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# Benefits of the Southwest Intertie Project-North (SWIP North)

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This report was prepared for Great Basin Transmission, LLC. All results and any errors are the responsibility of the authors and do not represent the opinion of The Brattle Group or its clients.

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## Executive Summary

The Southwest Intertie Project-North (SWIP North) is a planned 275 mile 500 kV alternating current (AC) transmission line from the Midpoint substation in southern Idaho to the Robinson Summit substation in central Nevada. The addition of SWIP North (in conjunction with the recently completed One Nevada Line and CAISO-approved Harry Allen to Eldorado project) will create a major new transmission path that runs parallel to the existing constrained transmission corridors between the northwestern and southwestern portions of the Western Electricity Coordinating Council (WECC) region and connects low-cost renewable-generation areas in Wyoming to markets in California, Nevada, and Arizona.

We analyzed the potential benefits of SWIP North to the members of the Northern Tier Transmission Group (NTTG), WestConnect, and the California ISO (CAISO) for consideration in the upcoming Interregional Transmission Planning (ITP) process. Our analysis identified the following benefits of SWIP North:

- *Congestion Relief over COI:* SWIP North is expected to provide approximately 300 MW of congestion relief to the highly utilized California-Oregon Interface (COI). Annual congestion charges along the California-Oregon corridor (including COI and North-of-Oregon Border Intertie) have ranged from \$60 million to \$150 million per year from 2012 through 2014. Though CAISO's existing market simulation approach does not capture the real-world COI congestion, and understates the congestion relief provided by SWIP North, the CAISO analysis of SWIP North found that the project reduces congested hours on COI by 39%. Applying these reductions to the actual historical congestion charges, the project would potentially reduce congestion charges by \$23 million to \$59 million per year. Such congestion relief would decrease system-wide production costs, reduce utilities' purchase costs, or increase their sales revenues—benefits that likely would accrue primarily in NTTG and CAISO.
- *Energy Market Value:* SWIP North is estimated to provide a wholesale energy market value (a bookend estimate of production cost savings) in the range of \$110 million to \$150 million per year. This value is consistent with (1) projecting historical real-time wholesale energy market prices differences through 2030 and (2) an analysis of future production cost savings based on Center for Energy Efficiency and Renewable Technologies (CEERT) and National Renewable Energy Laboratory (NREL) market simulations. We expect the actual benefits will be higher than those estimated in the CEERT/NREL analysis because their simulations are based on normalized conditions without taking into consideration uncertainties in load, weather, hydro and renewable generation, unexpected generation outages, and transmission outages. NREL's prior Low Carbon Grid Study (LCGS) shows that SWIP North is highly utilized across several simulated high-renewable-generation scenarios. The direction of flow across SWIP North differs depending on market conditions, with annual net transfers of 2,600 gigawatt-hours (GWh) north-to-south in high hydro years and 6,600 GWh south-

to-north in low hydro years. The LCGS simulations show that the hourly changes in daily SWIP North flow pattern provide 3,000 MW of ramping capacity that will reduce customer costs in addition to the production cost savings (particularly in CAISO) by avoiding solar curtailments and reducing the need for flexible capacity procurement.

