Montana – Idaho Path
Open Season
Study Report

May 10, 2005

Electric Transmission Planning

Table of Contents

Summary 3

Open Season Transmission Service Requests 3

Summary of Results 4

NWE Internal Constraints 7

Move Power Across NWE System 9

Eastern Montana Area Sources (CS, SE, BL) 9

Existing System: 10

Approximate Non-binding Cost Estimates: 10

Transmission System Upgrades: 10

Approximate Non-binding Cost Estimates: 11

New Line(s) 11

One new 500 kV line: 11

Montana To Southeast (MTSE) 12

Great Falls Area Sources (GF) category: 13

Existing System 13

Approximate Non-binding Cost Estimates: 14

New Line(s) 14

One new 230 kV line: 14

Two new 230 kV lines: 15

Western Area Sources category: 16

Move Power from Montana to Idaho 17

500 kV Alternative: 17

345 and 230 kV Alternatives: 18

Appendix 1 19

Appendix 2 20

Path Description Detailed Discussion 20

Appendix 3 24

Summary

NorthWestern Energy (NWE) conducted an Open Season in December 2004 to identify potential interest in the use of the Montana to Idaho Path (Path 18 in the WECC Path Rating catalog). NWE received 17 OASIS requests totaling 2,250 MW of expressed interest. Using this information, NWE designed a high level study that would provide cost information regarding the need for transmission system improvements to move all or a part of the 2,250 MW to Idaho. This information is provided so that the Open Season respondents can make a decision whether to proceed to the next level of study by funding their Open Season request. For those participants that elect to continue to the next phase of this process, more studies will be conducted according to queue position, as preserved by the individual Open Season transmission service requests made on NWE's OASIS.

This report will provide these results in two parts.

1. Identify NWE's transmission improvements that may be necessary to deliver power from various points of origin in Montana to a northern terminal of the interconnection to Idaho. Depending on the area sources, the northern terminal could be located at the existing Garrison substation (for 230 kV options) or at a new substation at Townsend (for 230, 345 and 500 kV options). Both of these terminal points are on the 500 kV transmission system that traverses Montana from east to west.

2. Identify kV size for an Idaho interconnection that starts at Garrison or Townsend and terminates in Idaho (e.g., Borah or Brady or Midpoint substation). The size of the interconnection and its termination point will depend on the magnitude of the demand for usage of the path.

This initial Open Season study did not examine if the Idaho system can accept the power delivered to its transmission system, or what additional system reinforcements are needed to move the power beyond the Idaho terminal. The possible reinforcements needed in Idaho would depend on the amount of firm commitments on this new interconnection. The cost of the required reinforcements and the location of the southern terminal may also be affected by the amount of firm commitment.

Open Season Transmission Service Requests

Each of the 17 requests was assigned, for study purposes, a source area according to their general location in Montana. The area sources include:

- Eastern Montana Area Sources
    - Colstrip (CS)
    - Montana Southeast (SE)

  - Billings (BL)

- Great Falls Area Sources (GF)

- Western Area Sources (WE)

The following table summarizes the Open Season requests by Source Area and megawatts. A detailed listing of the requests is provided in Appendix 1.

Requests By Area Source	
Area	**MW**
Eastern Area Sources	1,300
Great Falls Area Sources	850
Western Area Sources	100
Total	**2,250**

Summary of Results

NWE used power flow analysis, limited stability analysis and results from prior studies to compile these study results. NWE did not include or consider in this study the potential sources of power that could come from NWE's Generation Interconnect Application or Transmission Service Request queues. Including these other sources would increase the stress on the existing Montana paths, which would impact these study results. However, in the next study phase these potential impacts will be considered in the studies.

The following table displays the study results for the Eastern Area Sources, the Great Falls Sources and the Interconnect choices to move the power from NWE transmission to Idaho. The first two columns provide the study results to move the power across NWE transmission. The third column provides the results to move power from NWE transmission system to Idaho. This table does not include any system improvements for the Western Area Sources. The reason that no system improvements will be required is because the western sources provide counter flow on the existing transmission system and the counter flow is not large enough in size when compared to the path capability to require system improvements.

Eastern Area Source choices:	Great Falls Area Source choices:	Interconnection choices:
Existing System:	**Existing System:**	**New Line - One 230 kV Line:**
Series Comp ampacity, RAS(N-2) Estimated Capacity Increase:	Relies on existing lines. Estimated Capacity Available:	Line from Garrison to Brady Estimated Capacity Increase:
150-200 MW	**200-300 MW**	**400 MW**
Estimated Cost of Improvements:	Estimated Cost of Improvements:	Estimated Cost of Improvements:
$42,000,000	**$7,000,000**	**$138,000,000**
Transmision System Upgrades-no new line Series Comp ampacity & % comp. Incr. (Shunt devices, static & dynamic RAS(N-2) critical design. Estimated Total Capacity Increase:	**New Line - One new 230 kV line:** GT Falls - Garrison 230 kV (109 mi) (Expand GT Falls, Ovando, Garrison) Estimated Total Capacity Increase:	**New Line - One new 345 kV line:** 500/345 kV at Townsend PST at Townsend 404 mi. 345 kV line Estimated Total Capacity Increase:
up to 700 MW	**400 MW**	**700 MW**
Estimated Cost of Improvements:	Estimated Cost of Improvements:	Estimated Cost of Improvements:
$192,000,000	**$51,150,000**	**$584,380,000**
New Line - One new 500 kV Line: Colstrip-Broadview-Townsend-Garrison 35 Percent Compensated Similar to Colstrip - Broadview B-Line Estimated Capacity Increase: **1100 MW** Estimated Cost of Improvements:	**New Line - Two new 230 kV lines:** GT Falls - Garrison 230 kV (109 mi) (Expand GT Falls, Ovando, Garrison Estimated Total Capacity Increase: **800 MW** Estimated Cost of Improvements:	**New Line - One new 500 kV line:** 404 mi. Series Compensated Shunt Compensated Intermediate station 1/2 way for SC Estimated Total Capacity Increase: **1500 MW** Estimated Cost of Improvements:
$733,400,000	**$98,300,000**	**$736,400,000**

