Rocky Mountain Power
Exhibit RMP___(RAV-2SR)
Docket No. 17-035-40
Witness: Rick A. Vail

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF UTAH

ROCKY MOUNTAIN POWER

Exhibit Accompanying Surrebuttal Testimony of Rick A. Vail

Transfer Capability Assessment March 30, 2018

May 2018

Aeolus West Transmission Path Transfer Capability Assessment

Updated Study Report
Revision 2.1

March 30, 2018

Prepared by
PacifiCorp – Transmission Planning

Updated
Aeolus West Transmission Path
Transfer Capability Assessment

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Updated
Aeolus West Transmission Path
Transfer Capability Assessment

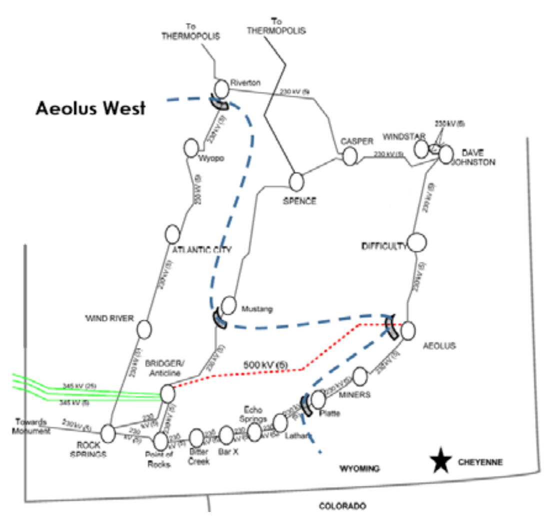
Executive Summary

This assessment was conducted to document the Transfer Capability of the Aeolus West[1] transmission path once the Gateway West – Subsegment D.2[2] (Bridger/Anticline – Aeolus) transmission facilities (D.2 Project) are added to the Wyoming transmission system and assumed resources identified in the PacifiCorp 2017R RFP[3] Shortlist were added.

The Aeolus West transmission path (see Figure 1) is a new path that will be formed by adding the D.2 Project in parallel with the TOT 4A[4] (Path 37) transmission path facilities. The anticipated in-service date for the D.2 Project is October 31, 2020. The D.2 Project is part of PacifiCorp's Energy Vision 2020 (EV2020) initiative which includes the following major transmission facilities and network upgrades to support new wind generation resources:

- Aeolus 500/230 kV substation,
- Shirley Basin – Freezeout 230 kV line loop-in to Aeolus,
- Anticline 500/345 kV substation,
- Aeolus – Anticline 500 kV new line,
- Bridger – Anticline 345 kV new line,
- Shirley Basin – Aeolus 230 kV #1 line rebuild,
- Shirley Basin – Aeolus 230 kV #2 new line,

Figure 1: Aeolus West Transmission Path



[1] The Aeolus West transmission path will include the following major transmission elements: Aeolus* – Anticline 500 kV, Platte* – Latham 230 kV, Mustang* – Bridger 230 kV and Riverton* – Wyopo 230 kV transmission lines. (*meter location)

[2] Gateway West – Subsegment D.2 is a key component of the Energy Vision 2020 (EV2020) initiative that was announced by PacifiCorp on April 4, 2017. Other components of the EV2020 initiative include repowering PacifiCorp's existing wind fleet in southeast Wyoming and adding approximately 1,100 MW of new wind generation east of the Aeolus West transmission path. [Subsequent to the initial announcement, technical studies have demonstrated that as high as 1,510 MW can be integrated east of the Aeolus West transmission path.]

[3] The PacifiCorp 2017R Request for Proposals for renewable resources (2017R RFP) solicited cost-competitive bids for up to 1,270 MW of new or repowered wind energy interconnecting with or delivering to PacifiCorp's Wyoming system with the use of third-party firm transmission service and any additional wind energy located outside of Wyoming capable of delivering energy to PacifiCorp's transmission system that will reduce system costs and provide net benefits for customers.

[4] The existing TOT 4A (Path 37) transmission path is comprised of the Riverton* – Wyopo 230 kV, Platte – Standpipe* 230 kV and Spence* – Mustang 230 kV transmission lines. (*meter location)

- Aeolus – Freezeout 230 kV line reconductor,
- Freezeout – Standpipe 230 kV line reconductor,
- Latham dynamic voltage control device,
- Separate the double-circuit portion of the Ben Lomond - Naughton 230 kV #1 and Ben Lomond - Birch Creek 230 kV #2 lines to create two single-circuit lines,
- Railroad – Croydon 138 kV partial line reconductor,
- Aeolus 230 kV shunt reactor,
- Shirley Basin 230 kV shunt reactor,

The WECC 2021-22 HW power flow base case was utilized for the Aeolus West transfer capability assessment studies. In support of the EV2020 initiative, which calls for the addition of new and repowered wind resources in Wyoming, the base case was modified to achieve the transfer levels evaluated by utilizing PacifiCorp 2017R RFP Shortlist resources as evaluated in the Large Generation Interconnection (LGI) queue, which added 1510 MW east of the Aeolus West "cut plane" and 221 MW in southwest Wyoming. For different Aeolus West transfer levels (heavy and light) and 2400 MW flow across the Jim Bridger West path, resource levels in eastern Wyoming were varied relative to the Jim Bridger Generation in central Wyoming and the Emery/Hunter and Huntington generation in central Utah.

