WECC

Year 20 Transmission Trends Assessment

June 2024

Executive Summary

In 2022, WECC and its stakeholders identified long-term transmission planning as a critical need for the West. FERC's recently issued Order 1920 bolsters this view and addresses the need for long-term, comprehensive regional transmission planning. Beyond the cost implications, the lack of long-term regional planning creates potentially severe reliability risks, given rapidly changing conditions and long lead times to plan and build new infrastructure. Because of the potential risks, WECC committed to building the capability to conduct long-term interconnection-wide planning.

One challenge in long-term planning, 20 years into the future, is the uncertainty of forecasting loads, resources, and transmission so far in advance. Currently, most transmission planners do not perform 20-year planning. The few that do use a range of approaches, and none study the entire interconnection. This required WECC to create a new approach to examine trends and identify potential risks in the 20-year future. To build and test its approach, WECC looked at several scenarios representing a range of conditions set in 2042 (Year 20) and then compared the results to identify trends in transmission use and energy flows. WECC compared five cases:

- 2032 Anchor Data Set (2032 ADS): Year 10 production cost model representing planned 10-year-out loads, resource, and transmission assumptions WECC receives from Balancing Authorities.
- Year 20 Foundational Case (Y20 FC): Created from the 2032 Anchor Data Set (2032 ADS) to serve as the starting point for WECC's Year 20 assessments.
- Year 20 Extreme Cold Weather Event (Y20 Cold Event): Examines a hypothetical extreme cold weather event in 2042, similar to Winter Storm Elliott in December 2022.
- Year 20 Extreme Heat Event (Y20 Heat Event): Examines a hypothetical extreme heat event in 2042 similar to the August 2020 heat event.
- Year 20 Compound Load Impacts (Y20 Compound Load): Examines the potential reliability impacts from large changes in load and load shifts caused by electrification

WECC analyzed net transfers between subregions in the West and path utilization on major WECC paths. Results were compared across the five cases to identify major changes, which may indicate risks. Among the observations:

- Most subregions required increased imports during both the extreme cold and extreme heat events.
- Under high-load conditions in the Y20 Compound Load study, the California–Mexico (CAMX) subregion was an exporter annually. However, during extreme weather, the CAMX subregion required imports.
- Each path is used differently in each season, month, and time of day, and during extreme weather events. Entities in the West cannot assume the direction of flows on paths today will be the same in the Year 20 future, nor that the predominant flow direction will be the same across all system conditions.

- Some results showed a decrease in path utilization but a high potential for load loss due to generation constraints.

WECC's analysis offers a first glimpse into the potential risks in the Year 20 future. This initial foray into Year 20 study work makes clear that understanding the potential system performance and related reliability risks in this time horizon is a complex undertaking. Continued study across a broad range of future scenarios will help WECC and others build their long-term planning capacity and better understand these complexities and the risks they reflect. The creation of more complete 20-year forecasts and assumptions, as well as continued model development, are necessary to this work.

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Background

In 2022, the WECC Board of Directors requested that staff perform a gap analysis to identify challenges with existing transmission planning processes and report on potential activities that may add value to transmission planning in the West.

WECC staff interviewed 26 stakeholders involved in transmission planning to better understand the challenges they face and gather ideas for new activities WECC can undertake to support transmission planning in the West. A common challenge among interviewees was the length of time large inter-subregional transmission projects take to build. From inception to construction, major transmission projects typically take 15 to 20 years. Inter-subregional and interconnection-wide planning studies use a 10-year time frame. The need for longer-term studies became apparent, and WECC committed to meeting this need with a transmission trends assessment that looks 20 years ahead. This report presents the input assumptions, analysis approach, and key observations from that analysis.

Long-term Transmission Planning

On April 21, 2022 FERC issued a Notice of Proposed Rulemaking (NOPR) on transmission planning that proposed to reform both the *pro forma* Open Access Transmission Tariff and the *pro forma* Large Generator Interconnection Agreement to remedy deficiencies in FERC's existing regional transmission planning and cost allocation requirements. Among other things, the NOPR proposes to require public utility transmission providers to conduct 20-year-and-beyond, long-term transmission planning. Subsequently, WECC held a workshop on October 6, 2022, on long-term transmission planning where various concepts and approaches were discussed regarding long-term transmission planning. To summarize the discussions at this workshop, WECC published "Long-term Transmission Planning in the West—October 2022 RAC Workshop Discussion Summary and Next Steps," which details the various factors, scenarios, assessment approaches, tools and modeling considerations for long-term transmission planning.

