INTRODUCTION

This report by the Quantum Planning Group (QPG) to WECC and the Scenario Development Subcommittee (SDS) covers significant Event-Pattern-Structure (EPS) events and developments in the electric industry and energy markets in the Third Quarter of 2019 (July, August, and September). This report focuses on:

1. Significant Uncertainties, Major Trends, and Wild Cards
2. Significant Key Driver Events for the 2018-2038 WECC Scenarios and their implications,
3. Trend developments and Early Indicators (EIs) for each Scenario, and
4. Movement and progress indicated by the trends towards one or more of the WECC Scenarios.

This report also includes coverage of Scenario 5: Energy, Water, and Climate Change since EPSs can be related to this Scenario, even though there are no specific Early Indicators for this Scenario other than a 3-degree F temperature rise by 2034.

While this report details selected events scanned, reviewed, and submitted as EPS for this report in July through September 2019, our analysis considers and builds on learnings from the trends reports since 2011. We refer the reader to the previous WECC Scenarios: Early Indicator, Trends, and Scenario Movement Analysis reports (Trends Reports) of October 2015 - Second Quarter 2019 for additional background information found here.

We have been asked to keep a focus on the implications for electric reliability in our trends analyses. To address this, we include summary remarks about what we see as possible implications for electric reliability after each of the Key Driver sections below.

In the Third Quarter of 2019, there were 99 EPS submitted to the WECC EPS system with 91 EPS with EIs flagged (92 %), for a total of 172 EIs. All EPS can be viewed and searched, and SDS members and WECC Staff can submit their EPS here.

The links to the EPS referenced in this report are “hot” and, when clicked, will take the reader directly to the referenced EPS. If the reader finds a problem with a link in this report, you can contact QPG directly for help.

Many times, a single EPS may affect more than one Scenario or multiple Key Drivers. And we may cite them multiple times in the report so the full impact of the EPS is clear.

We think direct reporting of the source article is essential for the reader’s learning, and therefore, the EPS items referenced will include excerpts taken directly from the referenced article text as well as Quantum Planning commentary. 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.
EXECUTIVE SUMMARY

This report of Key Driver Trends and Scenario Early Indicators (EIs)—the Trends Report—by the Quantum Planning Group (QPG) is produced for WECC and the Scenario Development Subcommittee (SDS). The report covers the Second Quarter of 2019. EIs and Trend identification and analysis in these reports utilize reviews of media and industry reports by WECC members, WECC staff, and QPG consultants.

The 2018-2038 WECC Scenarios are now 14 months old, and we think this would be a proper time to look more closely at the scenario matrix key drivers in this report. We provide a summary of key events for all of the eleven Key Drivers in the Executive Summary that follows, however, in the Recent Key Driver Trends section we will discuss the Key Drivers associated with the scenario matrix axis:

- Vertical Axis: Direction of State and Provincial Energy Policy, and the
- Horizontal Axis: Customer Adoption of Energy Service Options

Also, given the recent developments around Global Warming and WECC’s staff working with a National Labs consortium on Scenario 5: Energy, Water, and Climate Change, we will provide a more detailed look at events associated with the Key Driver Evolution of the Impacts of Climate Change and Environmental Issues on Electric Power Service. For this report, we also expand the section on Significant Uncertainties, Wild Cards, and Outliers.

Uncertainties, Wild Cards, and Outliers

**Trade Wars:** We believe the continuing trade war and tariffs constitute a significant uncertainty for the economies of the states and provinces within Western Interconnection, the broader US and Canada, and worldwide. Additional tariffs on China have been imposed by President Trump, with corresponding tariffs imposed by President Xi on the US. However, the trade war between the US and China is changing too rapidly to address in this report. The most recent tariffs imposed by the US include heretofore untouched consumer items, and if all of the tariffs become effective by the end of 2019, roughly 99% of made-in-China consumer goods imported to the United States will be taxed. As of this writing, some tariffs have been delayed by both parties as the two are set to begin new trade talks the week of September 23, and the US draws close to the 2020 election. Uncertainty will continue on this front.

On another front, the US won a long-awaited case against the EU dealing with subsidies for the Airbus consortium and will be allowed to place tariffs on the EU for an amount yet to be determined. Recent reports say the WTO will announce about $& billion in claw back value.

**Western Interconnection Water Issues:** On a different note, and of significance to WECC and the Western Interconnection, the Columbia River Treaty, an international agreement governing the flow of water between British Columbia and six U.S. states, will be 55 years old this year: 2013, Canada and the United States have been preparing to modernize the agreement. Either side can walk away, with ten years’ notice, as of 2024. But neither side wants to do that; instead, they want terms that will accommodate values that were ignored when the deal was ratified in September 1964. One round of talks was completed last month in Washington, with the next round scheduled for September 2019 in Cranbrook, B.C.

**Wild Cards**

**Cyber-Security:** We continue to track developments around cyber-security as a Wild Card. On September 9, NERC revealed details about a March 5 cyber event that caused an undisclosed utility in the western United States to temporarily lose visibility of certain system parts. As a result, NERC is urging all utilities to have as few internet-facing devices as possible on their systems, use a layered defense, and employ redundancies for resilience. An external entity exploited a known firewall vulnerability at one of the utility’s vendors, allowing an unauthenticated attacker to cause unexpected reboots of devices, according to NERC’s analysis. These unexpected reboots resulted in brief communications outages — less than five minutes — between field devices and the control center. The March cyberattack was the first time—at least the first time reported—that remote hackers interfered with U.S. grid networks.
Microsoft reported that IoT (Internet of Things) devices continue to be a soft point in network security for both individuals and organizations, and are a significant barrier to effective grid modernization. Microsoft has issued 1,400 nation-state notifications to the hackers' targets as a state-sponsored Russian hacking group has been taking advantage of IoT devices' inadequate security measures to infiltrate corporate networks, according to Microsoft.

The US is very close to improving power grid security by mandating the use of "retro" (analog, manual) technologies on US power grids as a defensive measure against foreign cyber-attacks that could bring down the power distribution system as a result. The idea is to use "retro" technology to isolate the grid’s most important control systems, to limit the reach of a catastrophic outage by replacing automated systems with low-tech redundancies, like manual procedures controlled by human operators.

**Hong Kong:** At least one investor sees the continuing protests in Hong Kong as a potential major disruptor of the global economy and the resolution of the ongoing trade war between the US and China. Steve Eisman, the investor of "Big Short" fame, says his biggest worry is the Hong Kong protests, which he says could endanger any kind of trade deal with China and hurt the global economy. "I think the potential black swan, if there is a black swan right now, is what’s happening in Hong Kong right now," said Eisman on CNBC’s Power Lunch. "If things escalate even further in Hong Kong that would have a real impact back on the global economy."

**BREXIT:** Great Britain is still facing an October 31st deadline for leaving the European Union, and by all accounts, it will be a no-deal exit—with the direst impacts—with no trade agreement between the two. We will wait until the situation resolves itself one way or another for our next update. Regardless of the outcome, there are sure to be global economic impacts, as well as between the US, the EU, and Great Britain.

**Key Driver Summary**
The SDS Scenario Development Workshop defined eleven Key Drivers for the 2018-2038 Scenarios. We summarized significant events from the Third Quarter below.

3. Evolution of Customer-side Energy Supply Technology and Service Options
4. Changes in the Character and Shape of Customer Demand for Electric Power
5. Changes in Utility-scale Power Supply Options
7. Evolution of Climate Change and Environmental Issues on Electric Power Service
9. Shifts in the Cost of Capital and Financial Markets
10. Economic Growth Within the Western Interconnection
11. Worldwide Developments in the Electric Power Industry

**Changes in State and Provincial Electric Energy Market Policies:** An extensive discussion on this primary axis driver is contained below. We see and discuss a dichotomy in various States and Provinces of policies which support growth in certain energy products and services, especially to meet environmental concerns or to support emerging technologies, e.g., storage; versus policies in which policymakers show concerns about containing potential cost increases and validating promised benefits. We think this issue warrants continuous monitoring for implications for how reliability is met.

**Evolution of Customer-side Energy Supply Technology and Service Options:** An extensive discussion on this primary axis driver is also contained below. We see and discuss a dichotomy in the market place for electric energy products and services in which there is producer push for products and services versus varying levels of consumer pull. We think this issue warrants continuous monitoring going forward to determine potential impacts on how reliability is met.

**Changes in the Character and Shape of Customer Demand for Electric Power:** This driver contributes to the horizontal driver in the scenario matrix, and the comments above apply here— we have combined research in
this area to monitor the evolution of electric energy product and services markets as customers adopt and implement emerging options.

We did not see any new significant uncertainties arise during the quarter.