Contingencies that were considered in this analysis include:

- N-1 of D.2 Project facilities
- N-1, N-2 Bridger contingencies
- All eastern, central and northern Wyoming transmission system contingencies performed as part of the TPL-001-4 annual assessment.

For this transfer capability assessment, simultaneous interaction between the Aeolus West path and the TOT 4B path was evaluated; however, the interactions with other transmission paths (Yellowtail South, Jim Bridger West, TOT 1A and TOT 3) were monitored throughout the study. Subsequent transfer capability assessments will evaluate interaction with TOT 3 (Path 36), Bonanza West (Path 33) and TOT 1A (Path 30) transmission paths. (See Appendix A.)

In this revision of the report, the power flow analysis was re-evaluated to identify maximum transfer capability by stressing both the Aeolus West and the TOT 4B paths simultaneously. If required, additional power from Western Area Power Administration (WAPA) was imported into the PacifiCorp East (PACE) balancing authority area.

Conclusions

Technical studies have demonstrated that the interconnected Bulk Electric System (BES) in Wyoming with the D.2 Project added can support the PacifiCorp 2017R RFP Shortlist resources, and that system performance will meet all North American Electric Reliability Corporation (NERC) and Western Electricity Coordinating Council (WECC) performance criteria.

Preliminary power flow studies demonstrate that by utilizing existing and planned southeast Wyoming resources[5], the Aeolus West transmission path can transfer up to 1829 MW under simultaneous transfer conditions with the TOT 4B transmission path, effectively[6] increasing the east to west transfer levels across Wyoming by 951 MW. Power flow findings also indicated:

- Dynamic voltage control is necessary at the Latham 230 kV substation to mitigate low voltage conditions resulting from loss of Bridger/Anticline – Aeolus transmission facilities.
- Under certain operating conditions, one Remedial Action Scheme (RAS) will need to be implemented to trip generation following outage of specific transmission facilities in southeast Wyoming.
- The location (and output level) of new and repowered wind resources can influence the transfer capability level across the Aeolus West transmission path and the Aeolus West vs. TOT 4B nomogram curve.

Dynamic stability studies evaluated a wide range of critical system disturbances in eastern Wyoming. The analyses identified two outages with poor voltage performance, and another outage identified a wind turbine modeling problem. These issues are all attributed to the wind turbine models at the Q0706, Q0707 and Q0708 projects. PacifiCorp is working with the wind turbine manufacture to resolve these issues. Aside from these issues, the studied outages evaluated meet the dynamic performance criteria with the system being stable and damped.

[5] Eastern Wyoming Resources: Existing Wind: 1124 MW, Dave Johnston (net) 717 MW; Wyodak (PacifiCorp – net) 268 MW, New Wind – behind the Aeolus West "cut plane": 1510 MW; east Wyoming: 1270 MW, north Wyoming: 240 MW.

[6] Effective transfers were determined by subtracting the existing TOT 4A path maximum[13] transfer level (960 MW) from the Aeolus West transfer level (1829 MW) and adding the Platte area loads (82 MW) that are up-stream of the Aeolus West metering point.

Updated
Aeolus West Transmission Path
Transfer Capability Assessment

1 Introduction

1.1 Purpose

The purpose of the study is to demonstrate that the interconnected transmission Bulk Electric System (BES) in Wyoming with the D.2 Project added can support the PacifiCorp 2017R RFP Shortlist resources and can be operated reliably during normal and contingency operations throughout the planning horizon. To achieve this purpose, the study will: (1) identify the new Aeolus West transmission path limitations, (2) evaluate the interactions between the Aeolus West and the TOT 4B transmission paths and develop a nomogram that depicts system limitations, and (3) identify any necessary Remedial Action Schemes (RAS).

This report will summarize the results of the power flow and dynamic stability analysis of the Aeolus West transmission path and will demonstrate that Wyoming transmission system performance with the D.2 project added meets all NERC and WECC performance criteria.