Approach

There is a great deal of uncertainty involved in forecasting loads, resources, and transmission assumptions beyond 10 years. This poses a challenge for planning entities and affects confidence in the results when performing 20-year assessments. Most entities do not perform this type of long-term planning. Those that do take various approaches to address the uncertainty and perform assessments that will be useful in decision making. One approach to Year 20[1] studies is to examine various scenarios representing a range of conditions, then compare the results to identify trends in transmission needs

[1] WECC uses the term Year 20 to refer to these assessments because they study a single year, 20 years in the future, as opposed to studying all the interim years.

and use. The premise for this approach is that transmission needs common to most or all the studied scenarios will likely be necessary no matter what course the future takes. This is the approach WECC took in this transmission trends assessment.

A comprehensive interconnection-wide Year 20 forecast of transmission topology does not exist. Because of this, WECC did not attempt to model future transmission additions beyond those included in the 2032 ADS for this assessment. To do so would have required WECC to make transmission addition decisions that would have skewed the results. Instead, this assessment compares transmission use across five separate assessments to identify trends in transmission use:

- 2032 Anchor Data Set (2032 ADS): Year 10 production cost model (PCM) representing planned 10-year out loads, resource, and transmission assumptions WECC receives from Balancing Authorities.
- Year 20 Foundational Case (Y20 FC): created from the 2032 ADS to serve as the starting point for WECC's Year 20 assessments. It represents one of many possible business-as-usual 20-year future scenarios. The Y20 FC does not represent the WECC expected future, but rather a resource-balanced starting point for studies that are performed for the Year 20.
- Year 20 Extreme Cold Weather Event (Y20 Cold Event): Examines a hypothetical extreme cold weather event in 2042. WECC extrapolated conditions for the simulated 2042 event from actual conditions and system performance during Winter Storm Elliott in December 2022.
- Year 20 Extreme Heat Event (Y20 Heat Event): Examines a hypothetical extreme heat event in 2042. WECC extrapolated conditions for the simulated 2042 event from actual conditions and system performance during the August 2020 heat event.
- Year 20 Compound Load Impacts (Y20 Compound Load): Examines the potential reliability impacts from large changes in load caused by electrification and how shifting the load increases caused by electrification to different parts of the day could relieve reliability risks.

This work is the first of its kind conducted at the interconnection-wide level. As such, WECC encountered some challenges and gathered invaluable lessons in performing longer-term transmission planning. This report, along with those listed above, provide insights about these lessons and how they can be applied to future Year 20 transmission planning work.

Data and Assumptions

Load and Resource Assumptions

Table 1 provides a summary of the load and resource assumptions used in each of the compared cases and studies.

Table 1. Summary of Assumptions

Case or Study	Load Assumptions	Resource Assumptions
2032 ADS V2.4.1	• Load forecasts as provided by BAs	• Resource forecasts as provided by BAs
Y20 FC	• Loads were increased linearly from 2032 ADS	• Resource retirements in 2032 ADS honored • Resource additions limited to wind, solar, and energy storage in line with AEO and NREL forecasts • Resource additions were distributed by area • CAISO-provided 20-year resource additions for their subregion
Y20 Compound Load	• Load magnitude increased due to load increase from electrification • Load shape modified for forecast electrification time of use	• Same as Y20 FC
Y20 Heat Event	• Load profiles from the western heatwave event that occurred August 14 through 19, 2020	• Resource profiles from the western heatwave event that occurred August 14 through 19, 2020
Y20 Cold Event	• Load shape from the December 2022 cold event • Load magnitude increased by 10% over the December 2022 cold event	• Limited natural gas capacity 5% • Decreased wind and solar to mimic December 2022 cold event • Doubled forced outage rates for thermal generators

Transmission Assumptions

WECC used the same transmission topology in each case studied as the 2032 ADS. That topology came from WECC's 2032 Heavy Summer Power Flow[2] base case.