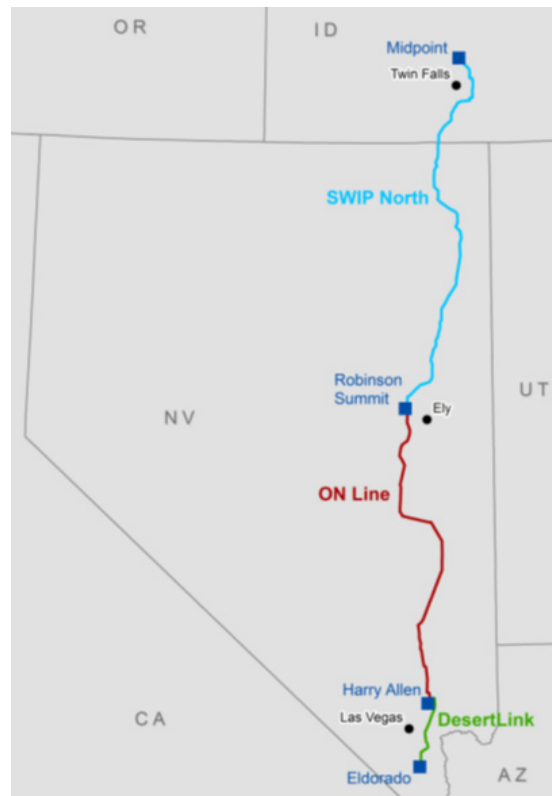
- *Energy Imbalance Market (EIM) Benefits:* SWIP North adds transfer capability between PacifiCorp and CAISO, which, as shown in previous studies, increases EIM-related benefits. For example, increasing transfer capability by 400 MW is expected to increase annual savings up to \$26 million.
- *Load Diversity Benefits and Capacity Cost Savings:* The additional transfer capability provided by SWIP North between balancing areas will allow for capacity sharing associated with load diversity across the balancing areas. For example, the additional transfer capability between PacifiCorp and CAISO would allow PacifiCorp to reduce its reserve margin requirements by 390 MW in 2020 and 450 MW in 2030. We estimate the potential savings of avoided capacity costs to be \$15 million in 2020 and \$45 million in 2030. SWIP North would facilitate sharing of planning reserves across balancing areas in NTTG and WestConnect by providing a more direct connection between the respective systems. The transfer capability provided by SWIP North between regions will allow the regions to take advantage of surplus capacity in other regions or access new capacity to be built in locations with the lowest capital costs. These additional benefits have not been quantified in this report.
- *Insurance Value:* SWIP North will mitigate the adverse impacts of extreme events and challenging future market conditions on electricity market participants and retail customer rates, providing “insurance value” against the risks associated with potentially very-high-cost events and future developments. For example, the energy market value associated with SWIP North, estimated based on historical price differences (as a book-end estimate for production cost savings), spiked to \$127 million in 2012. This value is more than twice the \$53 million average under “normal” conditions for the several years before and after 2012. The addition of SWIP North will mitigate the impact of future conditions similar to those that led to the doubling of the price differentials across the line in 2012. SWIP North will provide significant insurance value to mitigate the impact of high-cost events such as the gas supply issues due to the Aliso Canyon leakage or the loss of significant north-to-south transfer capability. NTTG, WestConnect, and CAISO will benefit from the insurance value provided by SWIP North, although this value has not been quantified in this report.
- *Reliability Benefits:* The addition of the 500 kV SWIP North line in northern Nevada (WestConnect) and southern Idaho (NTTG) will provide reliability benefits by reinforcing the local networks. By shifting flows off of existing lines, SWIP North will reduce the potential for reliability violations and the need for future reliability upgrades as the system load increases over time.
- *Increased Wheeling Revenues:* SWIP North offers opportunities for utilities with transmission rights at Midpoint to increase wheeling revenues associated with transfers out of and across their transmission systems. Based on current charges for annual point-

to-point transmission service on PacifiCorp's system, a 1,000 MW of "out" or "through-and-out" transmission reservations sold by NTTG or WestConnect utilities would generate incremental wheeling revenues of approximately \$28 million per year.

## I. Project Description

The Southwest Intertie Project-North (SWIP North) is a planned 275 mile 500 kV alternating current (AC) transmission line from the Midpoint substation in southern Idaho to the Robinson Summit substation in central Nevada. It is being developed by an LS Power subsidiary, Great Basin Transmission, LLC (GBT). In combination with the recently completed One Nevada Transmission Line (ON Line) from Harry Allen to Robinson Summit and the California ISO (CAISO)-approved Harry Allen to Eldorado (DesertLink) Line (with a 2020 in-service date), SWIP North will create a major new interregional transmission path from Midpoint to Harry Allen, which spans the Northern Tier Transmission Group (NTTG), WestConnect, and CAISO. Based on studies undertaken for the Western Electricity Coordinating Council's (WECC) path rating process, GBT anticipates that the new transmission path will have a bi-directional rating of at least 1,700 megawatts (MW).

**Figure 1: Map of Proposed SWIP North Line**



Source: LS Power.

SWIP North creates a parallel transmission path to the existing constrained paths—the California-Oregon Interface (COI) and North-of-Oregon Border Inter-tie (NOB)—that interconnects the northwestern portion of WECC with CAISO and the Southwest. SWIP North offers interconnection opportunities with PacifiCorp's planned Gateway West project, which collectively would provide a major new transmission path between the low-cost-wind-generation areas in Wyoming and markets in California, Nevada, and Arizona.

Based on an existing agreement with NV Energy (related to the ON Line), 700 MW of this new transmission path, from Midpoint to Harry Allen, will be contractually owned by NV Energy, assuming a final path rating of 1,700 MW. The remaining 1,000 MW transfer capability created between Idaho and southern Nevada, CAISO, and Arizona is owned by GBT and is currently unassigned.<sup>1</sup>

## II. Benefits of SWIP North

The addition of SWIP North results in benefits to the three regions participating in the Interregional Transmission Planning (ITP) process: (1) Northern Tier Transmission Group (NTTG), (2) CAISO, and (3) WestConnect. This report summarizes our preliminary analysis of the benefits that SWIP North is expected to provide across these regions. This summary of benefits should serve as a starting point for the three regions planning efforts as they consider this project in their regional and interregional planning processes.

