Economic Study Request: North Plains Connector

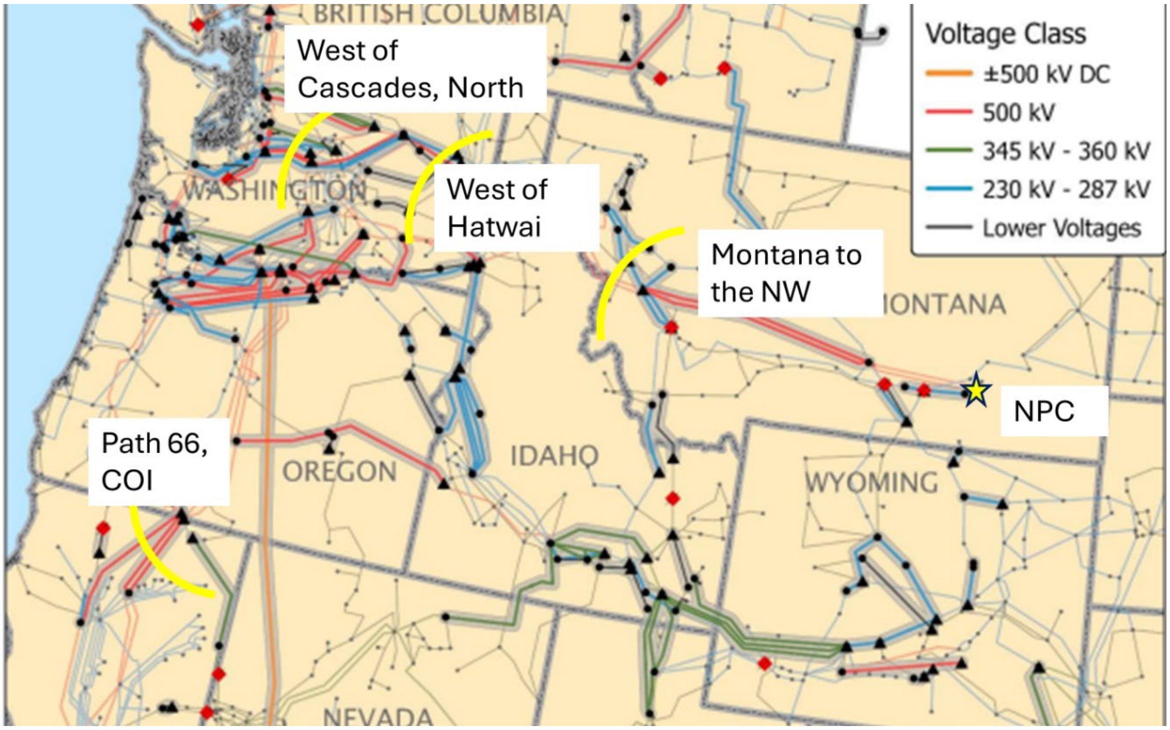
Request

In March of 2024, North Plains Connector, LLC submitted an Economic Study Request for consideration in the first year of the 2024- 2025 planning cycle. The North Plains Connector (NPC) project is a proposed 3,000 MW high-voltage direct current voltage source converter (HVDC VSC) 412 mile transmission line that would interconnect at the 500 kV Colstrip substation in Montana and terminate in North Dakota.

The request is to understand the potential impacts to the congestion in the NorthernGrid footprint. No new loads or generation resources were submitted in conjunction with this HVDC VSC project.

Discussion

The point of interconnection for the NPC project, the Colstrip 500 kV substation, currently exists at the terminus of a 500 kV transmission system. The original intent of the 500 kV transmission system was to take the generation output from the Colstrip generation plant and export it to serve load in the west. The 500 kV system is also at the "edge" of the Western Interconnection which resulted in predominate west-bound electric flows on the 500 kV system out of Montana on Path 8. The presence of NPC fundamentally changes the physics of the system such that a west-bound Path 8 may now experience either greater westbound flows/increased utilization of the path or increased eastbound flows, which is "new" from a physics perspective. Eastbound flows on Path 8/the 500 kV system into Montana were historically limited, generally, to the load in Montana combined with the exports on Paths 18, 80, and 83. From a reliability perspective, westbound flows are controllable through remedial action schemes that instantly turn down generation. Eastbound flows have historically been limited by an outage on the 500 kV system west of Garrison that overloads the underlying 230 kV system.