**Changes in Federal Electric Energy Market Policies:** Major events in the Third Quarter of 2019 included the Environmental Protection Agency announcing a new rule designed to replace the Obama Clean Power Plan—which was immediately challenged in court, and the US Department of Energy provided funding for 14 Tribal energy programs and released a study on full electrification in Indian country. Readers can find details of the noted events here:

- **EPA Replaces Clean Power Plan**
- **DOE announces $16 Million in funding for 14 tribal energy projects**
- **Full Electrification in Indian Country**

We see no reliability-related risks from recent developments in Federal Electric Market Policies. Recent trends in Federal policies are continuing to generally lean toward further reductions in reliability risk.

**Changes in Utility-scale Power Supply Options:** At this time, we see a continuation of the basic trends we reported on in our 2019 First and Second Quarter Trends Reports. The Western Interconnection is seeing a continuation of the movement towards more use of integrated storage technologies in hybrid systems in both new generation and as replacements to fossil fuel-fired plants, and we saw three innovations in storage technologies. Wind continues to be a generation choice in the western US, and storage is expected to grow across the US as costs continue to drop. A new study looks at the continuing drop in renewable generation costs and says that planned new gas-fired plants may become stranded in the next decade. Readers can find details of the noted events here:

- **Net Power moves toward innovative clean CO2 gas based generation**
- **Researcher Improve Supercapacitor Technology for New Battery Options**
- **Highview Power Unveils Giga-Scale Cryogenic Battery**
- **Los Angeles OKs a deal for record-cheap solar power and battery storage**
- **$3.3 billion wind investment will add 2,500 MW of clean energy in South Dakota**
- **'Cheaper Than a Peaker': NextEra Inks Massive Wind+Solar+Storage Deal in Oklahoma**
- **PNM proposes gas, solar + storage mix as cheapest option to replace San Juan coal plant**
- **Bloomberg: Energy Storage Investments Boom As Battery Costs Halve in the Next Decade**
- **Fossil Fuel Economic: PacifiCorp Forecasts Accelerated Coal Plant Retirements in Wyoming**
- **Renewables, storage poised to undercut natural gas prices, increase stranded assets**

We continue to see enhanced opportunities in recent developments in the area of utility-scale power developments, especially in hybrid renewable + storage systems, to improve electric system reliability by providing more flexibility in managing power generation. New technological options and approaches to service are increasing power supply and electric service company choices.

**Changes in State and Federal Electric System Regulations for Reliability:** Four events of significance occurred in the Third Quarter: Alberta rejected a proposed change from their current energy market to a capacity market, CAISO asked FERC for broader authority to utilize reliability-must-run (RMR) agreements to maintain reliability, the US Department of Energy began the development of a North America “energy resilience model” which includes the Western Interconnection and will impact WECC planning, and FERC and NERC announced new cyber event reporting rules. Readers can find the details of the noted events here:

- **ALBERTA: UCP's decision to stick with status quo on electricity market a boon for renewables, companies say**
- **California grid operator asks FERC for broader authority to maintain system reliability**
- **DOE begins development of North American 'energy resilience model'**
- **FERC expands cybersecurity reporting standards to include non-disruptive incidents**
- **FERC, NERC propose to publicly identify utilities violating cybersecurity standards**
In general, we see that the thrust of recent developments in Federal and State Regulations of electric systems reliability are intended to improve conditions in which reliability risks can be addressed and reduced.

**Evolution of Climate Change and Environmental Issues on Electric Power Service:** There were a number of significant events related to this driver in the Third Quarter, and we include a detailed look at them with footnoted EPS beginning on page 20. As we noted in our presentation to the SDS in their September meeting, the most significant of those events include:

- July 2019 was the warmest month ever recorded on Earth.
- A new UN Study: Changing climate imperils global food and water supplies.
- Alaska chokes on wildfires as heatwaves dry out the Arctic.
- Alaskan glaciers are melting 100 times faster than previously thought.
- Russian land of permafrost is thawing and burning.
- Scientists report that Canadian permafrost thaws 70 years early.
- A US Climate Report notes that indigenous peoples in the US are disproportionately affected by climate changes.

A new analysis of NOAA and NASA data from 1895 – 2018 by the Washington Post shows that many counties within the US, and especially in the Western Interconnection, have already reached or exceeded a 2°C average temperature rise. A second article looking at NOAA, NASA and Berkeley Earth data shows that many regions in the world have also reached or exceed the 2°C threshold. The point of the articles is that while on average the global temperature rise may not be at 2°C yet (although close), there are geographical areas worldwide that are below and above that global average – in the case of the Western Interconnection, considerably above. Knowing what is happening within a region or country hits home harder than considering global averages.

Due to widespread and varied impacts of potential climate change events, we continue to see recent developments in this area presenting significant risks to electric reliability in all four of the areas of concern. Climate-related events can destroy and disable power systems, e.g., the recent California wildfires, flooding of low-lying generation resources, drive population shifts, and increased need for air-conditioning affecting demand curves, and degrading transmission efficiencies, such that resource adequacy, operational, infrastructure, and system stability risks can emerge.

**Evolution of Fuel Markets in the Electric Power Sector:** During the Third Quarter, there were no events that directly impacted fuel markets in the Western Interconnection, and domestic natural gas resources serving the power sector continue to be abundant, thus enhancing the ability to add resources to address reliability concerns. We do note the recent attack on Saudi oil installations that appears to have created a short-term spike in crude prices and a ten-cent per gallon rise in US gasoline prices within the last week. We continue to monitor growing growth in capacity and international trading in natural gas.

**Shifts in the Cost of Capital and Financial Markets:** In this quarter, there were significant developments in the global economy that could impact both short and long-term financial markets. South Korean exports dropped for the ninth straight month while manufacturing output also shrunk in China, Japan, and Taiwan. Asian central banks are projected to deliver more stimuli into their economies. Among the emerging market economies of Southeast Asia, Indonesia registered a contraction, but others have benefited from a redirection of trade flows away from China. The global economy continues to cool. Readers can find the details of the noted events here:

- S. Korea Aug exports tumble for 9th month as world economy cools
- 5 Things Weighing on the World Economy
- GLOBAL ECONOMY-Manufacturing pain spreads through Asia, more stimulus seen ahead
- GLOBAL ECONOMY-Factories faltered in June, trade truce fails to brighten outlook

We see no new emerging issue in capital markets that raises a significant risk to electric reliability in any of the key categories. Continued low cost and abundant sources of capital exist for the power industry for development with sound credit quality.
Economic Growth Within the Western Interconnection: The main themes in this driver continue to be that by all indications that the US and Canadian economies are stable, but are showing increasing signs of slowing as the trade war continues and the continued global economic slowdown affects both countries. Events noted in the Third Quarter include downward revised GDP numbers and slowing job numbers for the US, confirming a slowing economy, loan repayment problems by farmers in the mid-western US are increasing, and anecdotal reports by the trucking industry also indicate a slowing economy. Canada reported an increase in 2Q19 GDP amidst steady job growth. We suggest that the broader US and global economies are more heavily impacted by the current trade war, the retreat from globalization, and a push towards nationalism in some countries than from the result of a “normal” economic cycle as seen in the past. With no resolution in sight, we think the continuing trade war should be seen as a significant uncertainty in both the near and long-term (see page <>).

Readers can find the details of the noted events here:

- Aided by Exports, Canada’s GDP Growth Soared in Q2
- Canadian Job Growth, Unemployment in August
- US Hiring Slowed in August, but Wage Gains Accelerated
- US economy slows and new GDP data confirms tax cuts aren’t working
- US Economic Indicator: Loan repayment problems grow as American farms are billions in debt
- ‘Quietest in 20 years’: Truckers feel chill of slowing US economy
- Here’s a List of Recession Signals That Are Flashing Red
- US Economic Indicators: Top Five Risks

At this time, economic indicators in the Western Interconnection are showing a stable, though slowing economy, even within an environment of increasing uncertainty, and do not indicate an emerging threat to power system reliability. Likewise, global economic indicators do indicate a slowing of the global economy; however, they do not indicate an emerging risk to reliability in the Western Interconnection.

Worldwide Developments in the Electric Power Industry: There are forces of change impacting the electric power industry worldwide (e.g., more aggressive clean energy standards and reduced costs for renewable energy) and we see an acceleration of these changes driven by technology, policy choices, (e.g., addressing climate change), economics, and public demand. We did not see any events or developments of note in the context of this driver’s scope in the Third Quarter.

Worldwide developments in the power sector continue to suggest that the wide range of options for meeting electric reliability will continue to expand. However, we believe that cyber-security risks have grown to become a more significant risk to electric systems operations worldwide, we expect more intensive scrutiny of those risks and investment to address them will likely be a central issue in the power industry.

Implications for Reliability: At this time, we see no extraordinary challenges emerging that would lead to a decline in the ability of the industry to meet historical levels of reliability with two exceptions:

1. Developments related to the evolution of climate change and environmental issues that could impact the power sector. Actions by humans and policy developments to address climate change nationally and globally are not sufficient to slow the forecasted increasing destructive effects (e.g., drought, wildfires, flooding, extreme storm events, etc.).

