—where the United Nations [estimates](#) around 42% of global exports are sourced—risk twisting their way through global supply chains just as shipments would usually ramp up for the Christmas holiday shopping season. As earlier snags have shown, problems that start in Asian ports can [ripple slowly](#), showing up later as delays in places like Los Angeles or Rotterdam and higher prices for consumers. And recently, a new threat to the recovery has emerged.

As we have noted in past reports, China has had significant short and long term impacts on the Western Interconnection via trade and economic growth. Imports from China and exports to China are major factors in economic activity in the Western Interconnection. China is now in the midst of an energy crisis which is shaping up as the latest shock to global supply chains as factories in the world's biggest exporter are forced to conserve energy by curbing production.

The disruption comes as producers and shippers race to [meet the demand](#) for everything from clothing to toys for the year-end holiday shopping season. They are grappling with supply lines upended by soaring raw material costs, long delays at ports, and shortages of shipping containers. Chinese manufacturers warn that strict measures to cut electricity use will slash output in economic powerhouses like Jiangsu, Zhejiang, and Guangdong provinces—which together account for almost a third of the nation's gross domestic product -- and possibly drive up prices. A significant amount of equipment and components used in the US power system is manufactured in Asia (especially China) and Europe. Many of the major components and apparatus are specially designed and one-off pieces. Supply chain and manufacturing slowdowns may cause delayed BPS and DPS plant, equipment, transmission maintenance and repairs, and new projects. References and additional information:

- EPS: [Global Supply Chains Are Being Battered by Fresh Covid Surges](#)
- Article: [Record numbers of giant ships are waiting off California | Popular Science \(popsci.com\)](#)
- Article: [Supply Chains Threatened as Energy Crisis Curbs China Factories - Bloomberg](#)
- Article: [Economists slash their forecasts for America's growth - CNN](#)
- EPS: [Economic recovery from Covid 'running out of steam' – OECD](#)
- Article: ['Widening fault lines' unbalance global recovery | Hellenic Shipping News Worldwide](#)
- Article: [Northern Trust's 5-Year Market Forecast Calls for Global Economy to Grow by 2.9% | Business Wire](#)

We have an additional discussion on another aspect of the current economy—cryptocurrencies and their impacts on capital and financial markets, the electric power system, and the Chinese banking system—in the Wild Card section on page 16.

Climate Change

Global climate change is accelerating, and human-caused emissions of greenhouse gases are the overwhelming cause. There is still time to avoid catastrophic warming this century, but only if countries worldwide stop burning fossil fuels as quickly as possible. In a new report entitled "[Climate Change 2021: The Physical Science Basis](#)", released on August 7, 2021, from the UN International Climate Change Panel (IPCC), climate scientists reached an "unequivocal" consensus on human-made warming. The findings from the United Nations-backed group throw a key goal of the Paris Agreement into danger as signs of climate change become apparent across every part of the world. The report makes clear that the planet will warm by 1.5° Celsius in the next two decades without drastic moves to eliminate greenhouse gas pollution. The message to world leaders is direr and more unequivocal than ever before.

One of the most significant recent advances in climate research is in the field of so-called attribution science, which ties global warming to individual weather events such as hurricanes or heat waves. Scientists can now say with certainty that humans are causing more extreme weather, including heavy downpours and extended heat waves and droughts. This whiplash—this increase in both extreme wet and dry events—is projected to increase through the 21st century. Additional warming would be expected to accentuate extreme natural events, one of WECC’s current Reliability Risk Priorities.

A month after the report was released, the UN released a new report based on the analysis of global emissions targets submitted by 86 member nations (out of 191 nations signatory to the Paris Agreement). According to the analysis, none of the world’s major economies—including the entire G20—has a climate plan that meets their obligations under the 2015 Paris Agreement, despite scientists’ [warning that deep cuts to greenhouse gas emissions](#) are needed now. In both reports, an urgent need to cut down on methane emissions moved to the forefront. Over 20 years, methane has more than 80 times the heat-trapping power of carbon dioxide, making it a major contributor to the climate crisis.

Taking the two new UN reports and recent events across the Western Interconnection into account, many implications and questions arise for WECC’s consideration, in addition to those posed above on page 10.

WECC’s Energy, Water, and Climate Change scenario, based on the best understanding of climate issues in 2013-2014, is out of date. In the past two years, understanding the causes of climate change and the ability to forecast the potential impacts have greatly improved. Data and studies have really improved, and many previous studies are now obsolete. The new reports make clear that the pace of climate change is accelerating and that extreme natural events are developing more often and occurring in clusters. In that light, we see three important questions for WECC.

1. Should the Scenarios Work Group update the Energy, Water, and Climate Change scenario in the face of these new findings? Should there be a new Year 20 study based on the updated scenario?
2. Should the Studies Subcommittee perform more frequent clustered and multi-variable climate change-related studies and in more near-term timelines?
3. Should the Studies Subcommittee create a group, e.g., Work Group or Forum, to deal specifically with Climate Change (or Extreme Weather Events if preferred) to keep information, knowledge, and data current to support new studies and a better understanding of potential reliability risks?

