NTTG 2012 Economic Study Report

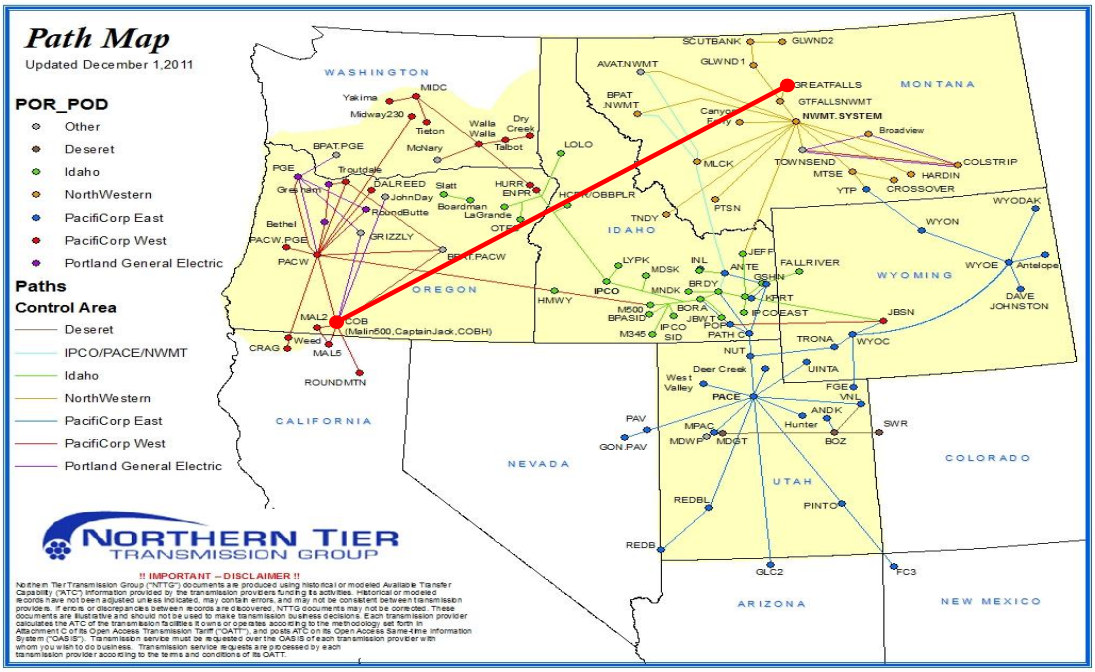
Great Falls to Malin 1500 MW Transfer

I. Introduction:

As part of the first quarter of the biennial study process, the Northern Tier Transmission Group (NTTG) planning committee sends out a request for ten-year forecast data from members of the group. This is also the time when any stakeholders can make requests for economic studies. During the 2012-13 planning process, three separate studies were requested – 1) review the best means of developing a path within the NTTG footprint having the capability to deliver up to 1500 MW of renewable wind energy from Great Falls, Montana to the California Oregon border at the Malin Substation; 2) a new 500 kV line from Townsend, MT to Midpoint, ID (MSTI project); and 3) a new 500 kV upgrade from Colstrip to Townsend in Montana to Mid-Columbia in the northwest. The NTTG planning committee evaluated these requests and determined that requests #1 and #2 and the Montana part of #3 could be combined together as one study. Figure 1 below shows the requested transfer study geographically. The stakeholder requested only power flow reliability analysis be performed as opposed to economic congestion studies. The purpose of this study is to demonstrate what, if any, additional transmission is required for transferring 1500 MW of wind generation from Great Falls to Townsend in Montana to Malin substation in southern Oregon; and 2) determining how much power, if not the full 1500 MW, can be moved from Great Falls to Malin with just a single new 500 kV line from Great Falls to Townsend to Midpoint.

Figure 1

Economic Study Plan



II. Study Objectives and System Conditions:

The objective of this study is to determine what transmission additions are needed to export 1500 MW of wind generation from Montana to northern California/southern Oregon. The evaluation included new 500 kV lines from Great Falls to the proposed Townsend substation in Montana to Midpoint substation in Idaho to Malin substation in southern Oregon. Two stressed base cases, with the 1500 MW transfer, were developed—one with peak coincident summer loads within the NTTG footprint, and the other with peak coincident NTTG export conditions, where there is heavy flow on transmission paths from Montana to the Northwest (path 8) and Idaho to the Northwest (path 14).