The options in this table are generally additive. While the precise cost estimate may vary because of mileage differences and terminal equipment needs, adding the costs will provide a reasonable estimate. For example, to move 900 MW to Idaho, 500 MW from eastern area and 400 MW from the Great Falls area, an estimate of the total cost would be $979.15 M (i.e., $192 M + $51.15 M + $736.4). Note that the total costs for the Great Falls – Garrison section is approximately equal to the total costs for the Great Falls – Townsend section. The cost detail is outlined in Appendix 3.

It is important to note that the costs are high level estimates only. Recent increases in steel prices have dramatically increased the costs to construct new facilities. NWE made these cost estimates by expanding and augmenting, with generic information and professional judgment, the limited information provided by the Open Season requests about their source of power.

Likewise, the MW increases are high level estimates. The MW increases for the various options represent the maximum transfer capability that meets system reliability criteria after line outages. With all lines in service, the capability of the transmission system would be higher. Note that all MW capability reported in this report reflect this philosophy.

NWE Internal Constraints

With the addition of the Open Season responses, NWE existing transmission system becomes more constrained. To expand the use of the Montana to Idaho Path, improvements to NWE's internal transmission system will be needed. The improvements necessary are different for each Area Source and may affect six different paths. All six paths are important elements in analyzing the transmission needs of the participants in the Open Season study. The six paths are:

1. West of Colstrip (WOC—See WECC Path Rating Catalog Path 10.)

2. West of Crossover (WOX—See WECC Path Rating Catalog Path 11.)

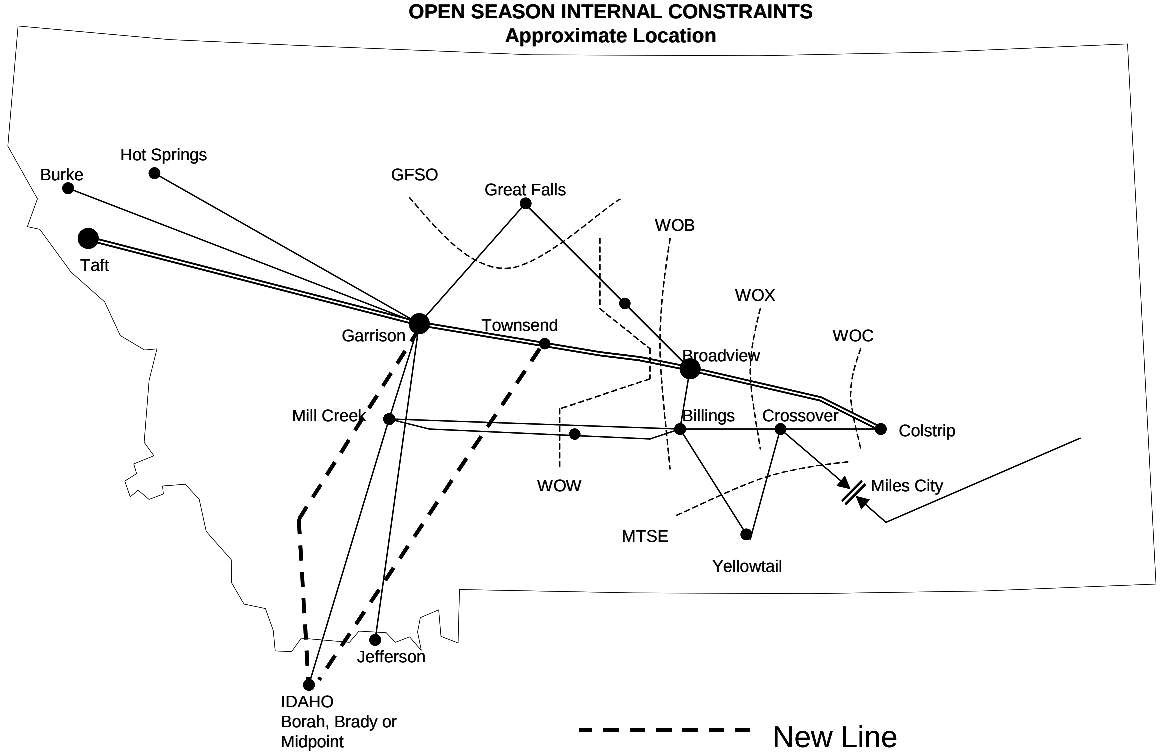
3. Montana Southeast (MTSE—See WECC Path Rating Catalog Path 80.)

4. West of Broadview (WOB—See WECC Path Rating Catalog Path 9.)

5. South of Great Falls (GFSO—Not listed in WECC Path Rating Catalog.)

6. West of wind farms (WOW—New Path.)

OPEN SEASON INTERNAL CONSTRAINTS
Approximate Location



NWE's transmission system improvements will be dependant upon the total amount of power that flows across these transmission paths. There is a mutual dependency between the three areas that make up the Eastern Montana Area Sources since all will make use of at least one common path to transmit their power from eastern Montana to the northern terminal (i.e., Garrison or Townsend) of the new interconnection to Idaho. See Appendix 2 for Path Description Discussion.

