NorthernGrid
Economic Study Request
Offshore Wind in Oregon

2023

Contents

Request

In March of 2022, The Oregon Public Utility Commission along with the Oregon Department of Energy jointly submitted to the NorthernGrid planning region a request for both economic and reliability analysis of the regional impacts to the transmission system resulting from the modeling of the installation of 3 GW capacity (nameplate)along Oregon's southern coastline. The high-level details of the request are listed below.

1. 3.0 GW of wind split with 1800 MW interconnected at the Fairview substation near Coos Bay, OR and 1200 MW at the Wendson substation near Florence, OR.

2. Planned in-development date of December, 2032

"This evaluation should also include an identification of transmission system upgrades necessary to accommodate the power flow capacities of key existing transmission corridors and paths (e.g., 230 kV to 500 kV) to enable the full deliverabilty of the power to load with minimal curtailment of generation due to transmission constraints."

Basis for 3 GW and the Selection/Split Across Two Coastal Substations in Southern Oregon

Through adoption of HB 3375 in 2021, the Oregon legislature established a state policy goal to plan for the development of up to 3 GW of floating offshore wind energy projects within federal waters off the Oregon coast by 2030 (see Chapter 376, Oregon Laws 2021). This policy goal is guiding Oregon's state agencies in their exploration of the potential impacts from integrating up to 3 GW of offshore wind into Oregon's electric grid, and is not a commitment to developing offshore wind.

Subsequently, on April 29, 2022, the federal Bureau of Ocean Energy Management (BOEM) identified two "Call Areas" in proximity to the Southern Oregon coast, one near Coos Bay, Oregon, and the other near Brookings, Oregon (see Federal Register, Vol. 87, No. 83. Call Areas are delineated for the purposes of BOEM's call for information and feedback on site conditions, resources, and ocean uses within the call areas; and for nominations of smaller areas of interest within the call areas for potential leases. As of April 2023, BOEM has not yet determined which areas, if any, within the Oregon Call Areas may be offered for lease.

- **Coos Bay Call Area** - BOEM estimates the entire Coos Bay Call Area is approximately 873,000 acres and could accommodate approximately 10.6 GW of offshore wind power capacity; and
- **Brookings Call Area** - BOEM estimates the entire Brookings Call Area is approximately 286,500 acres and could accommodate approximately 3.5 GW of offshore wind power capacity.

The combination of Oregon's state policy goal to plan for up to 3 GW of floating offshore wind, and the two Oregon Call Areas identified by BOEM, formed the basis for studying the economic and reliability effects of interconnecting a total of 3 GW split across two southern Oregon coastal substations located in proximity to the two Oregon Call Areas. The Fairview and Wendson substations were selected for this transmission study because previous Oregon offshore wind transmission studies identified these two existing coastal substations as having the largest capacity to potentially receive new injections of offshore wind power. [1]

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[1] PNNL, Exploring the Grid Value Potential of Offshore Wind Energy in Oregon, May 2020, https://www.osti.gov/servlets/purl/1618872; NREL, Evaluating the Grid Impact of Oregon Offshore Wind, Oct. 2021, https://www.nrel.gov/docs/fy22osti/81244.pdf.

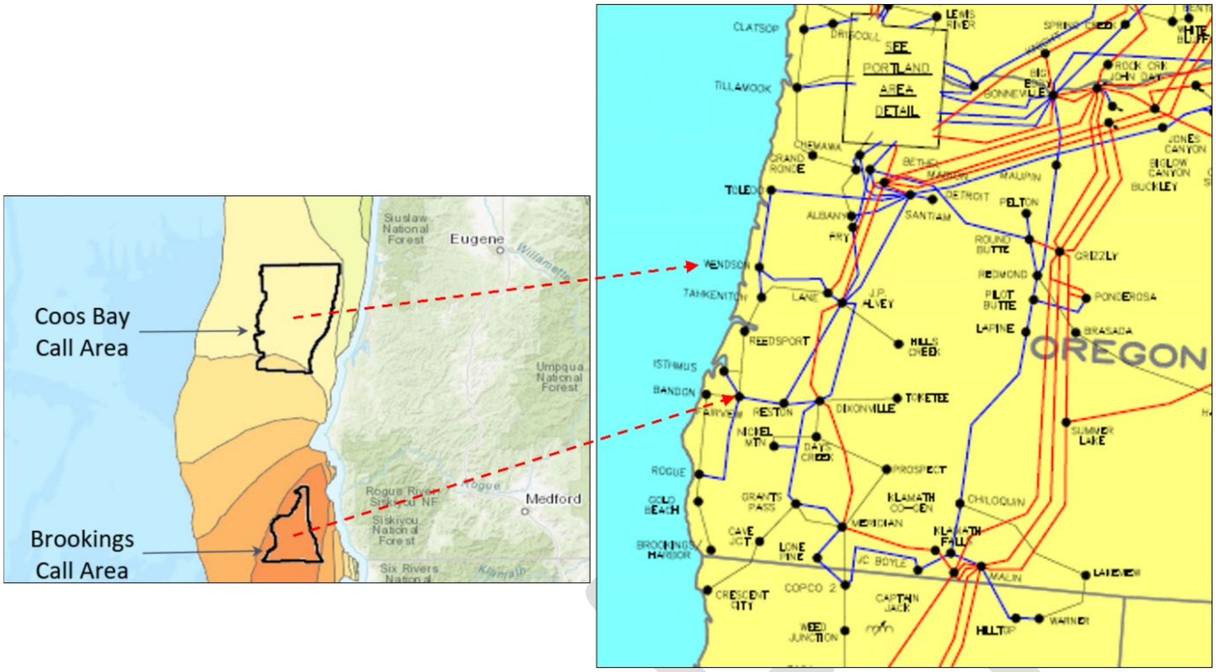


Figure 1: Call Area

BOEM's Oregon Call Areas (left) - yellow to orange color gradient correlates to offshore wind/energy quality in those locations. Wind/energy quality is highest in dark orange, and decreases from lighter orange to yellow. Southern Oregon's Transmission System (right) – Wendson and Fairview substations indicated. Blue transmission lines = 230 kV, red lines = 500 kV, black lines = less than 230 kV.

Given the more energetic resource to the south, the NorthernGrid study request was formulated as 1,800 MW at Fairview and 1,200 MW at Wendson for a total of 3,000 MW. This request sought to investigate more significant power flows through these substations than had been observed in preceding work.

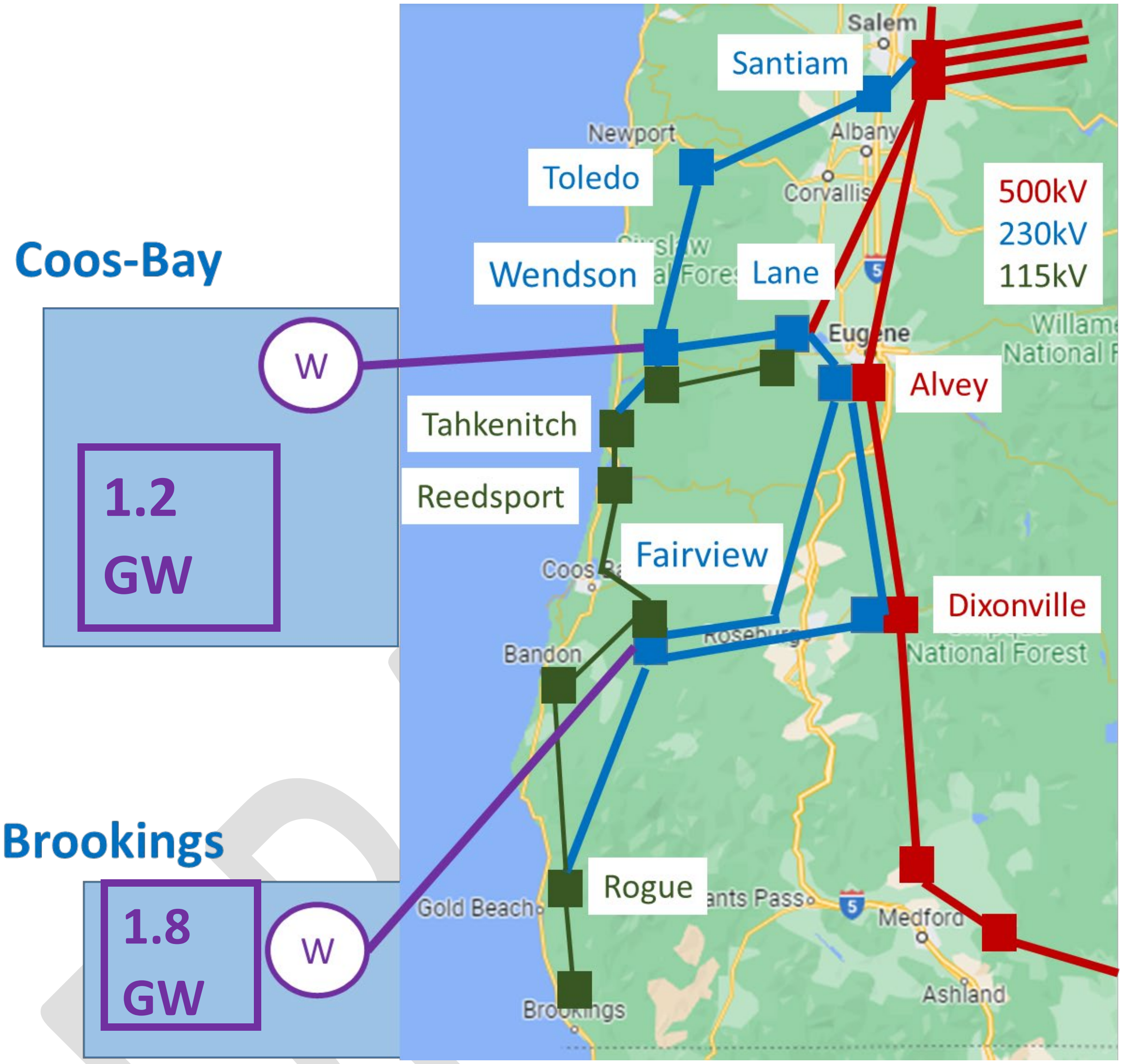


Figure 2: Offshore wind request

Figure 2: Offshore wind request is a pictorial representation of the offshore wind request. 1.2 GW of the wind will be modeled in the Coos Bay wind pocket with interconnection to the existing 230 kV bus at Wendson. The remaining 1.8 GW of wind will be modeled in the Brookings wind pocket with interconnection to the 230 kV bus at Fairview.

Study Scope

The study scope was developed with input from both the technical committee at NorthernGrid as well as the requesters. The two groups coordinated a set of analyses that addressed the feasibility of the proposed offshore wind project from both reliability and production cost perspectives. The group included subject matter experts from the Bonneville Power Administration (BPA), PacifiCorp, and Portland General Electric throughout the process. The Study Scope was ultimately approved by the Member Planning Committee and is posted publicly.

Analysis

All findings in this report are informative in nature and conclusions from this analysis should be limited to the assumptions built into the base cases used for the analysis. These findings do not represent a definitive future. The findings help to illustrate the possible reliability needs of the transmission system on a regional level in a potential ten-year future and do not address the myriad of impacts to the local transmission system. Nothing in this report should be interpreted as a construction plan or a replacement for any local transmission planning process.

The technical team supporting the analysis of this offshore wind request collectively identified that both steady state reliability and production cost analyses would be necessary to understand the impacts of the installation three gigawatts of offshore wind in the Oregon coast.

Steady state reliability analysis was performed first. The technical team used the 2032 Western Electric Coordinating Council (WECC) Heavy Summer base case as a starting point. Per agreement amongst the technical team and the requesters, the base cases were also stressed in both the north and south directions so as to fully capture the reliability concerns that may arise in either direction on the I-5 corridor.

Initially, the technical team identified a process that would allow for the three gigawatts of offshore wind to be analyzed on the expected 2032 transmission system before transmission upgrades were identified, per the process depicted in Figure 2.