Analysis

Production cost modeling analysis will be used to determine if the HVDC project would result in any impacts to congestion. The production cost analysis will consist of the following:

1. The same version of the 2034 ADS as the primary NorthernGrid regional planning effort will be used for the 2034 ADS request. The 2034 ADS will be modified to include any regional projects, generation changes, or load changes to most effectively reflect the 2024 Q1 NorthernGrid submittal. Because the NPC interconnects at a currently radial substation in Montana, the load and generation in Montana will have a direct impact to the output of the NPC. New renewable generation resources were added in Montana for the NorthernGrid analysis; these resources also have a direct impact on the operations of the NPC.
2. Production cost modeling will be run to establish the total production cost of the western interconnection over a year and identify areas of congestion; production cost modeling assumes all pieces of equipment are "in-service" with no unplanned outages.
3. The DC line will be modeled into the ADS as a pumped storage project. The WECC base cases terminate at Colstrip, which is at the eastern edge of the western interconnection. North Dakota is part of the eastern interconnection and is not modeled in WECC base cases. From a physics perspective, the proposed HVDC VSC at Colstrip would act similarly to a storage resource. When the HVDC VSC project is delivering energy into the eastern markets, it creates east-bound flows on the 500 kV Colstrip Transmission System (CTS). Similarly, when the HVDC VSC is delivering energy into the western markets, it creates west-bound flows on the CTS. It is the east- and west-bound flows on the CTS that may impact the congestion or reduce the overall

production cost to serve load. A storage resource with nearly instantaneous response will serve as replacement for the study purposes of understanding the congestion impact on the CTS.

The output for the HVDC model was derived as a function of the production cost model; no hourly, annual, or otherwise profile was used. The market drivers of the production cost model analysis were the determining factor for the output of the HVDC model.

4. Production cost modeling will be run on the modified ADS and comparisons will be made to the initial production cost and congestion values.

Results

The presence of the North Plains Connector has the potential to impact path flows, Locational Marginal Price (LMP), generation cost, generation dispatch, congestion, to list a few. The results of this analysis will focus on how the North Plains Connector project impacts both the local and regional areas through exploration of select myriad production cost modeling characteristics.

The NPC project interconnects to the 500 kV Colstrip substation which is part of WECC Path 8, Montana to the Northwest. Path 8 is a predominantly westbound path with a rating of 2200 MW in the westbound direction indicated by positive values and 1350 MW in the eastbound direction, indicated by negative values. Eastbound and westbound Path 8 flows were kept within the WECC path rating before and after the addition of the NPC project.