A second objective of this study is to determine how much power, if not the full 1500 MW transfer, can be delivered from Great Falls to Malin with just a single 500 kV line from Great Falls to Townsend to Midpoint with no additional transmission upgrades.

III. Study Schedule:

The NTTG study schedule calls for economic study reports to be completed by the end of the third quarter (Q2) of the study process. Since the 2022 base cases for the NTTG biennial study plan were not completed until the third quarter of the study cycle, the NTTG planning committee and the requesting stakeholder agreed to a delay in completing the report for this study request until the fourth quarter (Q4).

IV. Base Cases:

Five power flow base cases (core cases) for the NTTG biennial study plan were developed from data extracted from the 2022 TEPPC production cost case which included about 30 future transmission projects known as the Common Case Transmission Assumptions (CCTA)[1]. These cases were completed during the third quarter (Q3) of the study cycle. Some, but not all, of the Q1 transmission additions were included in the core cases. The MSTI project and collector, the Hemingway-Captain Jack 500 kV line, and several 230 kV lines in Oregon and Wyoming were not included. The planning committee also agreed that the TransWest Express DC line and resources would be excluded from this study request but will be studied in the biennial study plan as a separate scenario. For the purposes of this study request, additional cases were prepared from the summer and export core cases that represent the July 21 and November 6 time periods, respectively, from the TEPPC case. These cases were then modified to include a 1500 MW transfer from Great Falls to Malin. Additional cases were produced for studying this transfer for both summer and export conditions: 1) the 1500 MW transfer and a 500 kV line from Great Falls to Townsend (case 0); 2) case 0 plus a 500 kV line from Townsend to Midpoint (case1); 3) case 1 plus a 500 kV line from Hemingway to Captain Jack (case 2); and 4) case 2 plus a second 500 kV line from Midpoint to Hemingway (case 3). Several additional cases were also compiled in order to determine the maximum transfer that can be made with just a single 500 kV line from Great Falls to Midpoint. Bubble diagrams showing the flows between areas are provided in appendix B.

V. Study Procedure:

A. The first step in demonstrating the impact of the 1500 MW transfer from Great Falls to Malin was to study the NTTG summer and export cases without the requested transfer to determine if any transmission additions were required. This was done by performing a contingency analysis of over 400 contingencies in each case (see Contingencies in Appendix C). If any violations were indentified in this analysis, then they were

[1] A report on the CCTA is included in Appendix A.

investigated to resolve any incorrect information in the case or irrelevant buses, i. e. radial or sub-transmission buses. Once all of the violations were resolved for the two base cases, then these cases were used for the transfer studies.

B. Next, 1500 MW of new generation was added to the two base cases at Great Falls, Montana as well as a new 500 kV line from Great Falls to a new Townsend substation. A 1500 MW load was also modeled at the existing Malin substation in southern Oregon. With this additional transfer now added to the cases, the contingency analysis was repeated to determine if the results met the reliability criteria. Any violations were identified and solutions recommended.

C. If the full 1500 MW transfer did not have acceptable results, then additional transmission facilities were added and evaluated sequentially in the following order --1) the MSTI project consisting of a 500 kV line from Townsend to Midpoint; 2) a new 500 kV line from Hemingway to Captain Jack; and 3) a second 500 kV line from Midpoint to Hemingway. With each line addition, the cases were again tested to see if the reliability criteria were met for the contingency analysis. Any violations were identified and solution recommendations were provided in order to obtain acceptable results.

VI. Study Criteria:

The study results were evaluated based on the NERC and WECC performance criteria. An exception to the WECC voltage change criteria in the state of Wyoming was also taken into consideration. This exception allows for >5% voltage change for N-1 contingencies as long as the voltage at load buses is not less than 90%.