WECC is aware of some planned transmission projects that are not included in the transmission topology because they were not included in the 2032 Heavy Summer Power Flow, largely due to the timing of the data submission. The known projects that were not included are:

- Boardman to Hemmingway—500 kV transmission from Idaho (Hemmingway) to Oregon (Boardman)
- Crosstie—500 kV transmission from Utah (Clover) to Nevada (Robinson Summit)
- Southline—345 kV transmission line from El Paso to Tucson
- SunZia—500+ HVDC transmission line from New Mexico (SunZia East) to Arizona (Pinal)
- Southwest intertie Project—North and South; North: 500 kV transmission line from Idaho (Midpoint) to Nevada (Robinson Summit), South: 500 kV line from Nevada (Robinson Summit) to Harry Allen
- Transwest Express—High voltage DC Transmission line from Wyoming to Utah and 500 kV transmission line from Utah to Nevada
- Ten West Line—500 kV transmission line from Arizona (Delaney) to California (Colorado River)

Key Paths

Of the thousands of lines in its PCM, WECC chose 18 paths to focus on for this analysis. Table 2 provides the paths and their limits as defined in the WECC Path Rating Catalog.[3]

Table 2. Key WECC Paths and Ratings

Path Name	Positive Flow Limit (MW)	Negative Flow Limit (MW)
P01 Alberta-British Columbia	1,000	1,200
P03 Northwest-British Columbia	3,000	3,150
P04 West of Cascades-North	10,700	10,700
P05 West of Cascades-South	5,780	5,780
P08 Montana to Northwest	2,200	1,350

[2] Reliability Modeling Base Cases (wecc.org)

[3] 2023 Path Rating Catalog Public.pdf (wecc.org)

P14 Idaho to Northwest	3,400	2,250
P17 Borah West	--	4,450
P19 Bridger West	4,100	--
P30 TOT 1A	650	--
P31 TOT 2A	690	--
P35 TOT 2C	600	580
P36 TOT 3	1,843	--
P46 West of Colorado River (WOR)	13,400	13,400
P47 Southern New Mexico (NM1)	1,048	1,048
P48 Northern New Mexico (NM2)	2,150	2,150
P49 East of Colorado River (EOR)	10,200	10,200
P66 COI	4,800	3,675
P83 Montana Alberta Tie Line	300	325

Results and Observations

WECC used two methods to examine the transmission trends across the four Year 20 cases.

1. **Subregional Transfers:** Comparison of annual net energy flows between subregions. This provided an interconnection-wide look at net energy flow from exporting subregions to importing subregions.
2. **Path Utilization:** Comparison of path utilization for key WECC Paths. This provided a look at major WECC Paths that might experience congestion given studied conditions in 2042.

Subregional Transfers and Path Flow Directions

WECC's comparison of the subregional net transfers focused broadly on how energy moved between subregions, not on specific transmission lines or paths. To compare the net transfers, WECC selected a single resource-stressed scenario from each of the studies in the assessment and compared the net transfers in each to the net transfers in the Y20 FC to identify major changes. WECC also compared the changes in net transfers between the scenarios.

Figure 1. Subregions Used in Year 20 Studies

Figure 2 and Figure 3 show the results from two months in the Y20 FC compared to the Y20 Cold Event (December) and Y20 Heat Event (August). Most of the subregions required increased imports during both the extreme cold and extreme heat events. In both scenarios, transfers from British Columbia to the Northwest subregion increased substantially. WECC's analysis indicates a potential need for imports to the CAMX subregion during extreme events, despite large capacity additions in that subregion in the Y20 FC.