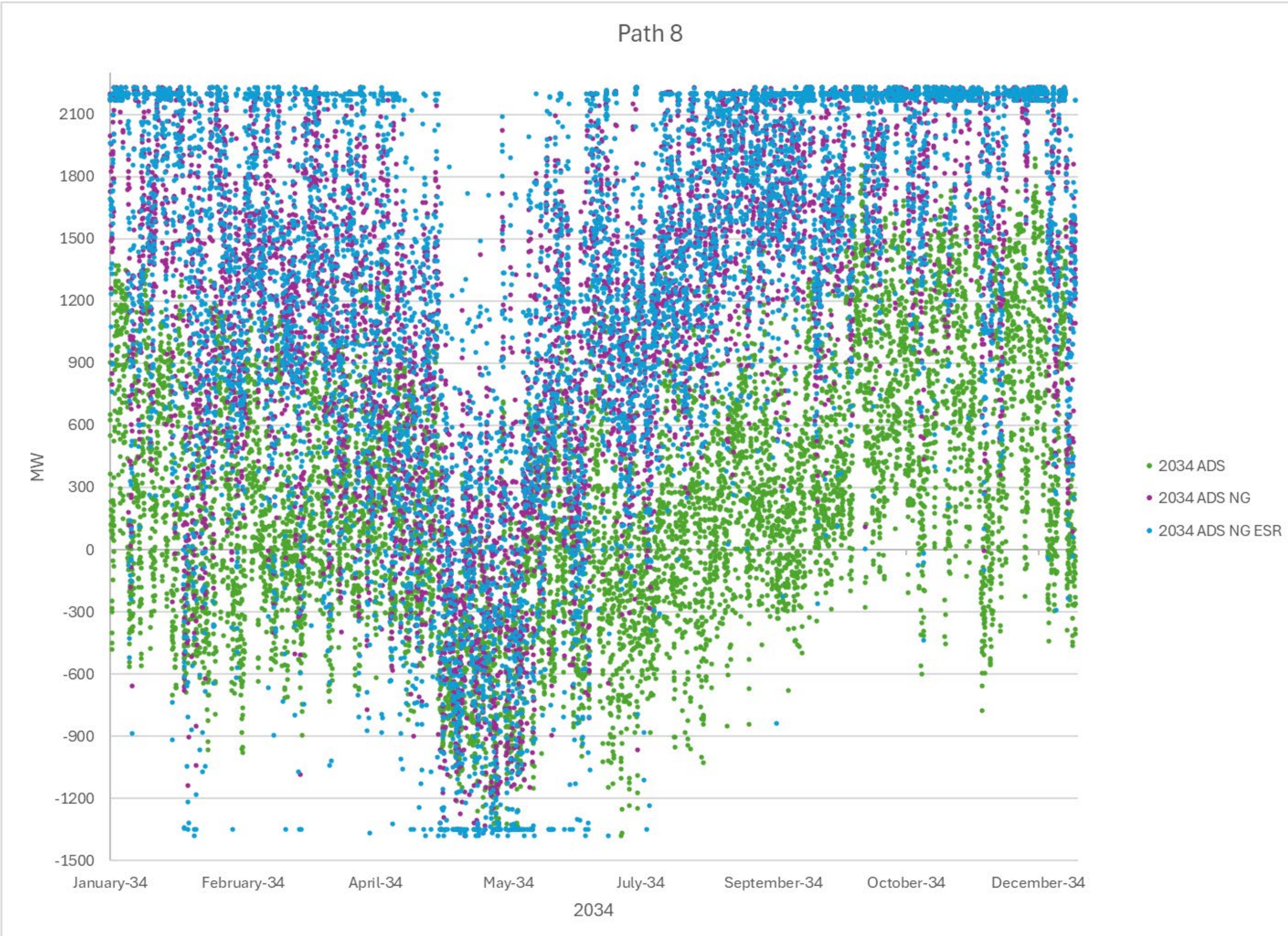


Figure 1: Path 8, Montana to the Northwest

Figure 1: Path 8, Montana to the Northwest represents the time series output of the 8760-hour production cost model run. The ADS case with no changes to generation in the Montana area results in demonstrably less power flow on Path 8. The "2034 ADS NG" case was modified to include generation additions to reflect NorthernGrid Members' IRPs. The 2034 ADS NG case along with the 2034 ADS NG ESR case (with NPC) both result in substantially higher activity on Path 8 in both the westbound, with the NPC contributing more to eastbound flows as can be seen in subsequent figures.

