NTTG 2014-15 Biennial Studies

Quarter 5 Additional Studies

Evaluating Transmission Segments Similar to Energy Gateway

Version 3

NTTG Technical Work Group

05/13/2015

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Executive Summary

The review of the Draft Regional Transmission Plan (DRTP) produced by the Northern Tier Transmission Group (NTTG) concluded that there were some deficiencies in that plan that would need to be addressed in Q5 and Q6. The loads in PacifiCorp's Balancing Authority Area (BAA) represented in NTTG's Q3-Q4 base cases that were chosen in Q1 of this NTTG biennial study cycle were not fully represented as per the loads submitted by PacifiCorp through the L&R resource submission in Q1. The base cases used to develop NTTG's DRTP were derived from the TEPPC 2024 common case. The loads in the TEPPC 2024 common case were derived by extrapolating the loads in the TEPPC 2023 common case due to a conflict in the timing for the L&R data submission by utilities within WECC and the deadline/requirement to have TEPPC 2024 case. This resulted in the under-representation of PacifiCorp BAA's load. This was discovered at a later stage of NTTG's Q3-Q4 study and, in order not to redo the entire set of studies again - only study cases that were directly affected by this change were restudied with more accurate PacifiCorp load and resource forecast submitted in Q1. PacifiCorp, as a member of the NTTG Planning Committee Technical Work Group (TWG), conducted additional study work with accurate PacifiCorp load and resource forecast for three different study cases (summer peak, winter peak, & maximum export).

The TWG recognizes that in PacifiCorp's Q1 submission to NTTG for the 2014-15 Biennial Study Program, the Energy Gateway Project ("EG") and its segments were identified as one complete project, which included four sub-projects, Gateway West, Gateway South, Gateway Central and West of Hemingway. While PacifiCorp had the opportunity to refine this definition of EG in the Q5 submission, no change was submitted. Based on previous NTTG Steering Committee inputs requesting a better understanding of the EG sub-segments, this study was performed to further evaluate transmission segments that are similar to sub-segments of EG project. While this analysis references EG transmission facilities (lines and substations), the reader should consider such references as similar to EG facilities. The finding of this report will be used to further redefine the DRTP facilities that would be constructed west of Windstar (Glenrock, WY) and south of Aeolus (Carbon County, WY).

This additional study work was performed to focus on how the updated PacifiCorp loads and Wyoming wind resources affect the need for the non-committed EG and its segments. In the study process, an analysis was made for each of the segments that form the EG project by removing one segment at a time, eventually removing the entire EG project while studying the impacts of the load increase. The study showed that not updating the load and resources to the actual forecasted levels could significantly impact the overall study results and provide incorrect study findings relative to the need for the proposed EG projects and its associated segments.

Analysis was also made without the EG project but with the addition of the Alternative Project (Aeolus-Anticline-Populus) identified in the DRTP in Q4. The results of these studies demonstrate that, with the updated loads and resources and without the EG project, the performance criteria is not met even with the proposed Alternative Project in the DRTP.

Study findings illustrate that in addition to the Alternative Project proposed in DRTP, additional facilities similar to Energy Gateway segments of transmission in the Wyoming area are also required to maintain the reliability of the transmission system if the updated load and resource forecast is represented.

Background

PacifiCorp, as a member of the TWG, has performed this additional study to demonstrate the purpose and need for the different transmission sub-segments that are similar to the EG Project. The EG Project is divided into four different sub-projects as shown in Table 1 below.

Table 1: List of Energy Gateway Project Segments

Project	Sub-Project	Transmission Line Segments
Energy Gateway Project[1]	Gateway West	Windstar – Aeolus 230 kV line
		Aeolus – Anticline 500 kV line
		Anticline – Bridger 345 kV line
		Anticline – Populus 500 kV line
		Populus – Borah – Midpoint -Hemingway 500 kV line
		Populus – Cedar Hill – Hemingway 500 kV line
		Midpoint - Cedar Hill 500 kV line
	Gateway South	Aeolus – Clover 500 kV line
	Gateway Central	Populus -Terminal 345 kV lines (In-service)
		2 Terminal – Oquirrh 345 kV lines
		Oquirrh – Limber – Mona 345 kV line (In-service)
	West of Hemingway	Boardman – Hemingway 500 kV line

Figure 1 shows the geographic diversity of the EG project and its segments which extend from Wyoming to Oregon and from Southern Idaho to Southwest Utah.

Figure 1: Energy Gateway Transmission Expansion Plan

The purpose of and need for the EG is to serve PacifiCorp's load using the existing and planned renewable resources in eastern Wyoming while maintaining the reliability of PacifiCorp transmission system, as well and its neighboring transmission systems, which in turn maintains the reliability of the NTTG footprint. The EG Project referenced in this report is referring to Gateway South, Gateway West, Gateway Central transmission projects, and the construction of the Hemingway – Boardman 500 kV line. The EG Project will provide access to existing and new resources in eastern

[1] In order to integrate the transmission lines identified in Table 1, additional mitigations such as new shunt devices and transmission line re-conductoring were also considered part of EG project, which are not listed in this table. The list of additional re-enforcements is shown in the "Study Assumptions" section of this report.

Wyoming that would be transmitted to PacifiCorp loads in Idaho, Utah, Washington, California and Oregon that is not accessible without the EG project due to full subscription on the TOT4A and Bridger West paths. With respect to system reliability, the Gateway South Project is necessary to provide a reliable backup to the Gateway West during line outage conditions.

Due to the high wind profile in eastern Wyoming, PacifiCorp currently has several customers who would like to develop wind projects in Wyoming and interconnect to PacifiCorp's transmission system. PacifiCorp currently has approximately 2000 MW of Generation Interconnection Requests in its Generation Interconnection Queue in eastern Wyoming that are in a suspended mode due to unavailability of transmission in central and western of Wyoming. System impact studies have shown that additional transmission is required from eastern Wyoming to the west in order to reliably interconnect these wind projects to PacifiCorp's transmission system.

Under system conditions studied, technical study results show that if the some segments similar to the EG Project are not included in the model, thermal overloads and bus voltage violations will be evident when the resources in eastern Wyoming are used to serve PacifiCorp loads in Idaho, Utah, Washington, California and Oregon. The overall results observed during the study are shown in Table 2.