### A. CONGESTION RELIEF ON COI, PATH 26, AND PATH 15

SWIP North provides a parallel path for flows across the highly utilized California-Oregon Interface (referred to as Path 66) and thus will provide congestion relief across this path. WECC power flow studies show that the addition of SWIP North provides approximately 300 MW of congestion relief on COI.<sup>2</sup> This is a substantial finding considering that the CAISO's annual congestion charges along the California-Oregon corridor (including COI and NOB) have ranged from \$60 million to \$150 million per year for 2012 to 2014 and other balancing areas along the corridor likely incurred additional congestion-related costs.<sup>3</sup>

Currently, based on the existing market simulation approach utilized by the CAISO, the economic analysis, contained in the 2015–16 CAISO Transmission Plan, does not capture the real-world COI congestion, and substantially understates the congestion relief provided by SWIP North and thus undervalues the benefit of adding the project to the Western transmission grid. Specifically, the 2015–16 CAISO Transmission Plan analysis projected COI congestion charges to be \$0.7 million in 2020 and \$0.3 million in 2025—a stark contrast with actual congestion costs in the \$100 million per year range.<sup>4</sup> Thus, the simulated results present a substantial understatement of congestion costs. Such understated results are likely due to the modeling assumptions that reflect only normalized system conditions (weather, hydro, and fuel prices),

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<sup>1</sup> If the path rating exceeds 1,700 MW, the capacity rights will be allocated between NV Energy and GBT according to an agreed upon formula.

<sup>2</sup> The COI congestion relief of approximately 300 MW is based on the preliminary WECC path rating study of SWIP North.

<sup>3</sup> CAISO, 2014 Annual Report on Market Issues & Performance, Department of Market Monitoring, p. 145.

<sup>4</sup> CAISO, 2015–2016 Transmission Plan, Board Approved, March 28, 2016, p. 297.



without adequately considering actual transmission and generation outages and the “frictions” encountered by market participants when scheduling power across the various paths between balancing areas. The stark discrepancy between actual historical and simulated congestion shows that more realistic simulation of the transmission congestion on the CAISO-WECC system will be needed to accurately capture the value of SWIP North. Both LS Power and the Transmission Agency of Northern California (TANC) have previously highlighted these issues to CAISO through comments on the CAISO’s transmission planning process and results.<sup>5, 6</sup>

Despite the stark discrepancy in congestion costs, the same 2015–16 CAISO transmission planning analysis of SWIP North found that the project reduces the number of congested hours on COI by 39%.<sup>7</sup> In addition, the same analysis shows that SWIP North reduces the duration of congestion on Path 15 by 5% and Path 26 by 11%.<sup>8</sup> If we apply this aspect of the CAISO’s analysis and apply these reductions to the actual historical COI congestion charges, we find that the project may reduce annual congestion charges by \$23 million to \$55 million per year. This reduction of congestion across COI will decrease production costs, reduce purchase costs, and increase sales revenues—benefits that likely would accrue primarily in NTTG and CAISO.

The creation of a new north-south path between the northwestern and southwestern portions of the WECC provides an opportunity for actively shifting power flows away from COI to further reduce congestion. The additional shifts of power flows could be achieved by means of topology control (*i.e.*, line switching or substation reconfiguration) and/or the installation of power flow control devices (such as phase shifters).

## **B. ENERGY MARKET VALUE**

The new path created by SWIP North will result in energy market benefits for NTTG, WestConnect, and CAISO by allowing for a more efficient dispatch of generation. To estimate the potential energy market value of SWIP North, we first reviewed historical energy market prices on each side of the new path created by SWIP North and estimated the resulting hourly

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<sup>5</sup> “We recommend that CAISO investigate the discrepancies between historical congestion and congestion identified in the economic study and make adjustments to its economic study model, as needed, to benchmark “projected” vs “actual” congestion. The studies should be conducted to accurately quantify congestion in future years, and study of the need for transmission solutions to address congestion issues should be based on this updated projection of intertie congestion.” Arora, Sandeep, CAISO 2015/16 TPP: Stakeholder Comments - Nov 16, 2015 Meeting, December 1, 2015.

<sup>6</sup> “TANC’s primary comment/issue is that the California-Oregon Intertie (COI) and/or full system is not being modeled to reflect the realities that continue to occur and are likely to continue on the high-voltage grid in the evolving marketplace.” Transmission Agency of Northern California, TANC Comments on the CAISO’s Draft 2015–2016 Transmission Plan, <http://www.caiso.com/Documents/TANCCommentsDraft20152016TransmissionPlan.pdf>

<sup>7</sup> CAISO, 2015–2016 Transmission Plan, Board Approved, March 28, 2016, p. 315.