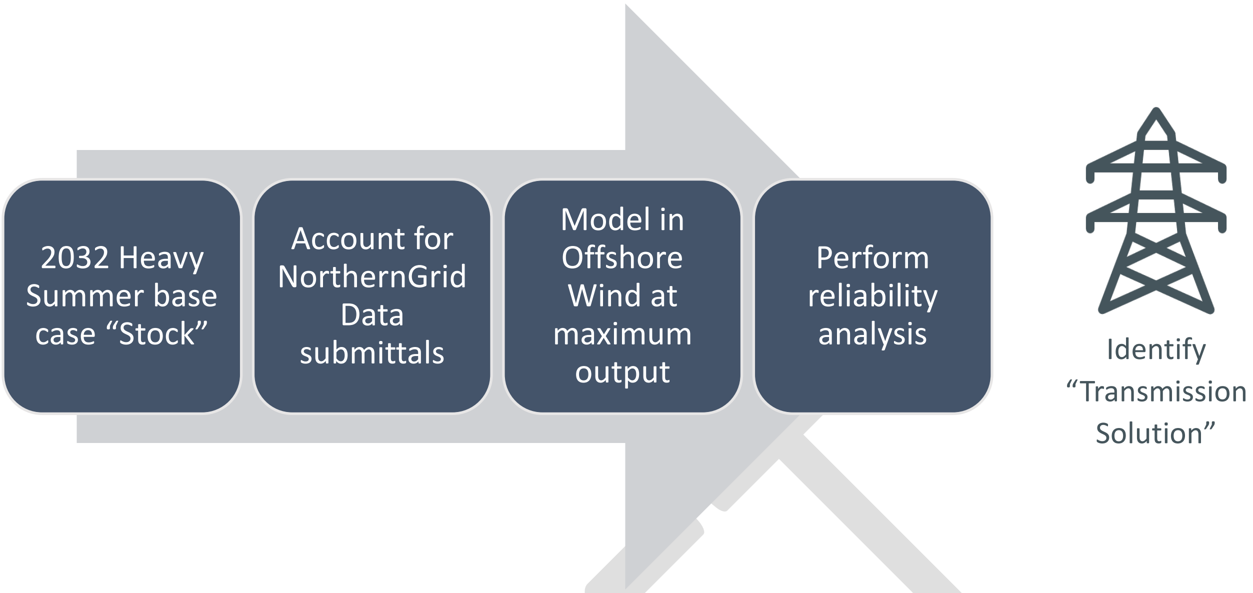


Figure 3: Proposed reliability analysis

In practice, the installation of three gigawatts on the 230 kV system in Oregon turned out to cause violations on the surrounding system, upwards of 200%, that the “Transmission Solution” as well as supporting solutions were needed before reliability analysis could be performed.

The existing 115 kV and 230 kV systems along the west coast of Oregon were not designed to pass through a large influx of energy from the coast along to the I-5 corridor. There are many known constraints that would necessarily restrict the output of the proposed wind farms-to a point that the analysis would be limiting. The technical team agreed on a set of supporting transmission solutions that was implemented in all the cases used for the analysis and are listed in Table 1: Transmission system improvements proposed to reinforce connectivity to the I-5 corridor.

Table 1: Transmission system improvements proposed to reinforce connectivity to the I-5 corridor

Improvements to existing system to allow for improved connectivity to the I-5 corridor	Upgrade Fairview-Alvey 230 kV
	Upgrade Wendson-Toledo 230 kV
	Rebuild Fairview-Reedsport-Tahkenich 115 kV

These 115 kV and 230 kV transmission system upgrades are assumed to be “in-service” for this analysis. Figure 4: Areas with notable overloads and generation at the 230 kV level provides a high-level depiction of areas impacted, and related facilities overloaded, upon the installation of the three gigawatts offshore wind on the 230 kV system. Despite the assumed upgrades on the 115 kV and 230 kV transmission system between the coast and the corridor, the facilities were loaded upwards of 200% of their improved ratings.

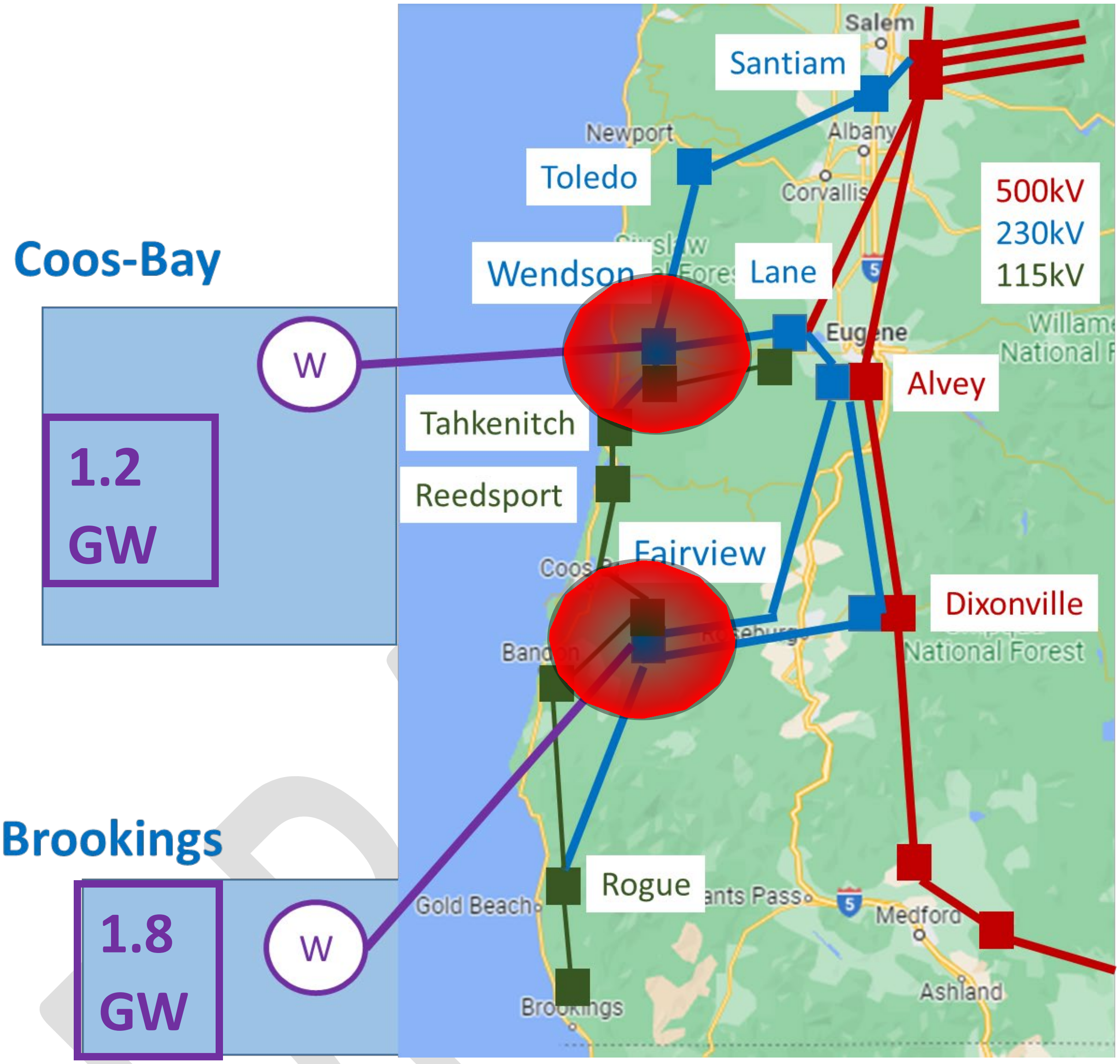


Figure 4: Areas with notable overloads and generation at the 230 kV level

For either northbound or southbound flows on the I-5 corridor, the injection of 1.2 GW and 1.8 GW of offshore wind at Wendson and Fairview, respectively, caused reliability violations that needed mitigation before further reliability analysis could be performed. The technical team coordinated on a transmission solution that was modeled into the base cases before the contingency analysis portion of the reliability analysis was performed.

The technical team implemented a “500 kV loop” solution. The “500 kV loop” consists of new 500 kV lines from Alvey to Lane, Lane to Wendson, Wendson to Fairview, and Fairview to Dixonville. The existing 500 kV line between Alvey and Dixonville closes the loop. The “500 kV loop” solution also assumes that the offshore wind farms are interconnected at the 500 kV level instead of 230 kV. This “500 kV loop” was modeled into the base cases that have the proposed upgrades for the 115 kV and 230 kV system, and then contingency analysis was performed.

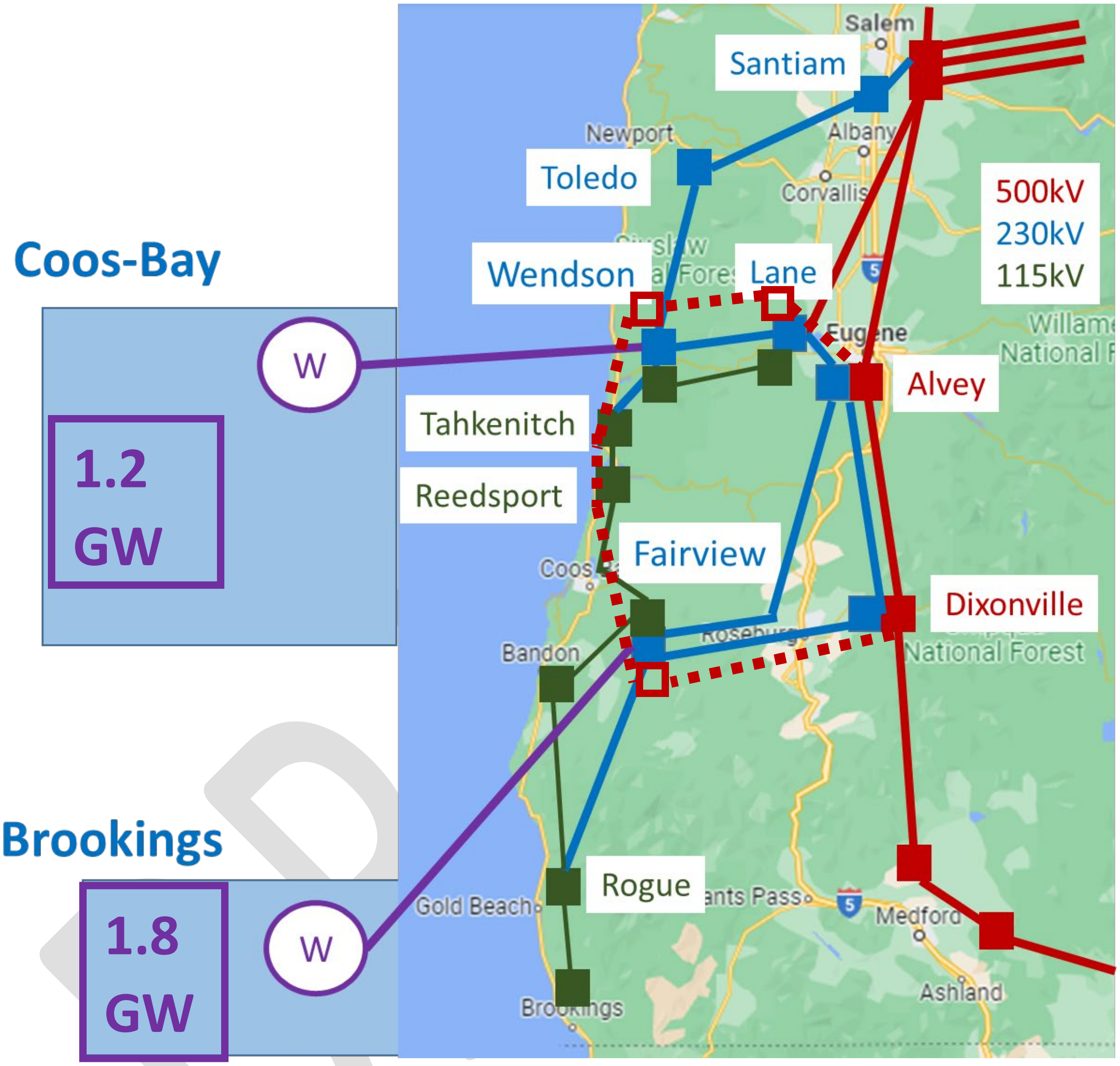


Figure 5: Proposed "500 kV loop"

With the "500 kV loop" modeled into the base cases, and along with the "supporting" transmission upgrades that were identified in Table 1: Transmission system improvements proposed to reinforce connectivity to the I-5 corridor, and the wind farms connected at the 500 kV level, the steady state contingency analysis concluded that the installation of three gigawatts of offshore wind interconnected at the 500 kV level is reliable with all pieces of equipment in service (N-0), or with the outage of any one piece of equipment (N-1). The single outages included either individual line or generation outages. The reliability finding for this analysis holds true for both northbound and southbound flows on the I-5 corridor.

Cost

High-level, non-binding costs were developed for the upgrades. The costs were developed with input from the entities involved and are not reflective of a full-blown estimation process. The costs reflect estimates of the equipment only and do not reflect the funds needed to procure the land, acquire the permits, or in any way account for the myriad of financial commitments needed to support a construction build. The costs were produced through internal reviews of recent projects and the source information is not available publicly. The "Existing System" upgrades are needed for both the 230 kV and 500 kV interconnection levels, as shown in Table 2.

Table 2: High-level, non-binding Estimates for the transmission facilities

	230 kV		**500 kV**	
	High-level Estimate ($M)	**High-level Estimate +50% ($M)**	**High-level Estimate ($M)**	**High-level Estimate +50% ($M)**
"500 kV Loop" transmission line			$501	$752
500 kV Supporting upgrades			$274	$411
Proposed 115 kV and 230 kV System Upgrades (Table 1)	$45	$68	$45	$68
Total	**$45**	**$68**	**$820**	**$1,231**

1. The costs in Table 2: High-level, non-binding Estimates for the transmission facilities only reflect the transmission equipment needed to support the transmission system and do not include any costs of the actual offshore wind farms or their associated infrastructure.
2. The estimates provided in Table 2: High-level, non-binding Estimates for the transmission facilities reflect high-level, non-binding estimates of the equipment needed for the physical facilities including the communications and labor. They do not include the permitting, right-of-way, land acquisition, or anything beyond the physical facilities needed for the transmission lines.
3. The "500 kV Supporting upgrades" line item represents the collective total substation cost estimates. In some instances, a new substation is needed and in others, the existing substation needs substantial infrastructure support.
4. "Existing System Upgrades (Table 1)" are those listed in Table 1: Transmission system improvements proposed to reinforce connectivity to the I-5 corridor of this report.
5. The costs in Table 2: High-level, non-binding Estimates for the transmission facilities assume there are no major "hurdles" such as the ability to acquire the land easily and quickly, no litigation concerns, no public pushback, or no Endangered Species concerns. Experience has shown that any one of these hurdles, or setbacks, can double or even triple the overall cost of the project.
6. Substation improvements are also needed for interconnection at the 230 kV level, and those costs are not reflected in Table 2: High-level, non-binding Estimates for the transmission facilities.