Table 2: Overall Results

B2P	Populus - Hemingway - Boardman part of EGW
OQ-TM	Oquirrh to Terminal # 3 and # 4 345 kV lines part of EGW
AE-CL	AEOLUS to Clover 500 kV line part of EGW
AE-ANT	Aeolus to Anticline 500 kV line part of EGW
ANT-POP	Anticline - Populus 500 kV line part of EGW
AE-WND	Aeolus - Windstar 230 kV line part of EGW

	B2P	OQ-TM	AE-CL	AE-ANT	ANT-POP	AE-WND
Segment 0 Case	X	X	X	X	X	X
Segment 1 Case	OOS	X	X	X	X	X
Segment 2 Case	OOS	OOS	X	X	X	X
Segment 3 Case	OOS	OOS	OOS	X	X	X
Segment 4 Case	OOS	OOS	OOS	OOS	X	X
Segment 5 Case	OOS	OOS	OOS	OOS	OOS	X
Segment 6 Case	OOS	OOS	OOS	OOS	OOS	OOS
Draft RTP Case(Q4) With Q5 L & R	OOS	X	OOS	X	X	OOS
X = IN SERVICE						
OOS = OUT OF SERVICE						
RTP - Regional Transmission Plan						

Branch Amp Violations

	Draft RTP Case With Q5 L & R	Segment 0 Case	Segment 1 Case	Segment 2 Case	Segment 3 Case	Segment 4 Case	Segment 5 Case	Segment 6 Case
Summer	21	2	2	2	10	118	115	117
Winter	2					4	4	2
Export	16	1	1	1	7	85	90	68

Bus Low Volts Violation

	Draft RTP Case With Q5 L & R	Segment 0 Case	Segment 1 Case	Segment 2 Case	Segment 3 Case	Segment 4 Case	Segment 5 Case	Segment 6 Case
Summer	10	2	2	2	2	30	40	113
Winter	1				1		1	1
Export						4	4	15

Bus High Volts Violations

	Draft RTP Case With Q5 L & R	Segment 0 Case	Segment 1 Case	Segment 2 Case	Segment 3 Case	Segment 4 Case	Segment 5 Case	Segment 6 Case
Summer	1					3	3	5
Winter	21					56	56	56
Export	1					45	45	19

Change Bus Low Volts Violations

	Draft RTP Case With Q5 L & R	Segment 0 Case	Segment 1 Case	Segment 2 Case	Segment 3 Case	Segment 4 Case	Segment 5 Case	Segment 6 Case
Summer	3		1	1	2	15	16	36
Winter								
Export	12				7	8	8	13

Note: Within the Western Interconnection, as 500 kV buses are nominally operated at 525 kV, voltages at or below 1.15 PU were allowed for 500 kV buses.

The results of this study illustrate that additional transmission from eastern Wyoming to the west, in the form of segments similar to EG, are required in order to reliably interconnect the projected level of renewable resources in Wyoming. A project like EG will effectively alleviate:

(1) Overloads on major transmission paths, specifically, Bridger West, TOT4A, Bonanza West, TOT3 and TOT1A,
(2) Under steady state (N-0) conditions, thermal overloads of 115% on the Dave Johnston – Laramie River 230 kV line and other thermal overloads of up to 130% in Wyoming, and
(3) Under facility outage conditions, low voltages of 0.78 pu on buses in Wyoming.

The results of this additional Q5 analysis demonstrates that in addition to the EG segments included in the "DRTP", EG segments similar to the Aeolus – Windstar 230 kV line, and the associated re-enforcements, should also be included in the Regional Plan to make the optimized use of the resources available in eastern Wyoming to serve the load in Idaho, Utah, Washington, California and Oregon and to alleviate the overloads and low voltage issues in Wyoming that result due to heavy flows across other transmission lines in its absence. The Anticline – Bridger 345 kV line provides a second path for transmission flows to reach Populus. The 230 kV transmission lines west of Aeolus up to Point of Rocks were overloaded over the emergency rating for the outage of the Anticline – Populus 500 kV line if the Anticline – Bridger 345 kV line was not modeled.

With respect to Gateway South project, the results of this additional study also demonstrated that the Aeolus – Clover 500 kV line is essential and should be included in the Draft Final Regional Plan as it alleviates overloads on the Bridger West Path and overloads on the Dave Johnston – Laramie River 230 kV line, Dave Johnston – Casper 230 kV line for the outage of Aeolus - Anticline – Populus 500 kV line. Prior to adding the Aeolus – Clover 500 kV line, the outage of Aeolus - Anticline – Populus 500 kV line also causes low voltages in the Wyoming area.

After the appropriate representation of the load and resource forecast based on the Q5 submission, analysis was performed to determine the necessity for the transmission facilities west of Populus that are part of the Energy Gateway West project and the Hemingway to Boardman project. The results of the study did not illustrate any additional facility thermal overloads or bus voltage violations with these Gateway West segments (west of Populus) and the Boardman – Hemingway 500 kV line removed.

The TWG has decided that the results of this analysis will inform the NTTG Final Regional Plan report and this study report will be included as an appendix to the NTTG Final Regional Plan study report.

Study Assumptions

In PacifiCorp's Q1 submission to NTTG for the 2014-15 Biennial Study Program, the Gateway West and Gateway South projects which are segments of the EG were identified as one complete project. While PacifiCorp had the opportunity to refine this definition of EG in the Q5 submission, no change was submitted. Based on previous NTTG Steering Committee inputs requesting a better understanding of the EG sub-segments, this study was performed to further evaluate transmission segments that are similar to sub-segments of EG. While this analysis references EG transmission facilities (lines and substations), the reader should consider such references as similar to EG facilities. The finding of this report will be used to further redefine the DRTP facilities that would be constructed west of Windstar (Glenrock, WY) and south of Aeolus (Carbon County, WY).

The NTTG TWG suggested that PacifiCorp perform this additional study to demonstrate the results with and without EG Project segments – taking into account representation of appropriate load forecast as submitted in Quarter 5 and appropriate modeling assumptions.