Each path shown above (except for item 6) has been recognized as an existing constraint on the NWE transmission system. Some of these paths are presently operating at flow levels that require the use of a Remedial Action Scheme (RAS) in order to assure the stable operation of today's grid. The two Montana Remedial Action Schemes that are presently in place are critical to the proper operation of the Montana transmission system. The protection schemes respond very quickly to certain transmission contingencies, tripping generators and switching shunt devices to protect the system from an unstable event. One of these schemes is adaptive, adjusting its response according to the actual system performance as the event unfolds.

Making heavier use of the existing paths will require either making a modification to the RAS or additions to the physical system. In some cases the adaptive character of the existing RAS means that additional stress increases the exposure of existing generators to tripping. An issue regarding how to modify the RAS and how to implement generator tripping for new generators that is both fair and effective is a confounding problem. This study assumes that these issues can be resolved, but NWE cannot guarantee this outcome. The exact nature of the modifications depends on the technical characteristics, the size and location of the new sources. Varying these parameters can have an impact on the performance of the existing RAS and the communications requirements associated with their location. At some flow level these problems become intractable, and the only reasonable solution is to add transmission lines to mitigate the requirement for RAS. While more costly, this approach assures a system with higher integrity.

This report does not address transmission improvements or additions needed in Idaho or Wyoming that may be necessary to move any additional power. The balance of this report will describe (1) the system improvements needed to move additional power across NWE transmission system; and (2) the MT-Idaho transmission path additions that are needed to move additional power from Montana to Idaho.

Move Power Across NWE System

NWE's transmission system must be upgraded or expanded to move significant amounts of additional power across the system. The magnitude of the upgrade or expansion will be dictated by the amount and location of the new sources of power. To complete this study, NWE put each source into one of three areas described above to identify the total MW within that area. Next, subsets of the total area MW were identified so as to provide discrete MW increases. Using this method, NWE identified answers to the following questions:

1. How much power can be moved across the existing system with minimal improvements?

2. How much power can be moved across the existing system without the addition of a new line?

3. How much power can be moved across the existing system with a new line(s)?

Eastern Montana Area Sources (CS, SE, BL)

This portion of the open season study is designed to test the feasibility of moving up to 1,300 MW out of eastern Montana. There are three stages of this section of the study:

1. How much power can be moved out of eastern Montana on the existing system with minimal improvements?

2. How much power can be moved out of eastern Montana with transmission system upgrades that do not include a new line?

3. How much power can be moved out of eastern Montana with a new 500 kV line going west?

These studies included power flow simulations and dynamic simulations. The studies were conducted on a 2005 light autumn base case with maximum east to west transfers. Power was injected into eastern Montana by connecting a generator directly to the Colstrip 230 kV bus. The intrinsic characteristics of multiple sources were not modeled. This combination of load and generation was chosen to place the maximum amount of stress on the transmission system east of Broadview. The most critical contingencies for all cases include, the loss of any one 500 kV line from Broadview east and the loss of any two side by side 500 kV lines from Colstrip west.

Existing System:

The results of this study indicate that approximately 150 to 200 MW of power may be injected into the existing transmission system with minimal system upgrades, without the need to build a new transmission line. The following system improvements presume that a RAS (assumed to be fast enough and precise enough to preserve transient stability performance, as well as coordinating with existing RAS) for all 500 kV double line contingencies can be developed. NWE cannot guarantee that a RAS can be developed that will maintain system reliability and coordinate in an equitable manner with existing RAS's.

- When the West of Broadview path reaches flows of greater than approximately 2,350 MW, additional RAS is needed for double line contingencies (starting with the Broadview - Garrison double contingency). With the existing RAS in place, the capability of this path without any new generation is 2,573 MW.
- It will be necessary to increase the ampacity of the series capacitors to 3,000 amps on the lines between Colstrip and Broadview and Broadview and Garrison for Colstrip area sources and on the lines between Broadview and Garrison for Southeast area sources. The ampacity of the affected series capacitors needs to be upgraded for any amount of additional generation. The existing series capacitors are rated at 2,000 amps.

Critical contingencies for this scenario include: the loss of any one 500 kV line from Colstrip west and the loss of any two side by side 500 kV lines from Colstrip west.

Approximate Non-binding Cost Estimates:

Assuming the conditions of the above bullets can be met in a timely and equitable manner, a high level estimate is as follows.

1. N-2 RAS (1st Stage) $10 million

2. Series Capacitor Ampacity Upgrade $32 million

Refer to Appendix 3, for cost detail.

Transmission System Upgrades:

Approximately 700 MW of power can be injected in eastern Montana with the addition of transmission system upgrades. For generation additions on the eastern side of NWE's system greater than 150 to 200 MW, the following system upgrades may be sufficient:

- Additional RAS (2^{nd} Stage) is needed for N-2 contingencies. It must be noted that a RAS that maintains system reliability and coordinates in an equitable manner with existing RAS's may not be feasible.
- Increase the ampacity of the series capacitors to 3,000 amps.
- Increase the series impedance compensation to 70% on the lines between Colstrip and Broadview and Broadview and Garrison for Colstrip area sources and on the lines between Broadview and Garrison for Southeast area sources.
- Add a new substation near the midpoint of the Broadview – Garrison 500 kV lines at Townsend. This substation would be the northern terminal of a new line(s) to Idaho.
- Add 36 MVAr of Dynamic VAr devices at Broadview and Garrison.
- Add Shunt capacitive devices at Broadview and Garrison sized between 100 and 150 MVAr depending on the amount of generation additions.
- Specific interconnection locations may require additional 500/230 kV transformers to eliminate transformer overloads caused by the additional power injection.