2. Cyber-security: Will the power industry successfully adopt the necessary tools and operating processes that can prevent or mitigate large-scale or cascading power system failures due to cyberattacks?

We are also concerned about a potential economic disruption due to recent events impacting the US and global economy (e.g., tariffs, high debt levels). In the past, these kinds of events have slowed energy demand growth but have directly reduced reliability. On a more positive note, we see enhanced opportunities to improve reliability driven by the falling cost of storage based technologies and their growing use in utility-scale applications.

---

1 EPS: US energy, transportation sectors not prepared for climate change, 2018 Climate Assessment, November 2018
**Scenario Trends**

Past Trends Reports, based on the WECC Legacy Scenarios, focused on an analysis of the movement from one scenario to another scenario of the Western Interconnection as a whole. As we noted in past SDS meetings, we believe that in the 2038 Scenarios, given the choices by the SDS for the Primary Scenario Drivers and other Key Drivers, states, and provinces within the region will not move in lockstep towards any particular scenario. Considering the new Scenario Matrix, this would imply that there would not be a region-wide “movement” that could be plotted against the new scenario matrix as in the Legacy Scenarios.

We think that developments and trends within each scenario, noting specific events at the state and local levels that fit that scenario are—at least at the beginning of the 20 years—more useful to WECC and the SDS. Please see Figure 4 on page 31, where we offer an updated view of state and province fit in the scenario matrix for discussion and further enhancement with SDS members.

However, we can say that, based on the Key Driver events we have seen in the past three months with differing state and provincial policy actions, from a high level these events tend to support movement in the Western Interconnection as a whole towards both Scenario 1 and Scenario 4. We can also see developments that argue for Scenario 3 in many states in the Western Interconnection. A key element of this assessment is the lack of any significant technological developments or other market-related issues that would lead to a quickened uptake of the kinds of energy-related services and products advocated most strongly in Scenario 2.

The main body of the report begins on page 10.
SIGNIFICANT UNCERTAINTIES, WILD CARDS, AND OUTLIERS

Significant Uncertainties

Trade Wars: Several SDS members have asked that we provide a window into the current trade wars between the US and China and the EU. We believe the continuing trade war and tariffs constitute a continuing significant uncertainty for the economies of the states and provinces within Western Interconnection, the broader US, Canada, and worldwide. We saw several events of note in the Third Quarter.

Unanticipated consequences - The current trade wars are not only affecting companies that produce America’s exports but are also cutting into the profits of the utilities that power them: Earnings at American Electric Power Co., which provides electricity in 11 states, slumped 13% in the second quarter. Chief Executive Officer Nick Akins said the “biggest economic headwind” was the Trump administration’s trade policies. AEP said sales to industrial customers fell 2.7% in the second quarter from a year earlier, a bigger decline than it reported for residential and commercial customers. “Sales to the industrial class have been slowing in recent quarters as the impact of the strong dollar and more restrictive trade policies have challenged export manufacturers.”

The extent of industrial companies affected by and the duration of the trade wars could have a significant impact on load demand in the Western Interconnection - this bears watching.

Lithium-Ion Batteries - Of particular significance to both battery storage and other users of lithium-ion batteries, on August 23, the U.S. Trade Representative (USTR) announced its latest increase in a wide range of tariffs imposed on Chinese goods, including an increase from 25% to 30% on $250 billion worth of Chinese imports effective October 1. The USTR is also raising tariffs from 10% to 15%, set to take effect on September 1, and these include lithium-ion batteries. Two-thirds (2/3) of the world’s lithium-ion battery manufacturing is in China, and Tesla's factory in Nevada is the only gigawatt-scale battery factory in the United States. As such, there is likely to be intensified demand for lithium-ion batteries from Korea, Japan, and Poland, which are the nations with the largest manufacturing capacity after China and the United States. These increases did go into effect on September 1.

Consumers Next to be Hit - President Trump’s latest round of tariffs on Chinese imports is likely to deliver a direct hit on many consumers primarily spared from higher prices in his previous series of import taxes. Beginning September 1, the U.S. government will begin collecting 15% tariffs on $112 billion in Chinese imports — items ranging from smartwatches and TVs to shoes, diapers, sporting goods and meat, and dairy products. For the first time since Trump launched his trade war, American households face price increases because many U.S. companies say they’ll be forced to pass on to customers the higher prices they’ll pay on Chinese imports.

Under the new schedule, 69% of the consumer goods Americans buy from China will face his import taxes, up from 29% now. That isn’t all. Higher tariffs are set to kick in for another batch of Chinese products — $160 billion’ worth — on Dec. 15. By then, roughly 99% of made-in-China consumer goods imported to the United States will be taxed. Overall, the ongoing trade war will have raised the average tariff on Chinese imports from 3.1% in 2017, before the hostilities began, to 24.3%.

UPDATE: Changes as China and the US are set to resume Trade Talks – On September 19, The Trump administration excluded a number of items, including Christmas tree lights, a series of pet supplies, plastic drinking straws and hundreds of other products from a 25 percent duty President Trump imposed on $250 billion worth of Chinese goods, according to three notices set to be published in the Federal Register on

2 EPS: Trade Wars Have U.S. Exporters Cutting Power Demand, Bloomberg, July 25 2019
3 EPS: Trade War Update: Trump ratchets up tariffs on Chinese products including batteries, PV Magazine, August 26 2019
4 EPS: Latest tariffs could hit consumers with higher prices, Associated Press, August 31 2019
The move comes as the United States and China are preparing for another round of high-level trade talks in early October. But the exclusions are less about placating Beijing than they are an effort to provide relief to some U.S. companies who say they have been harmed by Trump’s tariffs, and can’t find an alternative source of supply. We do not know the value of the trade represented by the exclusions.

China is beginning to feel the effects of the trade war - China’s growth fell to its slowest pace in nearly three decades, officials disclosed in July, as a resurgence of trade tensions with the United States and lingering financial problems take an increasing toll on one of the world’s most vital economic engines. Chinese officials said the economy grew 6.2 percent between April and June compared with a year earlier. While such economic growth would be the envy of most of the world, it represented the slowest pace in China since the beginning of modern quarterly record-keeping in 1992. That marks a significant slowdown from earlier this year, when growth came in at 6.4 percent, matching a 27-year low reached during the global financial crisis a decade ago. Trade talks broke down on May 10, and President Trump raised tariffs sharply on Chinese goods, a step that damaged consumer confidence within China. Talks between the US and China are set to resume in October 2019.

The US and the EU – The World Trade Organization (WTO) will grant the United States permission to impose tariffs on the European Union as part of a prolonged scuffle over subsidies given to European plane builder Airbus, European officials said Monday, a move that is likely to exacerbate trade tensions across the Atlantic.

The ruling, to be published in the week of Sept. 30, is the global trade body’s final decision in a 15-year old dispute over the government assistance that Europe provides to its major plane manufacturer. It will clear the way for the United States to impose tariffs on European goods, worsening tensions that have become strained under President Trump’s confrontational approach. The WTO still must authorize a specific dollar amount that the United States can recoup through tariffs (Update: recent reports note that the WTO will announce roughly $7 billion of claw backs for the US). But the United States Trade Representative has already prepared two lists of up to $25 billion worth of products that it can tax, including airplanes, fish, wine, leather purses, carpets, and clocks. The trade body opened the door for the Trump administration to impose billions of dollars in retaliatory sanctions last May when it ruled that Europe had illegally subsidized Airbus to the detriment of its American competitor Boeing. The ruling could become fodder for Mr. Trump’s growing trade fight with the European Union, which he has accused of weakening its currency and criticized for exporting more goods into the United States than it buys.

The current trade wars show no real sign of letting up, even if the Trump administration moderates some tariffs in efforts to bring China to the negotiating table, or the president moderates further anticipating the 2020 election. Mr. Trump has shown that his tool of choice in trade matters is tariffs. The tariff trade wars have had a chilling effect on the global economy, and the US economy is cooling. We do not see any resolution in the near term.

**Western Interconnection Water Issues:** On a different note, and of significance to WECC and the Western Interconnection, the Columbia River Treaty, an international agreement governing the flow of water between British Columbia and six U.S. states, will be 55 years old this year. Given the current political and trade environment, this issue might not have been seen as uncertain. Since 2013, Canada and the United States have been preparing to modernize the agreement. Either side can walk away, with ten years’ notice, as of 2024. But

---

6 Article, *Hundreds of Chinese goods exempted from Trump’s tariffs*, Politico, September 19 2019
9 EPS: 5 Things Weighing on the World Economy, International Monetary Fund via WeForum, August 2 2019
11 EPS: *Canada, U.S. to renegotiate a critical water treaty*, The Globe and Mail, August 30 2019
neither side wants to do that; instead, they want terms that will accommodate values that were ignored when the deal was ratified in September 1964, by Prime Minister Lester Pearson and President Lyndon Johnson.