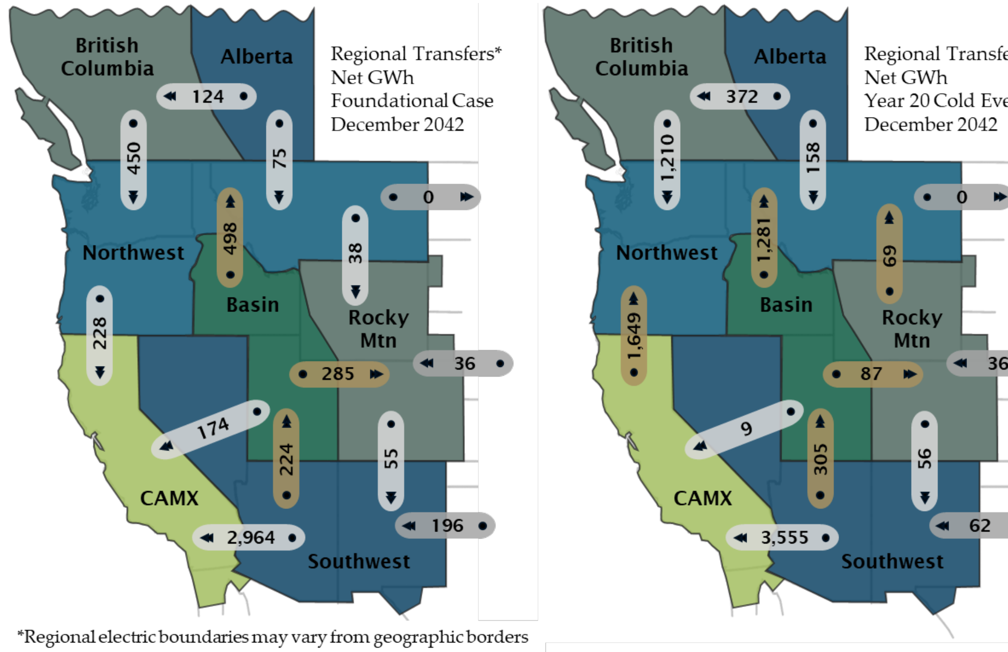

Figure 2: Comparison of Net Subregional Transfers between 2042 Foundational Case and Year 20 Extreme Cold Event

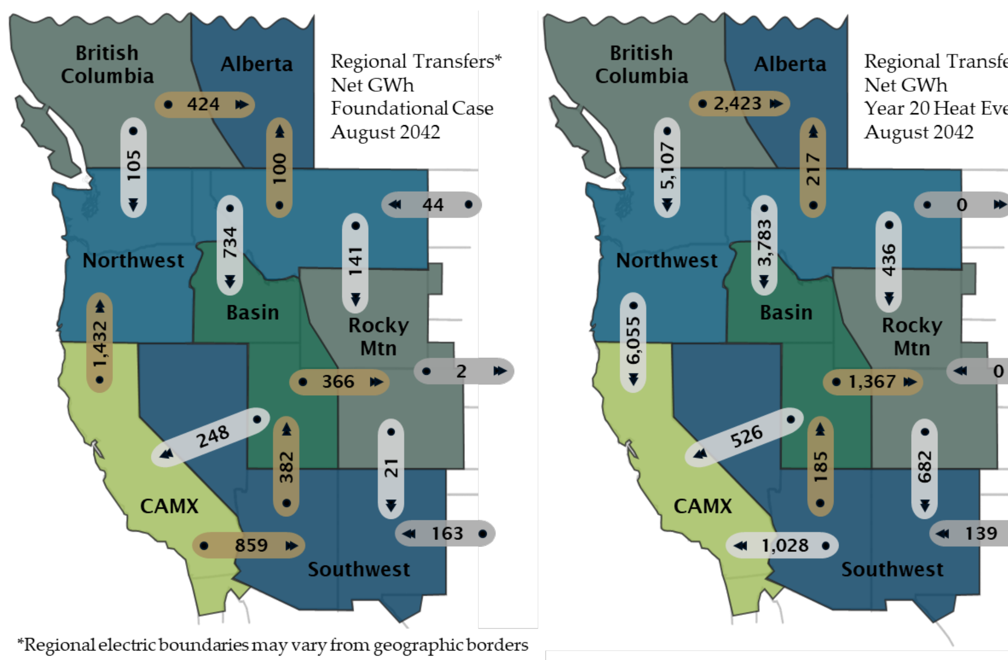

Figure 3: Comparison of Net Subregional Transfers between 2042 Foundational Case and Year 20 Extreme Heat Event

Figure 4 shows the comparison of the Y20 FC and Y20 Compound Load scenario. The results include the all of 2042. Under the high-load conditions caused by electrification in the Y20 Compound Load study, the CAMX subregion became a heavy exporter annually, due to the large amount of wind and solar that California entities plan to build by 2042. Contrasting this with the Y20 Heat Event results shown above highlights how extreme weather events can create different import and export behavior across the interconnection. The CAMX subregion was a net exporter under high load conditions in the Y20 Compound Load case, but required imports in the Y20 Heat Event case. The Alberta subregion had similar results—in the Y20 Compound Load scenario, it is a net exporter, but in the Y20 Heat Event scenario, the subregion relied on imports.

