# WestConnect Regional Transmission Planning

## 2022-23 Planning Cycle

## Model Development Report

Approved by WestConnect Planning Management Committee on

December 14, 2022

(Rev 1)[1]

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[1] *Revised to correct base plan tables 1/4/24*

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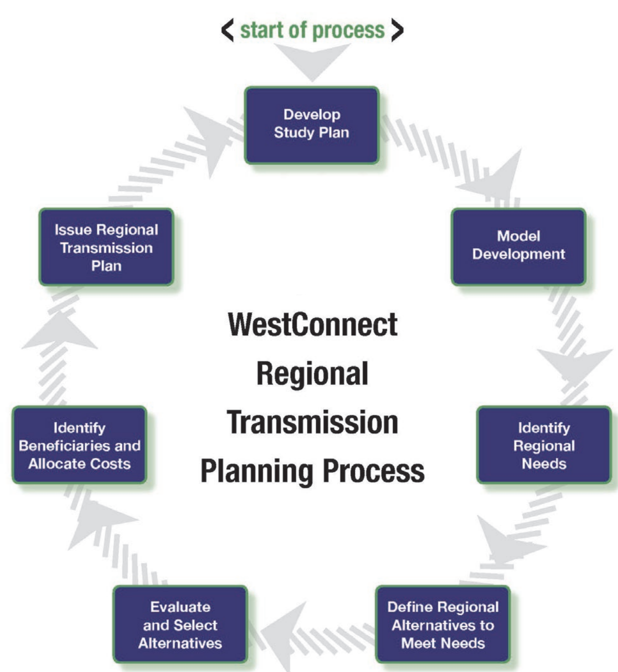
# 1.0 Introduction

The purpose of this report is to summarize the model development phase of the WestConnect 2022-23 Regional Planning Process. The Planning Subcommittee, which is responsible for developing the WestConnect regional models, has compiled this report to document major assumptions that have been incorporated into the models. The objective of model development is to support the overall purpose of the Regional Planning Process, which is to identify regional transmission needs and the more efficient or cost-effective solutions to satisfy those needs. The Planning Management Committee (PMC), which has decision-making authority over the overall WestConnect planning process, approves the regional models that are used during the transmission assessment. The PMC approved the base models described in this report on September 21, 2022. The results of the regional transmission assessment will be documented in the 2022-2023 Regional Transmission Needs Assessment Report.

## 1.1 WestConnect Regional Transmission Planning Process

The development of regional models is the second step in the WestConnect Regional Transmission Planning Process (Planning Process). The Planning Process was developed for compliance with Federal Energy Regulatory Commission (FERC) *Order No. 1000, Transmission Planning and Cost Allocation by Transmission Owning and Operating Public Utilities*, (Order No. 1000).[2] The planning process is performed biennially, beginning in even-numbered years, and consists of seven steps as outlined in **Figure 1**.

**Figure 1: WestConnect Regional Transmission Planning Process**




[2] *All references to Order No. 1000 include any subsequent orders.*

Additional details of the Planning Process can be reviewed in the WestConnect Regional Planning Process Business Practice Manual (BPM) posted to the WestConnect website (link). Readers can access the text of the FERC Order No. 1000 compliance documentation on the WestConnect website (link) and are encouraged to consult the compliance documentation and BPM for additional process information.

## 1.2 WestConnect 2022-23 Regional Study Plan

The first step in the planning process is the development of a Regional Study Plan. The 2022-23 WestConnect Study Plan (Study Plan) was approved by the PMC on March 16, 2022. The Study Plan identifies the scope and schedule of planning activities to be conducted during the planning cycle. The Study Plan also describes the models to be developed in the model development portion of the Planning Process.

# 2.0 Model Development Overview

During the second and third quarters of 2022, the Planning Subcommittee developed the regional models to be used in the identification of regional transmission needs for the 2022-23 Planning Process. Two types of studies are performed in the Planning Process: Reliability (power flow or PF) and Economic (Production Cost Model or PCM) studies. WestConnect will conduct an assessment of regional transmission needs using models developed for the 2032 timeframe, approximately 10 years into the future. WestConnect will also perform information-only scenario studies, as outlined in the Study Plan, which are designed to evaluate alternate but plausible futures.

**Table 1** lists the reliability and economic models developed for the 2022-23 cycle for the purposes of identifying regional transmission needs.

**Table 1: WestConnect Regional Needs Assessment Planning Models**

| WestConnect Base Case Name | Case Description | Seed Case(s) |
|---|---|---|
| **2032 Heavy Summer Base Case** | Summer peak load conditions during 1500 to 1700 MDT, with typical flows throughout the Western Interconnection. | WECC 2032 Heavy Summer 1 Planning Base Case (32HS1) |
| **2032 Light Spring Base Case** | Light load conditions during 1200 to 1400 MDT in spring months of March, April, and May with solar and wind serving a significant but realistic portion of the Western Interconnection total load. Case includes renewable resource *capacity* consistent with any applicable and enacted public policy requirements. | WECC 2033 Light Spring 1-S Base Case (33LSP1S) |
| **2032 Base Case PCM** | Business-as-usual, expected-future case with (1) median load, (2) median hydro conditions and (3) representation of resources consistent with TOLSO-approved resource plans as of March 2022. | WECC 2032 Heavy Summer 1 Planning Base Case (32HS1) and WestConnect 2030 Base Case from the 2020-21 planning cycle |

## Study Area

The WestConnect planning process evaluates the regional transmission needs solely for the WestConnect planning region, which is defined as the combined footprints of signatories to the Planning Participation Agreement (PPA) within the Transmission Owner (TO) Member Sector. A list of Members participating in the WestConnect 2022-23 planning process is available on the WestConnect website (link). WestConnect Members and participants updated the models, as described in more detail below, to create a more accurate representation of the WestConnect footprint in each case.

To the extent WestConnect received updated modeling data from TOs outside of the WestConnect planning region during the development of the regional models, it was considered, and if appropriate, incorporated into the regional models. The goal in seeking input from neighboring planning regions and TOs outside of the WestConnect planning footprint is to maintain a reasonable level of model consistency and align planning assumptions as closely as possible. Details about the types of information received from external participants (e.g., planning regions, other TOs) are included in the model descriptions in the sections that follow.

# 3.0 Reliability Model Descriptions

The information in this section summarizes each reliability model and provides details about the major assumptions incorporated into the reliability cases. Note that the cases have detailed change records documenting specific data changes made to the original starting point case. This report summarizes each case and does not document each specific assumption.

## 2032 Heavy Summer Base Case

**Description**: The case is designed to evaluate the Base Transmission Plan under heavy summer conditions. The seed case was the WECC 2032 Heavy Summer 1 Planning Base Case (32HS1), which was approved August 13, 2021. The 32HS1 case was updated with the latest topology (i.e. generator, load, and transmission) information from WestConnect participants while still representing typical heavy summer load conditions and generator dispatch.

**Generation**: Within WestConnect, the case features a dispatch of 40,028 MW of thermal, 8,480 MW of hydro, 4,461 MW of wind, 14,107 MW of solar, and 796 MW of Battery Storage resources.

**Load**: The aggregate coincident peak load level for the WestConnect footprint is 62,224 MW. The original WECC case represented the system coincident peak for a heavy summer condition between the hours of 1500 to 1700 MDT during the months of June – August. The intent was to continue these assumptions during its case development.

**Transmission**: No major planned transmission additions beyond the Base Transmission Plan were included in the case.

**Other assumptions**: WestConnect coordinated with NorthernGrid on certain assumptions during model development. A summary of the changes is below.

- Updates in the NorthernGrid footprint: The Boardman to Hemingway 500-kV Line (B2H) (a.k.a. Longhorn to Hemingway) was added for consistency with WECC and NorthernGrid transmission assumptions.

## 2032 Light Spring Base Case

**Description**: The purpose of the case is to assess Base Transmission Plan performance under light-load conditions with solar and wind serving a significant but realistic portion of the WestConnect total load. The seed case was the WECC 2033 Light Spring 1 Specialized Case (33LSP1), which was approved January 28, 2022.

**Generation**: Within WestConnect, the case features a dispatch of 23,359 MW of thermal, 4,707 MW of hydro, 3,701 MW of wind, 12,282 MW of solar, and -2,148 MW of Battery Storage resources.

**Load:** The total WestConnect load in the case is 42,498 MW, which is 68% of the WestConnect peak load in the WestConnect 2032 Heavy Summer Base Case. The load levels represent the system during 1200 to 1400 hours MDT during spring months of March, April, and May.

**Transmission:** Identical transmission assumptions as the 2032 Heavy Summer Base Case – see above for details.

**Other assumptions:** Identical other assumptions as the 2032 Heavy Summer Base Case – see above for details.

# Contingency Definitions, Dynamic Data, and Other Considerations

The regional reliability models identified as "base cases" will be used to identify regional transmission needs. Scenarios will be limited to identifying regional opportunities. Both assessments will be conducted using contingency definitions that were designed to limit the analysis to identifying regional transmission issues.

An initial list of automatically created single branch (N-1) outages 230 kV and higher was created and participants also submitted multi-element contingency definitions not automatically created. Participants reviewed the outage list and (a) identified invalid single branch outages to remove, and (b) identified other contingencies not included in the list that could potentially flag regional transmission issues.

The dynamic data needed to support the transient stability simulations was developed by first taking the dynamic data from the WECC seed cases and appending additional or revised dynamic data per participant submittals.

The Planning Subcommittee also considered the following when developing the cases:

- **Operating Procedures** – Any special operating procedures required for compliance with NERC reliability standards are considered and included in the power flow (PF) cases.
- **Protection Systems** – The impact of protection systems including Remedial Action Scheme (RAS) required for compliance with NERC reliability standards will be included in the PF cases.
- **Control Devices** – Any special control devices required will be included in the PF cases.

The quality of the base cases and contingency definitions were improved by iteratively developing draft cases with contingency definitions and performing test simulations. After each draft and test simulation, data owners had the opportunity to examine and submit corrections. This procedure resulted in four review drafts of the base reliability models.