1.2 Plan of Service

The D.2 Project, and supporting network upgrades consists of the following system improvements:

1. Add Aeolus 500/230 kV substation
2. Add Aeolus 500/230 kV, 1600 MVA transformer
3. Loop the Shirley Basin – Freezeout 230 kV line into Aeolus,
4. Add Anticline 500/345 kV substation
5. Add Anticline 500/345 kV, 1600 MVA transformer
6. Add the Aeolus – Anticline 500 kV transmission line, 137.8-miles, 3x1272 ACSR (Bittern) conductor
7. Add the Anticline – Bridger 345 kV line, 5.1-miles, 3x1272 ACSR (Bittern) conductor
8. Add the Aeolus 230 kV, 60 MVAr shunt reactor
9. Add the Shirley Basin 230 kV, 60 MVAr shunt reactor
10. Add Aeolus 500 kV, 200 MVAr shunt capacitor
11. Add Anticline 500 kV, 200 MVAr shunt capacitor
12. Rebuilding of the Aeolus – Shirley Basin 230 kV #1 line, 2x1557 ACSS/TW (Hudson/TW) conductor
13. Add the Aeolus – Shirley Basin 230 kV #2 line, 2x1557 ACSS/TW (Hudson/TW) conductor
14. Reconductor the Aeolus – Freezeout 230 kV line, 2x1272 ACSR (Bittern) conductor

15. Reconductor the Freezeout – Standpipe 230 kV line, 2x1272 ACSR (Bittern) conductor
16. Add dynamic reactive device at Latham 230 kV substation.
17. Separate eight miles of the double-circuit Ben Lomond - Naughton 230 kV #1 and Ben Lomond - Birch Creek 230 kV #2 lines to create two single-circuit lines, and
18. Reconductor 2.35 miles of the Railroad - Croydon 138 kV line, 1222 ACCC high temperature conductor,

1.3 Planned Operating Date

The in-service date for all facilities associated with the D.2 Project is October 31, 2020.

1.4 Scope

The Aeolus West transfer capability assessment assumes the addition of new wind generation facilities as noted in Table 1, which includes the PacifiCorp 2017R RFP Shortlist resources as evaluated in LGI queue studies. While the new technology and model information of the repowered units was used in the steady-state and dynamic stability analysis, no incremental MW output was considered; i.e., each repowered facility was limited to its current LGI agreement generation capacity levels. The study was performed using a 2021-22 heavy winter WECC approved case which was modified to include the D.2 Project facilities. The system model assumed summer line ratings to assess the thermal limitation of the Wyoming system. Load served from Platte is normally represented as an open point between Platte – Whiskey Peak 115 kV. The system configuration with Platte 115 kV normally open is presently the most limiting scenario for the existing TOT 4A/4B nomogram.

2 Study Criteria

2.1 Thermal Loading

For system normal conditions described by the P0[7] event, thermal loading on BES transmission lines and transformers is required to be within continuous ratings.

For contingency conditions described by P1-P7 category planning events, thermal loading on transmission lines and transformers should remain within 30-minute emergency ratings.

[7] Facility outage events that are identified with "P" designations are referenced to the TPL-001-4 NERC standard.

The thermal ratings of PacifiCorp's BES transmission lines and transformers are based on the most recent PacifiCorp's Weak Link Transmission Database and Weak Link Transformer Database.

Table 1: Generating Resources Studied

Existing Wyoming Thermal Generation	Existing East Wyoming Wind Generation	New Wyoming Wind Generation
2396 MW • Dave Johnston (DJ): 717 MW • Wyodak (PacifiCorp): 268 MW • Jim Bridger (PacifiCorp): 1411 MW	1124 MW (Foote Creek, Rock River, High Plains, Seven Mile Hill, Dunlap, Root Creek, Top of the World, Glenrock, Three Buttes, Chevron)	1731 MW • Eastern Wyoming (Aeolus, Shirley Basin, Windstar): 1270 MW • Northern Wyoming (Bighorn Basin): 240 MW • Southwest Wyoming (Uinta County) : 221 MW See Table 4.

2.2 Steady State Voltage Range

The steady state voltage ranges at all PacifiCorp BES buses shall be within acceptable limits as established in PacifiCorp's Engineering Handbook section 1B.3 "Planning Standards for Transmission Voltage[8]" as shown below.

Table 2: Voltage Criteria

Operating System Configuration	**Normal Conditions (P0)**		**Contingency Conditions (P1-P7)**	
	Vmin (pu)	**Vmax (pu)**	**Vmin (pu)**	**Vmax (pu)**
Looped	0.95	1.06[9]	0.90	1.10
Radial	0.90	1.06[9]	0.85	1.10

[8] PacifiCorp Engineering Handbook "Planning Standards for Transmission Voltage," April 8, 2013.