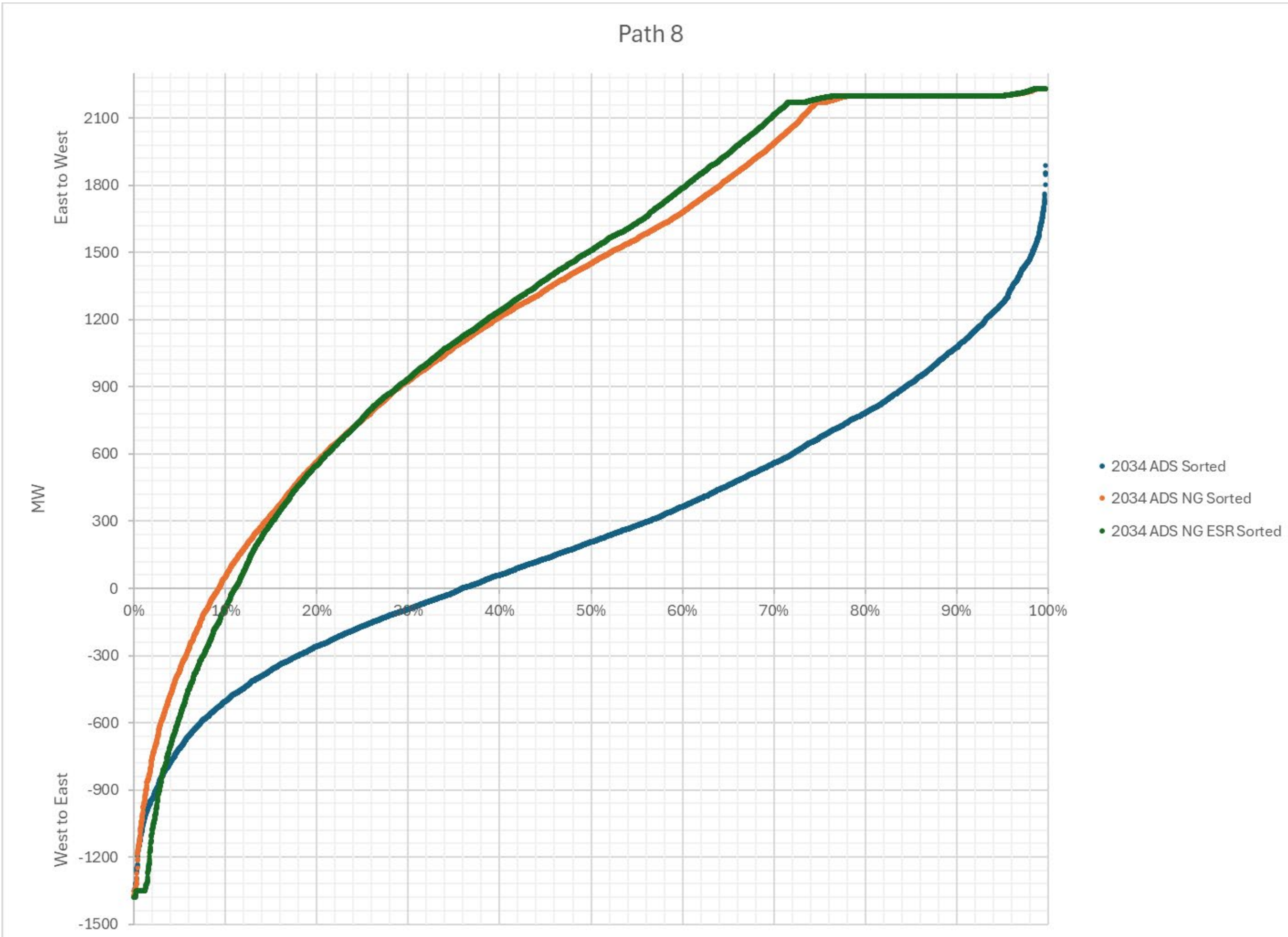


Figure 2: Sorted Values for Path 8

Figure 2: Sorted Values, or the cumulative density function (CDF) for Path 8 allow for further examination of the activity on Path 8. Positive MW values or westbound flows will be considered "exports" from the Montana perspective; correspondingly, negative values or eastbound flows will be considered imports.

Without changes to the Montana generation profile, Path 8 generally exports approximately 62% of the time/imports approximately 38% of the time. With additional generation in the Montana area in the 2034 ADS NG case, Path 8 becomes predominantly exporting with imports only occurring approximately 8% of the time. The addition of the NPC project contributes to both imports and exports on Path 8. With NPC, Path 8 does experience more imports increasing to 12% of the time. NPC does appear to force Path 8 to hit its import and export limits more frequently than in the cases without NPC.

Congestion occurs when Path 8 reaches its limit in either direction. Further examination of Figure 3: Path 8 Congestion confirms that the presence of NPC exacerbates the overall congestion observed on Path 8. Congestion in production cost simulations suggests that careful management of the transmission system during congested hours may be helpful to increase utilization and may result in fewer congested hours in real-time operations.