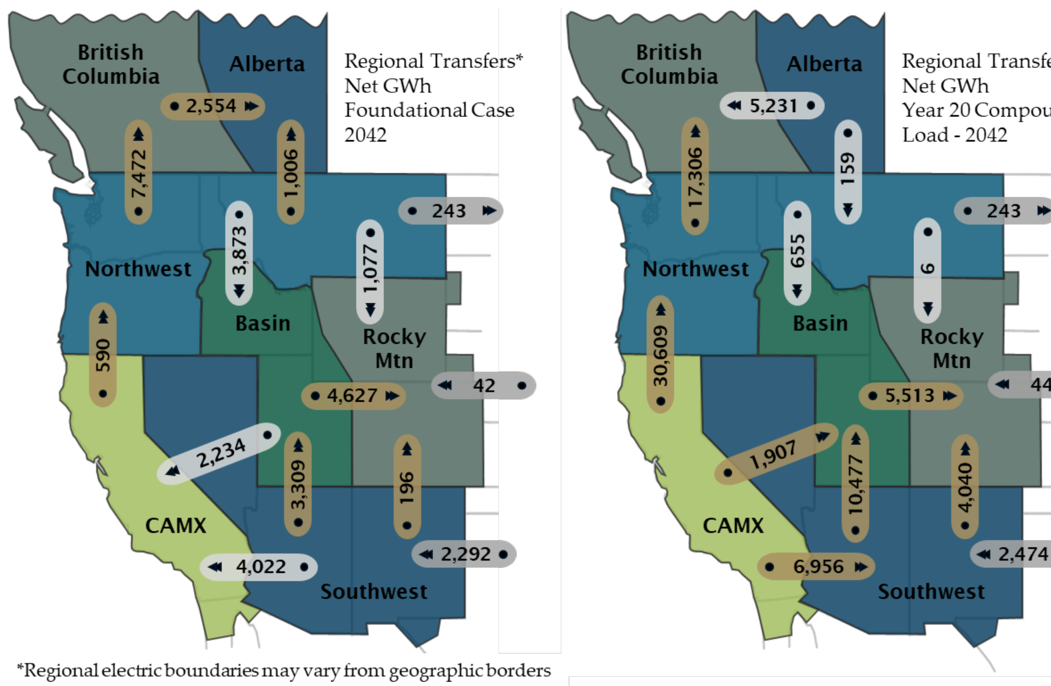

Figure 4: Comparison of Net Subregional Transfers between 2042 Foundational Case and Year 20 Compound Load Case

Path Utilization

WECC measures transmission path utilization with three metrics: U75, U90, and U99. For a given path, the metrics reflect the percentage of time in which path flows meet or exceed the path's rating. For example, U75 represents the percentage of time that the path flows meet or exceed 75% of the path limit(s) from Table 2 (including both directions of flow).[4] For each utilization metric, WECC identifies a

[4] Path definitions with an undefined limit are assumed to be four times the flow limit in the opposite direction.

threshold value, above which a path should be evaluated to ensure it does not become a constraint to the flow of energy. (See Table 3.)

Table 3. Path Utilization Metrics

Metric	% at or Above Rating	Threshold
U75	75%	50%
U90	90%	20%
U99	99%	5%

WECC compared the path utilization in each of the Year 20 cases to the path utilization in the 2032 ADS. The Y20 FC and Y20 Compound Load included the entire year, while Y20 Heat Event and Y20 Cold Event looked at a single months, August and December, respectively. Figure 5 compares the utilization metrics for seven noteworthy paths. The figure shows increased utilization in both the predominant flow direction (positive or negative) and with potential switching of the path flow direction. For example, utilization on Paths 36 and 47 increased in the positive direction, the same direction as the Y20 FC. This indicates that these paths may expect increased utilization in 20 years, including high-stress situations such as extreme events. While the utilization on these paths increased, their characteristic flow pattern did not. Paths 14 and 35 show the same behavior in the negative flow direction.