One round of talks was completed last month in Washington, with the next round scheduled for September in Cranbrook, B.C. The next round of negotiations has new issues for the countries to address:

1. **Climate Change** - Last October, BC Hydro noted a record seasonal low at one of its largest reservoirs on the Columbia, Kinbasket Lake. The flow of the river is governed by snowmelt as well as glacial melt, peaking in the spring and gradually slowing through to winter. But the province is warming, and the rhythm of the river's flow is changing. The U.S. bargaining team prefers the term "adaptive management," but climate change has emerged as one of the major issues at the table.

2. **Salmon** – An estimated four million salmon were harvested by Indigenous people throughout the Columbia River basin annually before dam construction, according to a 2015 report produced jointly by the three B.C. First Nations and the 15 U.S. tribes of the region. Today, those groups are proposing the reintroduction of salmon.

3. **Indigenous rights** - The rights of Indigenous people whose lives were dramatically affected by the development of the Columbia River will not be ignored in the new round of talks. Canada made history in June when it invited representatives of three First Nations to sit as official observers at the negotiations in Washington. Their case— that their traditional rights have been trampled—has elevated the restoration of salmon stocks to a serious consideration now. The U.S. tribes are still fighting for seats at the table, but their influence is recognized.

The river springs from the Columbia Icefield in the Rocky Mountains of B.C. and winds 1,930 kilometers through the Northwestern US of Washington, Oregon, Idaho, Montana, Nevada, and Wyoming. No other river in North America spills more water into the Pacific Ocean.

The value of the pact, in terms of power generation and flood control, has been lauded by both governments, who regard the agreement as a model of international co-operation. B.C. has reaped billions of dollars through the sale of hydroelectricity, while U.S. communities have been able to count on stable water levels and economic development backed by dependable electricity. Vancouver lawyer David Austin noted, "The value of the electricity that is generated in the U.S. from water released from Canadian reservoirs has dropped because of the dramatic decline in the cost of other forms of renewable generation such as wind and solar," he said. "These releases will have a higher value in the U.S. for other uses such as fisheries, flood control, and agriculture, which is a huge change from when the treaty was first signed."

**Wild Cards**

**Cyber-Security:** We continue to track developments around cyber-security as a Wild Card. In the Third Quarter, we saw three major events including an update on a March 5, 2019, utility system hack, more problems with IoT device security, and a new approach to dealing with critical grid protection. There is a new view of the disruptions in Hong Kong’s effects long-term on the global economy, and we update events surrounding BREXIT.

The North American Electric Reliability Corporation (NERC) on September 9 revealed details about a March 5 cyber event that caused an undisclosed utility in the western United States to temporarily lose visibility of certain system parts.12 As a result, NERC is urging all utilities to have as few internet-facing devices as possible on their systems, use a layered defense, and employ redundancies for resilience.

An external entity exploited a known firewall vulnerability at one of the utility’s vendors, allowing an unauthenticated attacker to cause unexpected reboots of devices, according to NERC’s analysis. These unexpected reboots resulted in brief communications outages — less than five minutes — between field

---

devices and the control center. The March cyberattack was the first time—at least publicly reported—that remote hackers interfered with U.S. grid networks.

The threat of a cyberattack is at an all-time high, NERC President and CEO Jim Robb said in his testimony before Congress in July. In a "lessons learned" document, published on Sept. 4, NERC said the cyber event "resulted in a denial of service (DoS) condition at a low-impact control center and multiple remote low-impact generation sites." According to NERC, the DoS conditions, caused by a firewall vulnerability, lasted for 10 hours with each device showing offline status for less than five minutes. NERC stressed that the cyber event did not impact generation. (NOTE: While this event did not affect generation, analysts say that it could have if the attackers wanted to.)

IoT (Internet of Things) devices continue to be a soft point in network security for both individuals and organizations and are a major barrier to effective grid modernization. Microsoft has issued 1,400 nation-state notifications to the hackers' targets as a state-sponsored Russian hacking group has been taking advantage of Internet of Things devices' inadequate security measures to infiltrate corporate networks, according to Microsoft.13

The company has revealed that researchers from Microsoft's Threat Intelligence Center have discovered hacking attempts on companies using popular IoT devices, namely VOIP phones, office printers, and video decoders. In a couple of cases, the bad actors didn't even have to crack passwords: the devices used their manufacturers' default ones. Microsoft has attributed the attacks to a group called Strontium, otherwise known as Fancy Bear and APT28. Fancy Bear is believed to be a group of state-sponsored Russian hackers involved in the 2016 DNC hack, various infiltration attempts on US officials and attempts to disrupt the EU elections earlier this year. Microsoft was able to identify the attacks in their early stages, though, so the group's objectives remain unclear. What's crystal is that the IoT devices became points of entry for the infiltrators, allowing them to look for a way to dig deeper into the network.

Continued efforts to come to grips with the increasing cyber-attacks on the US grid by use of increasingly sophisticated software tools by attacking ever more deep digitally controlled operating systems have not kept up with the sophisticated tools used by cyber-attackers. The US is very close to improving power grid security by mandating the use of "retro" (analog, manual) technologies on US power grids as a defensive measure against foreign cyber-attacks that could bring down the power distribution system as a result. The idea is to use "retro" technology to isolate the grid's most important control systems, to limit the reach of a catastrophic outage by replacing automated systems with low-tech redundancies, like manual procedures controlled by human operators.14

The U.S. Senate on June 27 passed a bipartisan cybersecurity bill that will study ways to replace automated systems with low-tech redundancies to protect the country's electric grid from hackers. The bill was inspired by the 2015 cyber-attack on Ukraine's power grid. The Securing Energy Infrastructure Act (SEIA) establishes a two-year pilot program to identify new classes of security vulnerabilities and to research and test solutions, including "analog and non-digital control systems." The U.S. Department of Energy would be required to report back to Congress on its findings. The SEIA legislation was included in the National Defense Authorization Act for Fiscal Year 2020. A companion bill has been introduced by bipartisan sponsors in the House of Representatives.

Hong Kong: At least one investor sees the continuing protests in Hong Kong as a potential major disruptor of the global economy and the resolution of the ongoing trade war between the US and China. Hundreds of thousands of protesters have taken to Hong Kong's streets since early June, due to opposition to a now-suspended extradition law that would have allowed people in the city to be extradited to Mainland China. The

---

13 EPS: Microsoft: Russian hackers are using IoT devices to infiltrate networks, End Gadget.com, August 6 2019
14 EPS: US wants to isolate power grids with 'retro' technology to limit cyber-attacks, Forbes, Utility Dive, ZDNet, July 2 2019
people who are protesting are not backing down, the Chinese government doesn't seem to be backing down, and if cooler heads don't prevail, its possible things in Hong Kong could get very ugly.

Steve Eisman, the investor of "Big Short" fame, says his biggest worry is the Hong Kong protests, which he says could endanger any kind of trade deal with China and hurt the global economy. 15 "I think the potential black swan, if there is a black swan right now, is what's happening in Hong Kong right now," said Eisman on CNBC's Power Lunch. "If things escalate even further in Hong Kong that would have a real impact back on the global economy." NOTE: Black Swan events are difficult to predict and particularly damaging because of that.

The conflict in Hong Kong could impact the trade war between the U.S. and China and could ripple through the global markets. "That is not going to be a positive in terms of negotiating a trade deal between the United States and China; it's not going to be a positive at all for the global markets."

**BREXIT Update:** Great Britain is still facing an October 31\(^{st}\) deadline for leaving the European Union, and by all accounts, it will be a no-deal exit with no trade agreement between the two. We will wait until the situation resolves itself one way or another for our next update. Regardless of the outcome, there are sure to be global economic impacts, as well as between the US, the EU, and Great Britain.

Why BREXIT Matters - We noted in past reports that BREXIT could have significant economic implications not just for Britain, but also for the global economy and the US. At this point, indicators point to a so-called "hard" exit, which means that Britain will leave not only the EU but also the single market and the customs union. In this scenario, the UK would instead aim to secure free-trade deals with the EU, ideally covering both goods and services. Drier would be a "no-deal" exit, where Britain would no longer be a member of the EU, and it would have no trade agreement. It would have all of the disadvantages of a hard Brexit, and there would be no trade agreement.

The US would not be immune from the global economic impacts, and more directly, many US businesses use Britain as their doorway into the EU, and under a hard BREXIT, that entry point goes away. That's going to cause a lot of complications for US businesses, as companies will find it harder and more expensive to move goods between the U.K. and rest of Europe, with delays, tariffs, and more paperwork. The net result could easily be a push accelerating the already slowing US economy and slowing electricity demand.