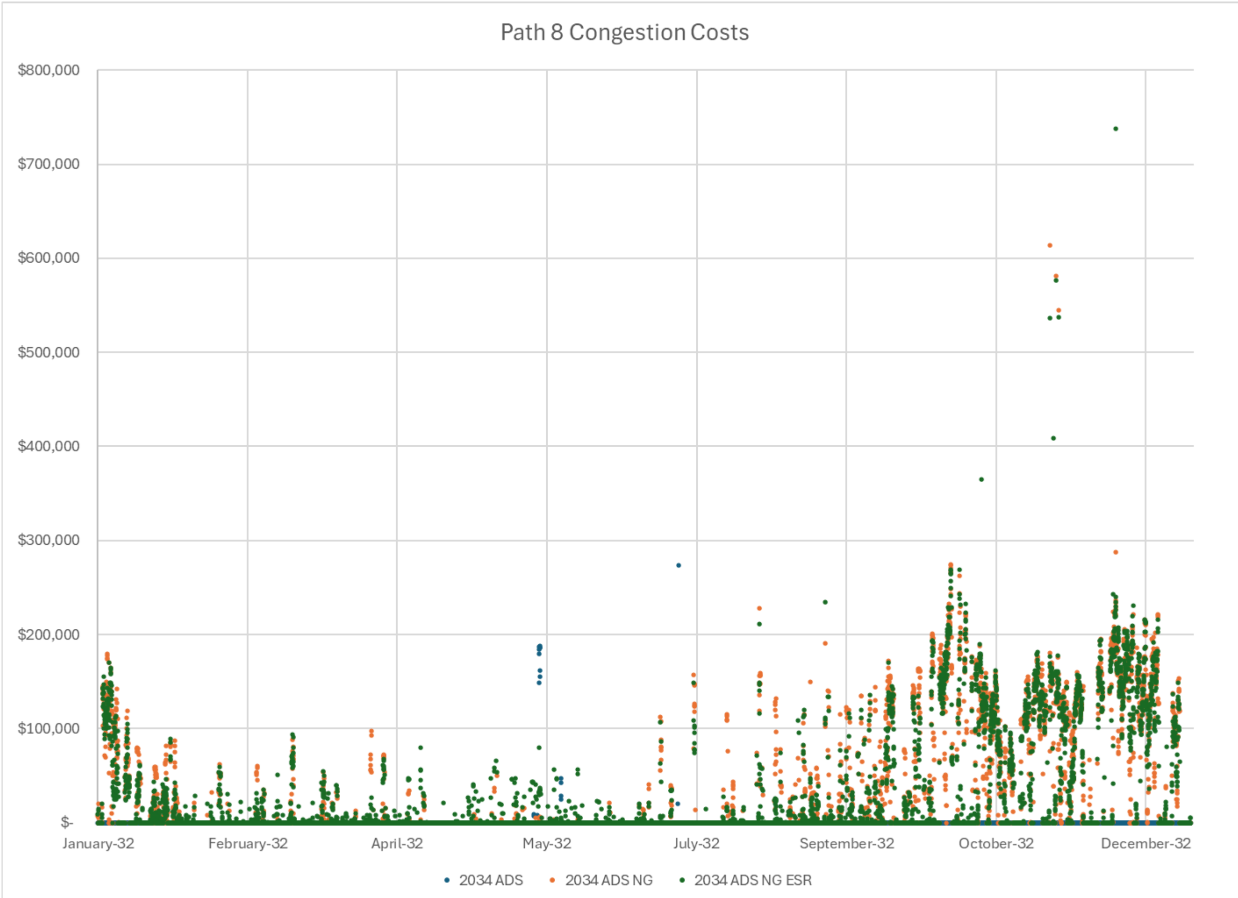


Figure 3: Path 8 Congestion

Moving out further into the Western Interconnection, Path 8 feeds directly into Path 6, West of Hatwai.