# 4.0 Economic Model Descriptions

The reliability and economic base models maintained consistent electric topologies (e.g., matching load, generator, and branch models) throughout their development.

## 2032 Base Case

**Description:** The case is a production cost model (PCM) dataset designed to represent a likely, median 2032 future. The WestConnect 2030 PCM from the 2020-21 planning cycle served as the seed case for the WestConnect economic model 2032 Base Case. The WestConnect 2030 PCM was reviewed and updated by WestConnect during Quarters 2 and 3 of the 2022-23 planning cycle, and the Quarter 3 updates included select assumptions from the WECC 2032 Anchor Dataset (ADS) interconnection-wide 10-year PCM (2032 ADS PCM Beta), which were released in August 2022[3]. These updates were consistent with the process described below, which focuses on what updates were completed with the WECC 2032_ADS_PCM__Beta dataset as the reference.

**Generation:**

- The WestConnect latest generator-specific modeling was developed and used to update the dataset. This included but was not limited to: generator type, commission and retirement date, forced outage rate, outage duration, minimum and maximum capability with applicable de-rates for plant load or seasonal ambient temperature, minimum up and down times, fuel assignments, variable operations and maintenance and start-up costs, linkage to reserve modeling and regional/remote scheduling, linkage to operational nomograms, hydro fixed shape or load/price-driven scheduling, and hourly shapes. **Table 2** provides a summary by fuel category of the generation updates made to the WECC 2032 ADS PCM V2.0. The positive (or negative) values represent the capacity (in MWs) and resulting generated energy (in GWh) added to (or removed from) the WECC 2032 ADS PCM V2.0in order to create the WestConnect 2032 Base Case PCM.

[3] *The WECC 2032 ADS was originally scheduled to be posted June 30, 2022. Beta versions were released on August 5 and August 12.*

**Table 2: Generation Differences from WECC 2032 ADS PCM V2.0. Percentages are in reference to the totals in the WECC 2032 ADS PCM V2.0**

| Fuel Category | Differences, WestConnect less WECC PCM | | | | Annual Generation (GWh) | | Capacity (MW) | |
|---|---|---|---|---|---|---|---|---|
| | Annual Generation | | Capacity | | | | | |
| | GWh | % | MW | % | WestConnect | WECC | WestConnect | WECC |
| **Coal** | 12,861 | 37.17% | 875 | 15.73% | 47,466 | 34,605 | 6,434 | 5,559 |
| **Gas** | 30,062 | 32.48% | -412 | -1.40% | 122,622 | 92,560 | 29,064 | 29,476 |
| **Water** | -1,547 | -9.04% | -2,285 | -31.89% | 15,565 | 17,112 | 4,880 | 7,164 |
| **Uranium** | 1,083 | 3.96% | 107 | 3.22% | 28,450 | 27,367 | 3,436 | 3,328 |
| **Solar PV** | -8,544 | -23.08% | -1,853 | -12.96% | 28,482 | 37,026 | 12,450 | 14,303 |
| **Solar Thermal** | 30 | 5.21% | 0 | 0.00% | 601 | 571 | 250 | 250 |
| **Wind** | 2,912 | 8.49% | 1,246 | 11.88% | 37,220 | 34,308 | 11,733 | 10,487 |
| **Bio** | -47 | -5.18% | -23 | -14.22% | 861 | 908 | 139 | 163 |
| **Geothermal** | -4,008 | -49.83% | -809 | -49.34% | 4,037 | 8,045 | 830 | 1,639 |
| **BESS** | 4,493 | 132.84% | 3,163 | 83.23% | 7,875 | 3,382 | 6,964 | 3,800 |
| **Other** | -26 | -14.29% | 503 | 83.61% | 154 | 180 | 1,105 | 602 |
| **Overall** | **37,268** | | **512** | | **293,332** | **256,064** | **77,284** | **76,772** |

- The behind-the-meter distributed generation (BTM-DG) assumptions were retained from the WECC 2032 ADS PCM V1.0[4] which modeled them on the resource-side, with the exception of the TEPC load area (for which the BTM-DG and DR shapes were merged with the load shapes to model the BTM-DG and DR on the load-side). **Table 3** summarizes the amount of BTM-DG by area represented in the WestConnect 2032 Base Case PCM.

**Table 3: Behind-the-Meter Distributed Generation**

| Area Name | Capacity (MW) | Generation (GWh) | Capacity Factor (%) | Dispatch at Area Peak Load (% of Capacity) |
|---|---|---|---|---|
| AZPS | 2,815 | 6,386 | 26% | 40% |
| BANC | 716 | 1,495 | 24% | 48% |
| EPE | 168 | 345 | 23% | 72% |
| IID | 199 | 453 | 26% | 57% |
| LDWP | 745 | 1,615 | 25% | 63% |
| PNM | 132 | 300 | 26% | 31% |
| PSCO | 1,513 | 2,971 | 22% | 48% |
| SRP | 438 | 999 | 26% | 46% |

[4] *These BTM DG capacity values did not change from the last cycle*

| Area Name | Capacity (MW) | Generation (GWh) | Capacity Factor (%) | Dispatch at Area Peak Load (% of Capacity) |
|---|---|---|---|---|
| TEPC | 433 | 998 | 26% | 22% |
| WACM | 60 | 119 | 22% | 66% |
| WALC | 324 | 733 | 26% | 49% |

**Load:** WestConnect made minor modifications to the load shapes and forecasts included in the WECC 2032 ADS PCM Beta. No changes were made to the load forecasts for areas outside of WestConnect. **Figure 2** and **Figure 3** provide the annual load energy, various load snapshots (peak load and load during system/WECC peak), and the average load on a "PCM Area" basis. The PCM Areas are generally analogous to BAAs rather than specific utilities. The "PF Load" – load in the WestConnect 2032 Heavy Summer Base Case – is provided for a frame of reference, though, some difference between the PCM and PF load snapshots is typical given the below-listed considerations.

- The PF model focuses on an extreme or more-stressed-than-normal system condition whereas the economic model load shapes do not contain extremely high or low load values since they are developed to support a median year-long simulation.
- The economic model load shapes do not include the impact of BTM-DG (except for TEPC) whereas the PF model loads may or may not contain BTM-DG.
- The economic model loads in the charts below include exports out of Western Interconnection via the direct current interties along the east side of the Western Interconnection – whereas they are not included in the PF load in the charts below.

**Figure 2: WestConnect PCM Areas' Annual Demand (GWh) in WestConnect 2032 Base Case (PCM)**

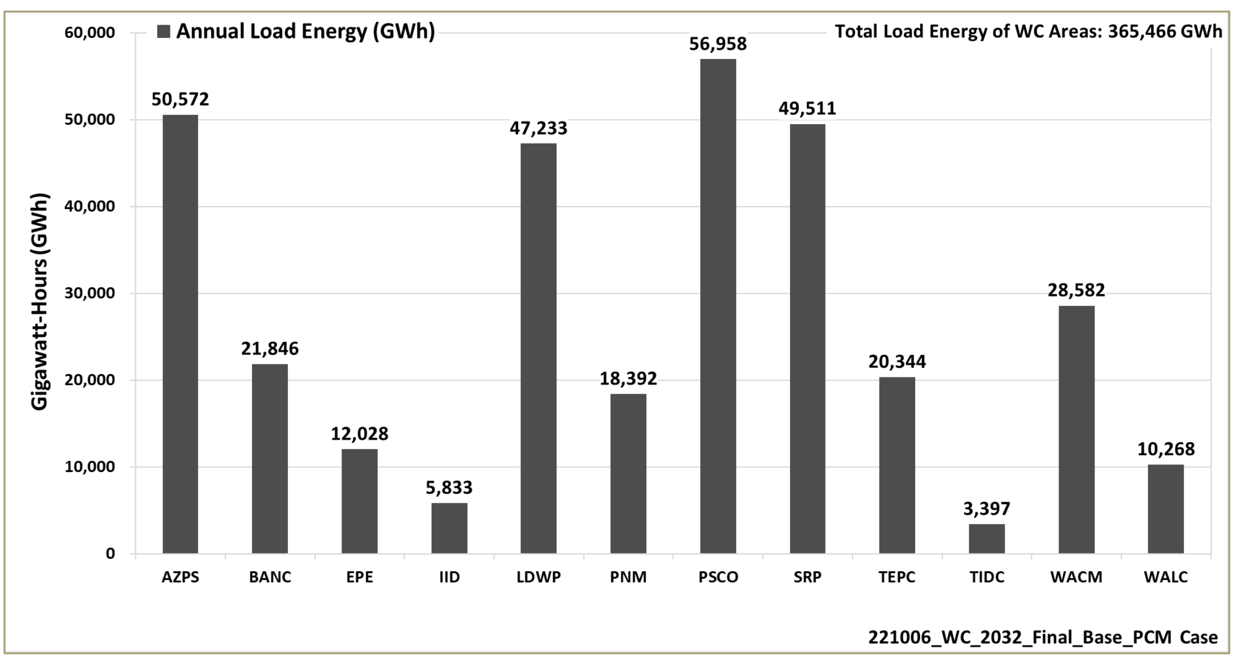
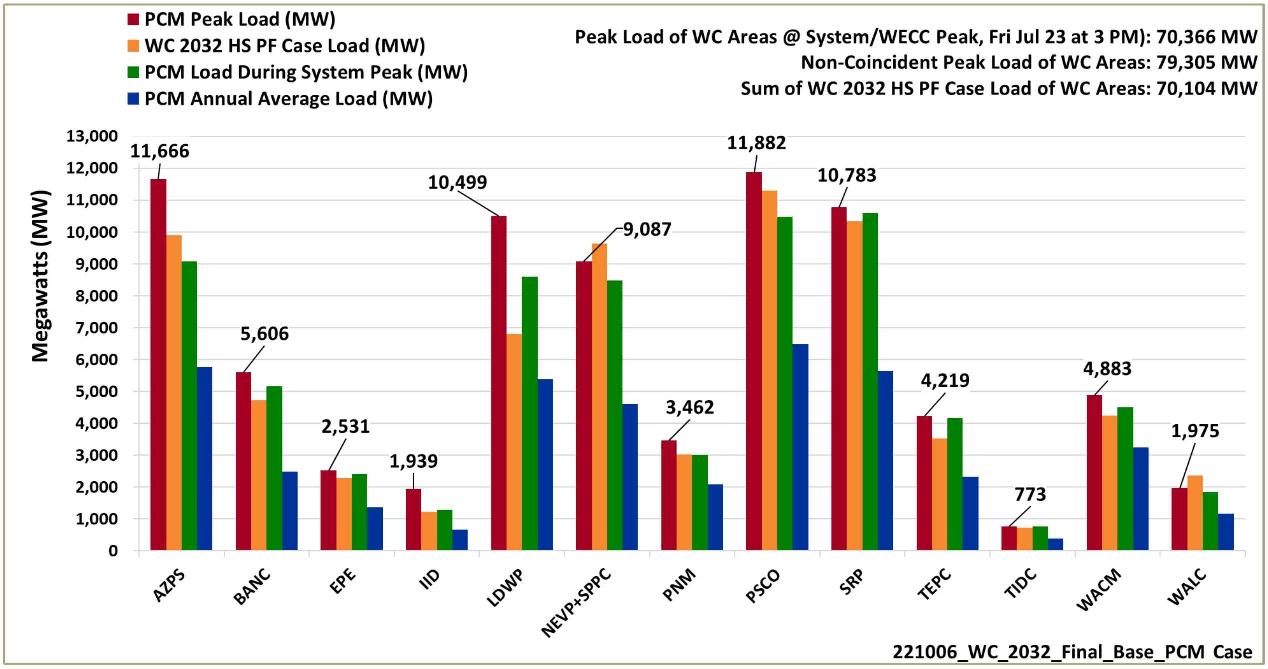


