NTTG Study Report
for the
2014 - 2015 Public Policy Consideration Scenario

NTTG Study Plan
for the
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1. Executive Summary

During Quarter 1 of the NTTG 2014-2015 Regional Planning Cycle, the Renewable Northwest Project ("RNP") submitted a Public Policy Consideration (PPC, defined in the NTTG Funders' Attachment K) request for a scenario analysis study for the NTTG 2014-15 transmission planning cycle. This study assessed the 2020 retirement of Colstrip Power Plant ("Colstrip") units 1 and 2 and integration of replacement wind resources at the Broadview substation. The results of the analysis are included in this report. The decision was made to model the windfarm at full output because that would put the most stress on the transmission system. In real-time operations, the wind dispatch is a function of the wind availability and cannot be relied upon as a continuous source of generation. This study does not constitute a full-blown total transfer capability study and the results herein should be used for informational purposes only. The results of this analysis do not suggest or imply that a one-for-one substitution of wind for coal is feasible without further analysis or system improvements.

2. Study Assumptions

Several assumptions were made to create the scenario to retire Colstrip units 1 & 2 (305 MW net per generator after accounting for auxiliary load) and replace with 610 MW of wind in Montana:

- 100% of the 610 MW will be exported on Path 8
- The 610 MW of new wind at the Broadview substation will be modeled as two 305 MW wind farms where the entirety of one farm can be tripped at a time at a speed commensurate with the Acceleration Trend Relay that protects the Colstrip units
- The wind farms are connected to the Broadview 500kV transmission bus through radial feeds
- This change occurs in 2020
- No new transmission lines or facilities beyond those already planned for operations in the year 2020 will be considered
- For any contingency that results in a loss of generation, generators in the Western Interconnection will be re-distributed according to their participation factor to account for the loss.

3. Base cases

NTTG used TEPPC's 2024 version 1 production cost model data to identify several system conditions. A production cost model captures all the costs of operating a fleet of generators to minimize costs while simultaneously adhering to a wide

variety of operating constraints. The data from the TEPPC's 2024 version 1 production cost model was then translated into power flow cases. A power flow model is a numerical analysis of the flow of electric power in an interconnected system.

The base cases used for this PPC study were a Summer Peak (peak coincident NTTG summer load condition), and a NW-MT Case (Path 8 high flow condition). For each case, there were 3 possible scenarios. The first scenario investigated a "baseline" in which there were no changes to Colstrip and no new wind at Broadview and no changes to exports on Path 8. The second scenario explored both Colstrip 1 and Colstrip 2 offline with no replacements and a reduction on Path 8 exports of 610 MW. Finally, the last scenario studied the addition of 610 MW of wind at the Broadview substation in place of both Colstrip units 1 and 2 and no changes to exports on Path 8. The export capability of Path 8 is largely a function of the generation on the 500 kV lines that comprise Path 8. If there is a loss of generation, as in the second scenario, then Path 8 exports must be reduced so the swing generator does not compensate for the loss in generation. The first and third scenarios did not require changes to the exports on Path 8 because the net available generation on the 500 kV lines remained the same.

It should be noted that the station service loads were smaller in the TEPPC 2024 production cost model than a typical Western Electricity Coordinating Council (WECC) power flow base case. Because of the lighter station service loads, the flows on the transmission lines were increased which established more conservative results than would have been seen if the station service loads were at their full values.

4. Power Flow Analysis Results

The power flow studies evaluated steady-state (N-0), single (N-1), and credible double contingency (N-2) conditions to confirm that the transmission system still meets the system performance requirements defined in the planning standards as identified in the NTTG 2014-15 Study Plan.

For the six scenarios considered, there were no new N-0 violations caused by either the replacement of wind for coal or the absence of coal. These results neither suggest nor imply that the substitution of wind for coal is feasible at the N-0 level.