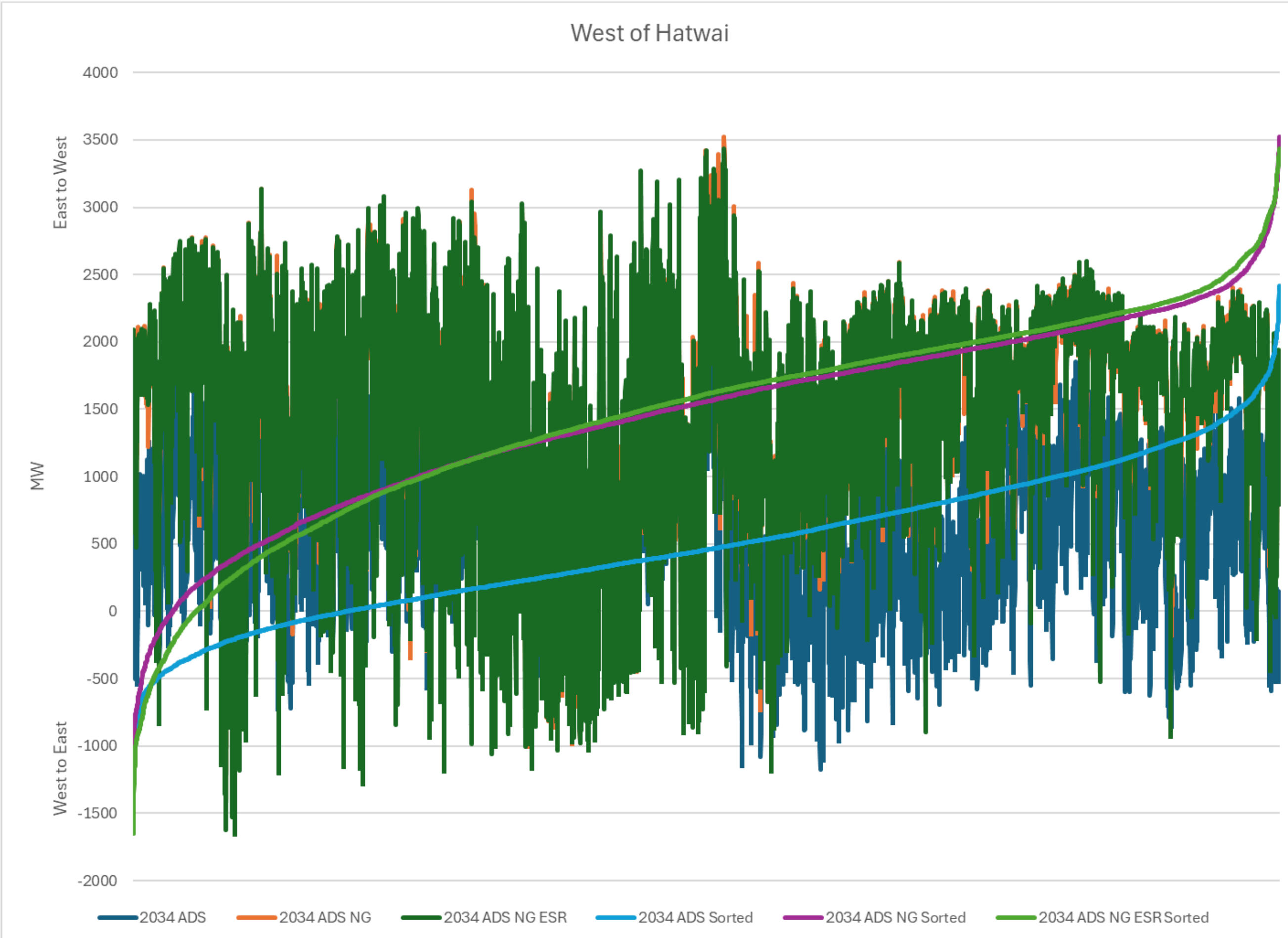


Figure 4: Path 6, West of Hatwai

The addition of generation in Montana has a noticeable impact on Path 6, West of Hatwai. Correspondingly, the CDF for Path 6, West of Hatwai demonstrates that there are increased westbound flows with the addition of generation in Montana and that similar to Path 8, there are also more eastbound flows due to the bi-directional nature of the NPC.

The impact of NPC changes west of Path 6. Path 6 essentially "splits" into two directions, one connecting to Path 4, West of Cascades North to feed into the Seattle area and the other feeds directly into the Mid-C area which is rich with transmission connectivity.