**Figure 3: WestConnect PCM Areas' Peak Demand, Demand During System Peak, and Average Demand (MW) in WestConnect 2032 Base Case (PCM), shown with the Demand of the 2032 Heavy Summer Base Case**




**Transmission:** The WECC 2032 ADS PCM Beta was updated with the WestConnect member topology to be consistent with the WestConnect Base Transmission Plan and the reliability model topology. WestConnect also reviewed the case for seasonal branch ratings, interfaces, and nomograms – making the below listed changes in each of these categories. The transmission topology outside of WestConnect, including the Common Case Transmission Assumptions, was not modified.

- Increased branch monitoring in the WestConnect footprint: Monitored transmission elements greater than 90 kV in WestConnect, greater than 200 kV outside of WestConnect, and all phase shifting transformers (PST) (phase angle regulators, or PAR).
- Updated interface definitions.

**Other Assumptions:**

- Any opportunity to more closely align the economic base case model with the reliability base case model was taken. For example, the summer and winter branch ratings and load distribution factors were aligned with the 2032 Heavy Summer Base Case.
- Fuel price forecasts and emission rate assumptions were initially pulled from the WECC 2032 ADS PCM Beta and subsequently updated with new coal prices accepted by the WECC PCDS during their meeting on April 14, 2020, as well as Member feedback. These assumptions are included in Appendix A.
- Reserve requirements modeling was updated from what was represented in the WECC 2032 ADS PCM Beta. These assumptions are summarized below:

- Contingency Reserves: the default assumptions are provided below. LADWP and PNM provided higher spinning reserve assumptions to better represent their BA's operating practices.
    - Assumed a 50/50 split between spinning and non-spinning.
    - Assumed that NW and SW BA's locally meet 25% and 90% (respectively) of their contingency reserve requirement based on previous WECC models citing [WECC EDT Phase 2 Benefits Analysis Methodology (October 2011 Revision)].
    - Kept non-spinning requirement unmodeled since neither dataset currently has quick-start generator designations.
    - Kept spinning requirement modeled at BA and Reserve Sharing Group (RSG); however, a single set of RSG spinning requirements was modeled similar to the WECC 2032 ADS PCM Beta, except that RSG_RM was removed and the TPWR, PSCO, and WACM areas were included in RSG_NW.
- Regulation Ancillary Service (AS) assumptions shown in **Table 4** were based on the CPUC Unified Resource Adequacy and Integrated Resource Plan Inputs and Assumptions – Guidance for Production Cost Modeling and Network Reliability Studies, February 20, 2019 (link).
- Load Following AS assumptions shown in **Table 4** were based on the CPUC SERVM model for their 2018-19 IRP.

**Table 4. Regulation and Load Following Ancillary Service Assumptions in WestConnect 2032 Base Case**

<table>
<tr><th>AS</th><th>Ramping Response Requirement (minutes)</th><th>Requirement (at RSG level)</th><th>What it represents</th><th>What can contribute</th></tr>
<tr><td>Regulation Up</td><td rowspan="2">10</td><td rowspan="2">1.5% of Load</td><td rowspan="2">Security against unexpected loss of generation.</td><td><ul><li>Dispatchable thermals (excludes biomass/geothermal/nuclear/co-gen) generators subject to available headroom and ramp rate</li><li>Storage and hydro resources as constrained by headroom</li></ul></td></tr>
<tr><td>Regulation Down</td><td>Same as Reg Up contributors<br>+<br>Wind & Solar (no more than 10% of Maximum Capacity)</td></tr>
<tr><td>Load Following Up</td><td>20</td><td>2.5% of load</td><td rowspan="2">Capacity reserved to accommodate load and/or renewable forecast error and sub-hourly deviations in forecasts. Not an actual product in most areas – proxy product to maintain reliability.</td><td>Same as Reg Up contributors</td></tr>
<tr><td>Load Following Down</td><td>20</td><td>1.5% of load</td><td>Same as Reg Down contributors</td></tr>
</table>

- Frequency Response AS assumptions were based on system-wide values from the NERC 2021 Frequency Response Annual Analysis (FRAA). This and the related assumptions are summarized in **Table 5**.

**Table 5. Frequency Response Ancillary Service Assumptions in WestConnect 2032 Base Case**

| AS | Ramping Response Requirement (minutes) | Requirement (at RSG level) | What it represents | What can contribute |
|---|---|---|---|---|
| Frequency Response | 1 | 1,253 | • Response to frequency changes within one minute<br>• 50% of constraint assumed to be met by hydro and renewable resources (full constraint is 2,506 MW) | • Storage, coal, and gas only<br>• Limit gas-fired contribution to 8% of their capacity/headroom (via Ancillary Max Contribution) |

- The below listed thermal generation modeling assumptions were taken from the WECC Intertek report dated May 12, 2020, "Update of Reliability and Cost Impacts of Flexible Generation on Fossil-fueled Generators for Western Electricity Coordinating Council."
  - Cost per start: used the warm, median values
  - Ramping limits
  - Minimum up and down times
  - Variable Operations and Maintenance (VOM) cost
- Wheeling charges, which represent the transmission service charges associated with transferring power between areas, were revised from the original WECC 2032 ADS PCM V1.0 values to peak and off-peak wheeling charges based on the latest Open Access Transmission Tariff (OATT) rate. These assumptions are provided in Appendix A. The WECC 2032 ADS PCM Beta also contained additional wheeling charges associated with modeling carbon emission charges applicable to California, and these rates were updated. Planning Subcommittee members reviewed these updates through draft model releases. Additional details for the wheeling charge modeling assumptions are included below:
  - The regular, inter-area wheeling charges were based upon the OATT on-peak and off-peak non-firm point-to-point transmission service charges (Schedule 8) as well as Schedule 1 (Scheduling System Control and Dispatch Service) and Schedule 2 (Reactive Supply and Voltage Control) charge components of transmission providers in the Western Interconnection.
  - Emission-related wheeling charges: The carbon emission charges applicable to California representing the California Global Solutions Act (AB 32) modeling and supplemental updates to the WECC 2032 ADS PCM Beta by the WECC Production Cost Data Subcommittee (PCDS) were implemented. Refer to the "Carbon emission charges updates" topic below for more details.
  - The WECC 2032 ADS PCM Beta included tiered wheeling constraints – zero wheeling charges up to a MW threshold and non-zero wheeling charges thereafter – on the Nevada, Idaho, Montana, and Canadian borders of the NW footprint as well as the PACE/APS border, and these wheeling charges were retained.

- Nomograms and transmission interfaces were modeled by starting with the WestConnect 2030PCM, pulling in updates based on the WECC 2032 ADS PCM Beta, and then enhanced with additional nomograms and conditional constraints provided by WestConnect members. These input conditions aim to address the operational needs of individual member systems, such as voltage support and other factors, including must run and must take conditions, that drive the need for certain generation resources to be committed in a particular way, consistent with the existing operational practices of the WestConnect member systems. The names of monitored interfaces are included in Appendix A. The "SMUD Op Nomogram", "EPE Balance", and "TEP Local Gen" were nomograms added to the model to commit local generation. In addition, other nomograms were added for generating plants containing a combination of solar PV and battery storage to ensure their combined output did not exceed their contractual limits, and others were added to ensure the battery storage only charged via the solar PV output for certain plants.
- Carbon emission charges updates: Details are below, in 2020 dollars.
  - California: Updated to \$64.293/MT based on the WECC PCDS recommendation (CEC 2019 IEPR Revised Carbon Price Projections) (California Carbon Price Assumption)
    - In addition, the reduced emission factor for NW imports was also updated to 0.0117 MT $CO_2$e/MWh based on CARB Mandatory GHG Reporting - Asset Controlling Supplier. This affected the above-mentioned updates to the emission-related wheeling charges.
  - Alberta: Updated to \$31.742/MT based on an Osler article RE Alberta carbon pricing
  - British Columbia: Updated to \$49.015/MT based on British Columbia Carbon Tax

# 4.1 Economic Sensitivity Models

Models were developed for sensitivity studies on the 2032 Base Case economic model to better understand whether regional transmission congestion may be impacted by adjusting certain input assumptions subject to significant uncertainty. The sensitivity analysis is intended to make relatively minor adjustments that would still remain within the expected future framework of the base models. The Planning Subcommittee determined four sensitivities of interest, and their assumptions are described below.