---

15 EPS: Hong Kong protests a big worry with economy, a possible ‘black swan’? CNBC, August 8 2019
**RECENT KEY DRIVER TRENDS**

**The WECC Scenario Matrix**

Each of the four WECC 2018-2038 Scenarios fits into one of four quadrants within a 2 x 2 matrix, using the two primary scenario drivers chosen by the SDS of 1), Direction of State and Provincial Energy Policy, and 2), Customer Adoption of Energy Service Options.

Each Scenario can thus be described – *at a high level* – by the combination of the matrix axes.

![Figure 1, WECC Scenario Matrix](image)

The matrix provides both a quick visual model for the Scenarios and a reference for the discussions that follow. However, for a complete understanding of the Scenarios, we encourage readers to read the WECC 2018-2038 Scenarios Narratives.¹⁷

This report is the last for the calendar year 2019, as our next report will be delivered in January of 2020. In order to focus our analysis a way that we think can be of most use to the SDS (particularly in its end of year work on metrics and modeling) we are covering developments that we believe impact the two key scenario axis drivers and the vital issue of climate change (in light of the work by WECC and a national labs consortium on Scenario 5: Energy, Water, and Climate Change). Summary update comments are made on the other key drivers and in most cases, we think the essential points complement further development of issues in those drivers covered in the July mid-year Trends Report. We begin our discussion of the focus area Key Drivers with the primary scenario drivers illustrated above.

---

¹⁷ [WECC 2018-2019 Draft Scenarios for Horizon Year 2038 V 0.1, July 25 2018](#)
Scenario Primary Driver Trends

Changes in State and Provincial Energy Market Policy

From the 2038 Scenario Report: "Fourteen Western states, two Canadian provinces, and Northern Baja California make up the geographical footprint of the Western Interconnection supported by WECC. They set policies and rates which directly impact how electricity markets function within their areas of jurisdiction and influence regional patterns as well. How electricity supply and demand is met is governed in large part by the policies set by individual states and provinces, including rules that govern markets—in conjunction with federal regulations—in places like California and Alberta where formal markets are in place to procure services such as imbalance energy and ancillary services. States and Provinces also set policies on cost recovery for plant investment in utility rates, renewable portfolio standards, climate change policies, rules governing the use of local distribution systems, and much more."18

The statement above presents the essential definition of this key driver. Over this year’s scanning and monitoring for developments in this area, and in particular with the most recent developments, we see a core dichotomous issue: State and Provincial regulatory policy development shaping and encouraging energy resource developments (i.e., support of electric vehicles, renewable and clean energy production, battery and storage, etc.) while simultaneously expressing concern about costs, benefits and consumer demand.

Of course, these two areas are interrelated as regulations and policies influence market development, product and service designs and prices. In reaction to those service offerings and prices, consumers assess their attractiveness and ultimate demand. Demand growth then determines increased (or decreased) investment and market growth (which can impact resources available for further product and service innovation and improvement).

We do not claim at this point to know the ultimate settling of this dynamic, only that it is essential to continue to monitor and that it has implications that fit well within the current WECC Scenarios. As the SDS works with WECC staff to calibrate key metrics in the scenario modeling, we think discussions in this area may help set significant differences in some metrics that might lead to different impacts on model results, and with that, implications for how to plan for electric reliability.

Regulatory Support for Certain Products and Services: In several states and the Provinces in Canada, we captured developments which show policymakers making efforts to set rules and regulation that support further development and integration into the power grid of some preferred products and services. In Arizona, California, New Mexico, Colorado, British Columbia, and Alberta, we see activity supportive of various products and services, including electric vehicles, electrification of transportation, distributed energy with storage, and solar power. Various activities also moved in the direction of increasing retail choice and even wholesale revision of how distribution systems and the bulk grid might work together in the future.

Our read of the underlying motivations for this activity includes a movement to a cleaner and less carbon-intensive power system, support for emerging technologies, advocacy for more customer engagement via information and communication systems, and belief in potentially lower electric rates and costs. The extent to which any of those actions are achieved we think remains an open question to be determined as real investments are made, and experience with them is gained in the real world.

These essential EPS submissions are suggested for review:

- Arizona’s top regulator spurs retail choice progress, pushes for rule drafting
- B.C. Hydro seeks special rate to offer transit EV conversion
- New Mexico governor wants to upend PRC as regulators skirt clean energy law
- CAISO Advances Work on Energy Storage Distributed Energy Resource Integration
- Study on Rate Design for Behind the Meter Energy Published

---

18 WECC 2018-2019 Draft Scenarios for Horizon Year 2038, July 24 2018
Concern and Uncertainty About Costs and Benefits of Emerging Products and Services by Policy Makers:

Fully assessing the short term and long term costs and benefits of any product or service is a complex endeavor, particularly if long term lifecycle costs matter and significant externalities occur which push costs onto other customers or society at large. When a vital service such as access to electricity is at stake, which can have life or death consequences as well as influence national, community and personal economic viability, controversy is practically unavoidable.

We see those differences in perspective in recent developments at the State and Province level, as well as in U.S. Federal policy developments. Projections of costs and benefits on new energy services and products are necessarily difficult because they involve projection into the future of factors which can change (fuel costs, interest rates, natural resource costs, operating costs, etc.). It is also in the interest of those offering and advocating for new services and products to bias (at least the descriptions of) benefits in their favor (marketing and promotion).

Full costs (including opportunity costs and total lifecycle costs) are often not finally determined until after the purchase of a product or service, making economic analyses of costs and benefits subject to uncertainty and estimated projections. Regulators and policymakers can rightfully be careful in their assessment and approval of energy investments and their long term projected benefits and costs.

In recent developments noted in the EPS listing below, we are seeing concern about costs and benefits extend beyond pure electric services costs and rates and into areas such as community development, job protection, local industry support, and encouragement of "innovation." We believe this area warrants continuous monitoring as we think different States and Provinces will manage this issue differently, an essential argument in the logic of Scenario 1. As we discussed with SDS members during the September 2019 meeting, we have not seen the emergence of a standard industry-wide peer-reviewed way to make economic analyses of new services and products as they are integrated into the existing power system. Integrated resource planning in a distributed energy world is under study as to how to assess costs, benefits, and impacts across customer classes. In this light, we note the EPS submission below for members to review:

- More States Hitting Electric Vehicle Owners With High Fees
- SDG&E Considers Rate Increase to Cover Solar Integration Costs
- B.C. Hydro seeks special rate to offer transit EV conversion
- Study on Rate Design for Behind the Meter Energy Published
- ALBERTA: UCP's decision to stick with status quo on electricity market a boon for renewables, companies say
- ALBERTA: Government no longer committed to $20/tonne carbon price for heavy emitters
- ALBERTA - Renewable Energy Plan killed
- City grids risk being overwhelmed by EV growth
- Four Colorado utilities join forces to explore joining regional trading market
- Pacific Gas & Electric Submits Vision of Grid Modernization in Rate Case Filing

Implications for Reliability:

We do not view the dichotomy described above as presenting a threat to electric reliability. However, we see it as a debate through which electric reliability will be shaped in different States and Provinces. The shape, costs, and timing of the evolution of the power grid as this unfolds over time is a core question in the WECC scenario analysis. Developments at this stage may argue for more intensive WECC planning analyses which can take into account varying policies in States and Provinces which also act on a regional basis.
Customer Adoption of Energy Service Options
The scenario matrix east-west horizontal axis descriptor of Customer Adoption of Energy Service Options was created by combining two of the Key Drivers: 3) Evolution of Customer-side Energy Supply Technology Service Options, and 4) Changes in the Character and Shape of Customer Demand for Electric Power.

Evolution of Customer-side Energy Technology and Supply Options
From The 2038 Scenario Report: "Distributed and smaller-scale energy supply options are evolving and expanding rapidly, especially solar power (both rooftop and ground-based), energy storage, fuel cells, demand response, energy efficiency, and small-scale natural gas-fired generators. Commercial and industrial customers have distributed energy resource options as well as residential consumers. Technological innovation appears to be expanding those options by making them less costly, easier to install, and by adding more features for customer management and engagement. As electric distribution systems evolve, more of those distributed energy supply options may become a part of the electric power infrastructure and change how assuring electric power reliability is managed."

Changes in the Character and Shape of Customer Demand for Electric Power
From The 2038 Scenario Report: "Customer demand for electric power can shift for a wide range of reasons, including economic growth, response to cost changes, customer desires for new features and benefits (like carbon reduction). The many segments of customers include large and small industrials, large and small commercial, both large and small agriculture, high income to low-income residential consumers, and other marketing defined segments. Customers within all of the segments may change the features they desire for electric power service as market conditions change. Economic factors may influence costs and features offered. Social values may shift and change how customers value different aspects of their electric power consumption, e.g., how clean or how exposed to cyber-security risk. The basis upon which customers are segmented or put into categories may shift as customers adopt new service options (especially those customers who have some level of onsite self-generation or use new information services). Customers’ adjustments will affect how power is supplied and thus have implications for sustaining electric reliability." 19

We suggest a look at a larger dynamic taking place in this scenario axis driver. In this case, the dichotomy we are seeing is the differences between producers pushing new energy products and services versus the levels of and factors influencing customer demand and uptake of those products and services.