Production Cost Modeling

The production cost analysis started with adding the “supporting” transmission upgrades to the 2032 Anchor Data Set (ADS) produced by WECC. The 2032 ADS topology is the same as that of the 2032 Heavy Summer base case. The ADS produced by WECC is a data set that puts together the ability to perform reliability and production cost analyses on cases that represent the WECC system in its totality. The program used to model the production cost analysis, GridView, allows for a simulation of all 8784 hours in 2032 (2032 is a leap year) where the generation in the transmission system gets dispatched for each hour of the year. This variation in generation dispatch changes and how those changes impact the transmission system allows for investigation into how the offshore wind project and the different transmission solutions impact the overall transmission system.

The offshore wind projects were modeled into the 230 kV system in the initial production cost run, and then again in a second production cost analysis with the “500 kV loop” added and the offshore wind projects at the 500 kV interconnection level. Both production cost runs included the system upgrades identified in Table 1: Transmission system improvements proposed to reinforce connectivity to the I-5 corridor. The following figures depict how certain components of the production cost analysis change as a function of the wind being interconnected to the different voltage levels.

In the following graphics below, there will be reference to the following cases.

- ADS Anchor Data Set. The ADS case does not have the updates listed in Table 1, and there are no offshore wind projects modeled.
- 230kV The 230kV case represents the offshore wind projects being modeled at the 230 kV level in the ADS. The case includes the upgrades in Table 1: Transmission system improvements proposed to reinforce connectivity to the I-5 corridor.
- 500kV The 500kV case represents the offshore wind projects being modeled at the 500 kV level in the ADS. The case has the upgrades in Table 1: Transmission system improvements proposed to reinforce connectivity to the I-5 corridor as well as the “500 kV loop”.

Production Cost Modeling Results

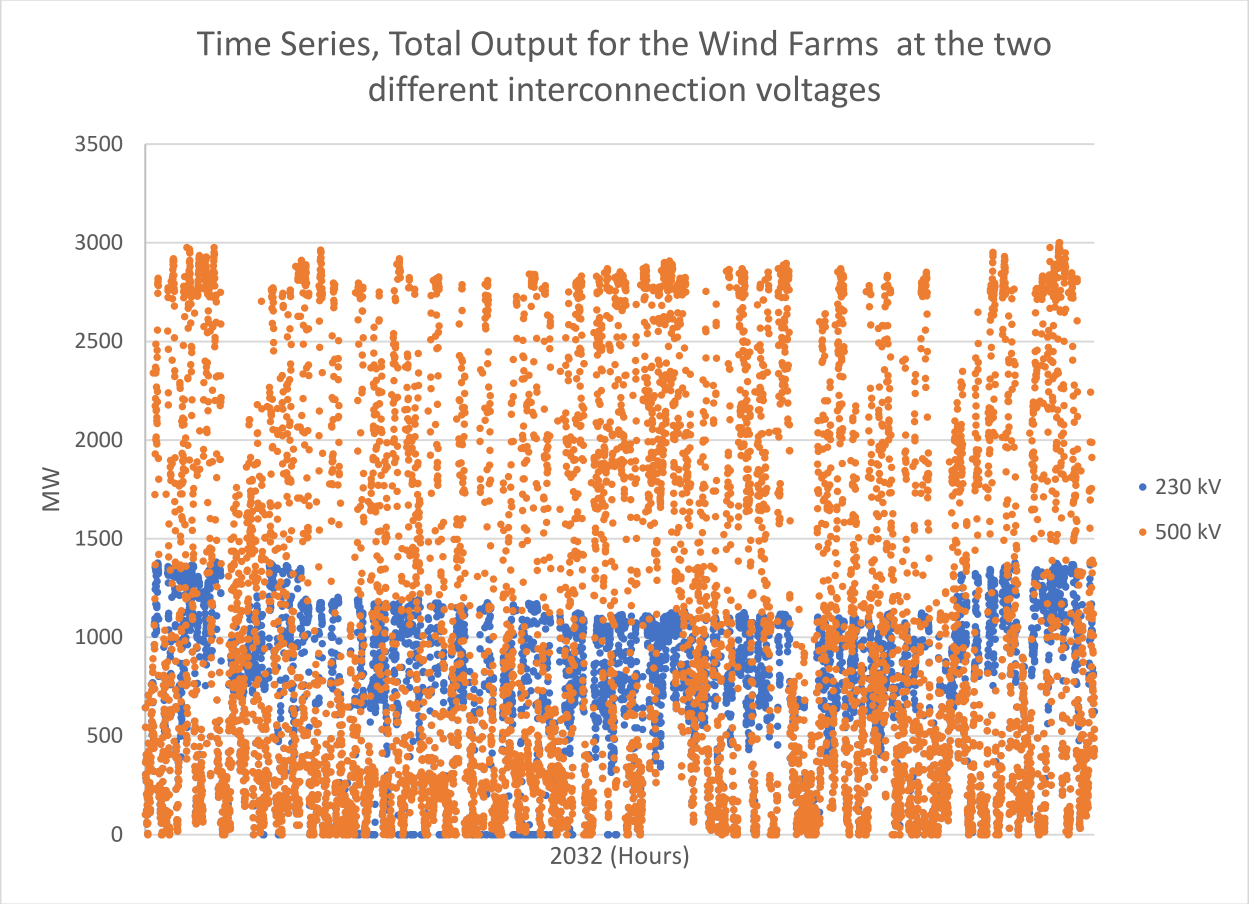


Figure 6: Offshore wind output for year 2032, time series

Figure 6: Offshore wind output for year 2032, time seriesshows the time series combined megawatt output for the two offshore wind farms. The 500 kV interconnection allows for the full output of the wind farms whereas the 230 kV interconnection is seasonally limited. The seasonal limitations observed in the 230 kV output are due to seasonal ratings on associated cut planes. These cut planes were introduced by the technical team to measure the output of the offshore wind farms as well as to honor the physical limitations of the associated branches. A cut plane is a collection of transmission lines that has a collective rating; this rating was established by the technical team and did not undergo the scrutiny and review that would be required of a formal path.

Table 3: Path limits proposed

	Path	**Summer (MW)**	**Spring (MW)**	**Winter (MW)**
230 kV	Wendson	444	481	549
	Fairview	453	484	561
500 kV	Wendson	1630	1730	1883
	Fairview	1534	1687	1974

Figure 7: Megawatts through the 230 kV Wendson and Fairview cut planes shows the collective megawatts across the Wendson and Fairview cut planes.

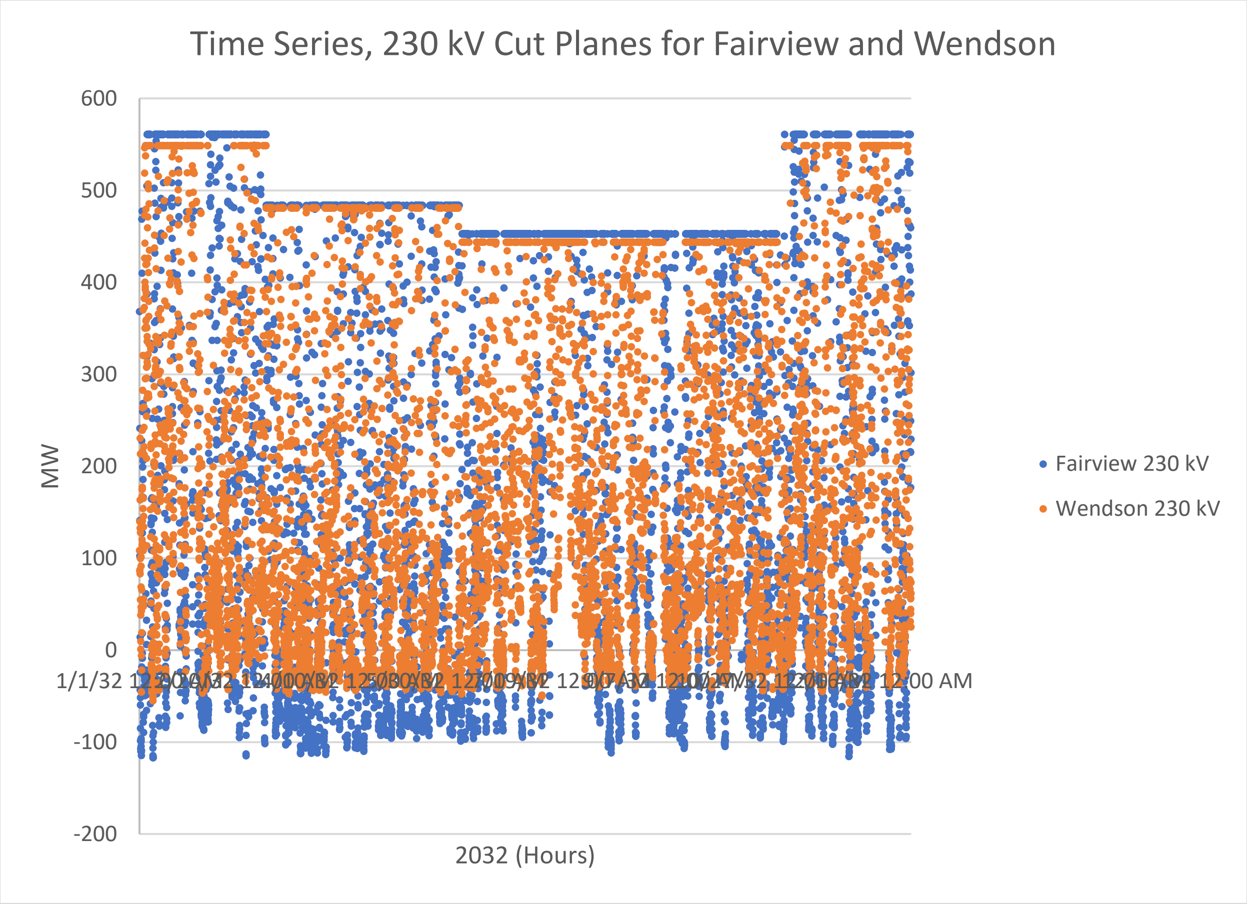


Figure 7: Megawatts through the 230 kV Wendson and Fairview cut planes

The 230 kV Wendson and Fairview cut planes limit the output of wind farms at the 230 kV level. This can be observed by the seasonal flat lines that are depicted in Figure 7: Megawatts through the 230 kV Wendson and Fairview cut planes. The cut plane limits are not exactly one to one with the output of the wind farms as the transmission system is a network of lines, and these cut planes only capture the bulk of the output. When interconnected at the 230 kV level, the output of the windfarms was curtailed a significant portion of the year.