## 2032 High Load Sensitivity Case

**Description:** Scaled up the hourly load shape of BAAs within WestConnect so their annual peak and energy is a 100%+ percentage of their value in the 2032 Base Case:

- TEPC: 105% of both peak and energy
- All other WestConnect Areas: 120% of both peak and energy

## 2032 Low Hydro Sensitivity Case

**Description:** Replaced hydro modeling with WECC 2001-based hydro modeling data developed by WECC in conjunction with their 2024 Common Case PCM dataset.

### 2032 High Gas Price Sensitivity Case

**Description:** Increased all the natural gas prices to 140% of their value in the 2032 Base Case.

### 2032 System-Wide Carbon Emission Cost Sensitivity Case

**Description:** Applied $CO_2$ emission charges to all generators in WECC via the below updates to the 2032 Base Case:

- Applied the above-mentioned "California Carbon Price Assumption" as the carbon emission price for all generation in California, Oregon, and Washington
- Kept the Alberta and British Columbia carbon emission prices unchanged
- Removed the carbon emission wheeling charges from all California borders except with Baja California (CFE)
- Applied a carbon emission price of $44/metric ton $CO_2e$ (2020 dollars) for all other generation in the WECC system

# 5.0 Modeling Public Policy

Enacted public policies are considered early in the planning process and are incorporated into the base models (both reliability and economic) through the roll-up of local TO plans and their associated load, resource, and transmission assumptions. In this context, enacted public policies are state or federal laws or regulations, meaning enacted statutes (i.e., passed by the legislature and signed by the executive) and regulations promulgated by a relevant jurisdiction, whether within a state or at the federal level. Enacted public policies that are subject to significant uncertainty within the planning horizon are also considered, but only as a part of a scenario.

**Table 6** summarizes the enacted public policies that were driving local transmission projects reflected in regional base economic and PF models. This table was originally in the WestConnect 2022-23 Regional Study Plan and has been scaled down in this report to show the enacted public policies driving local transmission needs. After their review of the models, each TOLSO member provided confirmation that the WestConnect 2032 economic and PF models met these public policies' conditions for the study year 2032 to the extent a plan for compliance with the enacted public policies was completed prior to the model development phase of the WestConnect 2022-23 planning cycle.

**Table 6. Enacted Public Policies Considered and/or Incorporated into 2032 WestConnect Planning Models**

| Public Policy Requirement | Description |
|---|---|
| Arizona Renewable Energy Standard | Requires IOUs and retail suppliers to supply 15% of electricity from renewable resources by 2025), with a minimum of 30% of the renewable resources provided by distributed generation |
| California AB398/SB32 | Requires the California State Air Resources Board to approve a statewide greenhouse gas emissions limit equivalent to the statewide greenhouse gas emissions level in 1990 to be achieved by 2020 and to ensure that statewide greenhouse gas emissions are reduced to at least 40% below the 1990 level by 2030 |

| Public Policy Requirement | Description |
|---|---|
| California SB100 | Requires Investor-owned utilities (IOUs) and municipal utilities to meet a 60% renewable portfolio standard (RPS) by 2030 |
| California SB350 | Requires IOUs and municipal utilities to meet a 50% RPS by 2030 and requires the establishment of annual targets for energy efficiency savings |
| Colorado HB 18-1270 (Energy Storage Procurement Act) | Directs the Commission to develop a framework to incorporate energy storage systems in utility procurement and planning processes. See C.R.S. § 40-2-201, et seq. The legislation broadly addresses resource acquisition and resource planning, and transmission and distribution system planning functions of electric utilities. Energy storage systems may be owned by an electric utility or any other person. Benefits include increased integration of energy into the grid; improved reliability of the grid; a reduction in the need for increased generation during periods of peak demand; and, the avoidance, reduction, or deferral of investment by the electric utility |
| Colorado HB 19-1261 and SB 1261 (GHG Reduction Bills) | HB 19-1261 requires the Air Quality Control Commission (AQCC) to promulgate rules and regulations for statewide greenhouse gas (GHG) pollution abatement. Section 1 of SB 1261 states that Colorado shall have statewide goals to reduce 2025 greenhouse gas emissions by at least 26%, 2030 greenhouse gas emissions by at least 50%, and 2050 greenhouse gas emissions by at least 90% of the levels of statewide greenhouse gas emissions that existed in 2005. A clean energy plan filed by a utility is deemed approved if the plan demonstrates an 80% reduction by 2030. |
| Colorado HB10-1001 | Established Colorado Renewable Energy Standard (RES) to 30% by 2020 for IOUs (Xcel & Black Hills) |
| Colorado HB10-1365 | Requires rate regulated utilities in CO with coal-fired generation to reduce emissions on the smaller of 900 MW of generation of 50% of a company's coal generation fleet. Full implementation to be achieved by 12/31/2017 |
| Colorado SB 07-100 | Requires IOUs to identify Energy Resource Zones, plan transmission to alleviate constraints from those zones, and pursue projects according to the timing of resource development in those zones |
| Colorado SB 18-009 (Energy Storage Rights Bill) | Protects the rights of Colorado electricity consumers to install, interconnect, and use energy storage systems on their property without the burden of unnecessary restrictions or regulations and without unfair or discriminatory rates or fees. |
| Colorado SB 19-077 (Electric Vehicles Bill) | The bill enables a regulatory approval process for electric utilities to invest in charging facilities and provide incentive rebates; thus, the investments and rebates may earn a return at the utility's authorized weighted-average cost of capital. Where approved, the costs for the investments and rebates may be recovered from all customers of the electric utility similar to recovery of distribution system investments. Natural gas public utilities may provide fueling stations for alternative fuel vehicles as non-regulated services only. |
| Colorado SB 19-236 ("PUC Sunset Bill") | The primary purpose of this bill is to reauthorize the CPUC, by appropriations, for a seven-year period to September 1, 2026. Reauthorization is required by the sunset process. Additionally, the bill carries numerous requirements for utilities and the CPUC to achieve an affordable, reliable, clean electric system. Included in the bill are requirements to reduce the qualifying retail utility's carbon dioxide emissions associated with electricity sales to the qualifying retail utility's electricity customers by eighty percent from 2005 levels by 2030, and that seeks to achieve providing its customers with energy generated from one-hundred-percent clean energy resources by 2050. The bill also subjects co-ops to Colorado Public Utility Commission rulemaking. |
| Colorado SB13-252 | Requires cooperative utilities to generate 20% of their electricity from renewables by 2020 |

| Public Policy Requirement | Description |
|---|---|
| Colorado SB21-072 | This bill requires electric transmission utilities in Colorado to join an organized wholesale market (OWM) by January 1, 2030, provided that the OWM meets certain criteria set forth in the statute. This bill also creates the Colorado Electric Transmission Authority, a governmental entity that is authorized to independently develop and finance transmission projects. |
| Colorado HB21-1266 | This bill is a broad policy measure to promote environmental justice in disproportionately impacted communities through the creation of an Environmental Justice Task Force. The bill requires wholesale generation and transmission cooperatives to file with the Public Utilities Commission a Clean Energy Plan to achieve 80% emissions reductions by 2030. |
| Colorado SB 21-246 | The primary purpose of this bill is to direct the approval of plans for the electrification of buildings that use fossil fuel-based systems through existing demand side management programs. |
| Colorado HB21-1238 | The primary purpose of this bill is to update the PUC's rules and decision-making process with respect to natural gas demand-side management programs including the use of the Social Cost of Carbon and Social Cost of Methane. |
| Colorado SB21-272 | The primary purpose of this bill is to update the PUC's rules and decision-making process to better incorporate the impacts and benefits to underserved or disproportionately impacted communities and groups including workforces impacted by generation acquisition and retirement. Other requirements include how utilities finance resources or investments, the retirement of renewable energy credits, and the inclusion of the Social Cost of Carbon in resource planning decisions. |
| Executive Order 14057 (EO 14057), Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability (Dec. 8, 2021) | The President's executive order directs the federal government to use its scale and procurement power to achieve five ambitious goals:<br>• 100 percent carbon pollution-free electricity (CFE) by 2030, at least half of which will be locally supplied clean energy to meet 24/7 demand;<br>• 100 percent zero-emission vehicle (ZEV) acquisitions by 2035, including 100 percent zero-emission light-duty vehicle acquisitions by 2027;<br>• Net-zero emissions from federal procurement no later than 2050, including a Buy Clean policy to promote use of construction materials with lower embodied emissions;<br>• A net-zero emissions building portfolio by 2045, including a 50 percent emissions reduction by 2032; and<br>• Net-zero emissions from overall federal operations by 2050, including a 65 percent emissions reduction by 2030. |
| New Mexico Efficient Use of Energy Act | Require utilities to include cost-effective energy efficiency (EE) and demand response (DR) programs in their resource portfolios and establish cost-effectiveness as a mandatory criterion for all programs |
| New Mexico Energy Transition Act (2019 SB 489) | Subject to the Reasonable Cost Threshold (RCT), the Energy Transition Act defines renewable energy requirements that are a percentage of a utility's retail energy sales and the type of utility:<br>• By 2020, 20% for public utilities and 10% for cooperatives<br>• By 2025, 40% for public utilities and cooperatives<br>• By 2030, 50% for public utilities and cooperatives<br>• By 2040, 80% for public utilities with provisions associated with carbon free generation<br>• 100% carbon-free by 2045 for public utilities and by 2050 for cooperatives |
| SRP Sustainable Energy Goal | Reduce the amount of $CO_2$ emitted per megawatt-hour (MWh) by 65% from 2005 levels by 2035 and by 90% by fiscal year 2050. |

| Public Policy Requirement | Description |
|---|---|
| Texas RPS | Texas RPS requires a total renewable capacity of 5,880 MW (which has already been achieved) by 2025 be installed in the state which is in turn converted into a renewable energy requirement. The renewable energy requirements are allocated to load serving entities based on their amount of retail energy sales as a percent of the total Texas energy served |
| Texas Substantive Rule 25.181 (Energy Efficiency Rule) | Require utilities to meet certain energy efficiency targets |

## Renewable Energy Check

During the model development process, there was interest in seeing if the WestConnect economic models indicated a renewable energy penetration trajectory consistent with enacted public policies. To address this interest, WestConnect conducted a high-level accounting and comparison of the energy sales and renewable energy from each PCM Area via the process outlined below.