The three cases (summer peak, winter peak, and maximum export) used by NTTG in their 2014-15 biennial study were used to perform this additional study with appropriate load forecast as submitted in Quarter 5 and removing the segments of the EG Project one at a time and eventually removing the entire EG completely. Each season was studied with seven different configurations. The different configurations studied are explained in Table 3 below:

Table 3: Different Studied Configuration

B2P	Populus - Hemingway - Boardman part of EGW
OQ-TM	Oquirrh to Terminal # 3 and # 4 345 kV lines part of EGW
AE-CL	AEOLUS to Clover 500 kV line part of EGW
AE-ANT	Aeolus to Anticline 500 kV line part of EGW
ANT-POP	Anticline - Populus 500 kV line part of EGW
AE-WND	Aeolus - Windstar 230 kV line part of EGW

	B2P	OQ-TM	AE-CL	AE-ANT	ANT-POP	AE-WND
Segment 0 Case	X	X	X	X	X	X
Segment 1 Case	OOS	X	X	X	X	X
Segment 2 Case	OOS	OOS	X	X	X	X
Segment 3 Case	OOS	OOS	OOS	X	X	X
Segment 4 Case	OOS	OOS	OOS	OOS	X	X
Segment 5 Case	OOS	OOS	OOS	OOS	OOS	X
Segment 6 Case	OOS	OOS	OOS	OOS	OOS	OOS
Draft RTP Case(Q4) With Q5 L & R	OOS	X	OOS	X	X	OOS
X = IN SERVICE						
OOS = OUT OF SERVICE						
RTP - Regional Transmission Plan						

For example, in Segment 0 Case all of the EG segments including the Boardman – Hemingway 500 kV Project were in service and for Segment 1 Case, the EG segments west of Populus including the Boardman – Hemingway 500 kV project were out-of-service but the rest of the segments were in-service.

The following assumptions were made for the additional studies.

(1) Incremental wind resources representing existing and new resources needed to serve adjusted PacifiCorp's loads were added to the Windstar and Aeolus 230 kV buses.

(2) The path definition for the TOT4A path and Bridger West path were changed for the cases without the EG Project. (Note: Addition of the Gateway projects resulted in redefining of the TOT4A and Bridger West path and it also resulted in addition of Aeolus West and South paths. Path 14 (Idaho – Northwest) was also redefined, after the segments west of Populus and Boardman – Hemingway 500 kV lines were taken out of service.)

(3) Additional re-enforcements required to integrate the Gateway West and Gateway South projects were included/ excluded in the studies as necessary as individual EG segments were taken out-of-service. The additional re-enforcements include:

a. Reconductoring of the Grace – Soda – Threemile Knoll 138 kV line.
b. Reconductoring of the Riverton – Casper 230 kV line.
c. Reconductoring of the Aeolus – Shirley Basin 230 kV line.
d. Reconductoring of the Shirley Basin – Difficulty 230 kV line.
e. Reconductoring of the Difficulty – Dave Johnston 230 kV line.
f. Increasing the ampacity on the series capacitor at Kinport.
g. New four-200 MVAR switched shunt capacitors at Aeolus 500 kV bus.
h. New switched shunt capacitors at Aeolus 230 kV with a total capacity of 550 MVAR in the form of one -200 MVAR, one -50 MVAR, and three-100 MVAR switched shunts.
i. New two-125 MVAR switched shunt capacitors at Windstar.
j. Additional 30 MVAR switched shunt capacitor at Mustang 230 kV.
k. Additional 30 MVAR switched shunt capacitor at Riverton 230 kV.
l. Additional 70 MVAR switched shunt capacitor at Bonanza 138 kV.
m. Additional 30 MVAR switched shunt capacitor at Chappel Creek 230 kV.
n. Additional switched shunt capacity at Clover which included two – 150 MVAR reactors and three-200 MVAR capacitors.

(4) As 525 kV is the nominal voltage for 500 kV buses, for 500 kV buses, voltages up to 1.15 PU under normal and contingency conditions were considered acceptable.

(5) The thermal overloads on the underlying transformers observed due to changes in the Quarter 5 Load and Resource submission were ignored provided they were related to the load change. (Such thermal overloads are considered local transmission issues.)

(6) Only the scalable loads were changed if the load forecast was modified.

The original NTTG cases have the characteristics with respect to PACE area as shown in Table 4.

Table 4: PACE Area load and generation characteristics for the five NTTG Cases

Case --------->	Summer Peak	Winter Peak	Export	Import	Max NW-MT
Hour	14:00	7:00	19:00	9:00	3:00
PACE Load (MW)	9261.66	7337.64	5925.22	4480.7	4276.76
PACE Generation (MW)	8004.96	6469.01	6928.13	3994.81	4085.35
Wyoming Wind Generation (MW)	110	144.08	1023	53.79	109.37

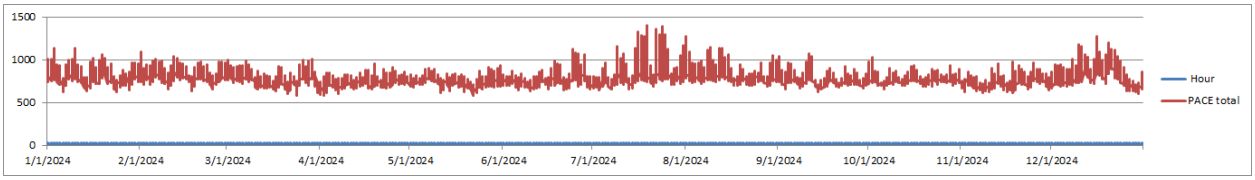
In order to reflect the accurate load forecast, the loads in three of the NTTG cases were adjusted as shown in Table 5.

Table 5: Load change of scalable loads in the PACE Area to represent the Quarter 5 load forecast.

Case	Date & Hour	Load Change by
Summer Peak	7/25/2024 14:00	19%
Winter Peak	1/10/2024 07:00	14%
Export Case	1/14/2024 19:00	14%

(7) Given the reduced wind capacity values that were associated with two of the three cases chosen for the analysis by NTTG (listed in Table 4), PacifiCorp used median values in conducting system reliability analysis. Figure 2 below shows hourly wind profile for the PACE BA in the TEPPC 2024 database[2]. PACE eastern Wyoming has an existing 1100 MW of the total wind capacity as depicted in the graph.

Figure 2: PACE Actual Wind Data



Data provided by 2005 NREL Wind shapes[3] suggest that using newer technology in turbines could result in higher capacity factors at a particular locations. These data is shown in Appendix E.

Currently PacifiCorp has approximately 2000 MW of new wind and other forms of Generation Interconnection Projects that are in suspended mode in the Generation Interconnection queue due to unavailability of transmission from eastern Wyoming to the west. Due to high wind profile in eastern Wyoming, these projects have still shown an interest in developing wind provided the transmission is present to transfer their power to the west. The interconnection queue is shown in the Figure 3 below.