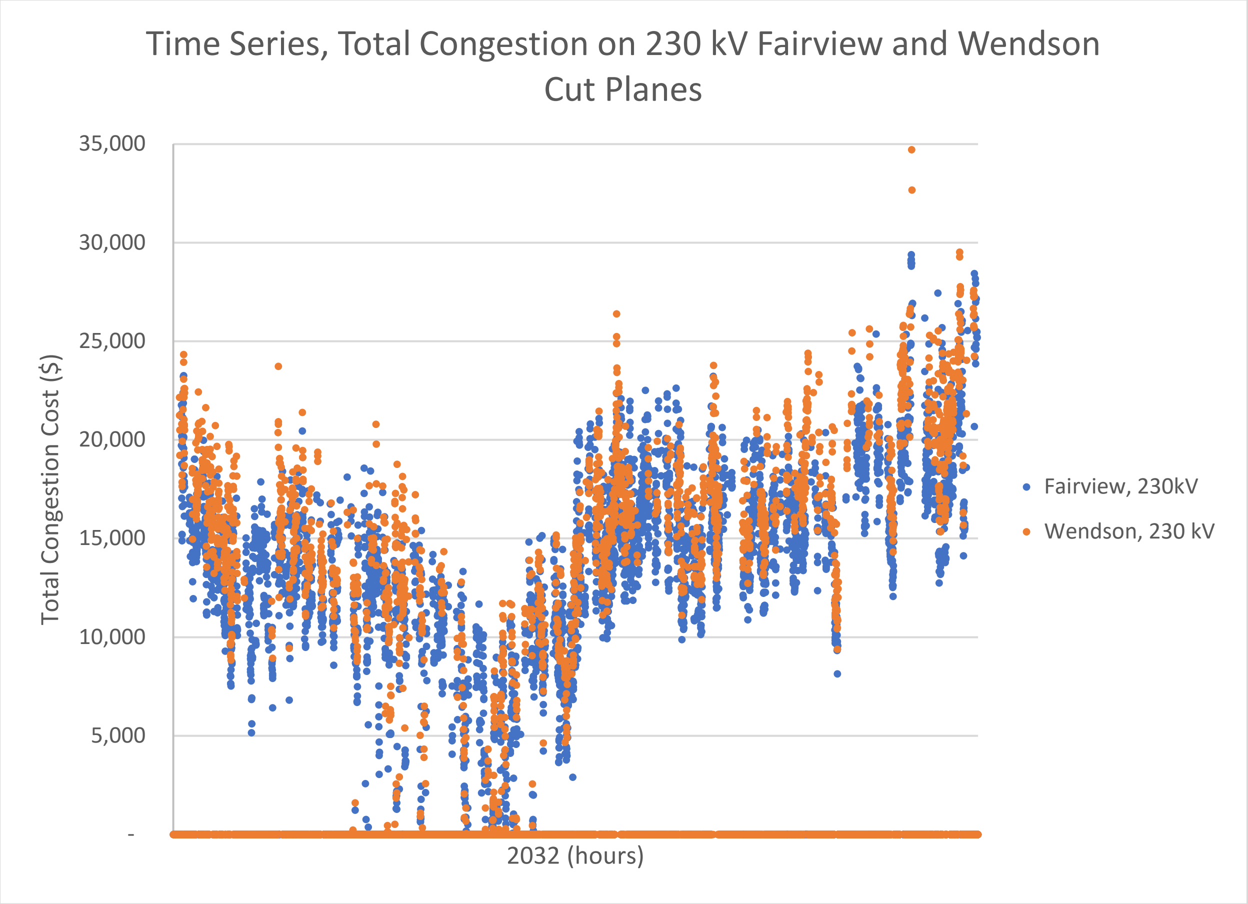


Figure 8: Fairview cut plane congestion

The congestion through the Fairview and Wendson 230 kV cut planes occurs regularly throughout the year. Congestion is generally reflective of the money that is lost due to a generator not being able to inject its generation onto the transmission system at a time when the generation is available to output onto the system. For example, if the wind is blowing and the wind turbines have the ability to send all three gigawatts onto the transmission system, the congestion of the cut planes translates into the amount of money lost because the transmission system was not able to accept the output and the offshore wind generators were curtailed.

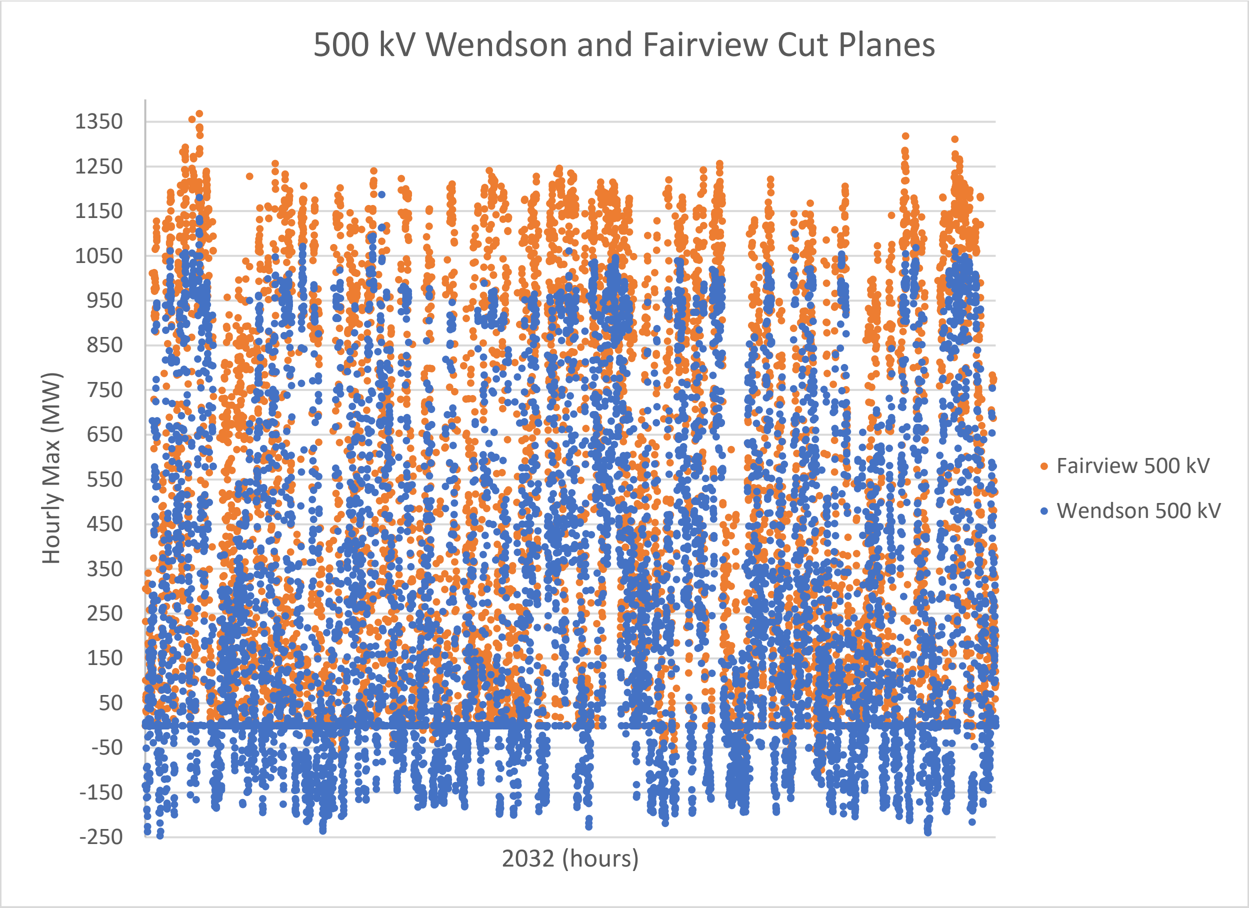


Figure 9: 500 kV Wendson and Fairview cut planes

The 500 kV cut planes for Wendson and Fairview allow for full output of the wind farms; there are no curtailments when the “500 kV loop” is modeled.

Because the “500 kV loop” assumes interconnection at the 500 kV level, it also assumes that the associated 500 kV substations have either been built or improved to handle the output from three gigawatts of offshore wind. Altogether, the “500 kV loop” allows for both the reliable operation of the wind farm under stressed operating conditions as well as relatively congestion-free generation opportunities. The biggest hurdle for the generation is to get from the coast to the I-5 corridor. The “500 kV loop” enables generation to reach the I-5 corridor and also acts as a new “backbone” for the coastal transmission system. The existing system upgrades listed in Table 1: Transmission system improvements proposed to reinforce connectivity to the I-5 corridor are required for interconnection at the 500 kV level.

Interconnection at the 230 kV level is possible. However, interconnection at the 230 kV level results in congestion that generally limits the total generation to less than half its total capability. The existing system upgrades listed in Table 1: Transmission system improvements proposed to reinforce connectivity to the I-5 corridor are required for interconnection at the 230 kV level. Interconnection at the 230 kV level would also require significant upgrades to the 230 kV Fairview and Wendson buses and would still result in significant congestion.

The following plots explore some of the larger, more regional, impacts of the installation of the offshore wind projects. The three cases used for the plots were the unmodified Anchor Data Set (ADS), the offshore wind interconnected at the 230 kV level (230 kV) , and the offshore wind interconnected at the 500 kV level (500 kV). The first set of plots will focus on four Western Electric Coordinating Council (WECC) paths:

1. South of Allston
2. “WOCS” West of Cascades South
3. Idaho to the Northwest
4. “COI” California Oregon Intertie

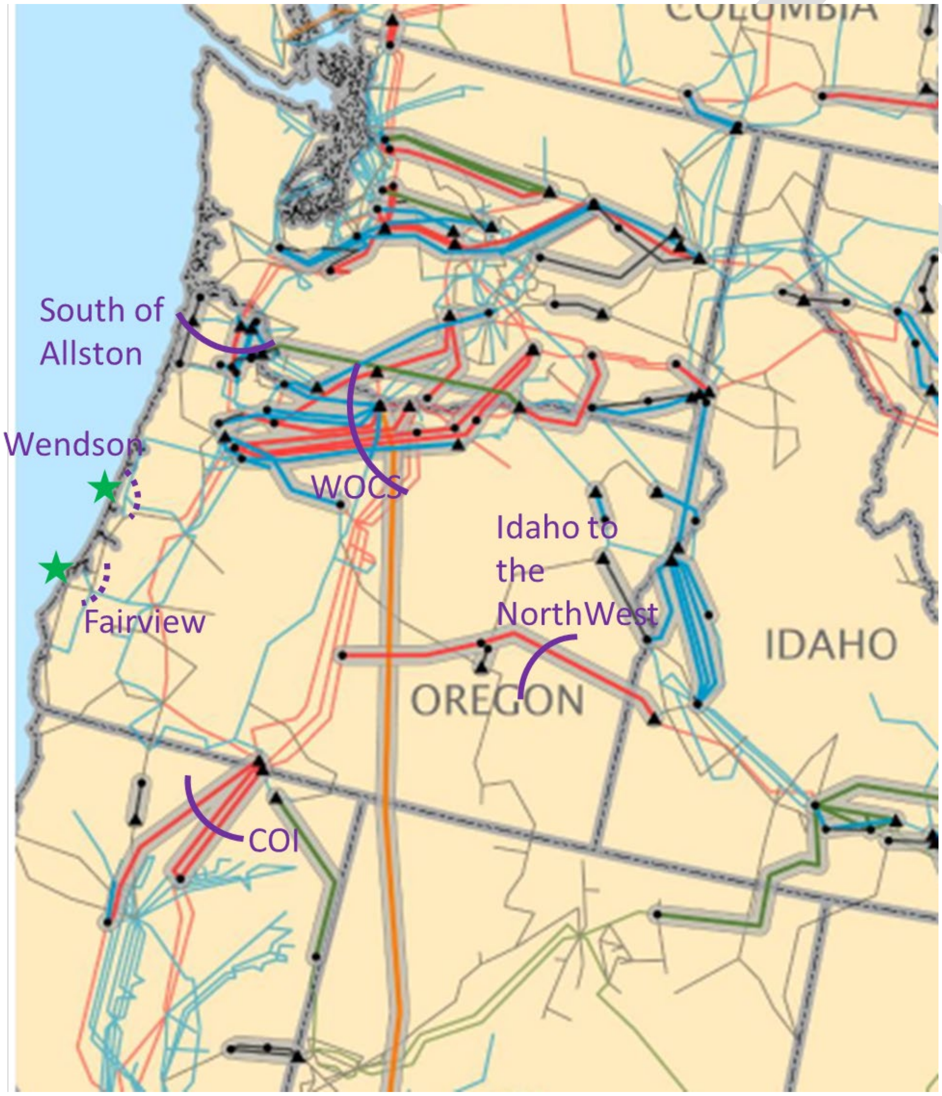


Figure 10: Western Interconnection with graphical depiction of main Paths

The green stars in Figure 10: Western Interconnection with graphical depiction of main Paths generally show the location of the two wind projects as well as their proposed cut planes which are dashed to indicate they are not formal WECC paths.

The California-Oregon Intertie (COI) portion of the transmission system connects California and Oregon and typically flows in the southbound direction. With the COI depictions, positive values indicate southbound flows.

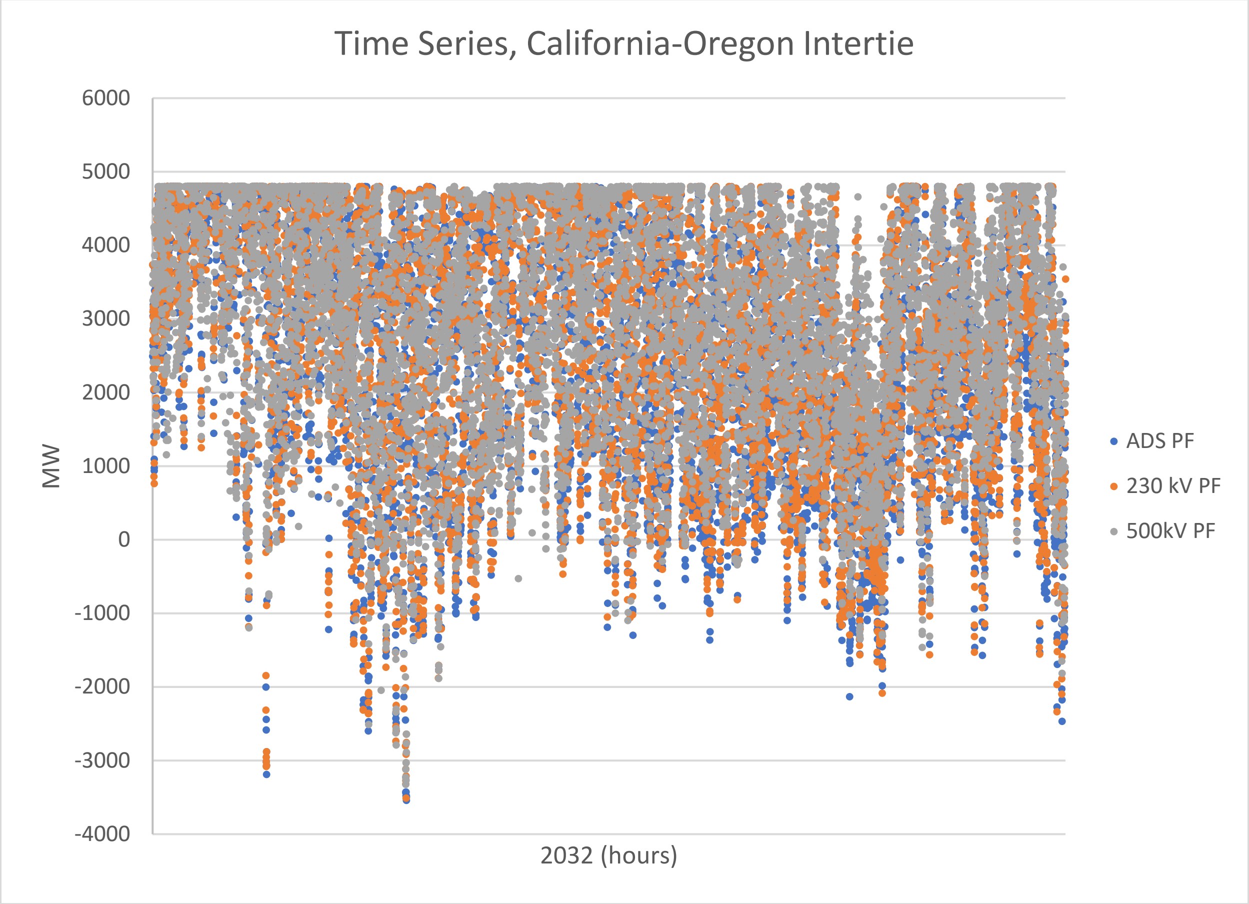


Figure 11: COI flows, time series

While it is clear that the majority of the time, the COI is flowing in a southbound direction, Figure 11: COI flows, time series does not provide an opportunity to understand how the COI differed for the three different cases that were examined.