[9] In some situations, voltages may go as high as 1.08 pu at non-load buses, contingent upon equipment rating review.

Steady state voltage ranges at all applicable BES buses on adjacent systems were screened based on the limits established by WECC regional criterion as follows:

- 95% to 105% of nominal for P0 event (system normal),
- 90% to 110% of nominal for P1-P7 events (contingency).

2.3 Post-Transient Voltage Deviation

Post-contingency steady state voltage deviation at each applicable BES load serving bus (having no intermediate connection) shall not exceed 8% for P1 events.

2.4 Dynamic Stability Analysis Criteria

All voltages, frequencies and relative rotor angles are required to be stable and damped. Cascading or uncontrolled separation shall not occur and dynamic voltage response shall be within established limits.

2.5 Dynamic Voltage Response

Dynamic stability voltage response criteria are based on WECC Regional Performance Criteria WR1.3 through WR1.5 as follows:

- Dynamic stability voltage response at the applicable BES buses serving load (having no intermediate connection) shall recover to at least 80% of pre-contingency voltage within 20 seconds of the initiating event for all P1-P7 category events, for each applicable bus serving load.
- For voltage swings following fault clearing and voltage recovery above 80%, voltage dips at each applicable BES bus serving load (having no intermediate buses) shall not dip below 70% of pre-contingency voltage for more than 30 cycles or remain below 80% of pre-contingency voltage for more than two seconds for all P1-P7 category events.
- For contingencies without a fault (P2-1 category event), voltage dips at each applicable BES bus serving load (having no intermediate buses) shall not dip below 70% of pre-contingency voltage for more than 30 cycles or remain below 80% of pre-contingency voltage for more than two seconds.

The following criteria were used to investigate the potential for cascading and uncontrolled islanding:

- Load interruption due to successive line tripping for thermal violations shall be confined to the immediate impacted areas and shall not propagate to other areas. The highest available emergency rating is used to determine the tripping threshold for lines or transformers when evaluating a scenario that may lead to cascading.
- Voltage deficiencies caused by either the initiating event or successive line tripping shall be confined to the immediate impacted areas, and shall not propagate to other areas.

Positive damping in stability analysis is demonstrated by showing that the amplitude of power angle or voltage magnitude oscillations after a minimum of 10 seconds is less than the initial post-contingency amplitude. Oscillations that do not show positive damping within a 30-second time frame shall be deemed unacceptable.

Stability studies shall be performed for planning events to determine whether the BES meets the performance requirements.

- Single contingencies (P1 category events): No generating unit shall pull out of synchronism (excludes generators being disconnected from the system by fault clearing action or by a special protection system).
- Multiple contingencies (P2-P7 category events): When a generator pulls out of synchronism in the simulations, the resulting apparent impedance swings shall not result in the tripping of any transmission system elements other than the generating unit and its directly connected facilities.
- Power oscillations are evaluated by exhibiting acceptable damping. The absence of positive damping within a 30-second time frame is considered un-damped.

3 Base Case Development

3.1 Base Case Selection

The base case development process involves selecting an approved WECC base case, updating the models to represent planned transmission facilities (D.2 Project) and existing and new wind generation (see Table 1) facilities, and then tuning the cases to maximum transfer levels on the WECC transmission path(s) being studied. For this study, the WECC approved base case 2021-22 HW (created on August 19, 2016) was selected. This case meets key criteria in that it is close to the Projects' in-service date of October 31, 2020, includes average load conditions based on 2021 load projections and has an accompanying dynamic stability base case available. This study focused on simultaneous transmission path interaction in the Wyoming area between the Aeolus West and the TOT 4B transmission paths; however, other transmission paths such as Yellowtail South (non-WECC path), Jim Bridger West, TOT 1A and TOT 3 (See Appendix A for path definitions) were monitored throughout the study.

The various critical components for this study purpose selected from the 2021-22 HW base case are listed below:

Table 3: Wyoming Load, Generation and Platte Normal Open Configuration in Base Case

Load or Generation	**Amount (MW)**
North Wyoming PAC Load (including Wyodak load of 42 MW)	391 MW
North Wyoming - WAPA Load	211 MW
Eastern Wyoming PAC Load (including DJ load of 56 MW)	474 MW
Eastern Wyoming PAC Loads on WAPA System	95 MW
Central Wyoming Load (including JB load of 130 MW)	434 MW
Yellowtail South Flow	192 MW
Yellowtail Generation	140/260 MW (Online/Max)
WAPA's Existing Small Generation[10] in North Wyoming	26/50 MW(Online/Max)
WAPA's Existing Small Generation[11] in Eastern Wyoming	484/584 MW(Online/Max)
Wyodak Generation (PacifiCorp/Black Hills)	350/380 MW (Online/Max)
Dry Fork Generation (Basin Electric)	420/440 MW (Online/Max)
Gross Laramie River Generation I (WAPA's swing machine)	605 MW(Max)