Approximate Non-binding Cost Estimates:

1. N-2 RAS $10 million
2. Series Capacitor Ampacity Upgrade $32 million
3. Series Capacitor impedance Compensation upgrade (70%) $40 million
4. Townsend Substation $60 million
5. 36 MVAr dynamic VAr device $5 million
6. 100 to 150 MVAr shunt capacitance $10 million

Refer to Appendix 3, for cost detail.

New Line(s)

One new 500 kV line:

Approximately 1,300 MW of power can be injected in eastern Montana with the addition of one westbound 500 kV transmission line from Colstrip to Garrison (with intermediate connections).

Note that if a RAS for 500 kV double line contingencies is not practical, a new line needs to be built for eastern generation additions of greater than 150 to 200 MW.

Approximate Non-binding Cost Estimates:

1. The Colstrip to Garrison 500 kV transmission line was assumed to be 341 miles long. Assuming the cost of this 500 kV line is $1.6 million per mile. Total line cost = $545.6 million.

2. Three sets of series capacitors for the new line $60 million.

3. Townsend substation with six line terminals $80 million.

4. New line terminal at Colstrip $6 million.

5. Two new line terminals at Broadview $10 million.

6. New line terminal at Garrison $6 million.

Refer to Appendix 3, for cost detail.

Montana To Southeast (MTSE)

The MTSE path import transfer capability is limited by unacceptable voltage excursion after critical 500 kV outages in Montana. Under certain conditions the import capability can be limited to 351 MW. The sum of NWE's firm import commitments and the Open Season requests exceed 351 MW. To achieve an increase to the MTSE import capability, system improvements in Montana and Wyoming are needed. In Wyoming, the unacceptable voltage excursion might be mitigated by transmission line improvements or installation of dynamic reactive devices in strategic locations. In Montana, the transmission improvements are captured in the Eastern Area Sources described above.

Approximate Non-binding Cost Estimates:

On a stand-alone basis, MTSE would require:

- Series capacitor ampacity increase at Garrison $16 million

- N-2 RAS $10 million.

- Wyoming system improvements - unknown

System improvements for the Eastern Area sources, including the SE sources, are captured in the Eastern Area Source transmission system upgrades (excluding Wyoming improvements). For the SE sources, the West of Crossover path is more critical than the West of Colstrip path. The reason is that the two tie lines entering NWE's control area at Crossover add flow to the West of Colstrip flow. This makes the total flow on the West of Crossover path greater than the flow on the West of Colstrip path. Approximately 40 percent of the MTSE import power flows into the control area at Crossover adding stress to this path.

Great Falls Area Sources (GF) category:

This portion of the open season study is designed to test the feasibility of moving up to 850 MW out of the Great Falls area. There are three stages of this section of the study:

1. How much power can be moved out of Great Falls on the existing system?

2. How much power can be moved out of Great Falls with one new 230 kV line going south?

3. How much power can be moved out of Great Falls with two new 230 kV lines going south?

These studies included only power flow simulations and were conducted on a 2005 light autumn base case with maximum Missouri river hydro generation in the Great Falls area. Power was injected into the Great Falls area by connecting generation directly to the Great Falls 230 kV bus. The intrinsic characteristics of multiple sources were not fully treated. This combination of load and generation was chosen to place the maximum amount of stress on the transmission system south of Great Falls. The most critical contingencies for all cases include, the loss of the 230 kV lines originating at Great Falls, the Judith Gap Wind Farm-Broadview 230 kV line, and the 230-100 kV transformers at the Great Falls 230 kV switchyard.

Existing System

The results of this investigation indicate that approximately 200-300 MW of power can be injected into the existing transmission system without the need to build a new transmission line.

- It will be necessary to add new substation equipment to the Great Falls 230 kV switchyard including breakers, bus work, etc.
- Additional 230/100 kV transformer capacity will be required at Great Falls to eliminate transformer overloads caused by the additional power injection.

Critical contingencies for this scenario include: the loss of both southbound 230 kV lines leaving the Great Falls 230 kV switchyard and the loss of the 230 kV line between the Judith Gap Wind Farm and Broadview. The loss of the 230 kV line between the Judith Gap Wind Farm and Broadview would cause overloading of the 230/100 kV transformer at Judith Gap and the 100 kV line between Judith Gap and Harlowton. Curtailing generation at the Judith Gap wind farm can mitigate these overloads. The loss of both of the existing 230 kV lines is regarded as a non-credible event, however this loss would require some form of RAS or OMS to manage the loss.

Approximate Non-binding Cost Estimates:

1. New substation equipment to the Great Falls 230 kV switchyard $5 million

2. Additional 230/100 kV transformer capacity $2 million

New Line(s)

One new 230 kV line:

Approximately 400 MW of power can be injected in the Great Falls area with the addition of one southbound 230 kV transmission line. Two possible termination scenarios were considered:

1. A 230 kV transmission line from Great Falls to Garrison by way of Ovando.

2. A 230 kV transmission line from Great Falls to Townsend that follows the path of the existing 100 kV lines between these points.

The Great Falls-Townsend option assumes that a new substation has been established on the 500 kV transmission line near Townsend. On a power flow basis, both options provide acceptable results. Additional detailed studies will be necessary to determine which option provides the best solution.