<sup>8</sup> CAISO, 2015–2016 Transmission Plan, Board Approved, March 28, 2016, p. 315.

price difference. The absolute hourly value of this historical price difference provides a “book-end” estimate of the potential region-wide production cost savings due to SWIP North.<sup>9</sup>

As proxies for the locational prices at each end of the new path created by SWIP North, we have identified trading hubs and pricing nodes that are indicative of the wholesale energy prices expected at the northern and southern end of the newly-created path. At the northern end, we use forward prices at the California-Oregon Border (COB) trading hub and CAISO locational marginal prices (LMPs) at the CAISO’s Malin pricing node as proxies.<sup>10</sup> We find these prices to be reasonable proxies for the northern end of the project because they are geographically closest to the north end of the path and there is limited congestion between COB and southern Idaho (the actual SWIP North’s northern terminus), which means there should not be a large price differential between SWIP North and COB. At the southern end, we use the Mead trading hub and the CAISO’s Eldorado pricing node. Eldorado is the southern terminus of the 500 kV Desert Link line that is currently planned to be in service by 2020, which will directly interconnect with SWIP North via the ON Line. Thus, the logical southern market pricing point to represent the delivery point of energy through the new transmission path created the SWIP North is at Eldorado; and the Mead trading hub is directly connected to Eldorado by a 500 kV line.<sup>11</sup>

The analysis of historical CAISO hourly real-time LMPs at Malin and Eldorado shows that the absolute value of the hourly price differential between the two pricing points on either end of this transmission path averaged \$7.45 per megawatt-hour (MWh) over the 2010 to 2015 period.<sup>12</sup> When applied to the 1,000 MW portion of the path created by SWIP North, the energy market value associated with this path translates to an annual average value of \$65 million per year, with a range between \$40 million to \$130 million for individual historical years since 2010.<sup>13</sup> Table 1

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<sup>9</sup> For example, if energy prices at the northern end of the line are \$40/MWh (consistent with the marginal production cost in the region north of the line) and energy prices are \$50/MWh at the southern end of the line (consistent with marginal production costs in that region), transferring an additional 1 MW of energy from the north to the south would reduce system-wide production cost by \$10 in each hour.

<sup>10</sup> We analyzed LMPs at Malin for consistency with the COB trading hub prices because the COB trading hub “comprises the Captain Jack and Malin substations on the AC transmission system between Oregon and California.” See: [https://www.platts.com/IM.Platts.Content/MethodologyReferences/MethodologySpecs/na\\_power\\_methhod.pdf](https://www.platts.com/IM.Platts.Content/MethodologyReferences/MethodologySpecs/na_power_methhod.pdf)

<sup>11</sup> See: <http://www.caiso.com/Documents/PacifiCorpTransmissionSystemMap-PathRatings.pdf>

<sup>12</sup> Brattle analysis of CAISO average hourly real-time LMPs for 2010 to 2015 from Velocity Suite. For each hour, we calculated the price differential between the nodes and then calculated the absolute value of the differentials to capture the value of both north-to-south and south-to-north flows.

<sup>13</sup> Although the addition of SWIP North will add an estimated 1,700 MW or more of transfer capability along the line, we conservatively estimate the energy market value for just the 1,000 MW of incremental capacity added along the ON Line. The addition of a new path and the combined

Continued on next page

shows a summary of the annual averages of LMPs, price differences, absolute price differences, and associated energy value of SWIP North.

**Table 1: Eldorado-Malin Annual Real-Time Price Differences and Energy Value**

Year	Eldorado Average Price (\$/MWh)	Malin Average Price (\$/MWh)	Eldorado Average Premium above Malin (\$/MWh)	Average Absolute Difference (\$/MWh)	Absolute Annual Difference (\$/MW-year)
2010	\$39.58	\$36.57	\$3.01	\$4.95	\$43,000
2011	\$29.90	\$27.06	\$2.85	\$4.48	\$39,000
2012	\$25.32	\$22.15	\$3.17	\$14.45	\$127,000
2013	\$38.61	\$35.74	\$2.86	\$8.17	\$72,000
2014	\$41.98	\$40.29	\$1.69	\$6.97	\$61,000
2015	\$29.90	\$31.25	-\$1.34	\$5.68	\$50,000
6-yr Average	\$34.22	\$32.18	\$2.04	\$7.45	\$65,000

Sources: Velocity Suite, ABB Inc.

Real-time LMPs provide the most realistic representation of the incremental impact that the added transmission will have on the energy market and production costs. This is because real-time hourly prices reflect the actual marginal cost of energy at the time it is produced under real-time conditions. These conditions reflect the added costs incurred during unexpected system conditions and disturbances. In contrast, the day-ahead and monthly forward prices are based on forecasts of these conditions, not the actual conditions, and thus will miss short-term fluctuations and associated high-priced time periods that reflect the true value of increasing transmission capacity. For this reason, the absolute price differentials between the points on either end of the transmission path created by SWIP North are smaller when calculated with day-ahead prices or monthly forward prices from various sources. Table 2 below summarizes the 2010–2015 average of the absolute price differences (\$/MWh) and implied energy market values (\$/MW-year) based on real-time prices, hourly day-ahead prices, day-ahead forward prices, the monthly average of day-ahead forward prices, and monthly forward prices. As the table shows, forward prices capture a portion of the real-time value that can be provided by the new transmission path. The energy market value based on day-ahead prices is roughly 30% lower than that based on real-time prices, while the value based on monthly forward prices is roughly 50% lower.