[2] PACE HourlyWindData_TEPPC2024 vs Actual 2013.xlsx provided by Jamie Austin.
[3] NREL Data and Data from TEPPC is shown in Appendix F.

Figure 3: Generator Interconnection Project in Wyoming in suspended/ Executed LGIA projects without firm in-service dates.

Generator Interconnection Queue List

	Interconnect Request Information						Max MW Output		Location of Generating Facility		Location of Interconnection
Q#	Request Date	Request Status (OASIS)	Project Phase	Service Type	LGI, SGI, DGI, OGI or UGI	QF?	S	W	County	ST	Point of Interconnection
59	8/24/2005	Suspended	Suspended	NR	LGI		250.00	285.00	Campbell	WY	North of Antelope Mine substation
191	1/25/2008	Suspended	Suspended	ER	LGI	0	500.00	500.00	Carbon	WY	Jim Bridger - Aeolus
199	2/20/2008	Suspended	Suspended	ER	LGI	0	200.00	200.00	Carbon	WY	proposed Aeolus substation
200	2/20/2008	Suspended	Suspended	ER	LGI	0	100.00	100.00	Carbon	WY	proposed Aeolus substation
201	2/20/2008	Suspended	Suspended	ER	LGI	0	100.00	100.00	Carbon	WY	proposed Aeolus substation
267-A	4/13/2009	In Progress	Executed IA	NR with ER	LGI	0	18.30	22.00	Sweetwater	WY	Jim Bridger Power Plant, Point of Rocks, WY
290-A	9/22/2009	Suspended	Suspended	NR/ER	LGI	0	100.80	100.80	Sweetwater	WY	17 Miles South SE of Rock Springs, Wyoming
306-A	12/3/2009	Suspended	Suspended	NR/ER	LGI	QF	48.30	48.30	Converse	WY	Amassa substation, (DJ - Difficulty)
335	6/1/2010	In Progress	Executed IA	NR/ER	LGI	QF	49.60	49.60	Converse	WY	Amassa substation, (DJ - Difficulty)
375	3/4/2011	In Progress	Executed IA	NR/ER	LGI	0	230.00	230.00	Carbon	WY	Proposed Heward substation
407	1/17/2012	Suspended	Suspended	NR/ER	LGI	0	79.80	79.80	Sweetwater	WY	Rock Springs-Palisades switching station transmission line, 6mi West of Rock Springs, Wy
409	1/26/2012	In Progress	Negotiation	NR/ER	LGI	0	320.00	320.00	Albany	WY	Freezeout substation

Based on the data in Appendix F, new wind projects in Wyoming was assumed at 40% capacity factor and dispatched to that level.

In following the reasoning outlined above, wind generation in eastern Wyoming was increased to approximately 1800 MW in the Summer Peak, Winter Peak and Export cases.

Study Findings/ Observations

The results of the study are discussed individually for each of the three NTTG cases.

Results for the Winter Peak Case:

The winter peak case represents the hour at which the NTTG footprint had the highest load during the winter season. The hour selected for the Winter Peak Case does not coincide with the winter peak of PACE. In the original NTTG Winter Peak case, only 59% of the existing resources available in eastern Wyoming were online. The amount of resources that were kept online in the base case was based on the production cost model data which was kept unchanged.

The following N-0 thermal overloads were observed in the winter case with the adjusted load per the Quarter 5 submittals shown in Table 6 below.

Table 6: N-0 Thermal Overloads in winter cases

Segment	From N	From Nam	Fr	To Nu	To Name	To	Circuit	Status	MW From	Mvar From	MVA From	Lim MVA	% of MVA Limit (Max)
Draft RTP Case with Q5 L&R	67796	AEOLUS	230	69028	SHIRLYBS	230	1	Closed	-441.4	120.4	457.6	424	107.9
Draft RTP Case with Q5 L&R	65420	DAVEJOHN	230	65460	DIFICULT	230	1	Closed	446.6	33.3	447.8	424	105.6
Draft RTP Case with Q5 L&R	65460	DIFICULT	230	69028	SHIRLYBS	230	1	Closed	433	-75	439.4	424	104.4
Segment 4 Case	67946	FREEZOUT	230	69143	STNDPIPE	230	1	Closed	447.4	17.3	447.7	424	105.6
Segment 4 Case	67796	AEOLUS	230	67946	FREEZOUT	230	1	Closed	433.4	-3.8	433.4	424	102.2
Segment 5 Case	67946	FREEZOUT	230	69143	STNDPIPE	230	1	Closed	446.8	16.8	447.1	424	105.4
Segment 5 Case	67796	AEOLUS	230	67946	FREEZOUT	230	1	Closed	432.8	-4.2	432.8	424	102.1
Segment 6 Case	67946	FREEZOUT	230	69143	STNDPIPE	230	1	Closed	442.3	12.3	442.4	424	104.4
Segment 6 Case	67796	AEOLUS	230	67946	FREEZOUT	230	1	Closed	428.3	-10	428.4	424	101

The N-0 results demonstrate that removal of EG segments west of Aeolus would result in overloading of the underlying 230 kV system from Dave Johnston to Standpipe due to additional flows on the 230 kV system. Additionally, under these conditions, the TOT 4A path is overloaded (101%) above its limit. The entire set of contingencies was run on all seven cases, and the overall violations are shown in Table 7.

Table 7: Contingency Violations for Winter Case.

Row Labels	Branch Amp	Bus High Volts	Bus Low Volts	Grand Total
⊞ Draft RTP Case with Q5 L & R	2	21	1	24
⊞ Segment 3 Case			1	1
⊞ Segment 4 Case	4	56		60
⊞ Segment 5 Case	4	56	1	61
⊞ Segment 6 Case	2	56	1	59
Grand Total	12	189	4	205

As shown in the Table 7 above, Segments 0, 1 and 2 cases don't show any violations for the winter case. The Draft Regional Plan, along with Segment 4 Case, Segment 5 Case, and Segment 6 case showed some thermal overloads on Bonanza – Vernal 138 kV line for outage of Bonanza – Mona 345 kV line. The study also showed thermal overloads on the Casper – Spence 230 kV line for the outage of Aeolus – Freezeout 230 kV line and thermal overloads on the Platte – Latham 230 kV line and Aeolus – Shirley Basin 230 kV line for the outage of Casper – Spence 230 kV line. The detailed thermal and bus voltage violations table is provided in Appendix B.