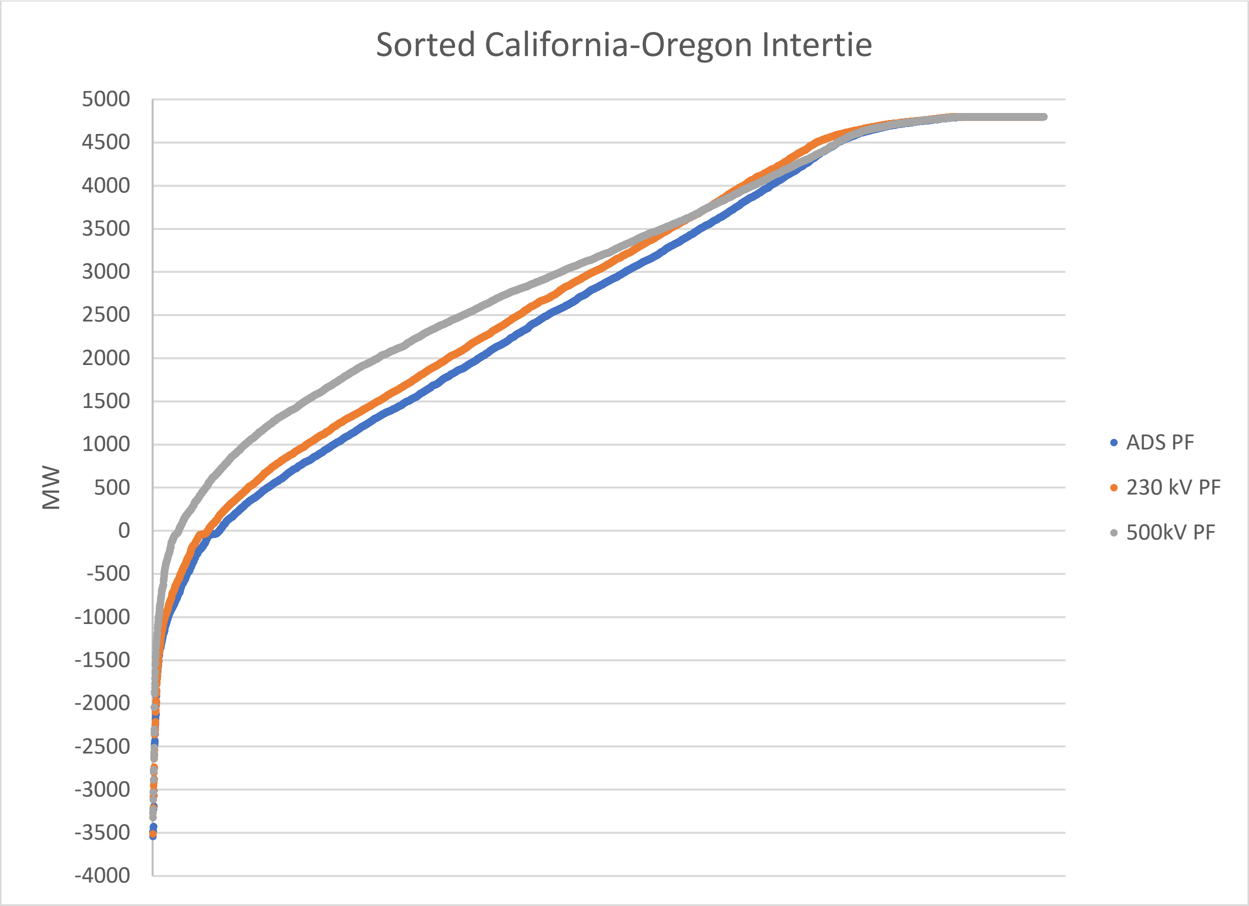


Figure 12: Sorted COI output, sorted by MW

Figure 12: Sorted COI output, sorted by MW demonstrates that the COI was impacted by the introduction of the wind farms. Using the ADS as the “baseline” for comparison, the sorted output indicates that there were more southbound flows on the COI as a result of the 230 kV interconnection and yet again more southbound flows for the 500 kV interconnection.

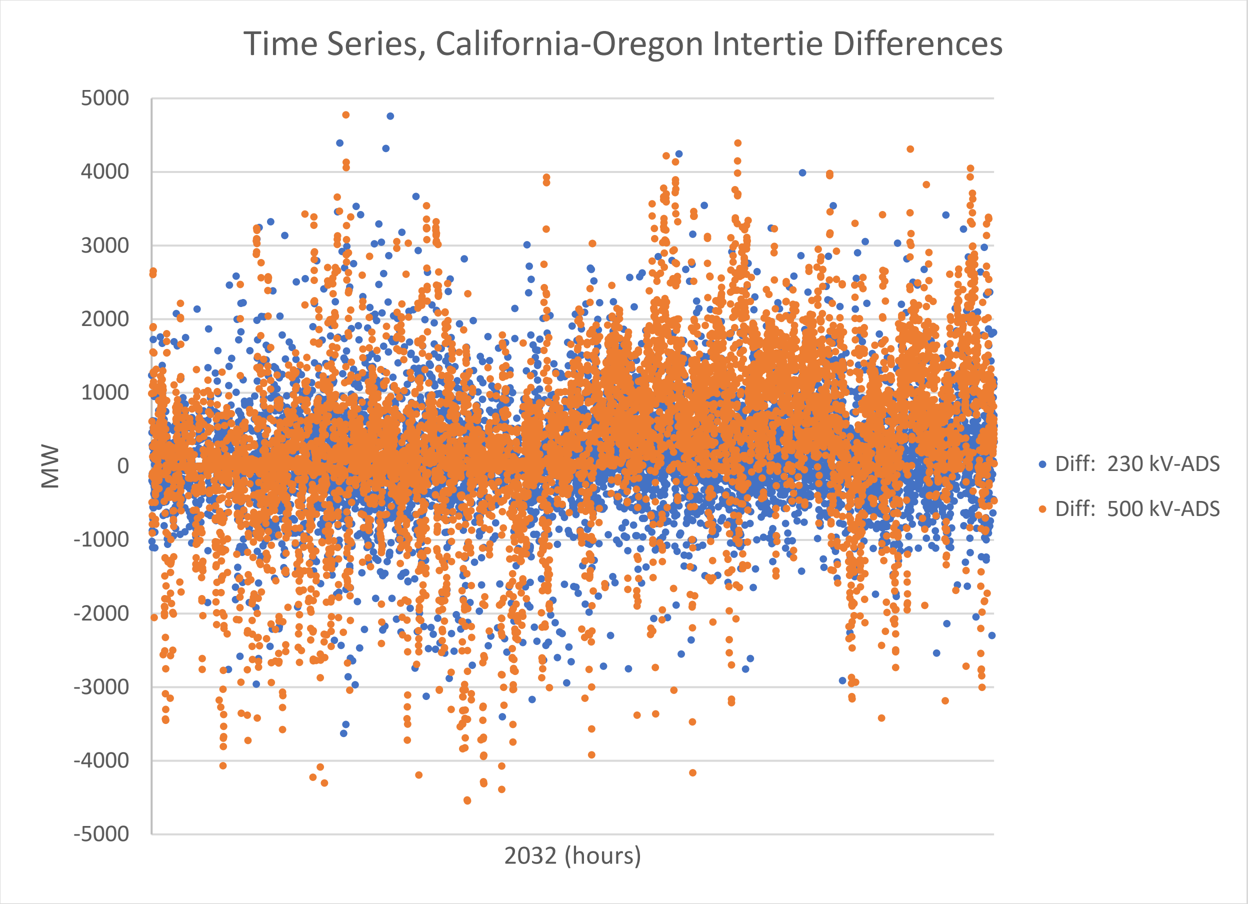


Figure 13: COI differences, time series

Another way to consider how the COI gets impacted by the installation of offshore wind is by looking at the difference between the COI flow on the ADS case versus the COI flows on the 230 kV and 500 kV cases. The difference was taken with ADS leading; positive values indicate that the southbound flows on the COI in the ADS case are less than the other cases, and negative values indicate that the southbound flows in the ADS case are more than that of the other cases. While it appears that the differences are larger between the ADS case and the 500 kV case than they are for the differences between the ADS and the 230 kV case, further examination is warranted.

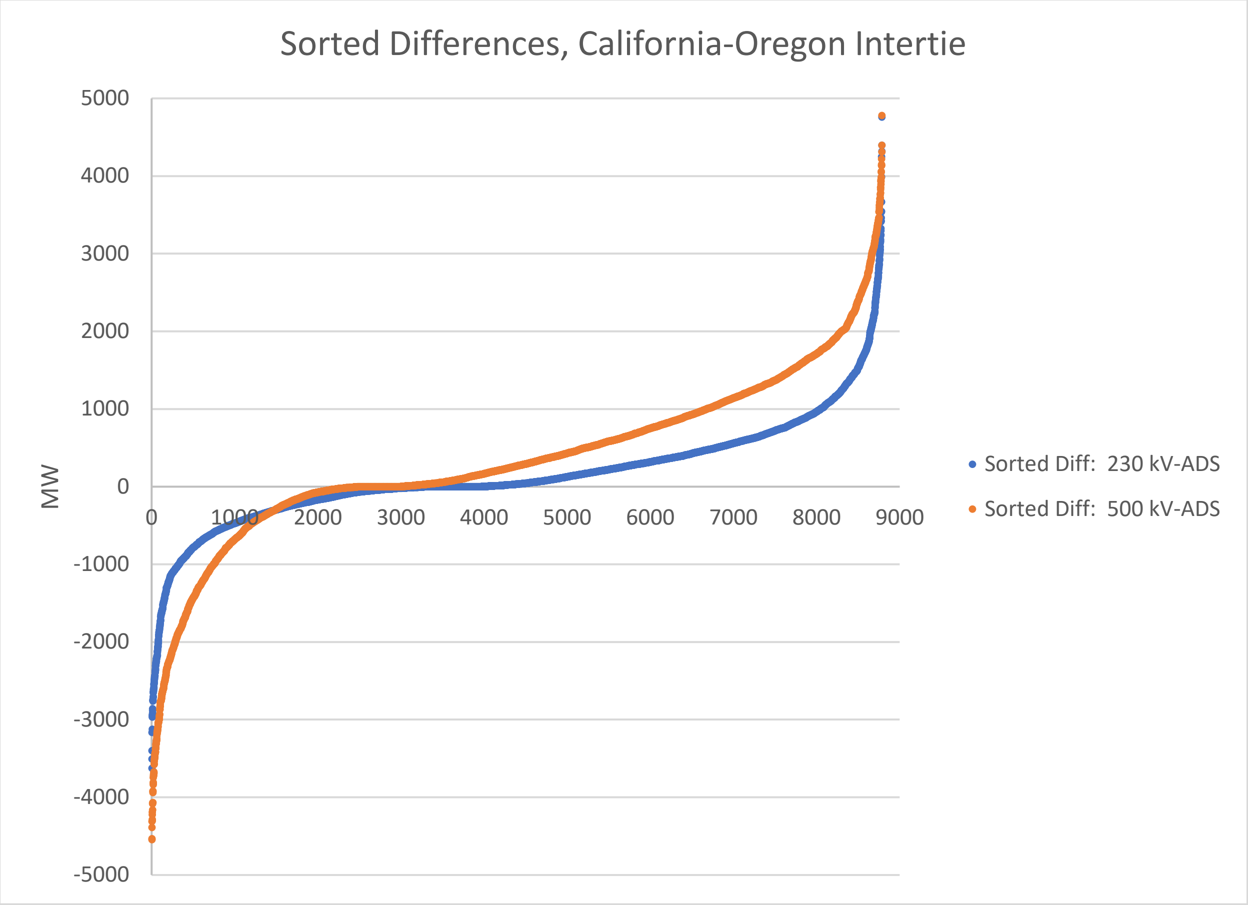


Figure 14: Sorted Differences, COI, sorted by MW output

Figure 14: Sorted Differences, COI, sorted by MW output shows the sorted differences for the three cases on the COI. The differences were consistently greater between the ADS and the 500 kV than the differences between the ADS and the 230 kV.