1. Annual generation consisting of Bio, Geothermal, Solar PV, Solar Thermal, & Wind were summed for each PCM Load Area as “Renewable Energy” (RE). The RE for the SRP PCM Area also included specific hydro and a combined solar & battery generation that was counted as RE based on the SRP plan to meet its public policy requirements, but hydro was otherwise not counted as RE. The Reserve Capacity Distribution settings in the 2032 Base Case PCM were used to allocate resources to their appropriate remote load area.
2. The “Energy Sales” from each PCM Load Area was determined by taking the “Served Load Includes Losses”, subtracting losses, adding the magnitude of negative generation (e.g., pumping loads with hourly profiles), and subtracting behind-the-meter generation (e.g., distributed generator or DG-BTM, energy efficiency or EE, demand response or DR)
3. The “Renewable Energy” was divided by the “Energy Sales” as the “RE as % of Energy Sales” for the 2032 Base Case PCM and compared with these same values from the 2030 Base Case PCM and the 2028 Base Case PCM from the previous two cycles (to allow for comparison between cycles).

Only the single year results from each study year were used in the RE check and no banking of renewable energy from other years was assumed. **Figure 4** shows the results of the renewable energy check, which the Planning Subcommittee determined show a reasonable trend towards WestConnect members meeting enacted public policies. **Table 7** shows the losses and load including losses used to calculate the WestConnect Energy Sales.

**Figure 4. Sum of Energy Sales, Renewable Generation, and Overall RE as % of Energy Sales Based on Single-Year Results from the 2032 Base Case PCM and the Base Case PCM's from previous cycles**

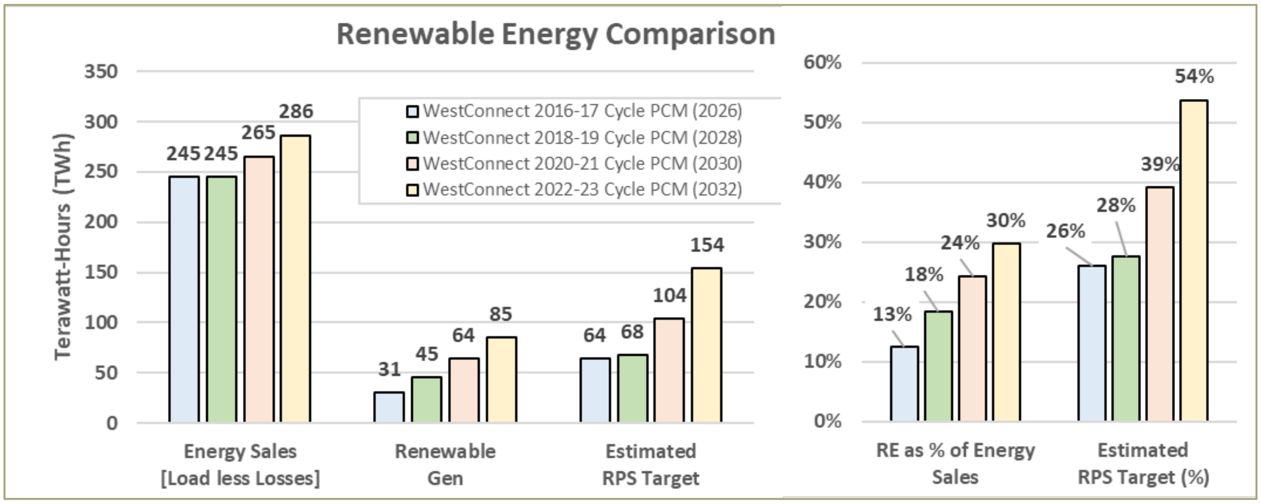



**Table 7. BAA Losses and Served Load Including Losses used to calculate the WestConnect Energy Sales in the Renewable Energy Check**

| BAA | Losses (MWh) | Served Load Includes Losses (MWh) |
|---|---:|---:|
| AZPS | 1,619,310 | 44,564,312 |
| BANC | 771,891 | 21,846,017 |
| EPE | 374,876 | 11,975,682 |
| IID | 199,304 | 4,791,888 |
| LDWP | 1,332,424 | 46,582,375 |
| PNM | 500,485 | 17,269,592 |
| PSCO | 1,839,963 | 55,987,612 |
| SRP | 1,687,780 | 48,656,614 |
| TEPC | 579,376 | 19,768,885 |
| WACM | 699,336 | 28,461,260 |
| WALC | 386,111 | 10,081,379 |
| **Total** | **9,990,856** | **309,985,617** |

# 6.0 Summary of Regional Base Transmission Plan

WestConnect created the regional base transmission plan at the beginning of the 2022-23 Planning Process to establish the transmission network topology that is reflected in the regional planning models for the 10-year timeframe and evaluated in the regional needs assessments. The base transmission plan consists of the "planned" incremental transmission facilities included by TOs in local transmission plans, as well as regional transmission facilities identified in previous regional transmission plans that are not subject to reevaluation.[5] It also includes any assumptions member TOs may have made with regard to other incremental regional transmission facilities in the development of their local transmission plans. "Conceptual" transmission projects are not included in the base transmission plan.

The base transmission plan was developed using project information collected via the WestConnect Transmission Plan Project List (TPPL), which is the tool that WestConnect uses for a project repository for TO member and TO participant local transmission plans as well as independently developed projects. The TPPL data used for the 2022-23 Planning Process was based on updates submitted as of January 2022, with subsequent updates to the data made by members through the Model Development Process. The full list of approved regional base transmission plan projects – prior to updates made during model development – can be found in Appendix B of the 2022-23 Regional Study Plan.

## 6.1 2022-23 Regional Base Transmission Plan Projects

The 2022-23 Base Transmission Plan project list includes 209 planned transmission projects that consist of 74 new or upgraded transmission lines, 66 substations, 31 transmission line and substations, 22 transformers, and 16 other planned projects. From the data reported in the TPPL, these projects span a reported total of 2,360 miles and add up to a total capital investment of $5,786.5 Million.[6] **Table 8** and **Table 9** summarize the Base Transmission Plan by project type and voltage.

**Table 8. Regional Base Plan Projects by Type, Reported Mileage, and Reported Investment ($K), based on TPPL data**

| Type of Project | Number of Projects | Length (Miles) | Planned Investment ($K) |
|---|---|---|---|
| Substation | 66 | - | $681,474 |
| Transmission Line | 74 | 1,329 | $1,968,091 |
| Transmission Line and Substation | 31 | 1,031 | $2,881,658 |
| Transformer | 22 | - | $70,001 |
| Other | 16 | - | $185,250 |
| **Total** | 209 | 2360 | $5,786,474 |

[5] *There are not any re-evaluation projects in the 2022-23 Base Transmission Plan.*

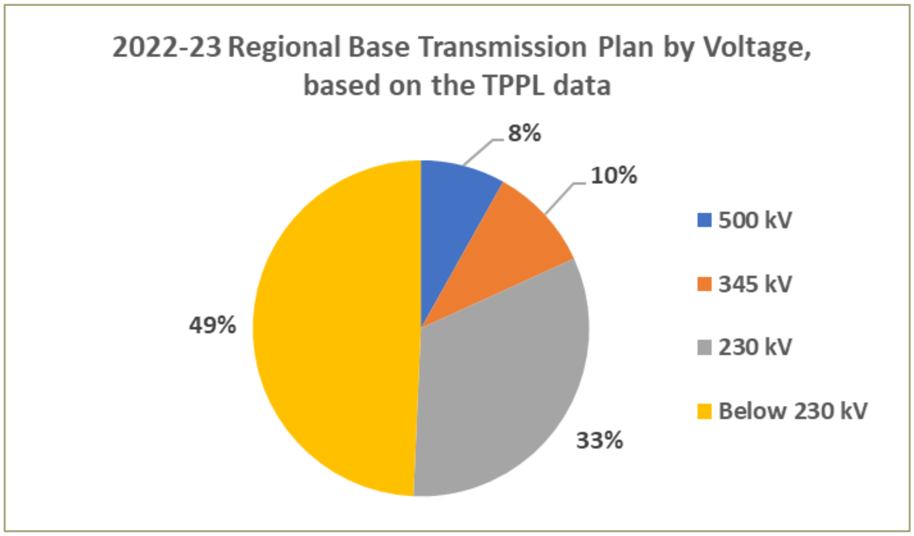
[6] *9% of the transmission line projects listed in the 2022-23 Base Transmission Plan did not report line mileage in the TPPL data and 50% of the projects did not report cost information in the TPPL data.*

**Table 9. Number of TOLSO Regional Base Transmission Plan Projects by Voltage and TOLSO, based on TPPL data**

| TOLSO | < 230 kV | 230 kV | 345 kV | 500 kV AC | TBD | Total |
|---|---|---|---|---|---|---|
| Arizona Electric Power Cooperative | 2 | - | - | - | - | **2** |
| Arizona Public Service | - | 10 | 1 | 3 | - | **14** |
| Black Hills Energy | 2 | - | - | - | - | **2** |
| Black Hills Power | - | 2 | - | - | - | **2** |
| Cheyenne Light Fuel and Power | 9 | 6 | - | - | - | **15** |
| Colorado Springs Utility | 4 | 3 | - | - | - | **7** |
| Deseret Power | - | - | - | - | - | **-** |
| El Paso Electric Company | 31 | - | 9 | - | - | **40** |
| Imperial Irrigation District | 1 | 1 | - | - | - | **2** |
| Los Angeles Department of Water and Power | - | 11 | - | 7 | - | **18** |
| Platte River Power Authority | 1 | 2 | - | - | - | **3** |
| Public Service Company of Colorado/ Xcel Energy | 2 | 6 | 1 | - | - | **9** |
| Public Service Company of New Mexico | 1 | - | 2 | - | - | **3** |
| Sacramento Municipal Utility District | - | 2 | - | - | - | **2** |
| Salt River Project | 2 | 9 | - | 4 | - | **15** |
| Transmission Agency of Northern California | - | - | - | - | - | **-** |
| Tri-State Generation and Transmission Association | 10 | 6 | 1 | - | - | **17** |
| Tucson Electric Power | 27 | 7 | 7 | 3 | - | **44** |
| Western Area Power Administration - DSW | 4 | - | - | - | - | **4** |
| Western Area Power Administration - RMR | 7 | 3 | - | - | - | **10** |
| Western Area Power Administration - SNR | - | - | - | - | - | **-** |
| **Total Projects** | **103** | **68** | **21** | **17** | **0** | **209** |

Review of the of the 2022-23 regional base transmission plan projects showed that 49% were classified as below 230 kV, 33% were classified as 230 kV, 10% were classified as 345 kV; and 8% were classified as the 500 kV. **Figure 5** illustrates the percentage breakout for the 2022-23 regional base transmission plan projects by voltage.