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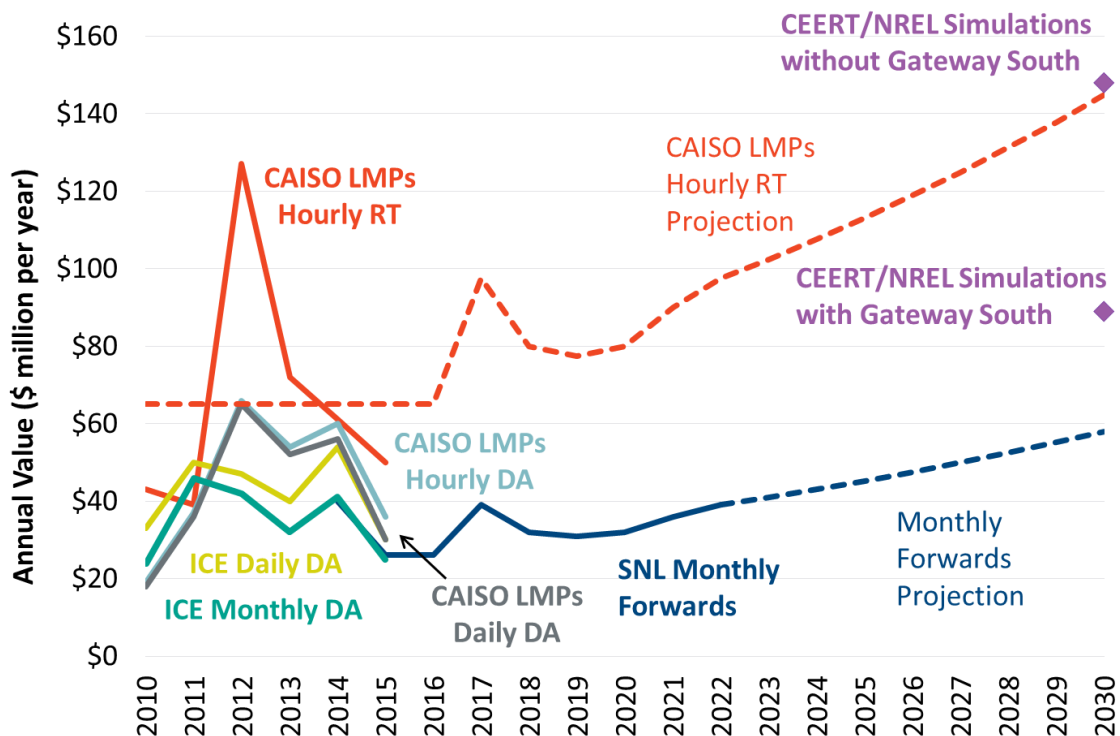
capacity along that path are likely to have a greater impact, though likely offset by the inability to provide the full value of the price differentials.

**Table 2: Analysis of Price Differentials across SWIP North Based on Real-Time and Forward Prices**

Energy Price Source	Period	North Node	South Node	Absolute Annual Difference (\$/MWh)	Absolute Annual Difference (\$/MW-year)
1 CAISO LMPs Hourly RT	2010 - 2015	Malin	Eldorado	\$7.45	\$65,000
2 CAISO LMPs Hourly DA	2010 - 2015	Malin	Eldorado	\$5.17	\$45,000
3 CAISO LMPs Daily DA	2010 - 2015	Malin	Eldorado	\$4.87	\$43,000
4 ICE Daily DA	2010 - 2015	COB	Mead	\$4.84	\$42,000
5 ICE Monthly DA	2010 - 2015	COB	Mead	\$3.99	\$35,000
6 SNL Monthly Forwards	2014 - 2016	COB	Mead	\$3.49	\$31,000
7 SNL Monthly Forwards	2017 - 2022	COB	Mead	\$3.96	\$35,000

Sources and Notes: Velocity Suite, ABB Inc. and SNL Financial LC.

Figure 2 below shows various estimates of the annual energy value and production cost savings of the transmission path created by SWIP North based on: (1) the different sources of historical prices included in the table above (solid lines); (2) a projection of the real-time energy value (as a book-end estimate of production cost savings) based on extrapolating the historical real-time energy value using the trend of monthly forward market prices (dashed lines); and (3) production cost savings based on market simulations for 2030 conducted by the Center for Energy Efficiency and Renewable Technologies (CEERT) and the National Renewable Energy Laboratory (NREL) (marked with a purple diamond and discussed further below).