There were some bus high voltages violations mostly in the Platte/ Latham area due to outages of the 230 kV lines in the Wyoming area which are shown in Appendix B. These bus high voltage violations could be resolved by switching the shunt capacitors that are online at Platte and other locations in the central Wyoming that are supporting the voltage during high load conditions.

Results for the Summer Peak Case:

The summer peak case represents the hour at which the NTTG footprint had the highest load during the summer season. The hour selected for the Summer Peak Case does not coincide with the summer peak of PACE. In this case, for the PACE Area, only 57% of the existing resources available in the eastern Wyoming area was online. The amount of resources that were kept online was based on the production cost model data, which was kept unchanged.

The following N-0 thermal overloads were observed in the summer peak case with the adjusted load as per Quarter 5 submittals as shown in Table 8 below.

Table 8: N-0 Thermal Overloads in Summer Cases

Segment	From Number	From Name	To Number	To Name	Circuit	Status	Branch Device Type	Xfrmr	MW From	Mvar From	MVA From	Lim MVA	% of MVA Limit (Max)
Segment 4 Case	67946	FREEZOUT	69143	STNDPIPE	1	Closed	Line	NO	523.2	66.4	527.4	424	124.4
Segment 4 Case	67796	AEOLUS	67946	FREEZOUT	1	Closed	Line	NO	512.7	44.6	514.7	424	121.4
Segment 4 Case	66240	PLATTE	69143	STNDPIPE	1	Closed	Line	NO	-506.5	32.9	507.6	478	111
Segment 4 Case	66240	PLATTE	67499	LATHAM	1	Closed	Line	NO	435.5	56.4	439.1	403	109
Segment 4 Case	65425	DAVEJOHN	73070	DAVEJTPN	1	Closed	Line	NO	168.6	27.9	170.9	163	104.8
Segment 4 Case	65105	BAR-X	67530	ECHOSPRG	1	Closed	Line	NO	-397.6	134.3	419.6	403	104.1
Segment 4 Case	66250	PT ROCKS	67529	BITR CRK	1	Closed	Line	NO	-371.1	186.7	415.4	401	103.6
Segment 4 Case	65105	BAR-X	67529	BITR CRK	1	Closed	Line	NO	387.2	-140	411.8	401	103.6
Segment 4 Case	67499	LATHAM	67530	ECHOSPRG	1	Closed	Line	NO	411.7	-41.3	413.8	403	102.7
Segment 5 Case	67946	FREEZOUT	69143	STNDPIPE	1	Closed	Line	NO	523.1	67.2	527.4	424	124.4
Segment 5 Case	67796	AEOLUS	67946	FREEZOUT	1	Closed	Line	NO	512.6	45.3	514.6	424	121.4
Segment 5 Case	66240	PLATTE	69143	STNDPIPE	1	Closed	Line	NO	-506.3	31.7	507.3	478	111
Segment 5 Case	66240	PLATTE	67499	LATHAM	1	Closed	Line	NO	435.3	57.3	439	403	108.9
Segment 5 Case	65425	DAVEJOHN	73070	DAVEJTPN	1	Closed	Line	NO	168.7	28.7	171.2	163	105
Segment 5 Case	65105	BAR-X	67530	ECHOSPRG	1	Closed	Line	NO	-397.3	133.8	419.3	403	104
Segment 5 Case	66250	PT ROCKS	67529	BITR CRK	1	Closed	Line	NO	-370.8	186.3	415	401	103.5
Segment 5 Case	65105	BAR-X	67529	BITR CRK	1	Closed	Line	NO	387	-139.5	411.4	401	103.5
Segment 5 Case	67499	LATHAM	67530	ECHOSPRG	1	Closed	Line	NO	411.5	-40.6	413.5	403	102.6
Segment 6 Case	67946	FREEZOUT	69143	STNDPIPE	1	Closed	Line	NO	541.1	83.6	547.6	424	129.1
Segment 6 Case	67796	AEOLUS	67946	FREEZOUT	1	Closed	Line	NO	530.8	59.2	534.1	424	126
Segment 6 Case	66240	PLATTE	69143	STNDPIPE	1	Closed	Line	NO	-522.4	21.9	522.9	478	115.6
Segment 6 Case	66240	PLATTE	67499	LATHAM	1	Closed	Line	NO	451.4	62.7	455.7	403	113.1
Segment 6 Case	66250	PT ROCKS	67529	BITR CRK	1	Closed	Line	NO	-383.5	212.5	438.5	401	109.3
Segment 6 Case	65105	BAR-X	67530	ECHOSPRG	1	Closed	Line	NO	-410.7	153.8	438.6	403	108.8
Segment 6 Case	65105	BAR-X	67529	BITR CRK	1	Closed	Line	NO	400.4	-159.5	431	401	108.6
Segment 6 Case	67499	LATHAM	67530	ECHOSPRG	1	Closed	Line	NO	426.2	-47.9	428.9	403	106.5
Segment 6 Case	65425	DAVEJOHN	73070	DAVEJTPN	1	Closed	Line	NO	167.9	28.5	170.3	163	104.5

As seen in Table 8, there were several N-0 thermal overloads on in the summer peak case as the transmission lines which are part of Gateway West project were placed out-of-service with the Quarter 5 load and resource changes.

Additionally, thermal overload of 122% on the Bridger West path was observed for the "Draft RTP Case with Q5 L&R", and, TOT4A path was seen overloaded to 116% of its limit in the "Segment 6 Case".

The entire set of contingencies was run on all seven cases, and the overall violations are shown in Table 9.

Table 9: Contingency Violations for Summer Case.

Row Labels	Branch Amp	Branch MVA	Bus High Volts	Bus Low Volts	Change Bus Low Volts	Grand Total
⊞Draft RTP Case with Q5 L&R	21		1	10	3	35
⊞Segment 0 Case	2	1		2		5
⊞Segment 1 Case	2	1		2	1	6
⊞Segment 2 Case	2	1		2	1	6
⊞Segment 3 Case	10	1		2	2	15
⊞Segment 4 Case	118	1	3	30	15	167
⊞Segment 5 Case	115	1	3	40	16	175
⊞Segment 6 Case	117	1	5	113	36	272
Grand Total	387	7	12	201	74	681

As seen from Table 9 above, the number of thermal overloads increases after "Segment 2 Case". The "Segment 3 Case" is the case without Gateway South (Aeolus – Clover 500 kV line) project, in which the outage of the Populus 500/345 kV auto transformer or Aeolus – Anticline 500 kV line outage causes thermal overloads on the Platte – Latham 230 kV line (105.24%), Echo Springs – Bar X 230 kV line(102%). The outage of Aeolus – Anticline 500 kV line in the absence of Aeolus – Clover 500 kV line causes the Bridger West path to overload above its rating. With respect to reliability, Gateway South Project provide backup to Gateway West during line outage conditions.