**Figure 5. 2022-23 Regional Base Transmission Plan Transmission Line by Voltage, based on the TPPL data**




## 6.2 Updates to the 2020-21 Regional Transmission Plan Projects

Review of the 2020-21 Regional Study plan base transmission projects showed several projects have gone into service, started construction, or have had other updates to their development status. The full list of 2020-21 regional base transmission plan projects can be found in the 2020-21 Regional Transmission Plan, Appendix A. Updated information provided to the TPPL showed that 32 projects were placed in service, 25 projects were updated to under construction development status, 16 projects were updated to conceptual development status and 32 projects were withdrawn from the 2020-21 Regional Transmission Plan. The remaining 2020-21 regional base transmission plan projects continued as planned projects in the 2022-23 regional base transmission plan. Additionally, 123 new planned projects were added to the TPPL and included in the 2022-23 regional base transmission plan. **Table 10** and **Table 11** summarize the updates to the 2020-21 regional base transmission plan projects.

**Table 10. 2020-21 Regional Base Transmission Plan Projects In-Service, Reported Mileage, and Reported Investment ($K), based on the TPPL data**

| Type of Project | Number of Projects | Length (Miles) | Planned Investment ($K) |
|---|---|---|---|
| Substation | 7 | - | $37,170 |
| Transmission Line | 14 | 166 | $29,851 |
| Transmission Line and Substation | 7 | 93 | $84,157 |
| Transformer | 3 | - | $5,279 |
| Other | 1 | - | $250 |
| **Total Projects** | **32** | **259** | **$156,707** |

**Table 11. 2020-21 Planned Regional Transmission Plan Projects Withdrawn or Changed to Conceptual by Voltage, based on the TPPL data**

| New Status | Type | < 230 kV | 230 kV | 345 kV | Total |
|---|---|---|---|---|---|
| Conceptual | Substation | 4 | 1 | 1 | 6 |
| | Transmission Line | 5 | 2 | - | 7 |
| | Trans Line and Sub | 1 | - | - | 1 |
| | Other | - | 1 | - | 1 |
| | Subtotal | 10 | 4 | 1 | 15 |
| Withdrawn | Substation | 7 | 1 | - | 8 |
| | Transmission Line | 15 | 1 | - | 16 |
| | Trans Line and Sub | 1 | - | - | 1 |
| | Transformer | 1 | 1 | 1 | 3 |
| | Other | 3 | - | 1 | 4 |
| | Subtotal | 27 | 3 | 2 | 32 |
| | **Total** | **37** | **7** | **3** | **47** |

## 6.3 Regional Base Transmission Plan Projects by State

The 2022-23 regional base transmission plan has projects in multiple states in the WestConnect footprint and in some instances, projects span multiple states. **Table 12** summarizes the number of projects by states with aggregated capital investment.

**Table 12. 2022-23 Regional Base Transmission Plan Projects by State, Reported Mileage, and Reported Investment ($K), based on the TPPL data**

| State | Number of Projects | Length (Miles) | Planned Investment ($K) |
|---|---|---|---|
| Arizona | 49 | 400 | $1,346,239 |
| California | 15 | 179 | $876,780 |
| Colorado | 33 | 999 | $2,367,265 |
| New Mexico | 5 | - | $104,900 |
| South Dakota | 1 | - | - |
| Wyoming | 9 | 58 | $25,000 |
| Multiple | 97[7] | 724 | $1,066,290 |
| **Total Projects** | **209** | **2360** | **$5,786,474** |

Review of the 2022-23 regional base transmission plan projects by state showed that many (23%) of the projects are located in Arizona, 16% of the projects are located in Colorado, 7% are located in California, and 46% span multiple states. The remaining projects are located in in New Mexico, South Dakota, and Wyoming.

[7] *Multi-state value is overstated due to aggregation of data during collection process*

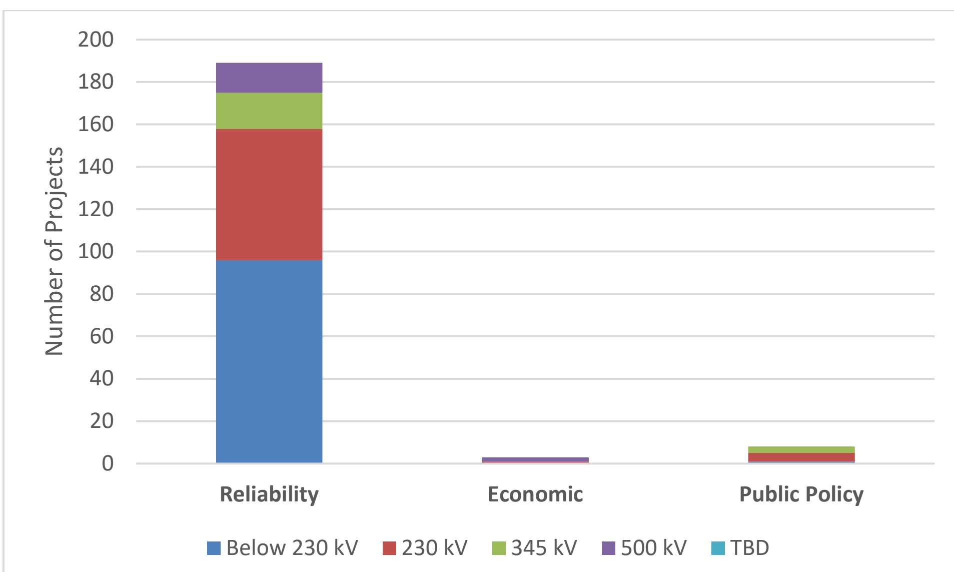
## 6.4 Regional Base Transmission Plan Projects by Driver

Review of the 2022-23 regional base transmission planned projects showed that nearly all of projects (90%) are primarily driven by reliability needs, 3% are primarily driven by public policy, and 1% are primarily economic driven. **Table 13**, and **Figure 6** below breakout the projects by length, planned investment costs, and voltage.

**Table 13. 2022-23 Regional Base Transmission Plan Projects by Driver and Voltage, Reported Mileage, and Reported Investment ($K), based on the TPPL data**

| Driver (Primary/Secondary) | < 230kV | 230 kV | 345 kV | 500 kV | TBD | Total |
|---|---|---|---|---|---|---|
| Reliability | 90 | 53 | 16 | 10 | - | 169 |
| Reliability/Public Policy | 2 | 8 | 1 | 4 | - | 15 |
| Public Policy | 1 | 2 | 2 | - | - | 5 |
| Public Policy/Reliability | - | 2 | 1 | - | - | 3 |
| Other | 6 | 1 | 1 | 1 | - | 9 |
| Economic | - | - | - | 2 | - | 2 |
| Economic/Reliability | - | 1 | - | - | - | 1 |
| Reliability/Economic | 4 | 1 | - | - | - | 5 |
| **Total Projects** | **103** | **68** | **21** | **17** | **0** | **209** |

**Figure 6. 2022-23 Regional Base Transmission Plan Number of Projects by Primary Driver and Voltage, based on the TPPL data**



# 7.0 Scenario Studies

A single scenario study involving two scenario cases is included in the Study Plan, which WestConnect will perform on an "information-only" basis. Details regarding the process used to develop the scenarios and their purpose in the planning process is located in the 2022-23 Study Plan and provided below for quick reference:

**High Clean Energy Penetration Scenario Study**: The purpose of the High Clean Energy Penetration Scenario Study is to evaluate the regional congestion in and reliability of a 2032 future in which the renewable and clean energy target-focused Public Policy Requirements of that study year are satisfied within the WestConnect footprint, as well as use the models representing this future to understand the gap between this future and a future in which the WestConnect footprint is carbon free. The study will begin with updating the assumptions within the WestConnect 2032 Base Case PCM in order to develop a 2032 High Clean Energy Penetration PCM case whose results reasonably satisfy the renewable and clean energy target-focused Public Policy Requirements applicable to year 2032, confirmed by TOLSO Members. Next, a reliability model will be developed based on a WestConnect Member-selected system condition from the 2032 High Clean Energy Penetration PCM simulation. The development of these models and the analyses they will undergo are described in more detail below.

It is expected that the 2032 High Clean Energy Penetration PCM case will be developed through several iterative rounds of review by the WestConnect Members. Given the numerous ways in which some of the Public Policy Requirements can be complied with, the final assumptions of the case are expected to contain simplifications in many instances and will be extremely important for Members and stakeholders to keep this in mind during the course of the study. Even more so than in the Regional Assessments, the focus will be on regional impacts rather than local issues. Whenever possible, WestConnect will look to leverage WestConnect Members' internal studies or other recent assessments that have investigated strategies for compliance with Public Policy Requirements, including, but not limited to, thermal generation retirements, generation and/or storage additions, demand-side programs, or local transmission expansion focused on new resource delivery. TOLSO Members will be asked to consider any gap identified between the Public Policy Requirements in the WestConnect 2032 Base Case PCM and provide assumptions to reasonably fill the gap.