The other paths (1, 66, and 83) showed increases in utilization but in the opposite direction as the Y20 FC in some scenarios. This means that, in some scenarios, the predominant flow on these paths changed directions. Under some circumstances, not only might these paths be more heavily utilized, but they may also be utilized in an uncharacteristic flow pattern. This comports with the subregional transfers results, in which, under certain conditions, some subregions switch from being net importers to exporters or vice versa.[5]

These results show that each path is used differently in each season, month, and time of the day, as well as during extreme weather events. The location of high loads and resource availability drive the different flow directions and magnitudes. Entities in the West cannot assume that the direction of flows on paths today will be the same in the Year 20 future, nor that the predominant flow direction will be the same across all system conditions.

[5] Some paths do not have a path rating defined in one of the flow directions. The utilization change for these paths is not included in this analysis, as there is no path rating from which to calculate a U75, U95, or U99 amount.

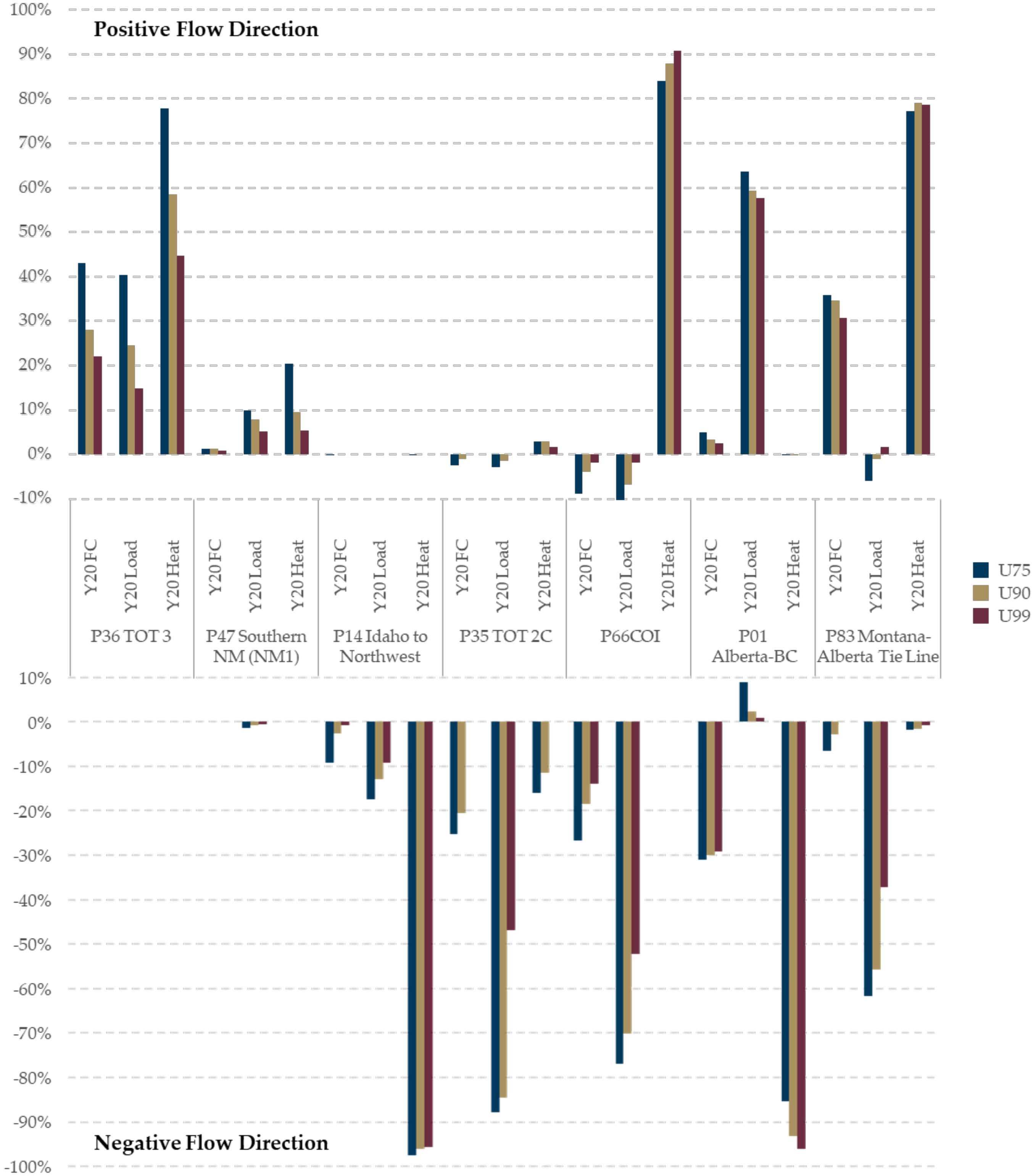

Figure 5: Path Utilization Change from 2032 ADS to 2042 Study Cases (in megawatts)

Stressed Cases

