THE NECESSITY OF THE 500 KV SYSTEM IN NWE'S TRANSMISSION SYSTEM TO MAINTAIN RELIABLE SERVICE TO MONTANA CUSTOMERS

2/27/2018

ELECTRIC TRANSMISSION PLANNING

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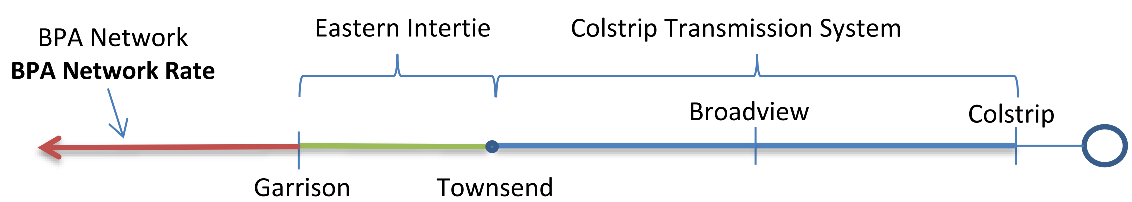
Executive Summary

NorthWestern Energy (NWE) conducted a study to analyze the importance of the 500 kV system to NWE's overall transmission reliability. With the imminent shutdown of Colstrip units 1 and 2, and the larger Colstrip units potential early shutdown driven by regulatory and legal processes outside Montana, it is critical to understand the importance of the 500 kV Transmission system to reliable operation of the overall transmission system in Montana.

Background

The 500 kV transmission system was built in 1981. It runs approximately 300 miles from the Colstrip switchyard across NWE's service territory to an interconnection with BPA at the Garrison substation. The 500 kV system is divided into two segments – the Eastern Intertie and the Colstrip Transmission System ("CTS") – each segment with different ownership (shown below).



The CTS runs 248 miles from the Colstrip generation switchyard to just south of Townsend, Montana. This portion of the facility is jointly owned by PacifiCorp, NWE, Puget, Portland and Avista and governed by the Colstrip Transmission Agreement. Capacity on the portion of the CTS between Colstrip and Broadview is 2,260 MW while the capacity on portion between Broadview and Townsend is 1,930 MW.

The second segment of the 500kV system is called the Eastern Intertie. It runs from just south of Townsend, Montana to Garrison, Montana, where it interconnects with the Bonneville Power Administration's (BPA) main grid. The Eastern Intertie is owned by BPA. Each of the five Colstrip transmission owners take service on the Eastern Intertie from BPA, pursuant to the Montana Intertie Agreement.

This study showed that not only is the entirety of the 500 kV system vital for moving power across NWE's transmission system, it is also essential for providing reliability for customers within NWE's service territory under critical outages.

NWE analyzed its system under stressed conditions with projected 2020 load growth to see just how important the 500 kV system is to the overall reliability of NWE's transmission system. System conditions chosen were peak load, seasonally lower hydro generation, and zero wind output; a situation NWE has experienced multiple times in the last year. The study included the following scenarios:

- 2020 Heavy Winter with the 500 kV system intact and only Colstrip unit 4 online

- 2020 Heavy Winter with the 500 kV system intact and no Colstrip generation
- 2020 Heavy Winter without the 500 kV system or Colstrip generation

The study focused on single element outages (NERC TPL-001-4 Category P1).

Assumptions

Base Case

The WECC 2018 Heavy Winter case was chosen as a starting base case. Loads were modified to 2020 levels and included executed, new NITSA loads. Hydro generation was adjusted to represent low-to-moderate levels usually seen in the winter. Wind generation was reduced to zero as this represents the worst case, but still a very realistic scenario. These levels were very similar to those which occurred on February 5, 2019 when NWE set a new hourly integrated peak load of 1894 MW. During this time, there was zero wind generation across NWE's system, NWE's hydro facilities were at low levels due to river conditions and there was zero solar generation output.