We think there are several factors behind producer push including the opportunity for potential profits, desires to use and implement emerging technologies (for example new communications and information technology and energy storage technologies), and values around environmentalism and clean energy. Customer demand, on the other hand, we see as being influenced by levels of consumer income, consumer assessment of benefits balanced with costs, and consumer values (for example driven by environmental issues, support for local industry, interest in new technology and many others we can only imagine).

In the near term, the possibility of an economic recession driven by trade issues or the normal cycles of economic growth might reduce consumer willingness and interest in new, unproven services and products, especially when the risk of cost increases are present. There are EPS submissions below which suggest a possible near term decline in economic growth in the U.S. and possibly globally. During past recessions, demand for energy has fallen with declines in economic activity and consumer spending. Deep recessions can lead to structural changes in the economy (like the housing debacle of 2008-2009) that can influence long term consumer behavior. We are not predicting this in the near future, but we can watch for it.

Because of the wide variation in electrical products and services, it is not possible to make a general statement about consumer demand that applies to all (beyond the economic issue above). However, outside of electric vehicles and rooftop solar panels, we do not see prominent new energy services and products with

19 WECC 2018-2019 Draft Scenarios for Horizon Year 2038_V 0.1, July 25 2018
significant consumer pull. We have covered advanced meters in the past, and there was no market revolution associated with those products. EVs and solar panels appear to be growing at moderate rates but still benefits from policy support and subsidies to maintain their sales.

We see an uptick in consumer choice aggregation activity which may include new energy service and customer engagement options. We are unclear as to the long term structural impact on these developments in terms of fundamentally reshaping consumer demand and preferences (and at what costs). Further development may need to occur to assess this. The EPS submissions below touch upon recent developments.

- Arizona's top regulator spurs retail choice progress, pushes for rule drafting
- CAISO Advances Work on Energy Storage Distributed Energy Resource Integration
- California grid operator asks FERC for broader authority to maintain system reliability
- California opens $1B in efficiency funding to electrification
- Arizona's new EV growth plan
- L.A. Mayor Garcetti's 'Green New Deal' would phase out gas-fueled cars

**Implications for Reliability:** We do not view the dichotomy above as presenting a threat to electric reliability. However, we see it as a debate through which electric reliability is shaped as consumer demand and market determine which services and products are valid and valuable. The shape, costs, and timing of the evolution of the power grid as this unfolds over time is a core question in the WECC scenario analysis.

Developments at this stage may argue for more in-depth WECC planning analyses—these analyses would take into account actual impacts on power demand as consumers use and implement new products and services.

**Implications for the Scenarios, Modeling, and Metrics:** The dichotomy of issues we discussed above relating to the axis drivers of the scenarios suggests another way of seeing how the core ideas in the scenarios may play out. Here is how we might consider discussing their developments with the SDS in light of the dichotomies.

**Scenario 1:** Consistent with the arguments contained in the scenario narrative we suggest that State and Province level variations in producer push in markets, policy push on environmental concerns, and concern for costs and benefits varying by State and Province. In some cases, policy supporting key technologies might lead market developments with variations by State and Province. Consumer pull will be weak and vary by State and Province, as benefits balancing out costs are slow to evolve. Key metrics to adjust in light of the above could be in the areas of limited growth in electrification and related energy demand.

**Scenario 2:** Consistent with the arguments contained in the scenario narrative we suggest that across the WECC region producer push in markets, and policy push on environmental and other concerns shapes the products and services emerging in the market. Consumer pull strengthens over time as benefits of new services and products are worth the costs. Producer push using new technologies leads and shapes energy policy via advocacy by producers, achieving common results within the Western Interconnection. Key metrics to adjust in light of the above could be in the areas of higher levels of growth in electrification and related energy demand.

**Scenario 3:** Consistent with the arguments contained in the scenario narrative we suggest that across the WECC region: producer push in markets is constrained by policy concerns about costs and benefits of new energy services and products. Consumer pull is weak due to the limited offerings and concern over costs that do not balance benefits. In a few cases, policy supporting key technologies might lead to market developments based on proven costs advantages. Key metrics to adjust in light of the above could be in the areas of limited growth in electrification and related energy demand growth.

**Scenario 4:** Consistent with the arguments contained in the scenario narrative we suggest that across the WECC region: producer push in markets is targeted and directed by policy concerns about costs and benefits of new energy services and products. Proven products and services will be taken up by consumers based on
policy direction and support. Consumer pull will focus on the limited offerings where concern over costs balancing with benefits has been determined by regulatory oversight. In select cases, policy supporting key technologies will lead to market developments based on proven costs advantages. Key metrics to adjust in light of the above could be in policy directed areas of growth in electrification and related energy demand growth.

Scenario 5 (EWCC): Consistent with the arguments contained in the scenario narrative we suggest that across the WECC region; producer push in markets is targeted and directed by policy concerns about carbon reduction and clean energy. Proven products and services will be taken up by consumers based on policy direction and support related to environmental concerns. Consumer pull will focus on the limited offerings where direct environmental benefits are achievable. In select cases, policy supporting key technologies will lead to market developments based on addressing environmental policies. Key metrics to adjust in light of the above would be those metrics that can have an impact on meeting environmental policies.

Evolution of the Impacts of Climate Change and Environmental Issues on Electric Power Service

From The 2038 Scenario Report: “Addressing climate change is a central issue in the evolution of electric power supply systems in the US, Canada, and the world. Other environmental issues like air and water quality and land use are also important. Policies set by governmental agencies will influence electric supply and demand choices for all customers, and those policies will impact the cost of power. How customers see, and value climate and environmental issues will impact future legislation placed on the power industry.”

There were enough significant events related to both this driver and Scenario 5: Energy, Water, and Climate Change, plus the current work in progress by WECC Staff and a consortium of National Labs on Scenario 5 that we thought this Key Driver should be looked at in detail in this report. First, we’ll look at events reporting the effects of global warming across the world, and then we’ll look at a detailed study of how warming is accelerating in the US, and refer readers to an article on global hotspots.

July 2019, The Hottest Ever: With temperatures soaring in Europe and Alaska, ice melting in Greenland and forests burning across Siberia, July 2019 seemed like a blistering one worldwide. It was. European climate researchers said that July 2019 was the hottest July — and thus the hottest month — ever recorded. While July is usually the warmest month of the year for the globe, according to data, it also was the warmest month recorded globally. July is part of a long-term trend: As human-related emissions of greenhouse gases have continued, the atmosphere has continued to warm. The past five years have been the hottest on record, including the record year of 2016. The ten hottest years have all occurred in the past two decades. This June was the warmest on record, and the previous five months were among the four warmest for their respective months, the climate researchers said. That puts this year on track to be in the top five, or perhaps the hottest ever.

UN Study says Changing Climate Imperils Global Food and Water Supplies: The world’s land and water resources are being exploited at “unprecedented rates,” a new United Nations report warns, which combined with climate change is putting dire pressure on the ability of humanity to feed itself. There is no shortage of facts in the new report on climate change and land, chief among them: For everyone who lives on land, the dangerously warmed future is already here (see Figure 2 below). Earth’s land has already warmed more than 1.5 degrees Celsius (2.6 degrees Fahrenheit) since the industrial revolution, according to the Intergovernmental Panel on Climate Change. That’s the same amount of warming that climate activists are hoping to prevent on a global scale.

---

20 WECC 2018-2019 Draft Scenarios for Horizon Year 2038 V 0.1, July 25 2018
The report found that the window to address the threat is closing rapidly. A half-billion people already live in places turning into desert, and the soil is being lost between 10 and 100 times faster than it is forming. Climate change will make those threats even worse, as floods, drought, storms, and other types of extreme weather threaten to disrupt, and over time shrink, the global food supply. Already, more than 10 percent of the world’s population remains undernourished, and some authors of the report warned in interviews that food shortages could lead to an increase in cross-border migration.

A particular danger is that food crises could develop on several continents at once. The potential risk of multi-breadbasket failure is increasing, and all of these things are happening at the same time. The report has an overarching theme that land is extremely scarce, we need it for everything, and we are already using most of it. More than 70 percent of the planet’s ice-free land is already shaped by human activity. As trees are felled and farms take their place, this human-managed land emits about a quarter of global greenhouse-gas pollution every year, including 13 percent of carbon dioxide and 44 percent of the super-warming but short-lived pollutant methane. People currently use one quarter to one-third of land’s potential net primary production for food, feed, fiber, timber, and energy. There could be “multiple bread-basket failures,” in which crops die across several major agricultural regions at the same time. Crops in Europe had already suffered this summer under successive heatwaves. Farmers in the Midwestern United States, meanwhile, have been hammered by spring and early-summer floods.