A deep look at the scenarios shows that path utilization can be an incomplete measurement of system performance. WECC observed results in which path utilization decreased, but the potential for load loss increased due to generation constraints. In one scenario of the Y20 Compound Load study—the High Electrification scenario—even with the transmission path limits relaxed, there were periods when generation constraints caused a reduction in path flow. Figure 6 shows the results for one high-load hour. The map shows path utilization across the key WECC paths and unserved load in each of the subregions. This map demonstrates where the energy might flow if there was sufficient generation to serve all of the load in this hour. The paths that are lower on the path utilization scale may be such because the respective subregions are high on the Load Not Served (LNS) Scale indicating that there may not be sufficient energy to flow across the path. If the subregions high on the LNS Scale were to add more energy capacity, it's possible the flows on some of the paths would increase as well.

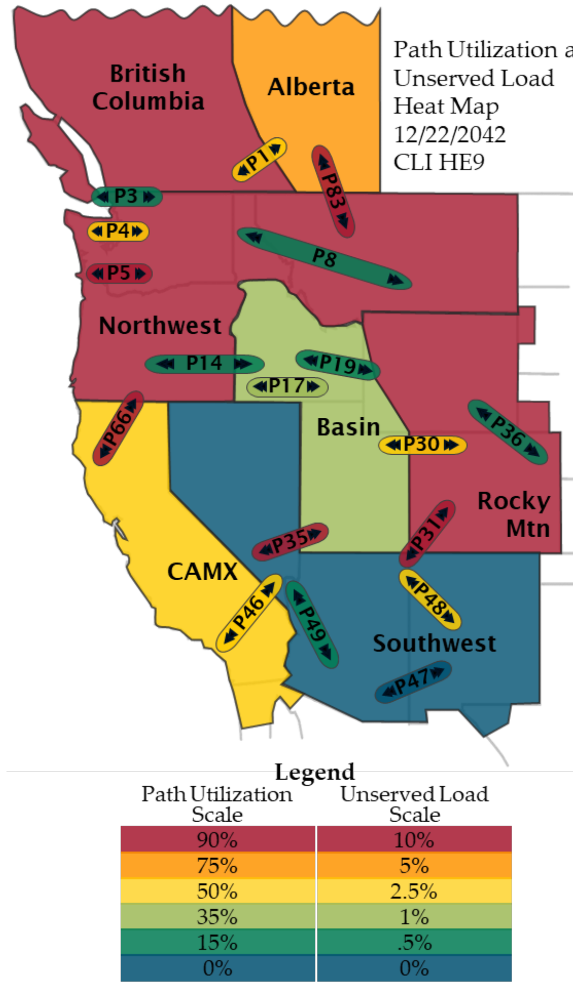

Figure 6: Heat Map of Unserved Load and Path Utilization

WECC's analysis of the transmission trends across its Year 20 cases offers a first glimpse into the potential risks in the Year 20 future. This initial foray into Year 20 study work makes clear that understanding the potential system performance and related reliability risks in this time horizon is a complex undertaking. Continued study across a broad range of future scenarios will help WECC and others better understand the complexities. The creation of more complete 20-year forecasts and assumptions, as well as continued model development, are necessary to this work.