Single Contingencies (N-1)

The following single contingencies were examined:

- Colstrip – Broadview 500 kV A or B line
- Broadview – Garrison 500 kV #1 or #2 line

- Garrison – Taft 500 kV #1 or #2 line
- Taft-Bell 500 kV line
- Taft-Dworskak 500 kV line
- Taft-Hot Springs 500 kV line
- Broadview 500/230 kV bank #3
- Garrison 500/230 kV
- Loss of 1 large Colstrip unit
- Langdon-Cranbrook 500 kV outage
- Antelope - Brady 230 kV line
- Mill Creek - Antelope 230 kV line
- Mill Creek - Garrison 230 kV line
- Mill Creek - Anaconda (BPA) 230 kV line
- Mill Creek – South Butte 230 kV line
- Mill Creek - Dillon Salmon 161 kV line
- Dillon Salmon - Big Grassy 161 kV line
- Big Grassy - Jefferson 161 kV line
- Hemingway - Summer Lake 500 kV line
- Hemingway – Boardman 500 kV line
- Statewide N-1, 100 kV and above

All six cases responded similarly in the steady state N-1 contingency analysis. There were no new thermal overloads or voltage violations caused by either the substitution of wind for coal or the absence of coal. Again, the results of this analysis do not suggest or imply that a one-for-one substitution of wind for coal is feasible without further analysis or system improvements.

Credible Double Contingencies (N-2)

For all cases, the N-2 contingencies studied were:

- Colstrip – Broadview 500 kV A and B lines (Category D)
- Broadview – Garrison 500 kV #1 and #2 lines
- Garrison – Taft 500 kV #1 and #2 lines
- Colstrip – Broadview –Garrison 500 kV, one circuit each segment
- Broadview – Garrison - Taft 500 kV, one circuit each segment
- Garrison – Taft – Bell 500 kV, one circuit each segment

In the scenarios that have Colstrip plants 1 and 2 in service with no additional wind generation at Broadview, it was assumed to compare these cases as a one-for-one tradeoff for tripping. Table 1, on the next page, summarizes the available MW per generating unit that would be available when a contingency requires tripping generation.

Table 1: MW Available per unit for Tripping for Contingencies

Units	Unit Type	MW Available for Tripping
1 small	Coal at Colstrip #1 or #2; OR Wind at Broadview	305
2 small	Coal at Colstrip #1 and #2; OR Wind at Broadview	610
1 large	Coal at Colstrip #3 OR #4	822
2 large	Coal at Colstrip #3 AND #4	1644
1 large 2 small	Coal at Colstrip #3 or #4; AND Coal at Colstrip #1 and #2 OR Wind at Broadview	1432

Under steady state conditions with proper generator tripping (either the wind machines at Broadview or the Colstrip units), it may be possible that two 305 MW wind generation resources interconnected to the 500 kV bus could possibly replace the net output (610 MW) of the coal-fired generation at Colstrip given full wind output. Such a substitution may possibly change the response of the Acceleration Trend Relay (ATR) at Colstrip.

Performance

If a contingency caused a violation, tripping either wind, coal or a combination of both was investigated to mitigate the observed violation. Tripping of either wind, coal or a combination of both alleviated any violations that were observed during the study and the scenario cases responded in a similar fashion to the baseline cases.

For this power flow analysis, the study tripped generation based on the expected response from the ATR given its historical performance. The ATR is a computer based relay which is designed to protect the Colstrip generators and to prevent unstable events from disrupting the interconnected grid in the Western Interconnection when faults and line outages occur on the Colstrip transmission system. The ATR is calibrated to prevent the violation of applicable reliability criteria which assures stable performance. The device monitors the real-time speed and acceleration of the four Colstrip units. It uses this information to assess the dynamic performance of the units and thus detect unstable events in progress. When a

contingency occurs that could cause an unstable result, the ATR trips generators as necessary to restore the system to a stable operating condition. As stated above, this study will be done strictly with steady-state power flow and a simulated ATR response; dynamics analysis will be required to verify the ATR performance for the contingencies that result in performance violations.

The TWG received a few comments about this PPC study, most of which centered around supporting the need for a dynamics analysis. Detailed reliability analysis that includes running dynamic simulations to assess system protection, control and loss of inertia are beyond the scope the currently approved NTTG study plan.

Given that, TWG provided the following response:

Should a dynamics study be requested, the case utilized should be already prepared for dynamics analysis, such as a current dynamics-ready WECC base case. The reasoning behind this suggestion is:

- By using a dynamics-ready case, there is no time wasted converting a TEPPC case to be dynamics-ready, a process that is speculated to take at least 2 person-months. Dynamics data is much more extensive than power flow data and as such, would take a significant amount of time to both track down and enter the appropriate data for the entire WECC system.
- The ATR simulation program used by NWE is internal to NWE at this time and relies on a dynamics-ready PSS/e case. The ATR software is not yet available to all WECC members.
- The limitation to using a dynamics-ready case instead of the 2024 TEPPC case is that a current dynamics-ready case may not have all the projects that are included in the 2024 TEPPC case. However, because the ATR helps to ensure the full capacity on Path 8 and none of the suggested projects are on Path 8, it is reasonable to conclude that the findings in a current case would be analogous to the findings in a 2024 case.