Each case below was analyzed both with, and without the 500 kV system in place. The entire Colstrip generation facility was assumed offline for each case with the removal of the 500 kV system. A case with the 500 kV system in place and only Colstrip unit 4 was also analyzed. Paths were adjusted to maximize imports from the Mid-Columbia power market. Case 1 focused on maximizing Path 8 imports, while case 2 allowed imports from all external paths. A brief summary of each case can be found in Table 1 and a more detailed summary in Appendix 1. It is important to note the in preparing the study work, no attempt was made to determine the actual market availability to import. That effort is beyond the scope of this transmission work. However, through many years of experience operating the Transmission system, it is not unusual to see heavy imports from Path 8 during peak/critical periods.

Table 1: Case Summary

	Case 1	**Case 2**
Area 62 Generation	661.0	661.0
Area 62 Load	2029.0	2029.0
Control Area Load	1976.9	1999.5
Path 18	-25.8	-3.8
Path 8	-1351.3	-1026.3
Path 80	-87.8	-358.9
Path 83	1.2	-96.1

***All values are in MW. A negative value indicates an import condition.**

Power Flow Analysis

The post-transient power flow analysis was used to study the steady-state impacts to the system following a system contingency. The primary focus of the study was power flow analysis, therefore no transient stability analysis was performed. The following assumptions were used:

- All manually operated voltage control devices were fixed to pre-contingency status
- PSTs were locked to pre-contingency tap position
- Automatically controlled Load Tap Changers and switched shunts were allowed to move

- Generators which manually control a high side remote bus were set to regulate the voltage at the terminal bus at pre-contingency voltage set point. Generators with automatically controlled remote regulation (i.e. LDC) were allowed to control the high side bus.
- Automatically controlled remedial action schemes (RAS), relay devices, and/or load shedding schemes were allowed to operate
- No lines were be allowed to be loaded over 100% of their emergency rating. If there was no emergency rating given to the line, lines were not be permitted to exceed 100% of their normal rating
- If automatic generation dropping occurred, system-wide generation was re-dispatched pro-rata to all generators within WECC
- TPL-001-WECC-CRT-3.1 Transmission System Planning Performance Criteria was used to determine system performance

Contingencies

The study focused primarily on the P0 and P1 contingencies listed in NERC TPL-001-4 Table 1 and were considered all across Montana including contingencies in neighboring utilities. P0 represents system normal conditions with all lines in service. P1 contingencies consider loss of a single element and all associated equipment. P2-6 analysis (N-1-1) was not performed for this study. This is an important point as the study finds major problems that exist with either no contingencies on the system or single contingencies.

Power Flow Analysis

The system was studied with the existing 500 kV system intact to give a good baseline to show any potential pre-existing issues. In this case, Colstrip was assumed to be 100% offline. The 500 kV system was then removed to see what potential issues this may introduce. The following is a summary of the results. A more detailed summary of results for each base case can be found in Appendix 2.

P0 – System Normal

With the 500 kV system in service and all other transmission lines in service, there were no thermal or voltage violations seen in the study. Once the 500 kV system was removed, the system could not obtain a valid solution. This means that without the 500 kV system, NWE does not have the ability to serve the entirety of its load, if it was required to import a majority of its power without the support that the 500 kV system provides. Other, significant issues also occur which are discussed in greater detail below.

P1 – Loss of a Generator, Transmission Line, Transformer, or Shunt

With 500 kV System

- Loss of the Mill Creek 230/161 kV #4 transformer loads the remaining Mill Creek 230/161 kV #3 transformer to 119%
    - This is an existing issue with planned mitigation
- Loss of either Mill Creek 161/100 kV transformer overloads the remaining Mill Creek 161/100 kV #1 transformer to 110%
- Loss of either Broadview 230/100 kV transformer causes low voltage in the Roundup 100 kV system with voltages as low as 0.85 pu.
- Loss of 230 kV circuits in the Billings area overload the Billings Rimrock 161/100 kV transformers up to 113%
    - This is an existing issue with planned mitigation
- Loss of 161 kV circuits between Butte and Bozeman overload the Trident Auto 100/50 kV transformer up to 130%
    - This is an existing issue with planned mitigation

Without 500 kV System

Note: In order to get the case to solve pre-contingency, small amounts of generation and/or VAR support was used across the system.