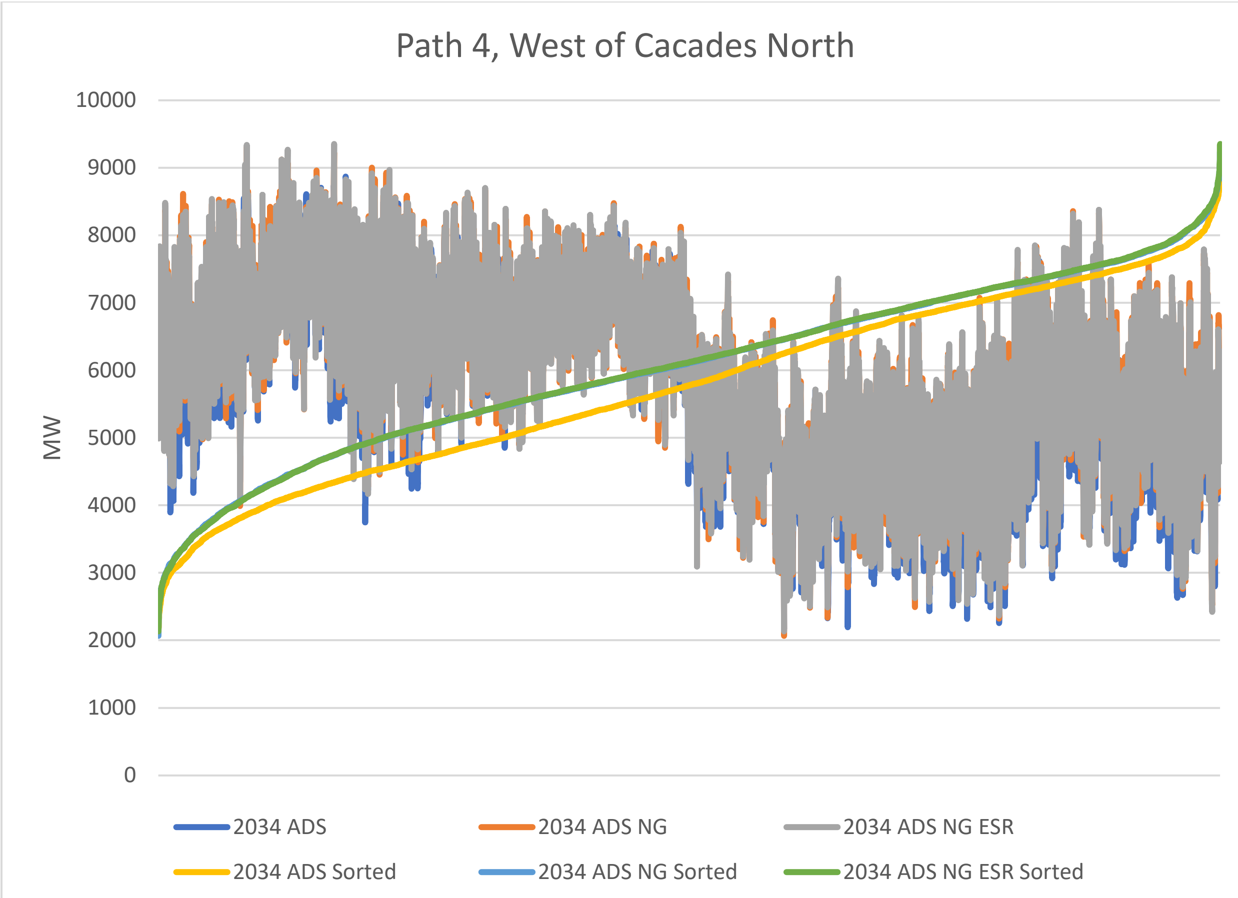


Figure 5: Path 4, West of Cascades North, Time Series and CDF; all flows are East to West

While Figure 6: West of Cascades North, Time Series and CDF contains a lot of information, the impact of the generation additions in Montana can be observed more cleanly in the CDF. The addition of generation in Montana increases the westbound transfers through Path 4, West of Cascades North, but has negligible impact to eastbound transfers. No congestion was observed on Path 4, West of Cascades North for any of the cases.

Interestingly, the change in Montana generation does have impacts as far west and south as the California-Oregon Intertie (COI).