References and additional information:

- EPS: [Climate Scientists Reach ‘Unequivocal’ Consensus on Human-Made Warming in Landmark Report](#) – NOTE: This EPS has links to a number of articles that covered the report and include a detailed look at the reports, findings, conclusions, and draw implications
 - The Report: [Sixth Assessment Report \(ipcc.ch\)](#)
- EPS: [The planet is on a ‘catastrophic’ global warming path, UN report shows](#) - NOTE: This EPS has links to a number of articles that covered the report and include a detailed look at the reports, findings, conclusions, and draw implications
 - The Report: [Nationally determined contributions under the Paris Agreement. Synthesis report by the secretariat | UNFCCC](#)
- EPS: [NYPA Launches First Study to Assess Potential Impact of Climate Change on Its Operations](#)
- EPS: [United Nations and U.S. government policy shifts to address social cost of carbon](#)
- EPS: [Greenhouse Gas Emissions are Concentrated Among Emitters](#)
- EPS: [To Address the Climate Crisis, More Focus on Methane](#)
- EPS: [Greenland: enough ice melted on single day to cover Florida in two inches of water](#)
- EPS: [Gulf Stream Collapse](#)
- Article: [Climate Crisis Catches Power Companies Unprepared - The New York Times \(nytimes.com\)](#)

Wild Cards

As mentioned in the Second Quarter Trends Report, the power industry is a capital-intensive industry and is thus sensitive to national and global developments in capital markets. Movements in the availability of and cost of financing, especially debt financing, can determine which kinds of assets are built (amount of capital needed), by whom (credit capacity), and at what costs (interest rates on debt). Higher interest rates also impact general levels of economic growth and can thereby impact the electric power demand and thus power prices. For this reason, we have continued to maintain capital and financial market developments as a key driver in WECC scenario analysis.

Wild Cards warrant monitoring and watching to see if any significant issues and risks develop. In this Third Quarter report, we want to alert readers to what might be increasingly risky developments in two financial areas—cryptocurrency markets and the Chinese banking system—that are raising alarms by financial regulatory and national government officials. Financial contagion occurs when the inability of one party to make good on its financial commitments impacts another entity, and then that secondary entity's problems affect others in a cascading-like manner. Generally, the cascade has to be stopped by a lender of last resort, e.g., the Federal Reserve Bank of the United States. This lender takes the credit failure risk from the larger system and generally resolves it over time by holding securities for an extended period until markets can "calm down."

As demonstrated in the 2008-2009 financial crisis, credit and financial markets are connected. Financial contagion can quickly take hold, leading to a seizing up of credit markets impacted by what were thought to be unrelated sectors. Electric power markets, fuel markets, and capital flow into the power sector can be impacted by events in Chinese real estate and cryptocurrency markets. However, the connection may only be apparent only in hindsight

The Financial System and Cryptocurrencies: Global financial markets might be influenced by development in the cryptocurrency market in the following ways:

1. The price of these currencies can swing wildly, so the value of investments based on holding these currencies can swing wildly, impacting the holder's credit capacity. A credit failure of a large player can then send shocks further into the market (such a credit failure of Lehman Brothers was a trigger for the 2008 global recession, along with housing market speculation)
2. There are dark and private markets where crypto-currencies are used to back key financial instruments such as insurance policies. A failure in these hidden markets (again similar to the insurance policies behind mortgage-backed securities, which played a role in 2008) could ratchet through to the larger public market.
3. State banking authorities and regulators are becoming increasingly concerned about how growth in crypto-currencies might impact the larger banking system. In many cases, these currencies function outside the banking system, making them useful for criminal activity. A sudden crackdown on this market by a large state player (such as China) could have a big impact on the value and functionality of crypto-currency markets and lead to sudden adjustments that could impact capital cost (interest rates).

Since our last report, there have been additional developments in this space that we think warrant a more heightened sense of awareness. The developments include a closing off of the entire Chinese economy from Bitcoin and cryptocurrency-related transactions by the Chinese central government; additional swings in cryptocurrency market values, movement by the US Treasury Department to quickly consider regulation of cryptocurrencies, including regulation of some forms as investment securities; news coverage of the growing waste stream of digital equipment used to operate and maintain cryptocurrency systems; a growing alarm at the more than \$100 billion levels of transactions occurring in opaque cryptocurrency markets; the entry of major Wall Street banks into the servicing; and trading activity of cryptocurrencies without clarity of the banking risks involved. Any or all of these developments can ripple across the economy, cause a major global financial crisis, stop economic growth in its tracks. They can impact the power system by tightening capital

with rising interest rates, thereby limiting funds available for developing resources and enhancing transmission infrastructure. References and additional information:

- EPS: [U.S. Financial Leader Express Concern Over Crypto Currency Evolution](#)
- Article: [Facebook, Biden officials poised for clash as tech giant seeks approval for new global payments system](#), Washington Post, September 10, 2021

Chinese Banking System and Evergrande Corporation Financial Crisis: At the time of this report, the full extent of the financial crisis at the Evergrande Corporation in China is unfolding. The Company is defaulting on loan payments and payments to suppliers in its far-flung operations (reported to exceed \$300 billion). The Chinese national government and banking authorities are reported to want to let the company fail, to some degree, as a warning against future debt-related corporate development in China. How such a failure might impact the Chinese and global economy is now only speculation. It will likely take several months for the full drama and impacts to play out. Underestimating the possibility of financial system contagion could make this a far more impactful event than what might be expected at this time. We remain concerned that there appears to be a lot of “smoke,” but we are not sure there is “fire” or its extent. References and additional information:

- Article: [China Evergrande Crisis, New York Times](#), September 26, 2021
- Article: [Evergrande Debt Crisis](#), September 10, 2021

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