VII. Study Results for 1500 MW Transfer:

A. The study results for the full 1500 MW transfer will be divided into two sections for the two separate stressed conditions of A) heavy NTTG summer load; and B) maximum NTTG export. A comparison summary of the study results for each study is presented in Tables 1 and 2[2].

B. <u>Heavy NTTG Summer Load:</u>

1. *Core Case:* The summer core case solved without any significant violations for N-0 conditions. All reported violations were investigated and determined to be

[2] Although the results show a number of overall violations in each case, the work group has investigated each violation to determine if it was a legitimate violation or a local issue or dummy bus, etc. The notes in the summary tables list some of the exceptions.

insignificant because they were either dummy bus voltage violations associated with series capacitors or local load service issues that would be remedied as load grows in the next ten years. The contingency study results also show no legitimate violations. These results are summarized in Table 1.

2. *1500 MW Transfer Case:* This case solved with no significant N-0 violations aside from high voltages at series capacitor dummy buses, which are acceptable. The contingency analysis showed some legitimate low voltages in Montana and Wyoming, and numerous voltage change violations that exceed the 5% voltage change criterion. Many of these are not deemed legitimate violations because 1) they are known local issues that will be resolved in the next ten years; and 2) because there are voltage change exceptions (i.e. in Wyoming) that are allowed under the WECC criteria. Even with these exceptions, however, a number of legitimate voltage violations (26) still remain that will require remediation. Low voltage violations (< 90%) and voltage change violations (>5%) occur in western Wyoming buses (Garland, Oregon Basin, and Frannie) for loss of the Yellowtail-Sheridan 230 kV line. Loss of the Hemingway-Grassland (Boardman) 500 kV line also results in voltage change violations at Dillon, Amps, Peterson Flats, as well western Wyoming. The Brady-Antelope 230 kV line outage results in voltage change violations in the Antelope area. Five branch overloads also resulted from the contingency study. Three of these branch overloads, the thermal overload of the Yellowtail 230 kV tie between PacifiCorp and WAPA, result from three outages on sections of the same line (Billings-Yellowtail 230 kV). The loss of the Hemingway-Grassland 500 kV line results in overloading the Hells Canyon-Brownlee 230 kV line (100%) and loss of the Millcreek-Garrison 230 kV line overloads the Anaconda-Millcreek 230 kV line (101%). Details of these contingency violations are shown in Appendix D – HS Results. These results demonstrate that additional transmission upgrades or remediation schemes are needed.
3. *1500 MW Transfer Case with MSTI added:* This base case solved with no significant violations. All voltage violations were investigated and deemed insignificant to the study due to dummy buses and local load-serving voltage issues. There were also no legitimate voltage violations and no branch overloads during the contingency analysis (see table 1). These results show that the number of overall violations was significantly reduced, and all of the legitimate violations were eliminated with the addition of the MSTI project.
4. *Other transmission additions:* Studies were also done with the addition of the Hemingway-Captain Jack 500 kV line and/or a second 500 kV line from Midpoint to Hemingway. Table 1 shows a comparison of the violations from these studies. As

shown in the table, these other transmission additions did not have a significant impact on the number of critical violations in the summer studies.

Table 1 - Summary of Heavy Summer Cases - Study Request

What's in the case?	Core Case	Case 0	Case 1	Case 2	Case 3
Added load at Malin (MW)	0	1500	1500	1500	1500
Added resources in Gt. Falls, MT	0	1500	1500	1500	1500
Gt. Falls to Townsend 500 kV line	No	Yes	Yes	Yes	Yes
Townsend to Midpoint 500 kV line	No	No	Yes	Yes	Yes
Hemingway to Captain Jack 500 kV line	No	No	No	Yes	Yes
2nd Midpoint to Hemingway 500 kV line	No	No	No	No	Yes
N-0 Results	**Core Case**	**Case 0**	**Case 1**	**Case 2**	**Case 3**
Branch Amps	1 (*1)	0	4 (*1)	4 (*1)	4 (*1)
Branch MVA	0	0	1 (*1)	1 (*1)	1 (*1)
Bus High Volts (>1.1)	0	14 (*1)	12 (*1)	12 (*1)	17 (*1)
Bus Low Volts (<0.9)	0	0	0	0	0
Total legitimate violations	0	0	0	0	0
N-1 Contingency Results	**Core Case**	**Case 0**	**Case 1**	**Case 2**	**Case 3**
Branch Amps	0	5	0	0	2 (*1)
Branch MVA	0	0	0	0	0
Bus High Volts (>1.1)	15 (*1)	11 (*1)	22 (*1)	22 (*1)	25 (*1)
Change Bus High Volts (>5%)	2 (*1)	9 (*1)	1 (*1)	1 (*1)	1 (*1)
Bus Low Volts (<0.9)	0	4 (*2)	0	0	0
Change Bus Low Volts (>5%)	0	148 (*1), 22(*2)	25 (*1)	22 (*1)	24 (*1)
Total legitimate violations	0	31	0	0	0