**Figure 2: Historical and Projected Annual Energy Market Value and Estimated Production Cost Savings of SWIP North**

Sources and Notes: Velocity Suite, ABB Inc. (CAISO LMPs), SNL Financial LC (ICE and Monthly Forwards), and Caldwell, James and Liz Anthony, Low Carbon Grid Study: SWIP North Economic Benefits, March 2016

(CEERT/NREL Simulations). Monthly Forwards Projection is calculated using the 2018–2022 compounded annual growth rate. CAISO LMPs Hourly RT Projection is calculated as the 2010–2015 average Hourly RT Value projected forward each year based on the Monthly Forwards annual growth rate. The CEERT/NREL Simulations values represent WECC-wide production cost savings and include Gateway West in both cases. The production cost savings have been escalated from the reported values in 2014 dollars to 2030 dollars.

The current monthly forward prices available through 2022 (solid blue line) indicate that the price differential across the path created by SWIP North is trending upwards. This trend is likely associated with projected increases in natural gas prices and a continued trend towards increased interregional power flows. For estimating the future real-time energy market value, first we projected the monthly forward prices through 2030 (dashed blue line) by increasing the 2022 forwards with the average historical annual increases between 2018 and 2022. We then projected the real-time energy market value through 2030 (red dashed line) by growing the 2010–2015 historical average real-time energy market value of \$65 million per year with the growth rate of the monthly forwards prices. As shown, these projections result in the estimated real-time energy market value increasing over time to approximately \$110 million in 2025 and \$145 million in 2030. These book-end estimates show that SWIP North must be expected to offer significant energy market value by providing the ability to purchase lower cost power and capture production cost savings for NTTG, CAISO, and WestConnect. These estimated bookends for the project’s production cost savings significantly exceed the benefits captured in the market simulations the CAISO conducted to date.

Also included in Figure 2 are the estimated 2030 production cost savings associated with SWIP North based on recent CEERT/NREL market simulation analyses (shown as purple diamonds).<sup>14</sup> The CEERT/NREL simulations analyzed the 2030 value of SWIP North under two cases, one assuming that Gateway South is not built by 2030 and another with Gateway South in service by 2030.<sup>15</sup> The CEERT/NREL market simulations reflect significant renewable capacity additions similar to the Target Conventional case in the Low Carbon Grid Study (LCGS), which achieves 50% greenhouse gas (GHG) emissions reductions from the California electric sector by 2030 through the addition of renewable capacity and increases in energy efficiency.<sup>16</sup>

These CEERT/NREL analyses found that the annual production cost savings in 2030 associated with SWIP North are in the range of approximately \$90 million (with Gateway South) and \$150

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<sup>14</sup> For details on the CEERT/NREL analysis, see: Caldwell, James and Liz Anthony, Low Carbon Grid Study: SWIP North Economic Benefits, March 2016. NREL completed this analysis for the purpose of valuing SWIP North utilizing many of the same assumptions as those made in the Low Carbon Grid Study released in February 2016.

<sup>15</sup> Both cases assume Gateway West is built.

<sup>16</sup> The Target Conventional scenario reaches 56% renewable penetration in California and 16% in the rest of WECC. For a detailed description of the Target Conventional scenario in the Low Carbon Grid Study, see: Brinkman, Jorgenson, Ehlen, Caldwell, Low Carbon Grid Study: Analysis of a 50% Emission Reduction in California, NREL/TP-6A20-64884, January 2016, p. 3.

million (without Gateway South).<sup>17</sup> The CEERT/NREL production cost simulation results do not reflect conditions with transmission outages or real-time load and generation uncertainties and, thus, they can be thought of as hourly day-ahead prices and market conditions. Actual production cost savings under the market conditions modeled by CEERT/NREL will be higher than the estimated savings due to the normalized and fully-deterministic nature of the simulations.<sup>18</sup> Thus, we expect the energy market value of SWIP North to be higher than what was captured in the CEERT/NREL analysis and likely higher than the historical real-time value extrapolated to 2030.

We also reviewed the utilization of SWIP North in the Phase II results of the LCGS.<sup>19</sup> The LCGS includes additional scenarios that demonstrate the projected utilization and value of SWIP North in 2030 across market conditions not captured in the most recent CEERT/NREL simulations. The results from those LCGS scenarios provide evidence of the future value of the project by showing that the path created by SWIP North is heavily utilized in the simulated renewables-rich future.<sup>20</sup> Figure 3 below shows flow duration curves across SWIP North for five different scenarios modeled in the LCGS. As seen in these flow duration curves, SWIP North is fully loaded at 2,000 MW (in either direction) for 25% to 31% of hours under the different scenarios.<sup>21</sup> In addition, the curves show that SWIP North is utilized in the north-to-south direction for delivering wind and hydro resources from regions in NTTG south to CAISO and WestConnect utilities, and is almost equally utilized in the south-to-north direction carrying excess generation from solar generation from CAISO and WestConnect regions to NTTG utilities, depending on

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<sup>17</sup> These values represent the nominal dollar equivalent to the CEERT/NREL values, which were reported in 2014 dollars.