- The following contingencies all result in extreme overloads and/or voltage collapse:
    - Loss of any 230 kV line between Mill Creek and Bozeman
    - Loss of the Garrison 500/230 kV transformer
    - Loss of the Billings Steamplant Phase Shifting Transformer
    - Loss of the Clyde Park 161/50 kV transformer

- Loss of the Mill Creek 230/161 kV #4 transformer loads the remaining Mill Creek 230/161 kV #3 transformer to 181%
- Loss of the Mill Creek 230/161 kV #3 transformer loads the remaining Mill Creek 230/161 kV #4 transformer to 112%
- Loss of either Mill Creek 161/100 kV transformer overloads the remaining Mill Creek 161/100 kV #1 transformer to 156% and overloads much of the 100 kV system around Butte up to 112%
- Loss of one Garrison to Mill Creek 230 kV line overloads the parallel 230 kV line up to 142%
- Loss of one Mill Creek to ASiMI 161 kV line overloads the parallel 161 kV line up to 132%
- Loss of 230 kV circuits in the Billings area overload the Billings Rimrock 161/100 kV transformers up to 125%
- Loss of 161 kV circuits between Butte and Bozeman overload the Trident Auto 100/50 kV transformer up to 161%

Results and Mitigation

The results of the power flow analysis show that without the 500 kV system, the NWE transmission system is susceptible to major issues all across the system. While importing from other Paths (MATL and Montana Southeast) lessened the severity of the overloads and voltage violations seen, it did not alleviate them completely. In order to reliably serve NWE peak load without the 500 kV system, all the following mitigation would be necessary:

- Construction of a new, approximately 215 mile long 230 kV line from Butte to Billings
- The Southwest Montana Initiative
    - Conversion of approximately 30 miles of the Rattlesnake to Mill Creek 161 kV line to 230 kV
    - Construction of a new Gold Creek substation which ties together the 161 kV line from Rattlesnake, the Garrison to Ovando 230 kV line, and the Garrison to Mill Creek 230 kV line
    - Replace the existing 200 MVA Mill Creek 230/161 kV transformer with a 400 MVA transformer
- Replace the existing 62.5 MVA Mill Creek 161/100 kV transformers with > 100 MVA transformers
- A second Garrison 500/230 kV transformer
- Two 75 MVAR shunt capacitors at Alkali Creek 230 kV substation
- Re-conductor the 20 mile long 100 kV South Butte to Renova line with 336 MCM
- New Belgrade West substation
- Two new, larger 161/100 kV transformers at South Butte
- Rimrock substation rebuild
    - Two new 200 MVA 230/100 kV transformers
- Tie the Mill Creek to South Butte 230 kV line into ASiMI substation with new 200 MVA 230/161 kV transformer

For purposes of this high level study work, no attempt was made to estimate the cost of the mitigation efforts described above.

Conclusion

The study work performed showed that the 500 kV system is critical to NWE's system in order to reliably serve Montana customers – including NorthWestern's retail customers and the large industrial and cooperative customers. Since the 500 kV system ties our largest load centers and large portions of our other Bulk Electric System together, without the 500 kV system, there would be a need for major system improvements in order to survive peak load conditions and reliably serve our customers. Additionally, without the existing 500 kV system (or without the mitigation measures described in this report), NWE would be unable to import all the power necessary to maintain reliability. The largest bottleneck observed without the 500 kV lines was the inability to get power from the west, mainly from Path 8, to the large load centers in central to eastern Montana.