Notes: *1- Acceptable because of the following reasons:
(a) Automatic relay schemes (i.e. FACRI and other RAS) in place for overvoltage or undervoltages
(b) Percentage deviations are within voltage magnitude limits of 0.9 and 1.1 (WECC exception in WY)
(c) Real Time Dispatch orders are established based on load and generation in the region or load pockets
(d) Some high voltages are on dummy (or pass through) buses.
(e) Voltage violations occur outside of study area or are local issues.

Notes : *2 - Unacceptable with following exceptions:
Low voltages at Chromeat (Bus 62225) are a pre-existing local radial line issue.

C. Maximum NTTG Export:

1. *Core Case:* The export core case solved with three branch violations for N-0 conditions. These were all slight overloads of the Burns series capacitors. These

overloads were eliminated by bypassing the Burns series capacitors in the core case. There were no significant voltage violations. Although a number of violations were reported in the contingency study, all of these were investigated by the work group and found to be insignificant because of dummy buses, local load-serving issues, etc.

2. *1500 MW Transfer Case:* This case solved but with six voltage violations and two branch overloads for N-0 conditions. These violations are shown in Table 2. The voltage violations are all series capacitor buses or local load-serving issues on distribution buses of no consequence to this study. The two branch violations indicate that the Burns (113% of 1732 amp rating on Summer Lake line) and Malin (104% of 2700 amp rating on Summer Lake line) series capacitors will need to be upgraded, however, to accommodate this transfer. Bypassing the Burns series capacitors in this case did not eliminate the N-0 overload. Additionally, several WECC rated paths are over the ratings in the case, namely the Montana-Northwest path (155% of 2200 MW limit), West of Hatwai path (121% of 2800 MW limit), and Hemingway-Summer Lake path (110% of 1500 MW limit). Additional path rating studies would be required in order to determine the scope of improvements required to operate these paths at the flows in this case. Contingency analysis on this case resulted in about 136 voltage violations and 14 branch overloads, as shown in Table 2. One of the branch overloads is a local issue in eastern Utah (Rangely-Calamridge 138 kV line for loss of Bears-Bonanza 345 kV line), which is not related to the transfer in question. Twelve of the branch overloads were Burns series capacitor overloads for various line outages, and the Garrison series capacitor overloads for the outage of the Townsend-Garrison 500 kV line. The voltage violations were mostly located in the northwest area and can be resolved with the many existing automatic reactive-switching schemes. However, more transmission improvements, i.e. series capacitor upgrades at Burns and Garrison, need to be added to eliminate the N-1 contingency violations.
3. *1500 MW Transfer Case with MSTI added:* This case solved but with seven voltage violations and three branch overloads (see Table 2). All of the voltage violations are either series capacitor dummy buses or buses outside of the area (Arizona) which are deemed as not significant to the study. The series capacitors at Burns (135% of 1732 amp rating on Summer Lake line), Malin (107% of 2700 amp rating on Summer Lake line), and now Midpoint (108% of 1732 amp rating on Hemingway line) will need to be upgraded to eliminate the N-0 branch overloads. The contingency analysis results show there are numerous voltage violations but all are deemed acceptable because of high voltages on series capacitor dummy buses or local load-serving voltage issues that would be resolved in the next ten years. Additionally,

several WECC rated paths are over the proposed future ratings in the case, namely the Idaho-Northwest path (123% of 3400 MW limit), Montana-Northwest path (105% of 2200 MW limit), and Hemingway-Summer Lake path (129% of 1500 MW limit). Additional path rating studies would be required in order to determine the scope of improvements required to operate these paths at the flows in the case. The contingency results also show 14 branch overloads, 12 of which would be eliminated with the Burns series capacitor upgrade and one with the Midpoint series capacitor upgrade. One branch overload is a known local problem in eastern Utah that will be resolved prior to 2022.