Approximate Non-binding Cost Estimates:

Scenario 1:

1. The Great Falls-Garrison 230 kV transmission line was assumed to be 109 miles between Great Falls and Ovando and 33 miles from Ovando to Garrison. Cost of this line is approximately $350,000 per mile. Total line cost = $49.6 million.

2. Because all of the 230 kV lines in the area originate at Great Falls, it will be necessary to ensure that the bus is designed and modified in such a way that no single event can cause the loss of the entire bus, thereby causing the loss of all 230 kV Great Falls area transmission lines. The cost of these improvements could cost $5 million dollars, depending strongly on the number of new sources to be connected.

Scenario 2:

1. Great Falls-Townsend 230 kV transmission line was assumed to be 106 miles long. The line has a 478 MVA and 1200 Amp rating at 230 kV. Cost of this line is approximately $350,000 per mile. Total line cost = $37.1 million.

2. Two 500/230 kV transformers were also added at Townsend. These were assumed to be identical to the existing 500/230 kV transformers at Broadview. These could be expected to cost approximately $6 million each.

Two new 230 kV lines:

Approximately 850 MW of power can be injected in the Great Falls area with the addition of two southbound 230 kV transmission lines. Again, two possible routes were considered:

1. A 230 kV transmission line from Great Falls to Garrison by way of Ovando.

2. A 230 kV transmission line from Great Falls to Townsend that follows the path of the existing 100 kV lines between these points.

Combinations include two Great Falls-Townsend lines, one Great Falls-Townsend line and one Great Falls-Garrison line, or two Great Falls-Garrison lines. All of these combinations provide acceptable results and further study is required to determine the most appropriate transmission line connection scheme.

Approximate Non-binding Cost Estimates:

Scenario 1:

1. The two Great Falls-Garrison 230 kV transmission lines were assumed to be 109 miles between Great Falls and Ovando and 33 miles from Ovando to Garrison. Cost of this line is approximately $350,000 per mile. Total line cost = $99.2 million.

2. Because all of the 230 kV lines in the area originate at Great Falls, it will be necessary to ensure that the bus is designed and modified in such a way that no single event can cause the loss of the entire bus, thereby causing the loss of all 230 kV Great Falls area transmission lines. The cost of these improvements could cost $6 million dollars, depending strongly on the number of new sources to be connected.

Scenario 2:

1. The two Great Falls-Townsend 230 kV transmission lines were assumed to be 106 miles long. The line has a 478 MVA and 1200 Amp rating at 230 kV. Cost of this line is approximately $350,000 per mile. Total line cost = $74.2 million.

2. Two 500/230 kV transformers were also added at Townsend. These were assumed to be identical to the existing 500/230 kV transformers at Broadview. These could be expected to cost approximately $6 million each.

Western Area Sources category:

Those proposals that are from Western sources will provide counter flow on the Montana – Northwest Path (Path 8 in the WECC PRC). This will generally counter the normal east-to-west flow on the path. No system improvements will be required to provide service for these proposed transfers.

Move Power from Montana to Idaho

Once additional power is moved away from the Source Area across NWE's transmission system, it must be moved from Montana to Idaho. There are two possible locations examined in this analysis. The first was the construction of a new 500 kV substation at Townsend. The second was expansion of the Bonneville Power Administration (BPA) 500 kV substation at Garrison. NWE has not confirmed with BPA that this second option is viable. Because of the benefits achieved by improved transient stability performance when the Broadview – Garrison lines are subdivided, a substation at Townsend will be recommended.

500 kV Alternative:

The size of the interconnection to Idaho will depend on the amount of Open Season participation. A preliminary investigation shows that a single series-compensated 500 kV line with two segments and two series compensation stations roughly dividing the overall distance in half can move approximately 1,400 MW from Montana into Idaho. Transferring the full 2,250 MW of proposed transfers would require a second 500 kV line.

A set of system improvements that would accommodate all parties that have expressed an interest could cost in excess of $2 billion including all internal improvements, a pair of phase-shifting transformers at Townsend, and two 500 kV lines for the Idaho interconnection. This would include a third 500 kV line from Colstrip to Broadview, Broadview to Townsend, and Townsend to Garrison each complete with 35 percent series compensation, line shunt reactors state-of-the-art relay protection, high-speed circuit breakers, and breaker-and-a-half bus design at Townsend. This figure is just a high level estimate (not meant to be precise) and it does not include any estimate for improvements beyond the basic connection at the Midpoint station in Idaho. If participation were lower the cost would go down step-wise as the various elements of a complete solution are removed.

The following table outlines the estimated cost for a single 500 kV line.

Estimated Cost for a single 500 kV line		
Item	**Townsend**	**Garrison**
Line	$650M	$625M
Terminal equipment	$12M	$12M
Phase shifting transformers	$30M	$30M
Series Capacitors	$40M	$40M
Shunt Reactors	$8M	$8M
Total	**$740M**	**$715M**

Double the above for two 500 kV lines.

345 and 230 kV Alternatives:

Transferring a lesser amount (less than 1,400 MW) would be feasible with less series compensation, or possibly with a 345 or 230 kV line instead.

A 345kV line would cost about two thirds of the price of a 500 kV line and carry one half as much power (roughly 700 MW). Also, a 345 kV line would require a 500/345 kV transformation at the northern terminal. This would add about $10M depending on the desired rating.

A single 230 kV line from Garrison to Brady with stops at Mill Creek, and Antelope could be built at a total cost of $150M. The cost from Townsend to Brady is about the same. This could deliver up to 300-400 MW depending upon the exact design (to maximize the capacity, stronger towers with double conductor and series compensation would be required, this might increase the cost per mile above that used in our estimate of the cost for this option).