<sup>18</sup> A detailed discussion of these limitations can be found in section VI.A of Chang, Pfeifenberger, and Hagerty, *The Benefits of Electric Transmission: Identifying and Analyzing the Value of Investments*, WIRES and The Brattle Group, July 2013.

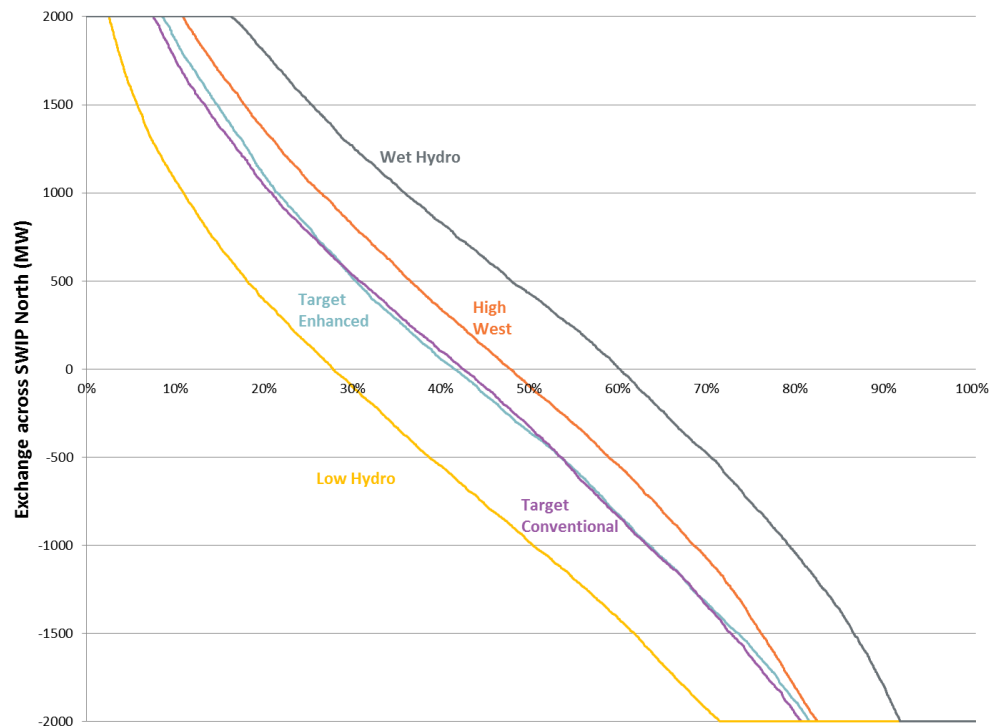
<sup>19</sup> Brinkman, Jorgenson, Ehlen, Caldwell, *Low Carbon Grid Study: Analysis of a 50% Emission Reduction in California*, NREL/TP-6A20-64884, January 2016.

<sup>20</sup> The LCGS modeled several 2030 scenarios that achieve 50% GHG emissions reductions in California. In 2030 while these scenarios for renewable additions and GHG emissions reductions across WECC by 2030 are more aggressive than any specific actions currently planned, it is likely that the WECC region will continue to move closer to the scenarios modeled in the LCGS due to the continued GHG emissions reduction in California to achieve 40% GHG emissions reductions in 2030 (relative to 1990 levels) and the likely ultimate implementation of the EPA's Clean Power Plan or other clean-energy regulations in the other western states, such as Oregon's recent legislation implementing a 50% renewable energy target. For details on the LCGS assumptions, see: Brinkman, Jorgenson, Ehlen, Caldwell, *Low Carbon Grid Study: Analysis of a 50% Emission Reduction in California*, NREL/TP-6A20-64884, January 2016.

<sup>21</sup> Data provided by NREL from Brinkman, Jorgenson, Ehlen, Caldwell, *Low Carbon Grid Study: Analysis of a 50% Emission Reduction in California*, NREL/TP-6A20-64884, January 2016. The LCGS assumed SWIP North capacity of 2,000 MW, which is consistent with the range anticipated by GBT based on the preliminary WECC path rating study.

the scenario. Across all hours, the average utilization in the LCGS scenarios is approximately 60%.

**Figure 3: SWIP North Flow Duration Curves in LCGS Scenarios**



Source and Notes: Data provided by NREL from Brinkman, Jorgenson, Ehlen, Caldwell, Low Carbon Grid Study: Analysis of a 50% Emission Reduction in California, NREL/TP-6A20-64884, January 2016. Positive values indicate north-to-south flows.

SWIP North’s utilization will reduce production costs throughout the West (as shown in the NREL simulations in Figure 2 above) as well as relieve solar curtailments in the southwest and reduce the capital costs of installing additional renewable capacity to meet RPS and GHG reduction goals. These additional benefits have not been quantified in this report.