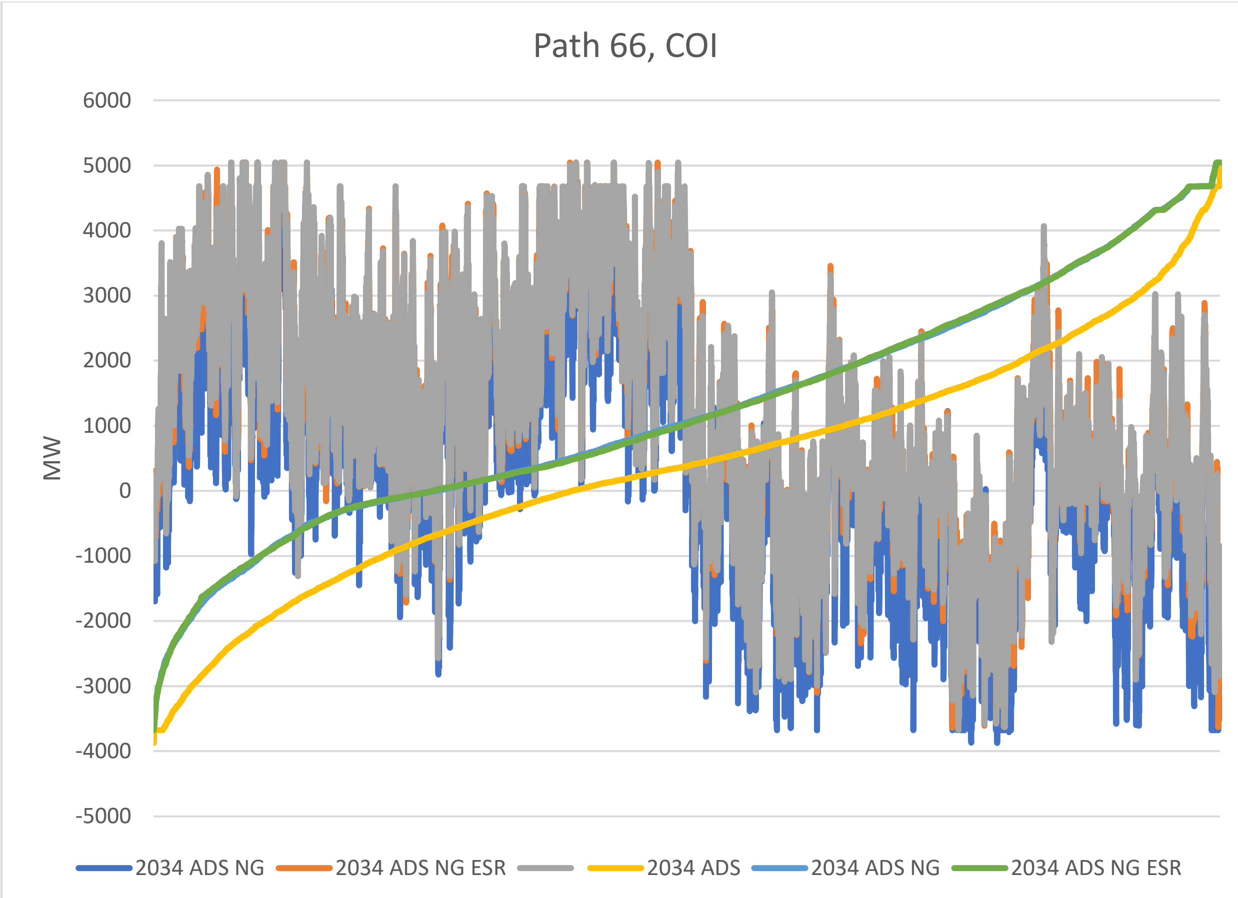


Figure 6: Path 66, COI Time Series and CDF

Figure 7: Path 66, COI Time Series and CDF demonstrates the wide-ranging impact of changing the resource mix in Montana. An increase in westbound flows from Montana translates into an increase in southbound flows on the COI (southbound is positive on COI).

Table 1: Production cost outputs, yearly summary

Characteristic	Area	Montana	NorthernGrid	WECC
Generation (MWh)	ADSNGUpdate	16,113,798	372,064,874	1,155,870,585
	ESR	16,020,514	372,159,011	1,155,847,437
	Impact of ESR on ADS	(93,284)	94,137	(23,148)
Generation Cost (k$)	ADSNGUpdate	138,276	5,044,339	22,743,737
	ESR	135,415	5,033,892	22,715,347
	Impact of ESR on ADS	(2,861)	(10,448)	(28,390)
Load (MWh)	ADSNGUpdate	12,630,534	353,570,180	1,122,377,302
	ESR	12,630,652	353,562,607	1,122,377,759
	Impact of ESR on ADS	118	(7,573)	456
Load Payment (k$)	ADSNGUpdate	461,400	20,365,662	72,511,388
	ESR	464,616	20,440,389	72,704,596
	Impact of ESR on ADS	3,216	74,727	193,208
Estimated Losses (MWh)	ADSNGUpdate	-	9,119,865	32,060,892
	ESR	$ -	$ 9,116,678	$ 32,036,899
	Impact of ESR on ADS	$ -	$ (3,187)	$ (23,993)
LMP Congestion Component ($/MWh)	ADSNGUpdate	(176,245)	(931,541)	(1,909,030)
	ESR	(172,214)	(921,379)	(1,901,911)
	Impact of ESR on ADS	4,031	10,162	7,119
Simple Average LMP ($/MWh)	ADSNGUpdate	291,426	7,132,087	15,956,353
	ESR	295,260	7,169,409	16,025,016
	Impact of ESR on ADS	3,835	37,322	68,663
Spillage (MWh)	ADSNGUpdate	265,640	3,714,230	11,058,645
	ESR	224,148	3,598,597	10,901,635
	Impact of ESR on ADS	(41,492)	(115,633)	(157,010)
SO2 Amt	ADSNGUpdate	10,240	719,998	22,944,162
	ESR	9,861	718,814	22,956,701
	Impact of ESR on ADS	(379)	(1,184)	12,539
CO2 Amt	ADSNGUpdate	11,226,648,494	112,013,854,976	387,349,739,498
	ESR	$ 11,203,459,888	$ 112,146,152,964	$ 386,958,473,674
	Impact of ESR on ADS	(23,188,607)	132,297,988	(391,265,824)
NOx Amt	ADSNGUpdate	1,429,861	53,511,014	295,155,787
	ESR	1,388,406	53,382,837	294,929,152
	Impact of ESR on ADS	(41,455)	(128,176)	(226,635)

In conclusion, from a production cost modeling perspective, the presence of the NPC project contributes to the general east-to-west/north-to-south megawatt flows in the western interconnection. The increased utilization of the paths may result in some spot-instances of congestion; however, the results also suggest the megawatt flows and benefits from the increased utilization on the paths outweigh the detriments from the increased congestion costs.

The results are expected. Per the Discussion section above, it was expected that the presence of NPC could both increase westbound and eastbound flows. The production cost model is limited; real-time trading and operations may yield system conditions that result in increased path utilization without introducing congestion.