Figure 15: Idaho to the Northwest Westbound MW flows, time series has predominately westbound MW flows. With the Idaho to the Northwest depictions, positive values indicate westbound flows.

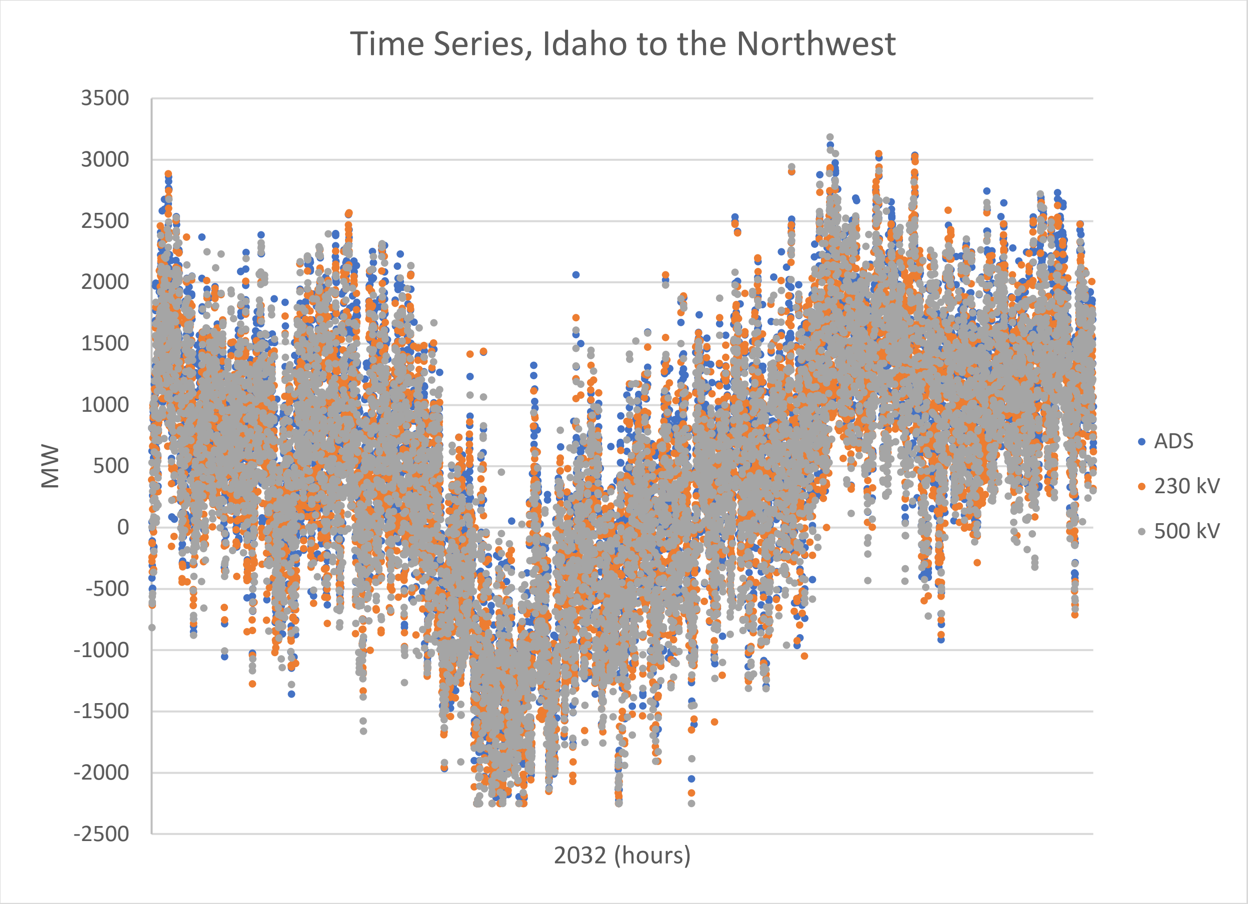


Figure 15: Idaho to the Northwest Westbound MW flows, time series

It is unclear from the time series how Idaho to the Northwest is impacted by the presence of the offshore wind projects and further scrutiny is warranted.

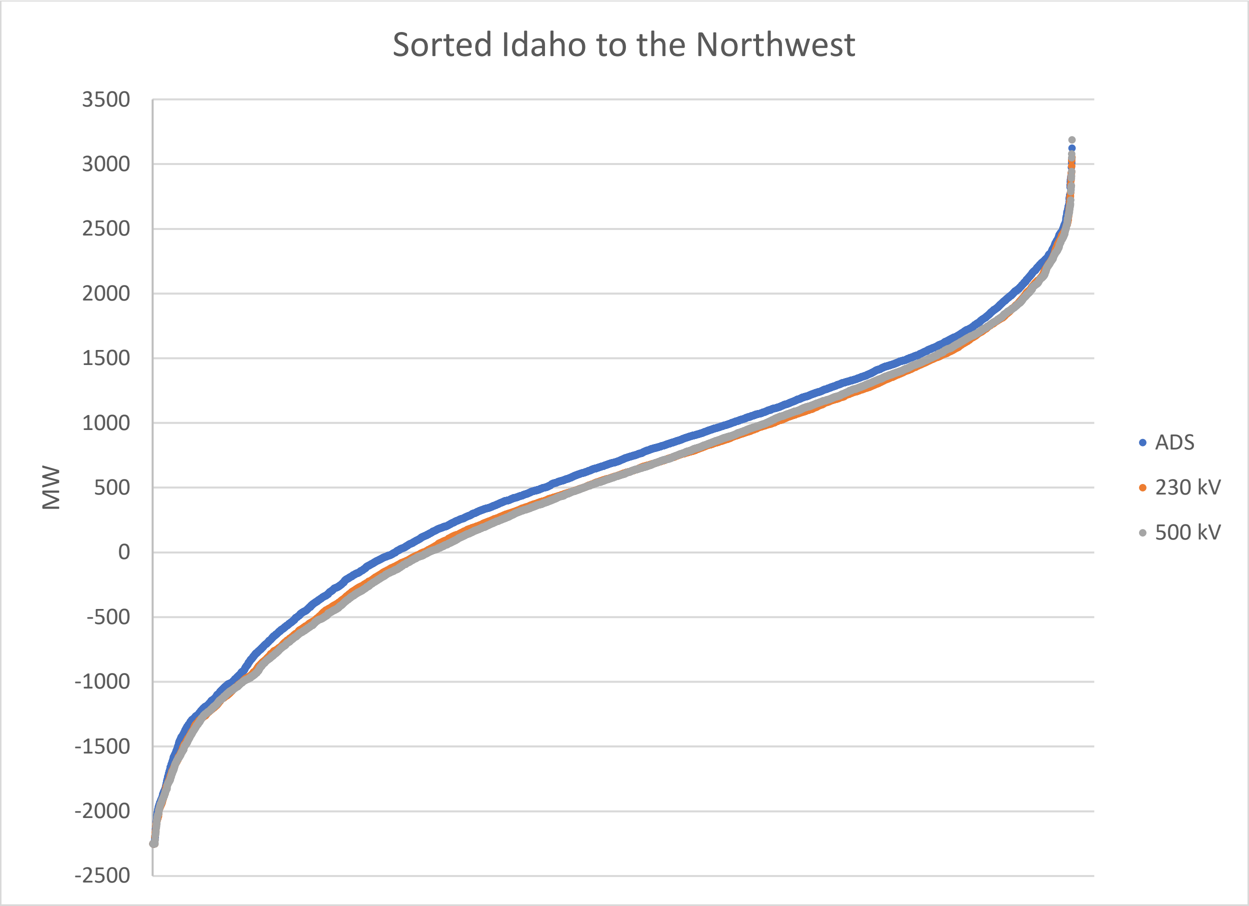


Figure 16: Path 14, sorted by MW

Figure 16: Path 14, sorted by MW depicts the sorted values for westbound Idaho to the Northwest MW. The 230 kV and 500 kV cases show fewer westbound flows on Idaho to the Northwest than the ADS case; this indicates that the presence of the offshore wind projects reduces the loading on Idaho to the Northwest.

The South of Allston path is predominately westbound in nature. With South of Allston depictions, positive values indicate westbound flows.

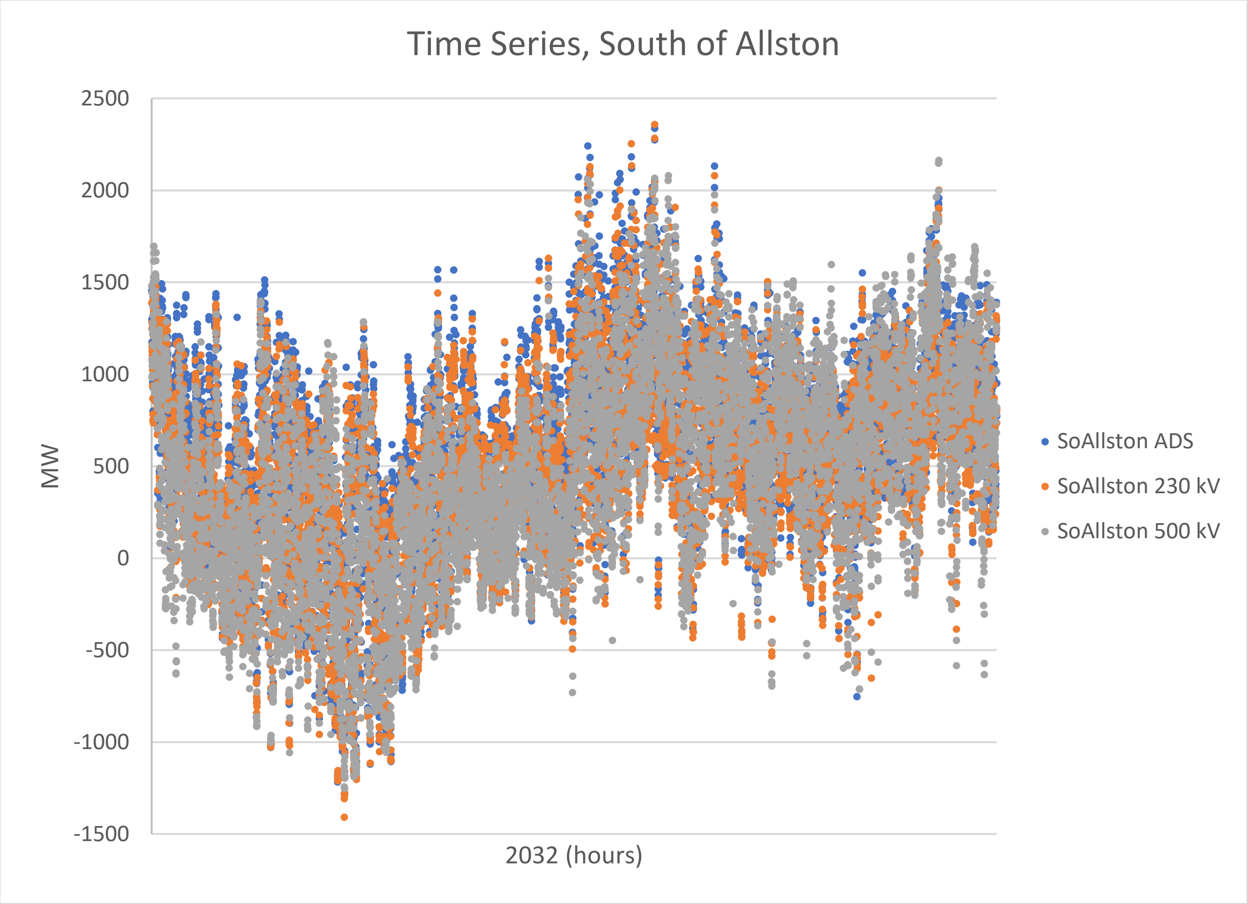


Figure 17: South of Allston, time series

Figure 17: South of Allston, time series suggests that the offshore wind project reduce the loading on South of Allston.