**Alaska – Heat, Glacier Melt, and Wildfires:** Fires are spreading farther north, burning more intensely and starting earlier, in line with what scientists have warned would happen with climate change. A region of Alaska about the size of California has sizzled under an intense, record-length heatwave for weeks. And it isn’t just the land that’s warming: the northern coast is losing its sea ice about two months earlier than average, and ocean surface temperatures are as much as 9 degrees Fahrenheit above normal in the Chukchi Sea. Across the state:

- For the first time in the 95-year record, the year-long July-to-June average temperature for Alaska as a whole was above freezing, showing the persistence of much warmer than average temperatures over the state.
- For the year to date, the Alaska statewide average temperature was 7.9°F above average, according to NOAA’s latest National State of the Climate report.
- During the last 67 years, Anchorage saw a total of 17 days with a temperature of 81°F or above. This year, 81 was the average temperature for a 12-day stretch in late June and early July.
- On July 4, Anchorage hit 90°F, breaking the city’s all-time record by 5 degrees.

Wildfires - So far this year (as of July 2019), wildfires have scorched more than 1.2 million acres in Alaska, making it one of the state’s three biggest fire years on record to this date, with high fire danger expected to persist. Several studies, as well as ongoing satellite monitoring, show that fires are spreading farther north into the Arctic, burning more intensely and starting earlier in the year, in line with what climate models have long suggested would happen as sea ice dwindles, and ocean and air temperatures rise.

**Glacial Melting** - A new way of measuring how some glaciers melt below the surface of the water has uncovered a surprising realization: Some glaciers are melting a hundred times faster than scientists thought they were. In a new study published in Science, a team of oceanographers and glaciologists unpeeled a new layer of understanding of tidewater glaciers—glaciers that end in the ocean—and their dynamic processes. Students at Petersburg High School near LeConte Bay started collecting data about the position of the glacier’s terminus in 1983. Their noting of the glacier’s retreat several years ago alerted scientists, piquing interest in better understanding melting at the glacier. They’ve discovered that the melt that’s happening is fairly dramatically different from some of the previous assumptions.

---

23 EPS: Alaska Chokes on Wildfires as Heat Waves Dry Out the Arctic, Inside Climate News, July 11 2019
24 EPS: Alaskan glaciers melting 100 times faster than previously thought, National Geographic, July 25 2019
Some of this calving and glacial melt is a normal process that glaciers undergo during seasonal transitions from winter to summer, and even through the summer. But a warming climate accelerates glacier melting across the globe, potentially through melting across the surface of the glacier, but also through underwater melting, and glaciers can extend hundreds of feet below the surface. Finding higher rates of submarine melting tells us that glaciers are a lot more sensitive to ocean change than we've even thought.

Russia - Permafrost Melting and Burning: A vicious environmental circle is taking hold in Russia and other parts of the Arctic as permafrost – the frozen ground beneath a quarter of the Northern Hemisphere and almost 20% of Earth's landmass – thaws. Russia's permafrost is melting and burning in wide swaths across Siberia, and there is no way yet to stop the fires. They are already causing weather pattern shifts and disruptions in Northeastern Europe. Russia has declared a state of emergency in five Siberian regions after wildfires engulfed an area of forest almost the size of Belgium amid record high temperatures as a result of climate change.

Permafrost warming has the potential to amplify global climate change, as frozen sediments thaw and unlock soil organic carbon. Previously frozen organic matter in permafrost decomposes and generates carbon dioxide and methane, and could increase global warming by as much as 0.27 °C by 2100. The Arctic is warming twice as fast as the rest of the planet, research shows, and longer, hotter summers are expediting the melting process. That's causing vast areas of land to erode and slide.

Canada’s Permafrost: Fitting in with other observations in Alaska and Russia, permafrost at outposts in the Canadian Arctic is thawing 70 years earlier than predicted, an expedition has discovered, in the latest sign that the global climate crisis is accelerating even faster than scientists had feared. A team from the University of Alaska Fairbanks said they were astounded by how quickly a succession of unusually hot summers had destabilized the upper layers of giant subterranean ice blocks that had been frozen solid for millennia.

Indigenous Peoples Disproportionately Affected by Climate Change: Two reports issued in November 2018 by the US Government - the National Climate Assessment (NCA4) and the 2nd State of the Carbon Cycle Report, report that indigenous peoples of the United States are already dealing with harms from climate change, and the rapid rate at which reservation ecosystems are changing threatens traditional food practices, cultural identities, and economic development. Tribes have reported such threats as increased wildfires, diminishing wildlife, fish, and agricultural staples, and water shortages. The unique constraints inherent to remote tribal lands exacerbate stresses brought on by the changing climate. Despite legal limitations, tribes are at the forefront of mitigation strategies and could play a key role in efforts to curb greenhouse gas (GHG) emissions, preserving ways of life that have sustained for thousands of years.

Tribal lands are crucial not only to meeting GHG emissions' reductions but also to ecosystem and watershed management. As noted in NCA4, "Tribal trust lands provide habitat for more than 525 species listed under the Endangered Species Act, and more than 13,000 miles of rivers and 997,000 lakes are located on federally recognized tribal lands." The preservation of these important resources contributes to indigenous livelihoods and culture while helping non-Native communities maintain safe access to drinking water, irrigation sources, and biodiversity. Although tribal lands comprise a mere 2% of the United States, indigenous landholdings house more than 5% of the nation's renewable energy potential. If America hopes to meet GHG reduction targets, it will need to work with tribes to harness the abundant wind and sun on reservations.

20° C Beyond the Limit - Global Warming is Already in the US: As writer William Gibson says, "The Future is Already Here, It's Just Unevenly Distributed." A Washington Post analysis of more than a century of climate change data shows that the effects of global warming are already being felt in the United States. The National Climate Assessment (NCA4) reports that the country is experiencing changes in temperature, precipitation patterns, and extreme weather events that are altering ecosystems and human activities.

---

21 EPS: Russia’s permafrost is melting, and burning, and it could have a devastating global effect, World Economic Forum July 16 2019, Inside Climate News July 31 2019, and The New York Times August 8 2019
22 EPS: Scientists amazed as Canadian permafrost thaws 70 years early, Reuters, June 18 2019
23 EPS: Indigenous Peoples in the US are Disproportionately Affected by Climate Change, The University of Maryland Center for Sustainability, November 29 2018
24 Author William Gibson in The Economist, December 4 2003
National Oceanic and Atmospheric Administration temperature data across the Lower 48 states and 3,107 counties has found that major areas are nearing or have already crossed the 2-degree Celsius mark. Today, more than 1 in 10 Americans — 34 million people — are living in rapidly heating regions, including New York City and Los Angeles. Seventy-one counties have already hit the 2-degree Celsius mark.

- Alaska is the fastest-warming state in the country, but Rhode Island is the first state in the Lower 48 whose average temperature rise has eclipsed 2 degrees Celsius. Other parts of the Northeast — New Jersey, Connecticut, Maine, and Massachusetts — trail close behind.
- While many people associate global warming with summer’s melting glaciers, forest fires, and disastrous flooding, it is higher winter temperatures that have made New Jersey and nearby Rhode Island the fastest warming of the Lower 48 states.

The point of the article is that while on average the global temperature rise may not be at 2°C yet (although close), there are geographical areas worldwide that are below and above that global average – in the case of the Western Interconnection, considerably above. Knowing what is happening within a region or country hits home harder than considering global averages. In any one geographic location, 2 degrees Celsius may not represent cataclysmic global change, but it can threaten ecosystems, change landscapes, and upend livelihoods and cultures. The nation’s hot spots will get worse, absent a global plan to slash emissions of the greenhouse gases fueling climate change.

In many areas in the Western Interconnection region, we have already exceeded the 3°F (1.7°C) average temperature increase by 2034 anticipated in the scenario, some by a significant amount. Note the preponderance and locations of 2°C – 3°C rate of rise in temperature areas in the Western Interconnection in the figure below.

**Figure 2, Temperature Rise Rate 1895–2018 C to F, Source: The Washington Post**

Daniel Pauly, an influential marine scientist at the University of British Columbia, says the 2-degree Celsius hot spots are early warning sirens of a climate shift. "Basically,” he said, "these hot spots are chunks of the future in the present." Learnings from the research include:

2°C Beyond the limit - Extreme climate change has arrived in America, The Washington Post, August 13 2019
• **Warming is very uneven.** At the extreme, some regions show more than 2 degrees Celsius, or 3.6 degrees Fahrenheit, of warming. Others have barely warmed at all, or cooled slightly, over the entire period from 1895 to 2018. The average warming of the Lower 48 states, about 1 degree Celsius, obscures the severity of some of the nation’s temperature spikes.