The 2032 High Clean Energy Penetration PCM case results will be evaluated in two ways. First, the congestion in the case will be evaluated using the same method as the Regional Economic Assessment (described in Section 5.3). As in the Regional Economic Assessment, WestConnect may choose to conduct sensitivity studies on the 2032 High Clean Energy Penetration PCM. Second, the results of the simulation will be used to perform a "carbon free gap analysis", which will involve an accounting of the carbon emissions attributed to the WestConnect footprint in the 2032 High Clean Energy Penetration PCM in order to approximate the amount of further carbon reduction that would be necessary to make the WestConnect footprint carbon free by 2032.

The reliability of the system condition exported from the 2032 High Clean Energy Penetration PCM case will be evaluated using the same steady state contingency analysis as the Regional Reliability Assessment.

# 8.0 Next Steps

The Planning Subcommittee compiled this report to document major assumptions that have been incorporated into the base regional models and their sensitivity cases. Both draft and final versions of the regional models are made available to PMC Members and others that have executed the WestConnect Confidentiality Agreement.

The regional needs assessment was conducted in parallel with the later stages of the model development process and will culminate with a report from the Planning Subcommittee to the PMC. That report will document the findings of the regional assessments and the determination of regional transmission needs for the current planning cycle.

The scenario assessment will be conducted after the regional needs assessment and will culminate with a report from the Planning Subcommittee to the PMC. That report will document the findings of the scenario assessments and propose recommendations on any potential regional *opportunities*.

# 9.0 Appendix A: 2032 Base Case (PCM) Assumptions

This appendix contains select modeling assumptions reflected in the WestConnect 2032 Base Case.

**Table 14. Annual Average of Fuel Price Assumptions (2020$/mmBtu) in WestConnect 2032 Base Case PCM**

| Fuel Name | Annual Average of Fuel Prices (2020$/mmBtu) | Fuel Name | Annual Average of Fuel Prices (2020$/mmBtu) |
|---|---|---|---|
| Bio_Agri_Res | 0.568 | Coal_Sunnyside | 1.488 |
| Bio_Blk_Liquor | 0.011 | Coal_UT | 1.431 |
| Bio_Landfill_Gas | 2.379 | Coal_Valmy | 2.246 |
| Bio_Other | 3.052 | Coal_WY_PRB | 0.712 |
| Bio_Sludge_Waste | 0.001 | Coal_WY_SW | 1.991 |
| Bio_Solid_Waste | 0.001 | Coal_Wygen | 0.654 |
| Bio_Wood | 3.031 | Coal_Wyodak | 0.899 |
| Coal_Alberta | 1.323 | Geothermal | 0.001 |
| Coal_Apache | 2.061 | NG_AB | 3.629 |
| Coal_AZ | 1.673 | NG_AZ North | 3.531 |
| Coal_Battle_River | 1.323 | NG_AZ South | 3.486 |
| Coal_Boardman | 1.748 | NG_Baja | 3.606 |
| Coal_Bonanza | 1.531 | NG_BC | 3.628 |
| Coal_CA_South | 3.113 | NG_CA PGaE BB | 5.336 |
| Coal_Centennial_Hard | 1.060 | NG_CA PGaE LT | 5.336 |
| Coal_Centralia | 2.011 | NG_CA SDGE | 5.298 |
| Coal_Cholla | 1.682 | NG_CA SJ Valley | 4.381 |
| Coal_CO_East | 1.045 | NG_CA SoCalB | 3.520 |
| Coal_CO_West | 1.734 | NG_CA SoCalGas | 5.382 |
| Coal_Colstrip | 1.060 | NG_CO | 3.546 |
| Coal_Comache | 1.045 | NG_CO_Rifle | 2.064 |
| Coal_Coronado | 1.976 | NG_CO_Shafer | 2.027 |
| Coal_Craig | 1.710 | NG_ID North | 3.565 |
| Coal_Dave_Johnston | 0.732 | NG_ID South | 3.888 |
| Coal_Dry_Fork | 0.518 | NG_MT | 3.434 |
| Coal_Escalante | 1.746 | NG_NM North | 3.401 |
| Coal_Four_Corners | 2.131 | NG_NM South | 3.397 |
| Coal_Hayden | 1.734 | NG_NV North | 3.390 |
| Coal_Hunter | 1.348 | NG_NV South | 3.516 |
| Coal_Huntington | 1.488 | NG_OR | 3.683 |
| Coal_ID | 2.120 | NG_OR Malin | 3.142 |
| Coal_Intermountain | 1.668 | NG_TX West | 3.317 |
| Coal_Jim_Bridger | 2.120 | NG_UT | 3.418 |
| Coal_LRS | 1.130 | NG_WA | 3.683 |
| Coal_Martin_Drake | 1.163 | NG_WY | 3.434 |
| Coal_Naughton | 1.673 | Oil_DistFuel_TSGT | 24.792 |
| Coal_Navajo | 1.988 | Oil_DistillateFuel_2 | 24.567 |

| Fuel Name | Annual Average of Fuel Prices (2020$/mmBtu) | Fuel Name | Annual Average of Fuel Prices (2020$/mmBtu) |
|---|---|---|---|
| Coal_Neil_Simpson | 0.656 | Oil_DistillateFuel_H | 34.120 |
| Coal_Nixon | 1.167 | Oil_DistillateFuel_L | 12.200 |
| Coal_NM | 1.752 | Petroleum Coke | 1.484 |
| Coal_NV | 1.926 | Propane | 24.788 |
| Coal_Pawnee | 0.927 | Purchased_Steam | 1.053 |
| Coal_Rawhide | 1.001 | Refuse | 0.001 |
| Coal_San_Juan | 1.407 | Synthetic Gas | 7.357 |
| Coal_Springerville 3 | 1.707 | Uranium | 0.738 |
| Coal_Springerville 4 | 1.707 | Waste_Heat | 0.001 |
| Coal_Springerville12 | 1.315 | | |

**Table 15. Fuel Emission Rates by Type (lb/mmBtu) in WestConnect 2032 Base Case PCM**

| Fuel Groups or Fuel Name | Fuel Emission Rates by Type (lb/mmBtu) | | | Fuel Groups or Fuel Name | Fuel Emission Rates by Type (lb/mmBtu) | | |
|---|---|---|---|---|---|---|---|
| | $SO_2$ | $NO_X$ | $CO_2$ | | $SO_2$ | $NO_X$ | $CO_2$ |
| "Bio" Fuels | 0.00579 | 0.1766362 | 130 | Coal_Navajo | 0.571 | 0.459146 | 205.0311 |
| "NG" Fuels | 0.0006 | 0.08 | 117 | Coal_Neil_Simpson | 0.07 | 0.1 | 205.2 |
| Coal_Alberta | 0.35 | 0.5 | 205 | Coal_Nixon | 0.6911747 | 0.552889 | 204.7532 |
| Coal_Apache | 0.571 | 0.459146 | 205.0311 | Coal_NM | 0.3303097 | 0.3824139 | 203.5343 |
| Coal_AZ | 0.571 | 0.459146 | 205.0311 | Coal_NV | 0.112818 | 0.3485 | 202.6215 |
| Coal_Battle_River | 0.35 | 0.5 | 205 | Coal_Pawnee | 0.6911747 | 0.552889 | 204.7532 |
| Coal_Boardman | 0.621817 | 0.288333 | 205.2 | Coal_Rawhide | 0.6911747 | 0.552889 | 204.7532 |
| Coal_Bonanza | 0.6911747 | 0.552889 | 204.7532 | Coal_San_Juan | 0.3303097 | 0.3824139 | 203.5343 |
| Coal_CA_South | 0.3303097 | 0.3824139 | 203.5343 | Coal_Springerville 3 | 0.571 | 0.459146 | 205.0311 |
| Coal_Centennial_Hard | 0.6911747 | 0.552889 | 204.7532 | Coal_Springerville 4 | 0.571 | 0.459146 | 205.0311 |
| Coal_Centralia | 0.621817 | 0.288333 | 205.2 | Coal_Springerville12 | 0.571 | 0.459146 | 205.0311 |
| Coal_Cholla | 0.571 | 0.459146 | 205.0311 | Coal_Sunnyside | 0.6911747 | 0.552889 | 204.7532 |
| Coal_CO_East | 0.6911747 | 0.552889 | 204.7532 | Coal_UT | 0.6911747 | 0.552889 | 204.7532 |
| Coal_CO_West | 0.6911747 | 0.552889 | 205.2 | Coal_Valmy | 0.112818 | 0.3485 | 202.6215 |
| Coal_Colstrip | 0.6911747 | 0.552889 | 204.7532 | Coal_WY_PRB | 0.07 | 0.1 | 205.2 |
| Coal_Comache | 0.6911747 | 0.552889 | 204.7532 | Coal_WY_SW | 0.07 | 0.1 | 205.2 |
| Coal_Coronado | 0.571 | 0.459146 | 205.0311 | Coal_Wygen | 0.07 | 0.1 | 205.2 |
| Coal_Craig | 0.6911747 | 0.552889 | 204.7532 | Coal_Wyodak | 0.07 | 0.1 | 205.2 |
| Coal_Dave_Johnston | 0.07 | 0.1 | 205.2 | DefaultFuel | 0.35 | 0.276 | 200 |
| Coal_Dry_Fork | 0.07 | 0.1 | 205.2 | Geothermal | 0.00579 | 0.1766362 | 20 |
| Coal_Escalante | 0.3303097 | 0.3824139 | 203.5343 | Oil_DistFuel_TSGT | 0.00579 | 0.1766362 | 156.3 |
| Coal_Four_Corners | 0.571 | 0.459146 | 205.0311 | Oil_DistillateFuel_2 | 0.00579 | 0.1766362 | 156.3 |
| Coal_Hayden | 0.6911747 | 0.552889 | 204.7532 | Oil_DistillateFuel_H | 0.00579 | 0.1766362 | 156.3 |
| Coal_Hunter | 0.6911747 | 0.552889 | 204.7532 | Oil_DistillateFuel_L | 0.0006 | 0.116 | 161.3 |
| Coal_Huntington | 0.6911747 | 0.552889 | 204.7532 | Petroleum Coke | 0 | 0.028 | 224 |
| Coal_ID | 0.6911747 | 0.552889 | 204.7532 | Propane | 0.00579 | 0.1766362 | 123.1133 |
| Coal_Intermountain | 0.6911747 | 0.552889 | 204.7532 | Purchased_Steam | 0 | 0.028 | 224 |
| Coal_Jim_Bridger | 0.07 | 0.1 | 205.2 | Refuse | 0.00579 | 0.1766362 | 130 |
| Coal_LRS | 0.07 | 0.1 | 205.2 | Synthetic Gas | 0.0006 | 0.08 | 117 |
| Coal_Martin_Drake | 0.6911747 | 0.552889 | 204.7532 | Uranium | 0 | 0 | 0 |
| Coal_Naughton | 0.07 | 0.1 | 205.2 | Waste_Heat | 0 | 0 | 0 |