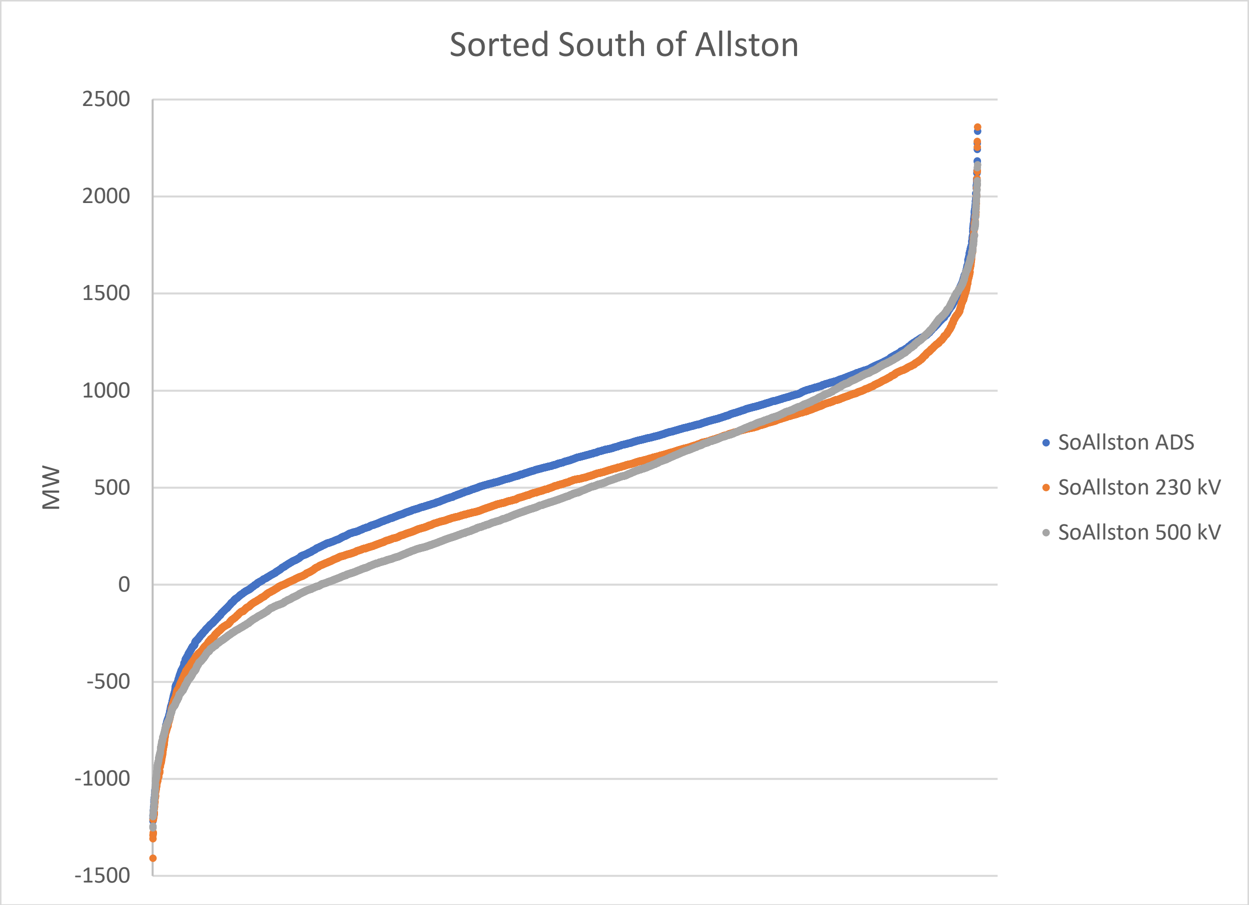


Figure 18: South of Allston, sorted by MW output

The sorted South of Allston output confirms that with the introduction of offshore wind in the Oregon area, the loading on South of Allston is generally reduced.

The last of the four WECC paths that were explored is the West of Cascades South (WOCS) path. For WOCS depictions, positive values indicate westbound flows.

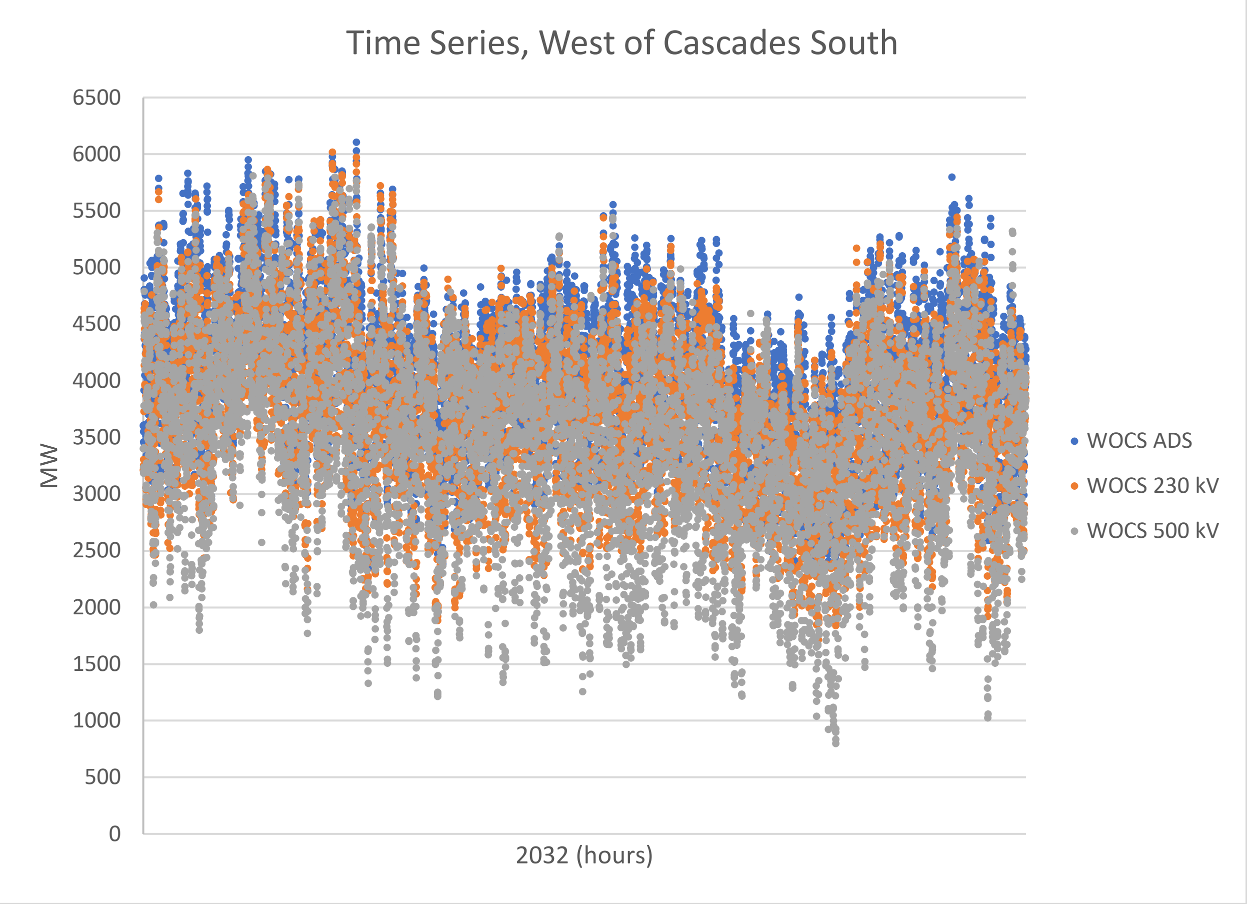


Figure 19: West of Cascades South, time series

It appears that the loading on West of Cascades South is less in the cases with the offshore wind.

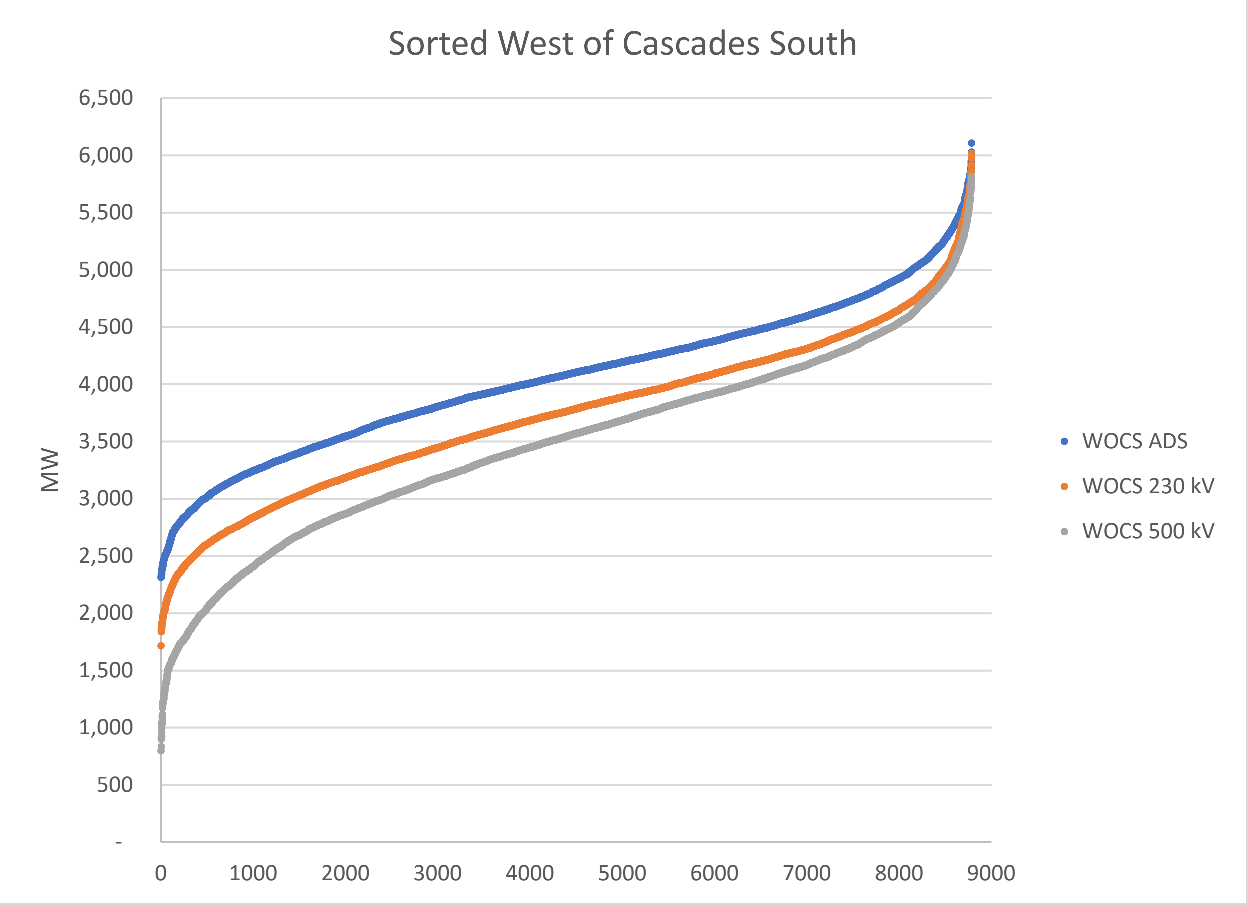


Figure 20: WOCS westbound flows, sorted by MW

Figure 20: WOCS westbound flows, sorted by MW demonstrates that the westbound flows on West of Cascades South are decreased in the presence of offshore wind in Oregon.

Interface Summary

Of the four paths that were examined in this paper, the following observations were made.

1. Paths that generally moved power into the Oregon area (Idaho to the Northwest, South of Allston, and West of Cascades South) experienced reduced loading.
2. The southbound flows on the California Oregon intertie increased.

These four paths do not represent the entirety of the western interconnection and should not be interpreted as the only paths that are impacted by the offshore wind installations; they were chosen to generally represent the possible regional impact of the offshore wind as modeled in Oregon.

Another point of interest is how the installation of three gigawatts of offshore wind impacts carbon-based resources. The following figures and table explore the output all facilities in the NorthernGrid region.