Also the number of thermal violations increases significantly from "Segment 3 Case" to "Segment 4 Case" as both Gateway South and Anticline – Populus 500 kV line (part of Gateway West) are removed from the case. Majority of the thermal overloads are observed in the Wyoming area as increased transmission flows load up the underlying 230 kV system. Thermal overload of 124% of the emergency rating on the Platte – Latham 230 kV line is observed for the outage of Casper – Spence 230 kV line in the "Segment 5 Case". There were three contingencies in the "Segment 6 Case" that did not converge, including: (1) Dave Johnston – Difficulty 230 kV line, (2) Difficulty – Shirley Basin 230 kV line, and (3) Shirley Basin – Aeolus 230 kV line. The outage of Aeolus – Freezeout 230 kV line causes thermal overloads of 145% of its emergency rating on the Shirley Basin – Difficulty 230 kV line and thermal overload of 140% on the Dave Johnston – Difficulty 230 kV line. The study also showed thermal overloads on the Dave Johnston – Laramie River 230 kV line for the outage of Aeolus – Freezeout 230 kV line.

The reactive requirements from the units at Dave Johnston is increased as different parts of the Gateway West staging and its associated re-enforcements are removed from the cases, which causes the step-up transformers at Dave Johnston Unit 3 and Unit 4 to overload above its rating. This overload can only be seen in the cases after "Segment 3 Case" as the associated re-enforcements required to integrate the Gateway West project are also removed from the case.

For "Segment 6 Case" the TOT4A path was pushed over its limit and overloaded to 116% of its rating.

There were several bus low voltage violations due to outage of the 230 kV lines in the Wyoming area that are shown in Appendix C. The study shows that all the re-enforcements associated with the Gateway West project are essential in alleviating these low voltage issues.

Detailed results are shown in Appendix C.

Results for the Export Case:

The maximum export case represents the hour at which the NTTG footprint had the highest export through its tie lines. Of the resources available in the eastern Wyoming area, 97% were online in the original NTTG Export case which was based on the production cost model data and was kept unchanged.

The following N-0 thermal overloads were observed in the maximum export case with the adjusted load as per Quarter 5 submittals as shown in Table 10 below.

Table 10: N-0 Thermal Overloads in Winter Cases

Segment	From Number	From Name	To Number	To Name	Circuit	Status	Branch Device Type	Xfrmr	MW From	Mvar From	MVA From	Lim MVA	% of MVA Limit (Max)
Draft RTP Case with Q5 L&R	65420	DAVEJOHN	73107	LAR.RIVR	1	Closed	Line	NO	358.6	11.2	358.8	319	112.5
Draft RTP Case with Q5 L&R	65420	DAVEJOHN	65445	DAVEJON4	1	Closed	Transformer	YES	-339.6	-140.2	367.4	360	105.6
Draft RTP Case with Q5 L&R	67796	AEOLUS	69028	SHIRLYBS	1	Closed	Line	NO	-429.5	88.4	438.5	424	103.4
Draft RTP Case with Q5 L&R	65420	DAVEJOHN	65440	DAVEJON3	1	Closed	Transformer	YES	-219.7	-84.1	235.2	240	102.7
Segment 0 Case	65420	DAVEJOHN	65445	DAVEJON4	1	Closed	Transformer	YES	-357.6	-110.8	374.4	360	106.9
Segment 0 Case	65420	DAVEJOHN	65440	DAVEJON3	1	Closed	Transformer	YES	-229	-66.9	238.5	240	103.3
Segment 1 Case	65420	DAVEJOHN	65445	DAVEJON4	1	Closed	Transformer	YES	-357.6	-107.1	373.3	360	106.5
Segment 1 Case	65420	DAVEJOHN	65440	DAVEJON3	1	Closed	Transformer	YES	-229	-64.5	237.9	240	102.9
Segment 2 Case	65420	DAVEJOHN	65445	DAVEJON4	1	Closed	Transformer	YES	-357.6	-107.4	373.4	360	106.6
Segment 2 Case	65420	DAVEJOHN	65440	DAVEJON3	1	Closed	Transformer	YES	-229	-64.6	237.9	240	102.9
Segment 3 Case	65420	DAVEJOHN	65445	DAVEJON4	1	Closed	Transformer	YES	-357.6	-137.8	383.2	360	110.1
Segment 3 Case	65420	DAVEJOHN	65440	DAVEJON3	1	Closed	Transformer	YES	-229	-82.4	243.3	240	106.2
Segment 3 Case	65420	DAVEJOHN	73107	LAR.RIVR	1	Closed	Line	NO	327.7	5.4	327.8	319	102.7
Segment 4 Case	65420	DAVEJOHN	73107	LAR.RIVR	1	Closed	Line	NO	480.9	58.9	484.5	319	151.9
Segment 4 Case	65425	DAVEJOHN	73070	DAVEJTPN	1	Closed	Line	NO	184.2	31	186.8	163	114.6
Segment 4 Case	65420	DAVEJOHN	65445	DAVEJON4	1	Closed	Transformer	YES	-357.6	-138	383.3	360	110.1
Segment 4 Case	65420	DAVEJOHN	65440	DAVEJON3	1	Closed	Transformer	YES	-229	-82.5	243.4	240	106.2
Segment 4 Case	66240	PLATTE	67499	LATHAM	1	Closed	Line	NO	420	47.5	422.7	403	104.9
Segment 4 Case	66240	PLATTE	69143	STNDPIPE	1	Closed	Line	NO	-479	49.2	481.6	478	103.9
Segment 4 Case	65425	DAVEJOHN	73071	DAVEJTPS	1	Closed	Line	NO	167.1	25.6	169.1	163	103.7
Segment 4 Case	65105	BAR-X	67530	ECHOSPRG	1	Closed	Line	NO	-386.6	124.9	406.3	403	100.8
Segment 4 Case	66250	PT ROCKS	67529	BITR CRK	1	Closed	Line	NO	-364.1	172	402.7	401	100.4
Segment 4 Case	65105	BAR-X	67529	BITR CRK	1	Closed	Line	NO	378	-129.5	399.6	401	100.4
Segment 5 Case	65420	DAVEJOHN	73107	LAR.RIVR	1	Closed	Line	NO	481.8	59.3	485.4	319	152.2
Segment 5 Case	65425	DAVEJOHN	73070	DAVEJTPN	1	Closed	Line	NO	184.3	31	186.9	163	114.6
Segment 5 Case	65420	DAVEJOHN	65445	DAVEJON4	1	Closed	Transformer	YES	-357.6	-138	383.3	360	110.1
Segment 5 Case	65420	DAVEJOHN	65440	DAVEJON3	1	Closed	Transformer	YES	-229	-82.5	243.4	240	106.2
Segment 5 Case	66240	PLATTE	67499	LATHAM	1	Closed	Line	NO	419.2	47.5	421.9	403	104.7
Segment 5 Case	65425	DAVEJOHN	73071	DAVEJTPS	1	Closed	Line	NO	167.2	25.6	169.1	163	103.8
Segment 5 Case	66240	PLATTE	69143	STNDPIPE	1	Closed	Line	NO	-478.2	49.3	480.7	478	103.7
Segment 5 Case	65105	BAR-X	67530	ECHOSPRG	1	Closed	Line	NO	-385.9	123.9	405.3	403	100.6
Segment 5 Case	66250	PT ROCKS	67529	BITR CRK	1	Closed	Line	NO	-363.4	170.8	401.6	401	100.1
Segment 5 Case	65105	BAR-X	67529	BITR CRK	1	Closed	Line	NO	377.3	-128.5	398.6	401	100.1
Segment 6 Case	65420	DAVEJOHN	73107	LAR.RIVR	1	Closed	Line	NO	477.8	44	479.8	319	151.4
Segment 6 Case	65425	DAVEJOHN	73070	DAVEJTPN	1	Closed	Line	NO	185.6	35.2	189	163	115.9
Segment 6 Case	65420	DAVEJOHN	65445	DAVEJON4	1	Closed	Transformer	YES	-357.6	-136.9	382.9	360	110.1
Segment 6 Case	65425	DAVEJOHN	65435	DAVEJON2	1	Closed	Transformer	YES	-113.4	-52.7	125	120	109
Segment 6 Case	66240	PLATTE	67499	LATHAM	1	Closed	Line	NO	430.5	46.8	433	403	107.5
Segment 6 Case	66240	PLATTE	69143	STNDPIPE	1	Closed	Line	NO	-489.5	43.8	491.5	478	106.9
Segment 6 Case	65420	DAVEJOHN	65440	DAVEJON3	1	Closed	Transformer	YES	-228.9	-81.6	243	240	106.2
Segment 6 Case	66250	PT ROCKS	67529	BITR CRK	1	Closed	Line	NO	-371.9	198.3	421.5	401	105.1
Segment 6 Case	65425	DAVEJOHN	73071	DAVEJTPS	1	Closed	Line	NO	168.5	30.6	171.2	163	105.1
Segment 6 Case	65105	BAR-X	67530	ECHOSPRG	1	Closed	Line	NO	-394.9	146.1	421.1	403	104.5
Segment 6 Case	65105	BAR-X	67529	BITR CRK	1	Closed	Line	NO	386.3	-150.8	414.7	401	104.4
Segment 6 Case	67499	LATHAM	67530	ECHOSPRG	1	Closed	Line	NO	408.7	-51.3	411.9	403	102.3