5. Results

In an event that tripping either wind, coal or a combination of both alleviated overloads observed on the 500 kV system during contingency, Table 2, on the next page, summarizes the results for all the cases. The solved cases indicate the amount of generation tripping required for each contingency. A case indicating that it was unsolved shows the assumed tripping was insufficient for the particular contingency. For example, a double Colstrip-Broadview contingency is known to only solve if two large and one small unit is tripped offline, anything less fails to obtain solution.

Table 2: Results

			NW-MT			Summer		
N-2	**Units Tripped**	**MW Tripped**	**BV Wind Off, CS1 and CS 2 On**	**BV Wind On, CS1 and CS2 Off**	**CS1 off, CS 2 off, no BV WIND**	**BV Wind Off, CS1 and CS 2 On**	**BV Wind On, CS1 and CS 2 Off**	**BV Wind Off, CS1 and CS 2 Off**
Broadview-Garrison	Broadview Wind (Both)	610	Unsolved	Unsolved	Unsolved	Unsolved	Unsolved	Unsolved
	Colstrip Unit 3	822	Unsolved	Solved	Solved	Unsolved	Solved	Solved
	Colstrip Unit 3 & 1 Broadview Wind	1127	Solved	Solved	Solved	Solved	Solved	Solved
	Colstrip Unit 3 & Broadview Wind (Both)	1432	Solved	Solved	Solved	Solved	Solved	Solved
	Colstrip Unit 3 & Unit 4	1644	Solved	Solved	Solved	Solved	Solved	Solved
Colstrip-Broadview	Broadview Wind (Both)	610	Unsolved	Unsolved	Unsolved	Unsolved	Unsolved	Unsolved
	Colstrip Unit 3	822	Unsolved	Unsolved	Unsolved	Unsolved	Unsolved	Unsolved
	Colstrip Unit 3 & 1 Broadview Wind	1127	Unsolved	Unsolved	Unsolved	Unsolved	Unsolved	Unsolved
	Colstrip Unit 3 & Broadview Wind (Both)	1432	Unsolved	Unsolved	Unsolved	Unsolved	Unsolved	Unsolved
	Colstrip Unit 3 & Unit 4	1644	Unsolved	Solved	Solved	Solved	Solved	Solved
	Colstrip Units 1, 3 and 4	1949	Solved	Solved	Solved	Solved	Solved	Solved
Garrison- Taft	Broadview Wind (Both)	610	Unsolved	Unsolved	Unsolved	Solved	Solved	Solved
	Colstrip Unit 3	822	Solved	Solved	Solved	Solved	Solved	Solved
	Colstrip Unit 3 & 1 Broadview Wind	1127	Solved	Solved	Solved	Solved	Solved	Solved
	Colstrip Unit 3 & Broadview Wind (Both)	1432	Solved	Solved	Solved	Solved	Solved	Solved

	Colstrip Unit 3 & Unit 4	1644	Solved	Solved	Solved	Solved	Solved	Solved

6. Conclusions

The Renewable Northwest Project (RNP) submitted a Public Policy Consideration request for a scenario analysis study for the NTTG 2014-15 ten year transmission planning cycle. This study report assessed an accelerated phase-out of coal plants while developing utility-scale renewable resources, replacing 610 MW of coal with wind at the Broadview 500 kV bus.

Generation was tripped based on the expected response from the ATR given past studies and events. For this study, either tripping wind, coal or a combination of both alleviated overloads observed on the 500 kV system during contingency. However, it is very likely the response of the ATR would be affected for wind. This study shows that under the steady state conditions studied, assuming a MW for MW online exchange in generation, and proper generator tripping (either the wind machines at Broadview or the Colstrip units), it may be possible that wind generation interconnected to the 500 kV bus could possibly replace coal-fired generation at Colstrip. However, the study cannot definitively conclude that the wind for coal replacement is possible. Nevertheless, again it should be noted that the study assumptions only give a limited conclusion. Moving forth with Transient studies, using a dynamics ready case and the actual ATR simulation program would be the next step in confirming the assumptions made of the ATR for this study.