Appendix 1

Requests by Area Source		
	Capacity	**Source Location**
Eastern Montana - Colstrip Area Sources (CS)		
PPL Montana	75	Colstrip
PPL Montana	25	Colstrip
Great Northern Power Development	500	Colstrip
Idaho Power Company	150	Colstrip
PowerX	100	Harden
PPL Montana	50	Colstrip
CS Total	900	
Eastern Montana - Southeast Area Sources (SE)		
Sempra	25	Crossover
Sempra	25	Yellowtail
PowerX	100	Yellowtail
Sempra	25	Yellowtail
Sempra	25	Crossover
SE Total	200	
Eastern Montana - Billings Area Sources (BL)		
WEST	200	WKN
Great Falls Area Sources (GF)		
FAME	200	Glascow
FAME	300	Glascow
MATL	350	Alberta
GF Total	850	
Western Area Sources (WE)		
Sempra	50	BPAT(TT)
Sempra	50	TAFT(BPA)
WE Total	100	
Total Requests	**2,250**	

Appendix 2

Path Description Detailed Discussion

The following is a discussion of how each of the six critical paths.

The West of Colstrip path is only important for proposals to move power from the Colstrip Area Source. The most important lines in this path are the two 500 kV lines between Colstrip and Broadview. These lines are series compensated. Presently, the series capacitors in one of these lines may exceed their full time rating for the loss of the other 500 kV line. NWE has an overload mitigation scheme in place to reduce the flow on the series capacitor in response to this outage. Also, a three-phase fault at the Colstrip bus can result in unit tripping at Colstrip. Adding more flow on this path increases the generator-tripping requirement for this contingency. A third line between Colstrip and Broadview would eliminate both the need for unit tripping, and the need for an overload mitigation scheme.

The West of Crossover path is more critical than the West of Colstrip path. The reason is the two tie lines entering the Montana control area at Crossover add flow to the West of Colstrip flows, making the total flow on the West of Crossover path greater than the flow on the West of Colstrip path when there are imports from the Montana-Southeast (MTSE) path. Approximately 40 percent of the MTSE import power flows into the Montana control area at Crossover adding stress to this path. This path is important for proposals to move power from the Colstrip Area Source and from the Southeast Area Source.

The West of Broadview path moves power westward out of the Billings area. Presently, this path is the most critical path for moving power from eastern Montana to western Montana. It is limited primarily by transient stability performance. All increases in power moving into the Billings area over the West of Crossover and the MTSE path must ultimately add to the flow on the West of Broadview path. Generator tripping at Colstrip plays a big role in determining the transfer capability on this path. Adding additional flows on this path will increase the stress on the path and increase the requirements for generator tripping to maintain performance. There are a number of possible improvements to the path that could allow it to accommodate additional flow with less increase in the generator-tripping requirement. These improvements also mitigate problems caused on the West of Colstrip, West of Crossover, and MTSE paths. These include increasing the ampacity of the series capacitors in the 500 kV lines, increasing the series compensation in the 500 kV lines, adding switched shunt capacitors, adding static VAr devices, and placing a substation near the midpoint of the Broadview – Garrison lines to improve transient stability performance.

None of these improvements are very effective for a double contingency that results in the loss of both lines in a single segment of the 500 kV system. We refer to these as side-by-side contingencies. For side-by-side contingencies, generator tripping (by a RAS) would still be vital to system performance. Adding a third line between Broadview and Garrison or Colstrip and Garrison is the only reasonable way to reduce the need for more generator-tripping for side-by-side contingencies since the remaining system cannot be expected to remain stable.

There are two large wind farms that are proposed in the Billings area that are actually west of the official metering points for the West of Broadview path. For this reason it is necessary to define the new path “West of wind farms” (WOW) to properly measure the stress across the Montana system when these wind farms are in service. One of these wind farms is already committed to be in service in the near future. The other is one of the participants in this Open Season. These new wind farms will add significantly to the flows on this new critical path across Montana. This study recognizes that fact by defining this new transmission path. It is expected that this flow measurement will become more critical than the West of Broadview path that has been used in the past, since it will reflect the higher flows caused by the presence of these wind farms as well as the flows on the traditional West of Broadview path. The above remarks (previous paragraph) about the West of Broadview path will also apply to the West of Wind Farms path. The presence of these two wind farms will effectively increase the stress between eastern Montana and western Montana. One effect of this increase in stress will be increased flows on the 500 kV lines between Broadview and Garrison when generation is added at the wind farms. Thus, the West of Wind Farms flow will be a better measure of the total stress between eastern Montana and western Montana.

Summary:

Moving power from the Colstrip Area Source will require improvements to the West of Colstrip path and the West of Crossover path, in addition to improvements to the West of Broadview path and the West of Wind Farms path to deliver the proposed additional power to Idaho via the new interconnection.

Proposals to move power from the Southeast Area Source will require improvements to the MTSE path, the West of Crossover path, the West of Broadview path, and the West of Wind Farms path.

For projects that are in the Billings Area Source there may be a requirement to improve the West of Wind Farms path before the power can be delivered to Idaho via the new interconnection.

Projects in the Great Falls Area Source may require improvements to the Great Falls South path to deliver the additional power to be exported from the Great Falls area to Idaho.