For all seven cases, the N-0 results shows thermal overload on the step-up transformer for Dave Johnston Unit 3 and Unit 4. But as seen in Table 10 above, the thermal overload on these step-up transformers increase as different segment of Gateway West projects in Wyoming are removed indicating the increased need of reactive requirement from Dave Johnston Unit 3 and Unit 4, which were previously provided by the Gateway West segments and its associated re-enforcements. Also N-0 thermal overloads of 112% and 103% are observed on the Dave Johnston – Laramie River 230 kV line and Aeolus – Shirley Basin 230 kV line respectively with appropriate L&R in the "Draft RTP Case With Q5 L&R". Thermal overloading of 152% on the Dave Johnston – Laramie River 230 kV line is also observed for all the cases after "Segment 3 Case" indicating the necessity of transmission west of Aeolus. Overload of 107% on TOT4A path was also observed under N-0 conditions.

The complete set of contingencies was run on all seven cases, and the overall violations are shown in Table 11.

Table 11: Contingency Violations for Export Case.

Row Labels	Branch Amp	Bus High Volts	Bus Low Volts	Change Bus Low Volts	Grand Total
⊞Draft RTP Case with Q5 L&R	16	1		12	29
⊞Segment 0 Case	1				1
⊞Segment 1 Case	1				1
⊞Segment 2 Case	1				1
⊞Segment 3 Case	7			7	14
⊞Segment 4 Case	85	45	4	8	142
⊞Segment 5 Case	90	45	4	8	147
⊞Segment 6 Case	68	19	15	13	115
Grand Total	269	110	23	48	450

The highest thermal overload of 143% of its emergency rating was observed on the Dave Johnston – Laramie River 230 kV line for the outage of Platte – Latham 230 kV line in the "Segment 5 Case". Significant thermal overloads were present on the Dave Johnston – Laramie River 230 kV line after the "Segment 3 Case". The outage of Dave Johnston – Laramie River 230 kV line causes thermal overloads of 125% on the Platte – Latham 230 kV line. There are several other thermal overloads that are described in detail in Appendix D. Low voltages of 0.83 PU were observed on the Latham and Echo Springs 230 kV buses for the outage of Dave Johnston – Laramie River 230 KV line outage. Additional low voltages were also observed, which are shown in Appendix D. This low voltage is due to excess flows across the 230 kV system without the Gateway West project and its associated re-enforcements in-service.

In "Segment 6 Case", there were nine different single (N-1) contingencies that remained non-converged. They are:

(1) Bar X – Echo Springs 230 kV line
(2) Bar X – Bitter Creek 230 kV line
(3) Bitter Creek – Point of Rocks 230 kV line
(4) Platte – Latham 230 kV line
(5) Bridger – Rock Springs 230 kV line
(6) Latham – Echo Springs 230 kV line
(7) Dave Johnston – Difficulty 230 kV line
(8) Difficulty – Shirley Basin 230 kV line
(9) Shirley Basin – Aeolus 230 kV line

Due to these nine non-converged contingencies, the number of violations for the "Segment 6 Case" is lower than the "Segment 5 Case". The "Segment 6 Case" shows why Gateway West and its associated re-enforcements are required in

order to transmit power across Wyoming, where the resources are located, to the load in Idaho, Utah, Washington, Oregon, and California.