[10] WAPA's small generation in north Wyoming includes; Boysen, Buffalo Bill, Heart Mountain, Shoshone, Spring Mountain

[11] WAPA's small generation in eastern Wyoming includes; Alcova, Fremont, Glendo, Guernsy, Kortes, Seminoe, CLR_1, SS_Gen1 AND CPGSTN

Load or Generation	**Amount (MW)**
Gross Laramie River Generation II	590/605 MW(Online/Max)
Gross Dave Johnston (DJ) Generation	700/774 MW(Online/Max)
Total Existing PAC East Wyoming Wind[12] Generation	885.7/1124 MW (Online/Max)
Rapid City DC W Tie	130 w2e (200 MW-bidirectional)
Stegall DC Tie	100 e2w (110 MW-bidirectional)
Sydney DC Tie	196 e2w (200 MW-bidirectional)
TOT 4A Flow	627 MW
TOT 4B Flow	469 MW
Jim Bridger (JB) Generation	2200 MW
Jim Bridger West Flow	2027 MW
TOT 3 Flow	1259.1 MW
TOT 1A Flow	195 MW
Platte – Mustang 115 kV Normal Open Point	Platte – Normal Open

3.2 Generating Facility Additions

The transmission path assessment studies outlined in Section 4 were performed by utilizing the resources identified in Table 4 to evaluate the performance of the Aeolus West transmission path. Transmission and generation projects with an in-service date beyond 2020 were excluded from the analysis. While Table 4 provides the general location of the resources included in the study, Figure 2 provides an overview of PacifiCorp's Wyoming transmission system and provides a visual illustration of the location of each of the existing and new generation (noted in red) resources, and identifies the location of the Aeolus West and TOT 4B transmission path constraints.

[12] PAC eastern Wyoming wind generation includes; Root Creek, Three Buttes, Top of The World, Glenrock, Rolling Hills, Dunlap. Seven Mile Hill, Foote Creek and High Plains wind generation

Table 4: New Wyoming Wind Resources

Proposed New Wind Facilities	LGI Queue Number	Project Size	Point of Interconnection
Northern Wyoming (Bighorn Basin)	Q542	240 MW	Frannie - Yellowtail 230 kV line
Eastern Wyoming (Aeolus/Shirley Basin/Windstar Area)	Q706	250 MW	Aeolus 230 kV
	Q707	250 MW	Shirley Basin 230 kV
	Q708	250 MW	Shirley Basin 230 kV
	Q712	520 MW	Windstar 230 kV
Southwest Wyoming (Uinta County)	Q715	120 MW	Canyon Compression – Railroad 138 kV line
	Q810	101 MW	Canyon Compression – Railroad 138 kV line
TOTAL		**1731 MW**	

3.3 Base Case Modification and Tuning

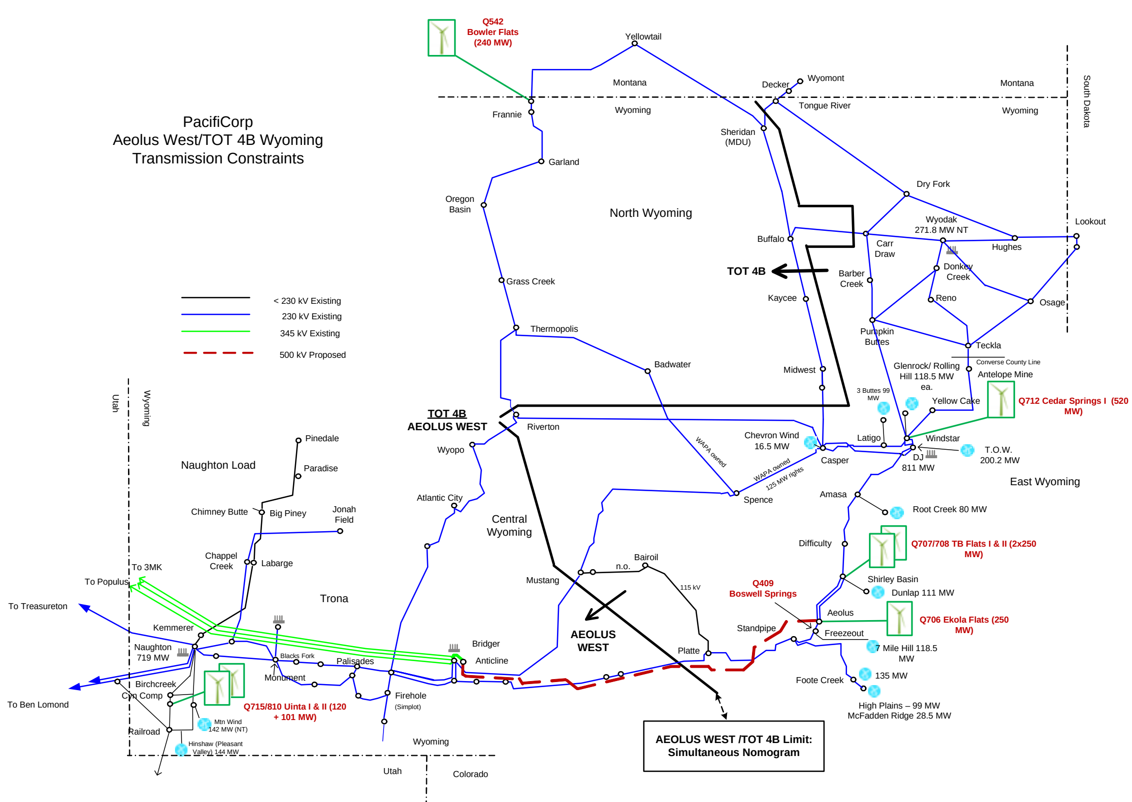
The 2021-22HW base case was modified to reflect the most recent Foote Creek, High Plains, Top of the World and Three Buttes wind generation modeling as per the recent MOD-032 data submitted by each generator owner (GO). Transmission line impedances between Dave Johnston and Standpipe were verified and updated and the transmission line ratings in the 2021-22 heavy winter case were modified to summer ratings, which represent the most conservative thermal limitations. The Platte – Standpipe 230 kV dynamic line rating of 608/666/680 MVA was assumed during the analysis.