• **Large regions show clear and strong warming signals.** Scientists tell us that it is difficult to draw conclusions about temperature changes — and their causes — over small areas because of random variability and other complexities. But some large swaths of the country have seen consistent, remarkable warming. They include the Northeast, much of the U.S. border with Canada, and major parts of Utah, Colorado, and Wyoming.

• **When it comes to the Northeast, the winter season has been transformed.** When the data was examined more closely, it became clear that winter is the fastest-warming season in the Northeast, consistent with the expectations of climate scientists. We also found that the pace of warming over the past 60 years or so has accelerated.

• **Some of the fastest-warming regions have very few people living in them. Others, though, are highly populated.** We found only a very weak relationship overall between the rate of warming in individual counties and their levels of population density. This suggests that urbanization, which is known to cause warming in local areas, cannot explain most features of this map. NOAA also tries to control for urbanization in its data set, though it cannot be ruled out as a cause.

• **These changes are already having major impacts, which vary depending on the location.** In the Northeast, changes are being felt in agriculture — which is witnessing a strong shift of the seasons and of winter most of all — and in greater pressure from insects, such as ticks and agricultural pests, which plague humans and wildlife alike. And that barely scratches the surface.

To find the world’s 2°C hot spots—its fastest-warming places—The Post analyzed temperature databases, including those kept by NASA and NOAA; peer-reviewed scientific studies; and reports by local climatologists. The global data sets draw upon thousands of land-based weather stations and other measurements, such as ocean buoys armed with sensors and ship logs dating as far back as 1850. The complete analysis protocol using NOAA data is described at the end of the article.

The Global Warming Picture: In looking at long-term data, The Post did not stop with the US. A new Washington Post article reports the same type of analysis of multiple temperature data sets found numerous locations around the globe that have warmed by at least 2 degrees Celsius over the past century. That’s a number that scientists and policymakers have identified as a red line if the planet is to avoid catastrophic and irreversible consequences. But in regions large and small, that point has already been reached. The article in the EPS referenced below has details of the study and a visualization of the extent of global hot spots already at or above the 2°C threshold. A new UN report, a synthesis of the most up-to-date climate science on oceans and ice, shows that climate change is heating the oceans and altering their chemistry so dramatically that it is threatening seafood supplies, fueling cyclones and floods, and posing profound risks to the hundreds of millions of people living along the coasts.

The Upshot: WECC’s Scenario 5: Energy, Water, and Climate Change, is based on a 3°C rise in average temperature by 2034. The effects of such a degree of warming described in the narrative represented the level of understanding of global warming as of 2014. It seems clear that not only is global warming continuing, but it is accelerating, and many areas of the US, Canada, and the rest of the world have already met or exceeded a 3°C temperature increase (1.7°C). We think the effects of global warming described in WECC’s Scenario 5: Energy, Water, and Climate Change narrative should be seen as happening at a faster pace than initially thought, with more extreme effects well within WECC’s Year 20 planning timeframe.

For further reading, we suggest these additional EPS:

30 EPS: Dangerous New Hot Zones are Spreading Around the World, The Washington Post, September 11 2019
31 Article: The World’s Oceans Are in Danger, Major Climate Change Report Warns, the New York Times, September 25 2019
• **Climate change: Current warming 'unparalleled' in 2,000 years**
• **Climate change impacts worse than expected, global report warns**
• **US energy, transportation sectors not prepared for climate change**
• **US Climate Report Warns of Damaged Environment and Shrinking Economy**

**Implications for Reliability:** Due to widespread and varied impacts of potential climate change events, we continue to see recent developments in this area presenting significant risks to electric reliability in all four of the areas of concern. Climate-related events can destroy and disable power systems, e.g., the recent California wildfires, flooding of low-lying generation resources, drive population shifts, and increased need for air-conditioning affecting demand curves, and degrading transmission efficiencies, such that resource adequacy, operational, infrastructure, and system stability risks can emerge.
SCENARIO TRENDS AND EARLY INDICATORS

The purpose of this section is to give SDS members a sense of how recent developments might reflect on the key potential developments in each scenario. Members should hold in mind that the scenarios are intended to be different possible future states and not “good or bad” or “opposites,” just different plausible futures that can be considered for learning and analysis.

At this time the WECC Scenarios have been active for a period of 14 months, therefore it is too early to determine a course of events that would make any of the scenarios irrelevant—(since the scenarios extend for 20 years, at least a few years of developments would be needed: Each scenario remains relevant for study.

In the recent Summer Trends Report preceding this report, we pinpointed developments for each scenario that we think validated the continued assessment of events for each of the scenarios. We believe those developments still hold and events covered in this report only support those. Therefore, we would suggest that as members review earlier parts of this report, they keep the scenarios in mind, and in that course, we are sure that several events will resonate with the reader in each of the scenarios.

Over the next months working with WECC staff and SDS members, we will turn our attention to targeting EPS submissions and trend analysis on research which supports information that will help setting metrics in the modeling of the scenarios.

Specifically, we will seek both qualitative and quantitative information that can support the SDS and WECC staff in setting key metrics (for example levels of electrification in the different scenarios) that will vary from one scenario to another. Even though we will share this information and data with the SDS Scenario Task Force (WSTF), we will gather those specific pieces of research for each scenario in a year-end report for the broader readership.

Variations in the metrics' values will lead to differences in the modeling results and thus enable learning and assessments of how key variables might impact factors that are important in sustaining electric reliability. This aligns with the purpose of the scenario work in the SDS protocol to conduct analyses to determine as events unfold in the scenarios, what risks or opportunities occur for meeting electric reliability.

---

32 As noted at the beginning of this report, WECC has a fully functioning EPS system related to the current 2018-2038 Scenarios.
SCENARIO MOVEMENT

We believe in the 2038 Scenarios, given the choices by the SDS for the Primary Scenario Drivers and other Key Drivers that the states and provinces within the region will not move in lockstep towards any particular scenario. Considering the new Scenario Matrix, this would imply that there would not be a region-wide “movement” that could be plotted against the new scenario matrix as in the Legacy Scenarios.

We think that developments and trends within each scenario, noting specific events at the state and local levels that fit that scenario is—at least at the beginning these 20 years—more useful to WECC and the SDS. We have asked SDS members to tell us where they think their state fits within the scenario matrix. Figure 4 below was discussed at the SDS meeting on September 17.

A broad issue with scenario movement in states and provinces is illustrated by Arizona. Note that Arizona is placed in both Scenario 3 and Scenario 4, as it has seen recent events that argue for both scenarios. We see this in other areas as well. In Arizona, we saw these events in the Third Quarter:

Scenario 3 - Arizona Corporation Commission votes to halt biomass bottleneck solution
Scenario 4 - Arizona’s top regulator spurs retail choice progress, pushes for rule drafting, and Arizona’s new EV growth plan

During future SDS meetings, we will seek review, comments, and suggestions from SDS members from those States and Provinces to improve this view of scenario movement at the state and provincial level. In the meantime, we would like readers of this report to email us at Quantum Planning Group and tell us where they think their state or province fits within the scenario matrix. Over time, we think reviewing those placements on the matrix will provide useful information for SDS members and WECC planning efforts.

You can email us at: gerald@artofquantumplanning.com, or richardmarrs@altamontcg.com
In the broader context of the Western Interconnection as a whole, we can say that, based on the Key Driver events we have seen in the past three months with differing state and provincial policy actions, from a high level these events tend to support movement in the Western Interconnection as a whole towards both Scenario 1 and Scenario 4. We can also see developments that argue for Scenario 3 in many states in the Western Interconnection. A key element of this assessment is the lack of any significant technological developments or other market-related issues that would lead to a quickened uptake of the kinds of energy-related services and products advocated most strongly in Scenario 2.

Events Impacting Scenario Movement in the Third Quarter include:

- State government leaders and regulators exercising power to determine energy industry economics and support targeted energy resources.
- State government leaders and regulators are making policy to assure electric reliability with oversight.
- The growth of policies and other forms of support for the expansion of electric vehicle use by consumers.
- The growing use of battery storage system in distributed energy applications and for utility-scale reliability.
- More sales promotion than actual fast growth in consumer purchases of behind the meter “innovation.”
FROM THE ARCHIVES: EPS OF CONTINUING SIGNIFICANCE

This EPS system originated with the first set of Legacy Scenarios created by WECC and the SDS. Much of the data and information gathered there remains relevant in understanding developments in electric energy markets and the electrical power industry in general.

In this section, we want to remind and reconnect members to some of that past research that we think will be useful and appropriate in understanding developments that shine a light on the current 2018-2038 WECC scenarios.

To provide context and additional thinking on the Key Driver dichotomies described in the section above, we suggest readers review the Second Quarter 2019 Trends Report found here, and specifically the following sections:

2. Customer Adoption of Energy Service Options, consisting of:
   3. Evolution of Customer-side Energy Technology and Supply Options............... Page 15
   4. Changes in the Character and Shape of Customer Demand for Electric Power ... Page 18