All the contingency thermal overloads and bus voltage issues are shown in detail in Appendix D.

Recommendations/ Conclusions

The study findings of the NTTG summer peak, winter peak and export cases, with updated L&R data submitted in Quarter 5 consistently demonstrate that additional transmission from the Wyoming area is required to fully utilize the existing available resources in the Wyoming area to serve the load in Utah, Idaho and Oregon.

The results also demonstrate that the DRTP prescribed in Quarter 4 is not adequate with the Q5 updated load and resource data. The "Draft RTP Case with Q5 L&R" showed N-0 thermal overloads and several contingency violations.

The result of this study, which removed one EG segment at a time also showed several N-0 thermal overloads and bus voltage violations especially when both the Gateway South and Gateway West projects and the associated re-enforcements are removed. The cases showed thermal overloads on the TOT4A and TOT 3 paths under N-0 conditions. With transmission lines that are part of Gateway West project removed, the cases showed several contingency violations that included thermal overloads and bus voltage issues. There were several contingencies in Wyoming that did not converge due to the absence of some of the EG segments especially the 230 kV line segment from Windstar to Aeolus and its associated re-enforcements. Based on these results, the TWG recommends that the DRTP be updated to include the Aeolus – Windstar 230 kV line and the associated re-enforcements which are part of the Gateway West Project in the Draft Final Regional Transmission Plan (DFRTP). The TWG also recommends that the Gateway South project (Aeolus – Clover 500 kV line) should also be included as part of the DFRTP to alleviate overloads on the Bridger West path for the outage of Anticline - Populus 500 kV line for N-0 conditions and to provide back-up to the Gateway West project under outage conditions.

The results of this study did not show any additional thermal overloads or bus voltage violations without any Gateway West segments that are west of Populus, which included the Hemingway – Boardman 500 kV project. However, these segments would presumably provide additional capacity to serve loads in the Pacific Northwest and access to the resources in northwest when required.

Appendix A: List of Aux Files

Scenario 1) No EG Project

1. Capacitor Changes.aux
2. LineRatingChanges.aux
3. Path_Interface.aux
4. Gateway_Branch_Status_off.aux
5. Path14rating_B2H_removal.aux
6. B2H_removal.aux

Scenario 2) No EG Project + Increased Load as per the load forecast

1. SummerPeak_Area65Scale.aux (For other NTTG cases, the respective "CaseName"_Area65Scale.aux should be utilized.)
2. Generator_Addition_Detailed.aux(The aux file adds offline generators at Aeolus and Windstar. The user needs to turn on the generators as needed)

Scenario 3) With EG + Increased Load as per the load forecast.

1. PostEG_CapacitorChanges.aux
2. PostEG_Lineratingchanges.aux
3. PostEG_PathInterface.aux
4. PostEG_Branch_Status_ON.aux

Appendix B: Sensitivity Case for Winter with increased load and no EG

Refer to "ContingencyViolations_Winter.xlsx"

Appendix C: Sensitivity Case for Summer with increased load and no EG

Refer to "ContingencyViolations_Summer.xlsx"

Appendix D: Sensitivity Case for Export with increased load and no EG

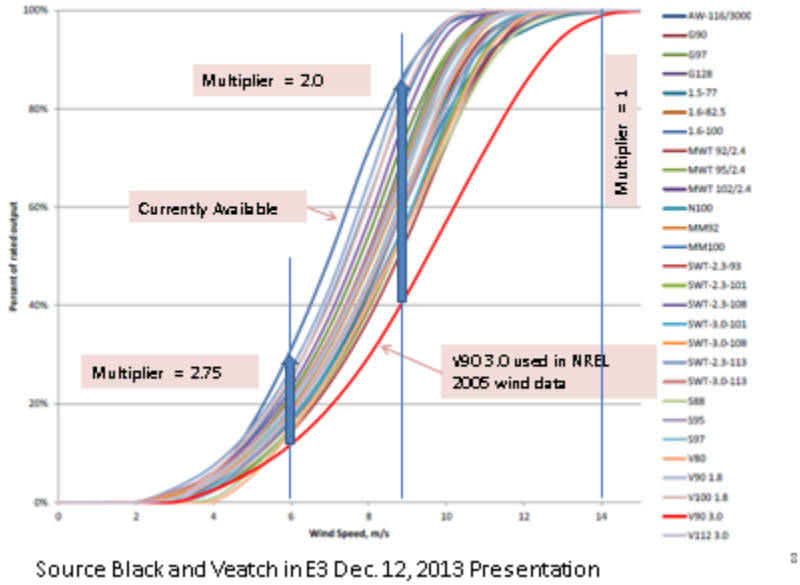
Refer to **"ContingencyViolations_Export.xlsx"**

Appendix E: NREL & TEPPC Data

RESULTS

Zone	Recommended CF	Wind Capacity, MW	Zone	Recommended CF	Wind Capacity, MW
AB_EA	34%	1500	CO_NE	40%	3000
AB_EC	34%	400	CO_SE	42%	3000
AB_SE	36%	3000	CO_SO	39%	400
AZ_NE	25%	3000	ID_EA	32%	400
AZ_NW	30%	218	ID_SW	31%	750
BC_CT	33%	750	MT_CT	41%	1500
BC_NE	42%	1500	MT_NE	39%	3000
BC_NO	37%	1500	MT_NW	38%	3000
BC_NW	34%	750	NM_EA	39%	3000
BC_SE	27%	138	NM_SE	35%	1500
BC_SO	30%	1500	NV_SW	26%	233
BC_SW	29%	1500	NV_WE	27%	199
BC_WE	33%	750	OR_NE	31%	1500
BJ_NO	38%	322	OR_SO	31%	400
BJ_SO	35%	750	OR_WE	33%	343
CA_CT	33%	750	TX	36%	750
CA_EA	32%	237	UT_WE	29%	1500
CA_NE	27%	400	WA_SO	31%	1500
CA_SO	33%	400	WY_EA	44%	3000
CA_WE	37%	1500	WY_EC	44%	3000
CO_EA	40%	3000	WY_NO	39%	3000
			WY_SO	46%	750

Wind Turbine Power Curve



Source Black and Veatch in E3 Dec. 12, 2013 Presentation