The generation resources listed in Table 4 were added to the base case and the existing repowered wind farm generator models and collector system data were updated. The Aeolus West path was stressed by maximizing the output on all of the existing and new wind generation facilities. Output for the repowered wind generation facilities was limited to the existing LGI agreement generation capacity levels. The additional generation in southeast Wyoming was displaced with Jim Bridger, central and southern Utah generation. The Jim Bridger generation output was maintained such that Jim Bridger West path flows were maintained near 2400 MW.

As per the available data obtained for the various wind generation facilities at the time of this study analysis, the base cases were reviewed and adjusted to ensure voltages in the collector system of wind generation facilities were below 1.05 p.u. and that there was no reactive power

GSU loop flow conditions for wind generation facilities that have multiple main generator step-up GSU transformers.

Figure 2
Existing/Proposed Wyoming Generation Resources, and Transmission Constraints



This process involved tuning transformer and generator parameters such that generators were producing appropriate reactive power output. Additionally, within the 230 kV transmission system it was verified that the shunt reactive devices were accurately represented, voltage profiles were normal, reactive power flows were within normal operating ranges and transmission system voltage was maintained to match acceptable PacifiCorp Transmission Voltage Schedules.

4 Path Studies

4.1 Aeolus West vs. TOT 4B

Based on the assumptions outlined above, the study demonstrated that the Aeolus West maximum transfer capability limit is 1829 MW, while meeting all NERC and WECC performance criteria. While this transfer level is 869 MW above the present TOT 4A (960

MW[13]) path limit for similar conditions, east to west transfers have effectively increased by 951 MW due to shifting the Platte area load (82 MW) east of the Aeolus West cut plane. The Aeolus West path was stressed by using 3351 MW of total generation resources, which includes thermal (Dave Johnston, 717 MW - net), existing wind (1124 MW), and new wind (1510 MW) resources. The 240 MW of new wind resource in Big Horn Basin was varied with Wyodak generation as necessary. It was assumed that only the thermal generation at Dave Johnston and Wyodak generating plants in eastern Wyoming would be adjusted to maintain transfers on the Aeolus West and the TOT 4B transmission paths.

Table 5: Aeolus West and TOT 4B Corner Point Cases (See Figure 3)

Case	Aeolus West (MW)	TOT 4B (MW)	Limiting Element	Outage
1	1829	100	Platte- Latham 230 kV line	Anticline – Aeolus 500 kV line outage with RAS
2	1803	300	Platte- Latham 230 kV line	Anticline – Aeolus 500 kV line outage with RAS
3	1777	500	Platte- Latham 230 kV line	Anticline – Aeolus 500 kV line outage with RAS
4	1763	607	Platte- Latham 230 kV line	Anticline – Aeolus 500 kV line outage with RAS
			Dave Johnston South Tap – Refinery Tap – Casper 115 kV line	Casper 230 kV CB 1H4001 failure causing Casper – Dave Johnston 230 kV and Casper 230/115 kV transformer outage or Casper – Dave Johnston 230 kV line outage
5	1628	699	Platte- Latham 230 kV line	Anticline – Aeolus 500 kV line outage with RAS

[13] Maximum nomogram point with normal open point at Platte utilizing the dynamic line rating on Platte – Standpipe 230 kV line.