The amount and cost of the required improvements for each path is clearly dependent on both the size of the new demands on that path due to the presence of new sources (and schedules) and on the intrinsic characteristics of that source. This report does not treat the intrinsic characteristics thoroughly, partly because the nature of each source has yet to be made available to NWE, and partly in the interest of delivering a prompt "feasibility" report. In the dialogue that follows each of the Area Sources is discussed individually:

Colstrip (CS) Area Source:

There are more constraining paths that may require improvements to deliver power from the Colstrip area source of interested parties than there are for any of the other Area Sources. The paths that will require improvement are West of Colstrip, West of Crossover, West of Broadview, and West of Wind Farms.

As noted earlier many of the most important limitations of these paths revolve around transient stability of the system for major 500 kV events. This is crucial to a proper understanding of what must be done to accomplish a greater transfer than the limits that are presently stated. Meeting the WECC performance for these paths is already difficult with the demands that the existing system places on these paths. Adding additional resources that require increased flow levels exacerbates a situation that is already challenging. What follows is a general discussion of the issues that arise when any of these paths are heavily loaded, and what flow levels will result in the need for a new line, as transient stability performance cannot be maintained. Because of the relative weakness of 230 kV lines compared to 500 kV lines, and because of the transient stability issues of these paths, no 230 kV line additions were considered for the improvements of the eastern paths in this study. The simultaneous operation of all participants in the Colstrip region will likely require the addition of a new 500 kV line from Colstrip to Broadview. This would increase the capacity of the West of Colstrip and the West of Crossover paths.

The fourth of these paths, West of Wind Farms, is certain to become an important path because it measures the additional stress that will be placed on the NWE system west of the Billings area due to the presence of the new wind farms that are either proposed to connect or are committed to be connected in the vicinity of Billings. Collectively these projects can generate well in excess of 500 MW. These will be an important stressor of the NWE system west of the Billings area.

Southeast (SE) Area Source:

Interested parties in the Southeast Area Source propose to inject power into the NWE system at either Crossover or Yellowtail. Both of these points of interconnection contribute to flow on the MTSE path (Path 81). Approximately 40 percent of the incremental flow on this path must also flow westward on the West of Crossover path. The MTSE path operating transfer capability is governed by a nomogram that reflects the dependence of the actual flow limit upon Yellowtail generation and Miles City DC tie flow. There is also a slight dependence upon loads, with a lower limit during heavy load hours. The future of the MTSE path operating transfer capability is uncertain because of the effects of unit tripping of Eastern Montana Generation upon the performance of this path. It is also uncertain because of the possibility that some of the lines in the Yellowtail area may have to be removed in the near future. This could result in a lower operating transfer capability for the path, or in an increase depending upon the adjustments that may be made to "restore" the capacity on this path by building new lines.

Billings (BL) Area Source:

The only interested party classified in the Billings Area Source is the WKN project. Given the size of the WKN project, there may be a need to add a 230 kV line (or some other connection) specifically to treat the local problems of the 230 kV system where it is to be located. The generator interconnection study for that project will address this issue. This Open Season Feasibility Study is not intended to evaluate that concern. The Billings Area Sources will add to the need to improve the system in the same way as the Colstrip Area Source and the Southeast Area Source projects by contributing to the total flow on the West of Wind Farms path.

Appendix 3

Item	Unit Cost $M		Description
Garrison-Mill Creek-Antelope-Brady 230kV	105	300	miles of 230 kV line. (@$350k/mi)
230 Kv PST (450 MVA, 60 deg)	8		Phase Shifting transformer for the new 230 kV line
Series Capacitors (230 kV line)	8		Required to achieve high transfer capbility of 400 MW.
Shunt Caps	5		Required to achieve high transfer capbility of 400 MW.
Expand Mill Creek	4		Two new 230 kV line terminals.
Expand Antelope	4		Two new 230 kV line terminals (may be optional).
Expand Brady	2		One new 230 kV line terminal.
N-2 (double contingency) RAS	10		RAS to provide for fast unit tripping of new generation in eastern clusters.
Further N-2 RAS enhancements	10		RAS enhancements to accommodate flows greater than 200 MW from Eastern MT.
Series Capacitor Ampacity upgrade	32		Enhance (4) existing series capacitors to 3200 Amps BV->CS & GR->BV
Series Capacitor 70pct (TCSC)	40		Increase percent compensation to 70 Percent & increase rating (4 existing series caps).
Townsend 500 kV four-terminal station	60		Station to sectionalize the existing two Broadview-Garrison lines (not including terminal for interconnection).
36 MVAr dynamice Var device	5		Thyristor controlled voltage regulating shunt device.
100-150 MVAr switched shunt Capacitor bank	10		Additonal Voltage support to improve system performance with the added flows from eastern Montana.
Midpoint - Townsend 500kV	646.4	404	miles 500 kV line (@1.6M/mi)
Series Caps at Du Bois	20		34 ohms 500 kV class series caps
Series Caps at TN for MP line	20		34 ohms 500 kV class series caps
Third Colstrip - Broadview line	185.6	116	miles of 500 kV line (@1.6M/mi)
Third Broadview - Townsend line	213.6	133.5	miles of 500 kV line (@1.6M/mi)
Third Townsend Garrison line	147.2	92	miles of 500 kV line (@1.6M/mi)
Series Caps at TN for BV line(1)	10		22.5 ohms 500 kV-class series caps
Series Caps at TN for BV line(2)	10		22.5 ohms 500 kV-class series caps
Series Caps at TN for BV line(3)	20		22.5 ohms 500 kV-class series caps
Series Caps at BV for CS line(3)	20		19.7 ohms 500 kV-class series caps
Series Cap at GR line(3)	20		17 ohms 500 kV-class series caps
modify existing caps to reduce X	5		change exist GR-BV caps to 17 ohms for 35 percent GR-TN
PST-TN(1)	15		650 MVA 500 kV class PST
PST-TN(2)	15		650 MVA 500 kV class PST
Midpoint 500 kV station	5		one new 500 kV line terminal with 2 breakers.
Townsend 500 kV six-terminal station	80		Six-500 kV lines, two PSTs, two 500/230 kV xfrmrs.
Townsend 500 kV line terminal	5		one new 500 kV line terminal with 2 breakers.
Broadview 500 kV station exp	10		two new 500 kV line terminals with 2 breakers.
Garrison 500 kV station exp	6		one new 500 kV line terminal with 1 breaker.
Colstrip 500 kV station exp	6		one new 500 kV line terminal with 1 breaker.
500/230 kV transformers TN	12		Two 500 MVA autotransformers for GF lines.
Townsend 230 kV station	6		Two 230 kV line terminals and two autotransformers.
Great Falls - Townsend 230 kV(1)	37.1	106	miles of 230 kV line. (@$350k/mi)
Great Falls - Townsend 230 kV(2)	37.1	106	miles of 230 kV line. (@$350k/mi)
Great Falls - OV - GR 230 kV(2)	38.15	109	miles of 230 kV line. (@$350k/mi)
Great Falls - OV - GR 230 kV(3)	38.15	109	miles of 230 kV line. (@$350k/mi)
Great Falls 230 kV station	5		four more 230 kV line terminals
Great Falls 230/100 kV Transformer	2		New autotransformer
Ovando expansion	4		four more 230 kV line terminals
Garrison expansion	2		two more 230 kV line terminals
Total Cost M$			