**Table 16. WestConnect Inter-Area Wheeling Rate Assumptions in WestConnect 2032 Base Case PCM. Non-public wheeling charges provided by WestConnect members are excluded from this table: WACM export wheel.**

| From Zone | To Zone | From PCM Area(s) | To PCM Area(s) | Wheeling Charge ($/MWh) | |
|---|---|---|---|---|---|
| | | | | Peak Hours | Off-Peak Hours |
| AB_AESO | BC_BCHA | AESO | BCHA | 2.338 | 2.338 |
| AB_AESO | NW_NWMT+ | AESO | NWMT, WAUW | 5.2 | 5.2 |
| BC_BCHA | AB_AESO | BCHA | AESO | 9.915 up to 590 MW, then 3.131 | 9.915 up to 590 MW, then 3.131 |
| BC_BCHA | NW_BPAT+ | BCHA | BPAT, CHPD, DOPD, GCPD, SCL, TPWR | 0 up to 1571 MW, then 7.755 | 0 up to 1571 MW, then 7.755 |
| BS_IPCO | NW | IPFE | AVA, BPAT, CHPD, DOPD, GCPD, PACW, PGE, SCL, TPWR | 0 up to 2160 MW, then 2.912 | 0 up to 2160 MW, then 2.912 |
| BS_IPCO | SW_NVE | IPFE | NEVP | 4.64 | 2.59 |
| BS_PACE | <Any> | PAID | <Any> | 6.902 | 3.283 |
| CA_BANC+ | <Any> | BANC, TIDC | <Any> | 2.3 | 2.3 |
| CA_CFE | CA_CISO | CFE | CIPB, CIPV, CISC, CISD, VEA | 12.2 | 12.2 |
| CA_CISO | <Any> | CIPB, CIPV, CISC, CISD, VEA | <Any> | 11.5 | 11.5 |
| CA_IID | <Any> | IID | <Any> | 3.06 | 3.06 |
| CA_LDWP | <Any> | LDWP | <Any> | 9.31 | 4.42 |
| NW | BS_IPCO | AVA, BPAT, CHPD, DOPD, GCPD, PACW, PGE, SCL, TPWR | IPFE | 0 up to 1080 MW, then 2.103 | 0 up to 1080 MW, then 2.103 |
| NW | NW_NWMT+ | AVA, BPAT, CHPD, DOPD, GCPD, PACW, PGE, SCL, TPWR | NWMT, WAUW | 0 up to 1215 MW, then 2.103 | 0 up to 1215 MW, then 2.103 |
| NW_BPAT+ | <Any> | BPAT, CHPD, DOPD, GCPD, SCL, TPWR | <Any> | 3.99 | 3.99 |
| NW_BPAT+ | BC_BCHA | BPAT, CHPD, DOPD, GCPD, SCL, TPWR | BCHA | 0 up to 1201 MW, then 2.103 | 0 up to 1201 MW, then 2.103 |
| NW_BPAT+ | SW_NVE | BPAT, CHPD, DOPD, GCPD, SCL, TPWR | NEVP | 0 up to 120 MW, then 2.103 | 0 up to 120 MW, then 2.103 |
| NW_NWMT+ | <Any> | NWMT, WAUW | <Any> | 4.56 | 4.56 |
| NW_NWMT+ | BS_PACE | NWMT, WAUW | PAID | 0 up to 192 MW, then 5.166 | 0 up to 192 MW, then 5.166 |

| From Zone | To Zone | From PCM Area(s) | To PCM Area(s) | Wheeling Charge ($/MWh) | |
|---|---|---|---|---|---|
| | | | | Peak Hours | Off-Peak Hours |
| NW_NWMT+ | NW | NWMT, WAUW | AVA, BPAT, CHPD, DOPD, GCPD, PACW, PGE, SCL, TPWR | 0 up to 2016 MW, then 5.166 | 0 up to 2016 MW, then 5.166 |
| NW_PACW | <Any> | PACW | <Any> | 6.902 | 3.283 |
| NW_PGE | <Any> | PGE | TH_Malin | 1.02 | 1.02 |
| RM_PSCO | <Any> | PSCO | <Any> | 8.238 | 4.753 |
| SW_AZPS | <Any> | AZPS | <Any> | 7.338 | 4.102 |
| SW_AZPS | BS_PACE | AZPS | PAID | 0 up to 300 MW, then 7.338 | 0 up to 300 MW, then 4.102 |
| SW_EPE | <Any> | EPE | <Any> | 5.95 | 3.40 |
| SW_NVE | <Any> | NEVP | <Any> | 7.09 | 4.28 |
| SW_PNM | <Any> | PNM | <Any> | 6.042 | 5.448 |
| SW_SRP | <Any> | SRP | <Any> | 4.36 | 2.48 |
| SW_TEPC | <Any> | TEPC | <Any> | 7.1 | 3.686 |
| SW_WALC | <Any> | WALC | <Any> | 1.811 | 1.811 |

**Table 17. Names of Monitored Interfaces in WestConnect 2032 Base Case PCM**

| Monitored Interface Names | |
|---|---|
| _IPP DC pole balancing | P62 Eldorado-McCullough 500 kV Line |
| Delisted-P22 Southwest of Four Corners | P65N Pacific DC Intertie (PDCI) |
| Delisted-P23 Four Corners 345/500 Qualified Path | P65S Pacific DC Intertie (PDCI) |
| Delisted-P50 Cholla-Pinnacle Peak | P66 COI |
| Delisted-P51 Southern Navajo | P71 South of Allston |
| FlowMonitor_18009_180514_1 | P73 North of John Day |
| P01 Alberta-British Columbia | P75 Hemingway-Summer Lake |
| P02 Alberta-Saskatchewan | P76 Alturas Project |
| P03 Northwest-British Columbia | P77 Crystal-Allen |
| P03East Side NW-BC | P78 TOT 2B1 |
| P03West Side NW-BC | P79 TOT 2B2 |
| P04 West of Cascades-North | P80 Montana Southeast |
| P05 West of Cascades-South | P81 Southern Nevada Transmission Interface (SNTI) |
| P06 West of Hatwai | P82 TotBeast |
| P08 Montana to Northwest | P83 Montana Alberta Tie Line |
| P14 Idaho to Northwest | P84 Harry Allen - Eldorado (HAE) |
| P15 Midway-LosBanos | P89 SNTI + HAE |
| P16 Idaho-Sierra | Palo Verde East |
| P17 Borah West | SeriesRctrLine_10231_12038_1 |
| P18 Montana-Idaho | SeriesRctrLine_12008_12007_1 |
| P19 Bridger West | SeriesRctrLine_30560_30527_1 |
| P20 Path C | SeriesRctrLine_30692_30690_1 |
| P24 PG&E-Sierra | SeriesRctrLine_30700_30527_1 |
| P25 PacifiCorp/PG&E 115 kV Interconnection | SeriesRctrLine_30700_30697_1 |
| P26 Northern-Southern California | SeriesRctrLine_34727_34700_1 |
| P27 Intermountain Power Project DC Line | SeriesRctrLine_34742_34704_1 |
| P28 Intermountain-Mona 345 kV | SeriesRctrLine_60275_60278_1 |
| P29 Intermountain-Gonder 230 kV | SeriesRctrLine_73414_78664_1 |
| P30 TOT 1A | xy AZ-CA |
| P31 TOT 2A | xy WY-UT |

| Monitored Interface Names | |
|---|---|
| P32 Pavant-Gonder InterMtn-Gonder 230 kV | z  Aeolus South |
| P33 Bonanza West | z  Aeolus West |
| P35 TOT 2C | z  CA IPP DC South |
| P36 TOT 3 | z  CA PG&E-Bay |
| P37 TOT 4A | z  ID Midpoint West |
| P38 TOT 4B | z CG Columbia Injection |
| P39 TOT 5 | z CG Net COB (NW AC Intertie) |
| P40 TOT 7 | z CG North of Echo Lake |
| P41 Sylmar to SCE | z CG North of Hanford |
| P42 IID-SCE | z CG Paul-Allston |
| P45 SDG&E-CFE | z CG Raver-Paul |
| P46 West of Colorado River (WOR) | z CG South of Boundary |
| P47 Southern New Mexico (NM1) | z CG South of Custer |
| P48 Northern New Mexico (NM2) | z CG West of John Day |
| P49 East of Colorado River (EOR) | z CG West of Lower Monumental |
| P52 Silver Peak-Control 55 kV | z CG West of McNary |
| P54 Coronado-Silver King 500 kV | z CG West of Slatt |
| P55 Brownlee East | zzz N Path 18 Exp 2 |
| P58 Eldorado-Mead 230 kV Lines | zzz N Path 18 Imp 2 |
| P59 WALC Blythe - SCE Blythe 161 kV Sub | zzz N Path 22_part1 |
| P60 Inyo-Control 115 kV Tie | zzz N Path 22_part2 |
| P61 Lugo-Victorville 500 kV Line | |