Case	Aeolus West (MW)	TOT 4B (MW)	Limiting Element	Outage
			Dave Johnston South Tap – Refinery Tap – Casper 115 kV line	Casper 230 kV CB 1H4001 failure causing Casper – Dave Johnston 230 kV and Casper 230/115 kV transformer outage or Casper – Dave Johnston 230 kV line outage
6	1125	880	Yellowtail – Sheridan 230 kV line	N-0

See Appendix B for power flow plots.

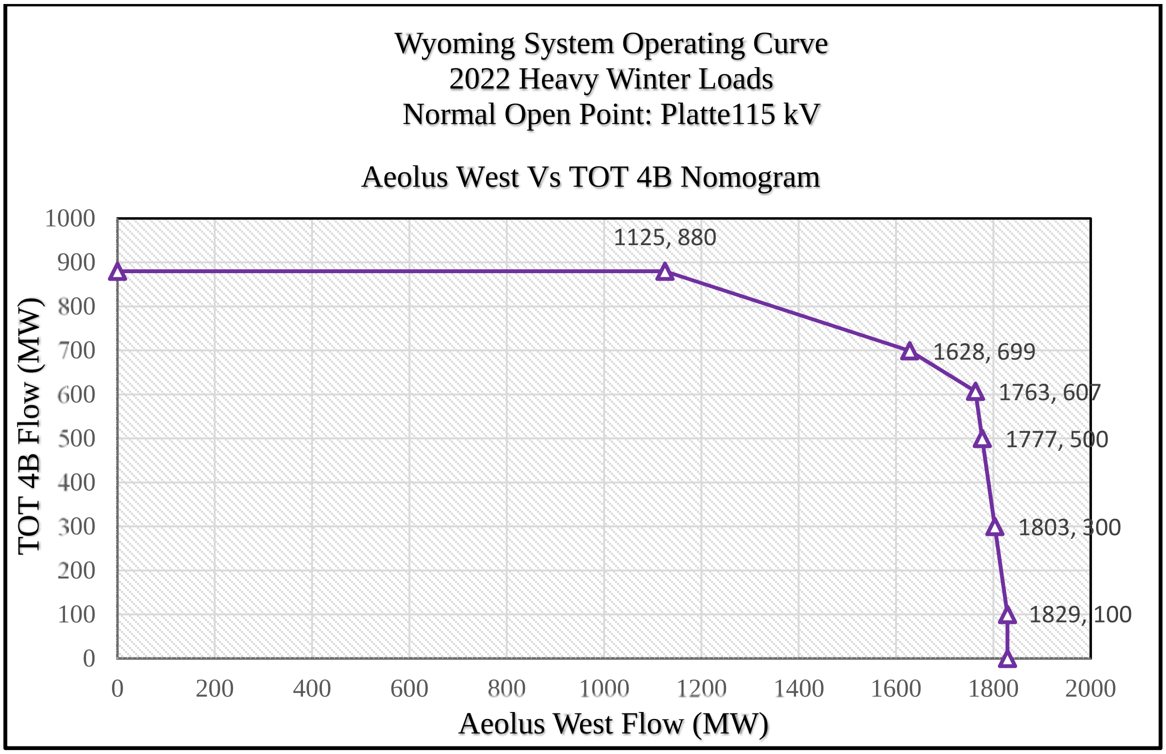
The low voltage issue in the Big Horn Wyoming area is an existing issue for the Yellowtail – Frannie 230 kV line outage or future Q0542 POI – Frannie 230 kV outage. This issue is resolved by adding capacitor banks at various locations in north Wyoming. A project to install a new 30 MVAr shunt capacitor bank at Grass Creek 230 kV, two new 20 MVAr shunt capacitor banks at Frannie and a new 7.5 MVAr capacitor bank at Hilltop 115 kV are proposed.

In the study, one RAS scheme was identified for N-1 outages:

i. Aeolus RAS to trip approximately 630 MW of wind generation depending on pre-outage flow conditions for any of the new transmission element outages between Aeolus – Jim Bridger.

Study results are summarized in Table 5 and illustrated in Figure 3. In reviewing Figure 3, it is evident that the Aeolus West and TOT 4B path interaction are minimized with the addition of the D.2 Project, as indicated by the straight horizontal line (implying no path interaction) when Aeolus West flows are below 1125 MW. The Aeolus West vs TOT 4B nomogram “knee point” is at Aeolus West flows of 1763 MW (TOT 4B, 607 MW). As TOT 4B flows increase from that point, Aeolus West flows reduce; likewise, from the knee point as TOT 4B flows decrease, Aeolus West flows increase.