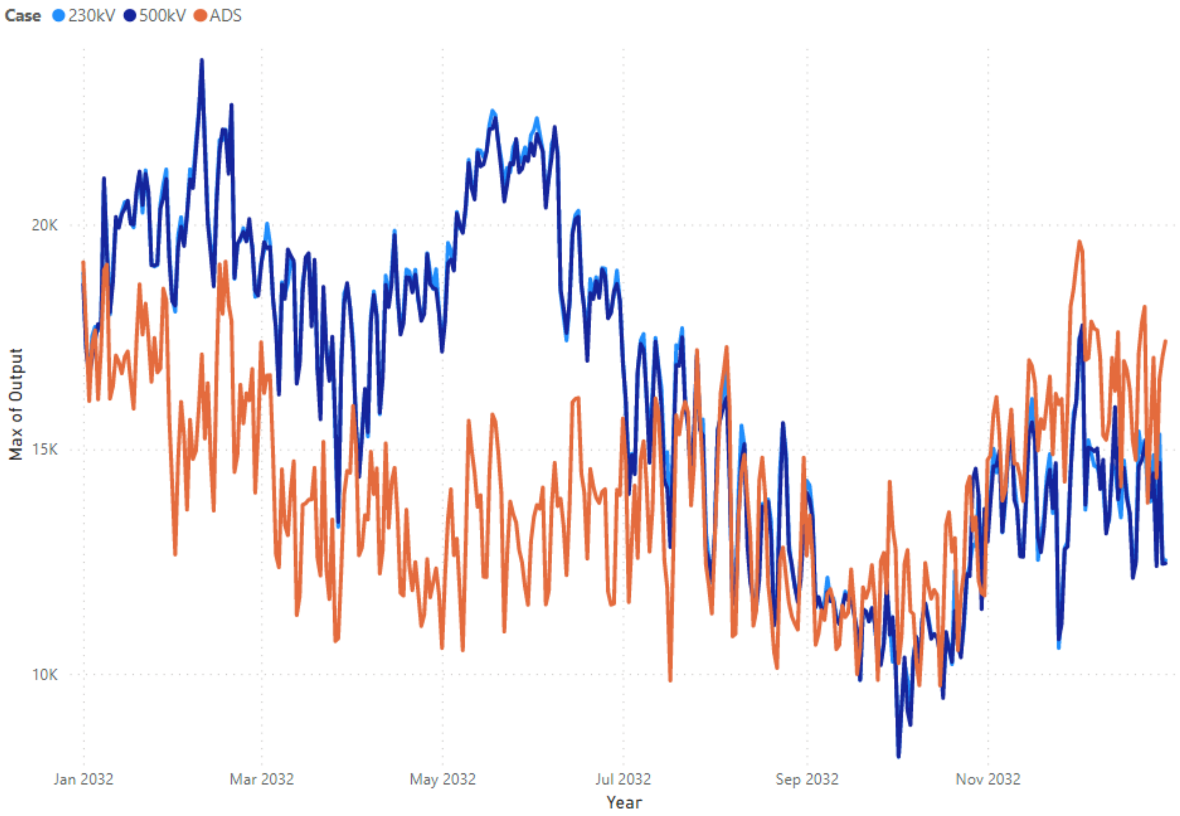
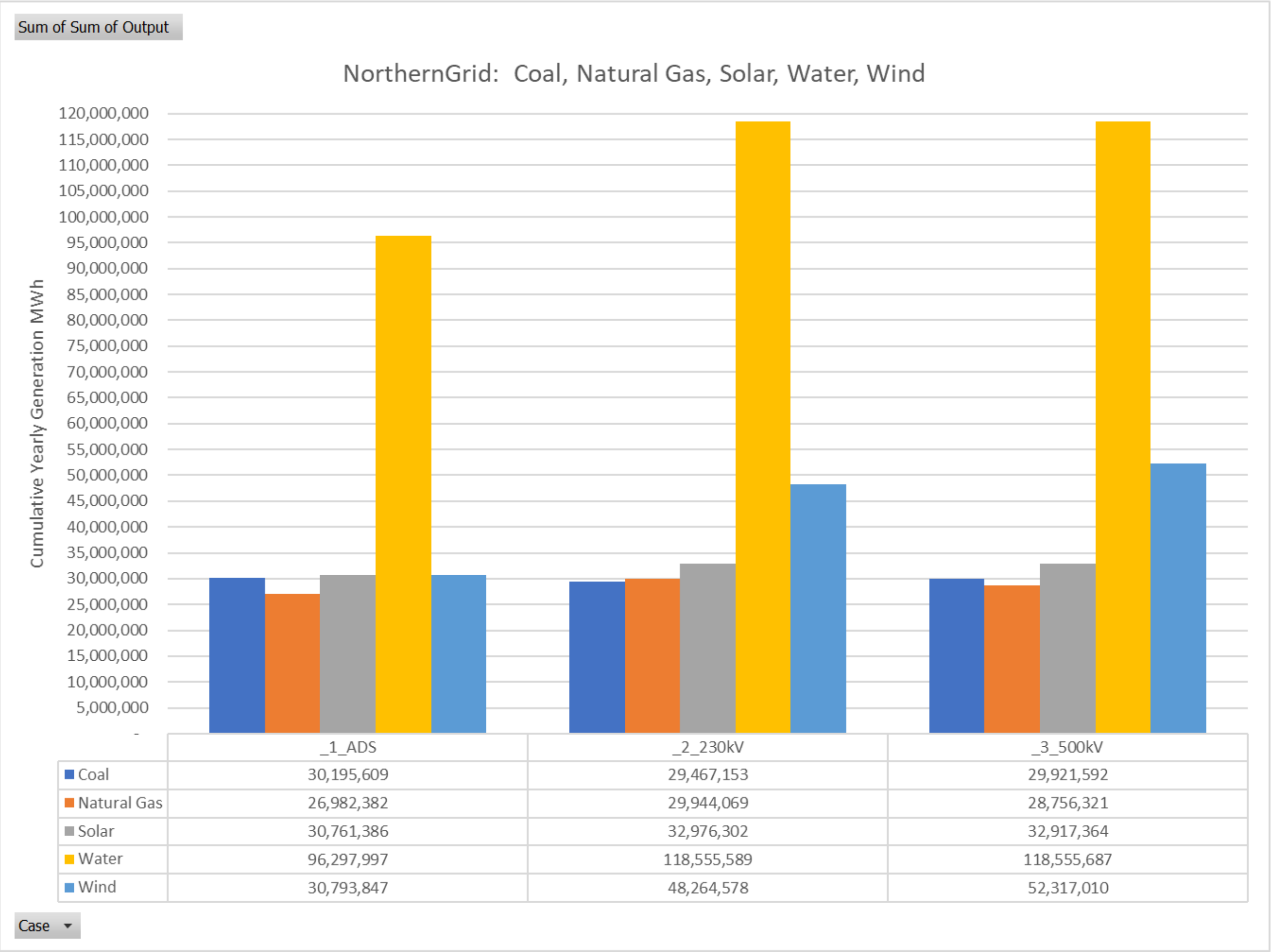


Figure 21: All generation in the NorthernGrid region

Figure 21: All generation in the NorthernGrid region suggests that with the addition of offshore wind, at either the 230 kV or 500 kV level, there is additional generation on the system. The figure represents the entire collection of different generation resources in the entirety of the NorthernGrid region. With the offshore wind resources present, there is more generation overall within the NorthernGrid region and Figure 21: All generation in the NorthernGrid region suggests that the offshore wind changed the overall dispatch of generation within the NorthernGrid region.



	_1_ADS	_2_230kV	_3_500kV
Coal	30,195,609	29,467,153	29,921,592
Natural Gas	26,982,382	29,944,069	28,756,321
Solar	30,761,386	32,976,302	32,917,364
Water	96,297,997	118,555,589	118,555,687
Wind	30,793,847	48,264,578	52,317,010

Figure 22: NorthernGrid broken down by Coal, Natural Gas, Hydro, Solar, and Wind, daily total output

Figure 22: NorthernGrid broken down by Coal, Natural Gas, Hydro, Solar, and Wind shows these selected fuel types in the NorthernGrid region. For the NorthernGrid region and with this offshore wind request modeled in, the following observations can be made:

- In the NorthernGrid Region, there is less total coal output in the cases with the offshore wind modeled.
- In the NorthernGrid Region, there is less total Natural Gas output in the cases with the offshore wind.
- In the NorthernGrid Region, there is more solar output in the cases with the offshore wind modeled.
- In the NorthernGrid Region, there is more total water output in the cases with the offshore wind projects modeled.
- In the NorthernGrid Region, there is more total wind output in the cases with the offshore wind projects modeled.

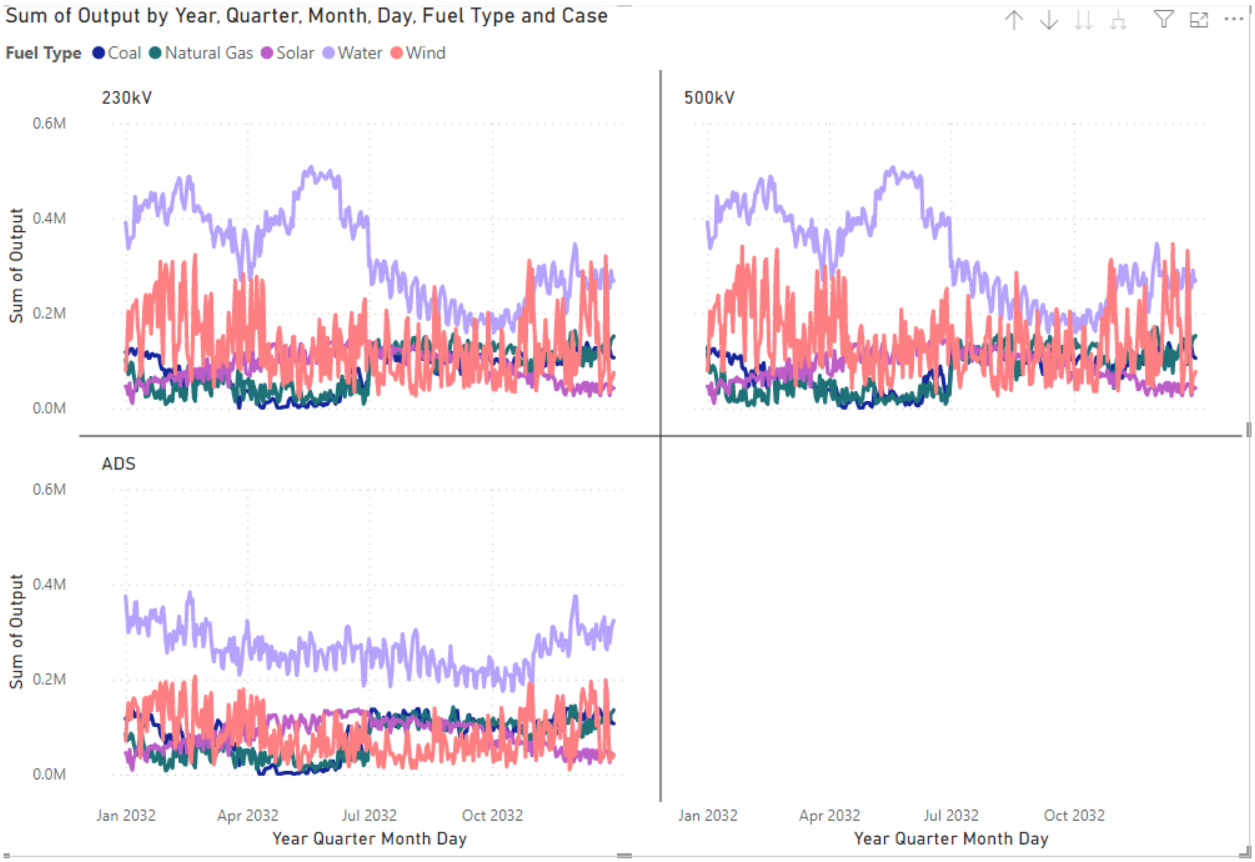


Figure 23: Total daily output for Coal, Natural Gas, Solar, Water, and Wind for the NorthernGrid Region

The colors in Figure 23: Total daily output for Coal, Natural Gas, Solar, Water, and Wind for the NorthernGrid Region do not match those of Figure 22: NorthernGrid broken down by Coal, Natural Gas, Hydro, Solar, and Wind, daily total output, but they do represent the same data. Visual examination of Figure 23: Total daily output for Coal, Natural Gas, Solar, Water, and Wind for the NorthernGrid Region allows for visual confirmation that the resources are behaving similarly for the three different cases.

The results herein this report represent the outcome of the results of a simulation that does not take into account the myriad of different outcomes that may have come about as a result of human intervention and operation. This report lacks a comprehensive review of every aspect of the output of production cost modeling and as such, there may be other characteristics that may more fully explain some of the changes observed between cases.

Table 4: Emissions

	Total SO2	Total NOx	Total CO2
ADS	502,951	36,514,565	69,920,966,237
230kV	489,133	34,966,414	67,430,741,789
500kV	491,841	34,574,063	66,627,837,531

Table 5 shows the overall emissions for the region; the introduction of offshore wind resources helps to reduce regional emissions.

Table 5: Regional Production Cost

Case	Total
ADS	$ 2,287,783
230kV	$ 2,204,824
500kV	$ 2,184,426

The regional production cost reduces with the offshore wind.

Summary

All the statements in the summary below assume that the existing system upgrades listed in Table 1 have been constructed. The statements pertain to the output of the offshore wind from the steady-state, post-transient power flow and production cost modeling analyses performed specifically for this request. This summary only addresses the impacts to the transmission system as a result of successful interconnection, and does not address anything needed to obtain that successful interconnection. The following were observed from this analysis:

1. Offshore wind in Oregon modified the flows on the WECC paths
    a. California to Oregon experienced increased southbound (export to California) flows
    b. Idaho to the Northwest, West of Cascades South, and South of Allston all experienced decreased flows
    c. South of Allston path experienced reduced north to south utilization
2. Carbon-based resources
    a. Regionally, the natural gas and coal generators were dispatched less when offshore wind was modeled
3. Interconnection at the 230 kV level
    a. Requires all Existing System upgrades listed in Table 1
    b. Offshore wind generators experienced congestion as a result of the transmission system limitations between the coast and the I-5 corridor
    c. Reduces the overall production cost compared to the ADS
4. Interconnection at the 500 kV level
    a. Requires all Existing System upgrades listed in Table 1
    b. Requires a new “500 kV loop” that connects the I-5 corridor with both wind facilities
        i. This “500 kV loop” may be constructed in phases as the offshore wind projects get developed; it only needs to be complete upon the complete installation of the additional wind.
    c. The output from the offshore wind generators was delivered to the I-5 corridor congestion-free
    d. The “500 kV loop” allows for other potential interconnection points along the Oregon coast
    e. The “500 kV loop” reinforces the existing transmission system in Oregon
    f. Further reduces the overall production cost from the 230 kV interconnection level

This report is for informational purposes only. The findings in this report may inform the NorthernGrid regional planning process.