4. *Other transmission additions:* Studies were also done with the addition of a new Hemmingway-Captain Jack 500 kV line along with the MSTI line, and then combining this line with a second 500 kV line from Midpoint to Hemingway. Table 2 shows a comparison of the violations from these studies. As shown in the table these transmission additions did reduce the number of legitimate violations in the heavy export studies but series capacitor upgrades are still required.
    a. With the addition of a new Hemingway-Capt. Jack 500 kV line in the base case, the Burns series capacitors no longer overload but the Midpoint series capacitors do overload (130% of the 1732 amp rating on the Hemingway line). The only path overloaded in this case is the Montana-Northwest path (102% of the 2200 MW limit). Additional path rating studies would be required in order to determine the scope of improvements required to operate this path at the flows in the case. In the contingency study there are still five branch overloads. Besides the one known local issue with a 138 kv line in eastern Utah, all of the other branch overloads can be eliminated with Burns and Midpoint series capacitor upgrades.
    b. By adding a new 500 kV line from Midpoint to Hemingway, in addition to the Hemingway-Capt. Jack line, the number of violations was again reduced. There are no series capacitor overloads in this base case. The Montana-Northwest path is still overloaded (101% of 2200 MW limit) as well as now the California-Oregon path (102% of 4800 MW limit). Additional path rating studies would be required in order to determine the scope of improvements required to operate these paths at the flows in the case. The contingency study shows there are no significant voltage violations and only 2 branch overloads, one the local 138 line in eastern Utah and the other one the Burns series capacitor that could be fixed with an upgrade.
5. Details on all legitimate violations are listed in Appendix E – HX Results.

NORTHERN TIER TRANSMISSION GROUP

Table 2 - Summary of Heavy NTTG Export Cases - Study Request

What's in the case?	Core Case	Case 0	Case 1	Case 2	Case 3
Added load at Malin (MW)	0	1500	1500	1500	1500
Added resources in Gt. Falls, MT	0	1500	1500	1500	1500
Gt. Falls to Townsend 500 kV line	No	Yes	Yes	Yes	Yes
Townsend to Midpoint 500 kV line	No	No	Yes	Yes	Yes
Hemingway to Captain Jack 500 kV line	No	No	No	Yes	Yes
2nd Midpoint to Hemingway 500 kV line	No	No	No	No	Yes
N-0 Results	**Core Case**	**Case 0**	**Case 1**	**Case 2**	**Case 3**
Branch Amps	0	2	3	1	0
Branch MVA	0	0	0	0	0
Bus High Volts (>1.1)	5 (*1)	6 (*1)	7 (*1)	10 (*1)	9 (*1)
Bus Low Volts (<0.9)	0	0	0	0	0
Total legitimate violations	0	2	3	1	0
N-1 Contingency Results	**Core Case**	**Case 0**	**Case 1**	**Case 2**	**Case 3**
Branch Amps	3 (*1)	13, 1 (*1)	13, 1 (*1)	4, 1 (*1)	1, 1 (*1)
Branch MVA	3 (*1)	0	0	0	0
Bus High Volts (>1.1)	22 (*1)	24 (*1)	31 (*1)	25 (*1)	18 (*1)
Change Bus High Volts (>5%)	4 (*1)	84 (*1)	56 (*1`)	23 (*1)	23 (*1)
Bus Low Volts (<0.9)	0	0	1 (*1)	3 (*1)	0
Change Bus Low Volts (>5%)	11 (*1)	28 (*1)	36 (*1)	31 (*1)	27 (*1)
Total legitimate violations	0	13	13	4	1

Notes: *1- Acceptable because of the following reasons:
(a) Automatic relay schemes (i.e. FACRI and other RAS) in place for overvoltage or undervoltages
(b) Percentage deviations are within voltage magnitude limits of 0.9 and 1.1 (WECC exception in WY)
(c) Real Time Dispatch orders are established based on load and generation in the region or load pockets
(d) Some high voltages are on dummy (or pass through) buses.
(e) Violations occur outside of study area or are local issues.