Figure 3: Aeolus West Vs TOT 4B Nomogram



4.2 Base Case Development

The 2021-22 HW WECC case was modified to simultaneously stress the Aeolus West and the TOT 4B path flows. The Aeolus West path was stressed using all of eastern and north Wyoming resources fora total of 3619 MW (existing and future) wind and net coal resources. These resources were displaced with Jim Bridger and resources in central and southern Utah such that the Jim Bridger West flows were maintained near 2400 MW.

The TOT 4B path flows were adjusted between a minimum of 100 MW and a maximum of 880 MW. Additional resources were exported from PACE to Montana and WAPA to Montana to adjust flows across the TOT 4B path between 300 MW and 880 MW using Crossover, Rimrock and Steam Plant phase shifting transformers in Montana.

The Shiprock, San Juan and Gladstone phase shifting transformers were locked to regulate flow across the TOT 3 path between Colorado and Wyoming.

4.3 Dynamic Stability Analysis

The dynamic stability analysis was performed using PSS/E models provided by both General Electric (GE) and Vestas's for the repowered and new wind generation. The generic model for the Root Creek wind model was updated to the GE0501 model (GE 1.85 units). Top of the World and Three Buttes wind farms in eastern Wyoming were updated to the GE 1.5 wind turbine model provided by GE for PTI V33. A generic WECC model was used for the Latham dynamic reactive device.

The stability study was focused in the eastern Wyoming region to demonstrate the acceptable performance from various new wind farms in the region. The real power, reactive power and voltage output from the new and the existing wind farm generators were reviewed to evaluate their ability to support the transmission grid voltage and system stability during various outage scenarios. Due to the combination of different wind turbine models, dynamic analysis also ensured that no interaction issues were being observed.

The dynamic stability study was performed for one (worst case) nomogram point on the Aeolus West vs. the TOT 4B nomogram curve, which reflected the heaviest Aeolus West flow conditions.

Dynamic stability analysis was performed on selective critical outages based on anticipated post fault impacts on the wind generation performance, especially for the portion of the system with a calculated short circuit ratio of approximately 2.3. See Appendix C for the dynamic stability analysis summary and dynamic plots.

5 Sensitivity Analysis

The sensitivity analysis focused on the evaluation of two different RAS generation tripping scenarios to ascertain which scheme would be the most effective at tripping generation following outage of the D.2 Project facilities between Bridger and Aeolus.

A dynamic stability sensitivity analysis was performed to evaluate the system impact and generator performance for a single element outage on the D.2 segment between Aeolus 230 kV and Bridger 345 kV buses which requires a RAS for generator tripping. Two different sets of generator tripping locations and tripping levels (approximately 630 MW) were selected. The generation tripping of 607 MW, which includes High Plains, Seven Mile Hill, Q706 and Dunlap wind generation was compared with generation tripping of 628 MW, which includes High Plains, Q0706 and Q0707 wind generation. For summary results and plots, please see dynamic simulation cases 1a – 1f2 in Appendix C.

6 Study Conclusions

Technical studies demonstrated that with the addition of the planned D.2 Project facilities to the Wyoming transmission system, system performance will meet all NERC and WECC performance criteria.

Updated power flow studies demonstrate that by utilizing existing and planned southeast Wyoming resources[5], the Aeolus West transmission path can transfer up to 1829 MW under simultaneous transfer conditions with the TOT 4B transmission path, effectively[6] increasing the east to west transfer levels across Wyoming by 951 MW. Power flow findings also indicated:

- Dynamic voltage control is necessary at the Latham 230 kV substation to mitigate low voltage conditions resulting from loss of Bridger/Anticline – Aeolus transmission facilities.
- Under certain operating conditions, one RAS scheme will need to be implemented to trip generation following the outage of specific transmission facilities.
- The location (and output level) of new and repowered wind resources can influence the transfer capability level across the Aeolus West transmission path, the Aeolus West and TOT 4B nomogram curve and the area under the nomogram curve.

Dynamic stability studies evaluated a wide range of critical system disturbances in eastern Wyoming. The analyses identified two outages with poor voltage performance, and another outage identified a wind turbine modeling problem. These issues are all attributed to the wind turbine models at the Q0706, Q0707 and Q0708 projects. PacifiCorp is working with the wind turbine manufacture to resolve these issues. Aside from these issues, the studied outages evaluated meet the dynamic performance criteria with the system being stable and damped.

Report Appendices

Appendix A – Path Definitions

Appendix B – Power Flow Plots

Appendix C – Dynamic Stability Results (Case C7)