Item	E-MT EX	E-MT TSU	E-MT New	GF EX	GF New 1	GF New 2	Int-New 230	Int-New 345	Int-New 500
Garrison-Mill Creek-Antelope-Brady 230kV	0	0	0	0	0	0	105	0	0
230 Kv PST (450 MVA, 60 deg)	0	0	0	0	0	0	8	0	0
Series Capacitors (230 kV line)	0	0	0	0	0	0	8	0	0
Shunt Caps	0	0	0	0	0	0	5	0	0
Expand Mill Creek	0	0	0	0	0	0	4	0	0
Expand Antelope	0	0	0	0	0	0	4	0	0
Expand Brady	0	0	0	0	0	0	2	0	0
N-2 (double contingency) RAS	10	10	0	0	0	0	0	0	0
Further N-2 RAS enhancements	0	10	0	0	0	0	0	0	0
Series Capacitor Ampacity upgrade	32	32	0	0	0	0	0	0	0
Series Capacitor 70pct (TCSC)	0	40	0	0	0	0	0	0	0
Townsend 500 kV four-terminal station	0	60	0	0	0	0	0	60	0
36 MVAr dynamice Var device	0	5	0	0	0	0	0	0	0
100-150 MVAr switched shunt Capacitor bank	0	10	0	0	0	0	0	0	10
Midpoint - Townsend 500kV	0	0	0	0	0	0	0	452.48	646.4
Series Caps at Du Bois	0	0	0	0	0	0	0	20	20
Series Caps at TN for MP line	0	0	0	0	0	0	0	20	20
Third Colstrip - Broadview line	0	0	185.6	0	0	0	0	0	0
Third Broadview - Townsend line	0	0	213.6	0	0	0	0	0	0
Third Townsend Garrison line	0	0	147.2	0	0	0	0	0	0
Series Caps at TN for BV line(1)	0	10	10	0	0	0	0	0	0
Series Caps at TN for BV line(2)	0	10	10	0	0	0	0	0	0
Series Caps at TN for BV line(3)	0	0	20	0	0	0	0	0	0
Series Caps at BV for CS line(3)	0	0	20	0	0	0	0	0	0
Series Cap at GR line(3)	0	0	20	0	0	0	0	0	0
modify existing caps to reduce X	0	5	5	0	0	0	0	0	0
PST-TN(1)	0	0	0	0	0	0	0	10.5	15
PST-TN(2)	0	0	0	0	0	0	0	0	15
Midpoint 500 kV station	0	0	0	0	0	0	0	3.5	5
Townsend 500 kV six-terminal station	0	0	80	0	0	0	0	0	0
Townsend 500 kV line terminal	0	0	0	0	0	0	0	3.5	5
Broadview 500 kV station exp	0	0	10	0	0	0	0	0	0
Garrison 500 kV station exp	0	0	6	0	0	0	0	0	0
Colstrip 500 kV station exp	0	0	6	0	0	0	0	0	0
500/230 kV transformers TN	0	0	0	0	0	0	0	8.4	0
Townsend 230 kV station	0	0	0	0	0	0	0	6	0
Great Falls - Townsend 230 kV(1)	0	0	0	0	0	0	0	0	0
Great Falls - Townsend 230 kV(2)	0	0	0	0	0	0	0	0	0
Great Falls - OV - GR 230 kV(2)	0	0	0	0	38.15	38.15	0	0	0
Great Falls - OV - GR 230 kV(3)	0	0	0	0	0	38.15	0	0	0
Great Falls 230 kV station	0	0	0	5	5	6	0	0	0
Great Falls 230/100 kV Transformer	0	0	0	2	2	4	0	0	0
Ovando expansion	0	0	0	0	4	8	0	0	0
Garrison expansion	0	0	0	0	2	4	2	0	0
Total Cost M$	42	192	733.4	7	51.15	98.3	138	584.38	736.4

Note: All Costs shown in Appendix 3 are high level cost estimates only.