Notes : *2 - Unacceptable with following exceptions:
Low voltages at Chromeat (Bus 62225) are a pre-existing local radial line issue.

VIII. Study Results for Maximum Transfer (No upgrades)

A. *Heavy NTTG Summer Load*: Studies were completed to demonstrate the maximum amount of power that could be transferred from Gt. Falls to Malin utilizing only a single 500 kV line from Gt. Falls to Townsend to Midpoint with no additional transmission upgrades. The acceptable transfer level had no significant violations. The study results show that at least 750 MW can be transferred with just the single line from Gt. Falls to Midpoint without any violations or path overloads.

B. *Heavy NTTG Export*: Studies were conducted for this stressed condition to determine the maximum amount of power that could be transferred from Gt. Falls to Malin utilizing only a single 500 kV line from Gt. Falls to Townsend to Midpoint with no additional transmission upgrades. The acceptable transfer level had no significant violations. The study results show that a maximum of 400 MW can be transferred with just the single line from Gt. Falls to Midpoint. This shows that the maximum transfer is limited by the export system condition.

IX. Conclusions:

A. *Heavy Summer Case*: The results of the heavy summer case show that the 1500 MW transfer can be accommodated in the base case (N-0) without adding any transmission upgrades. This is likely the case because of the 30 Common Case Transmission Assumption (CCTA) facilities that are included in the case. However, the contingency analysis results show that there are several line thermal overloads and numerous voltage violations that occur for various contingencies. These results demonstrate that even with the CCTA projects, additional transmission upgrades are needed and reactive support is also required at locations in Montana and Wyoming. Adding a 500 kV line from Townsend, Montana to Midpoint, Idaho (MSTI project) eliminates all of the significant violations in the heavy summer cases. The study results do not show a substantial improvement in adding the Hemingway to Captain Jack or Midpoint-Hemingway 500 kV lines for the summer load study.

B. *Heavy NTTG Export Case*: The results of the heavy export case show that in order to accommodate the 1500 MW transfer from Great Falls, Montana to Malin, Oregon in the base case, upgrades must be made to the Burns and Malin series capacitors. In addition to these upgrades, contingency analysis results show the need to also upgrade the Garrison series capacitors or add transmission improvements beyond the 30 CCTA projects that are already included. Results show that adding a 500 kV line from Townsend, Montana to Midpoint, Idaho (MSTI project) reduces some voltage violations and eliminates the Garrison series capacitor overload, but overloads the Midpoint series capacitors in addition to the ones at Burns and Malin. The study results do show a substantial improvement in adding the Hemingway to Captain Jack and/or Midpoint-Hemingway 500 kV lines for the heavy export study. However, even without these additional lines the results are acceptable with a new 500 kV line from Townsend to Midpoint and series capacitor upgrades at Burns, Malin, and Midpoint.

C. *Maximum Transfer With only MSTI Upgrade*: The Heavy NTTG Export case is the most limiting condition for establishing the maximum transfer utilizing a single 500 kV line from Gt. Falls to Townsend to Midpoint and no additional upgrades. The maximum transfer determined in the study is 400 MW based on power flow studies only.

D. Several WECC rated paths are over the proposed future ratings in the export cases, namely Idaho-Northwest, Montana-Northwest, West of Hatwai, and Hemingway-Summer Lake paths. Additional path rating studies would be required in order to determine the scope of improvements required to operate these paths at the flows in the export base cases. Only power flow studies and no stability studies were conducted in this study request.

E. These study results are contingent on the loads, resources, and transmission facilities used in the TEPPC 2022 production cost model. This includes 30 future transmission projects that constitute the Common Case Transmission Assumptions (CCTA). Any changes to these assumptions, the generation dispatch, or additional transmission would likely result in different transmission requirements.