Figure 4 below shows the total exchange and the net exchange across SWIP North on a seasonal basis for several LCGS scenarios. The LCGS analysis finds that SWIP North’s total utilization is similar across multiple scenarios, ranging from 10,300 GWh during high-hydro years to 10,900 GWh during low-hydro years.<sup>22</sup> The NREL LCGS study shows that SWIP North is utilized differently depending on the future capacity build out and power market conditions, especially hydro conditions. For example, while daily variations and system ramps remain very similar, the difference in the annual exchange between high- and low-hydro years is estimated to be 9,200 GWh: during high-hydro years there is an estimated annual net transfer across SWIP North of 2,600 GWh north-to-south, while during low-hydro years the estimated net transfer is 6,600

<sup>22</sup> Data provided by NREL from Brinkman, Jorgenson, Ehlen, Caldwell, Low Carbon Grid Study: Analysis of a 50% Emission Reduction in California, NREL/TP-6A20-64884, January 2016.



GWh south-to-north. These results reinforce the expectation that the path created by SWIP North can provide value to the system across a wide range of future scenarios with different portfolios of renewable generation and different hydro conditions.

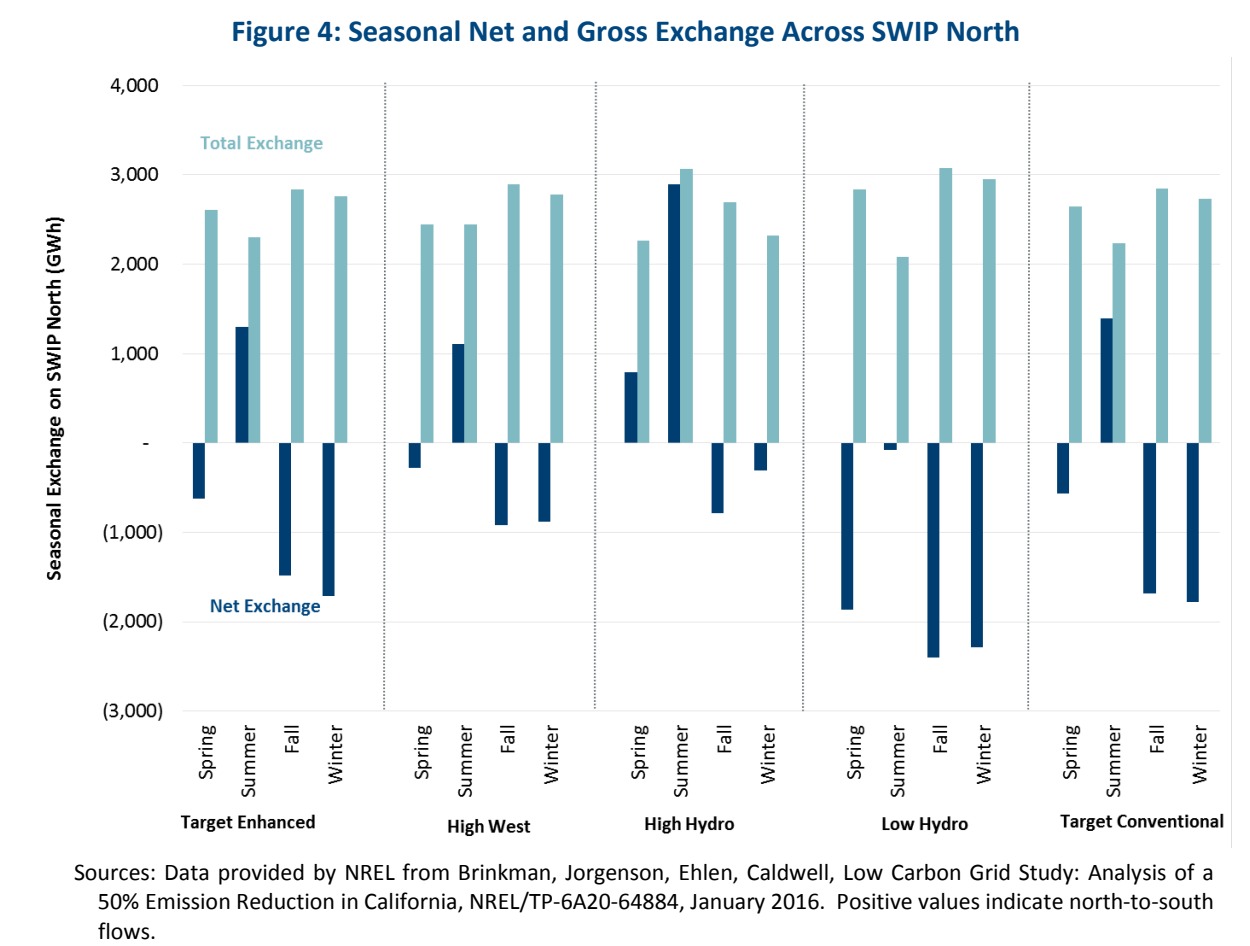
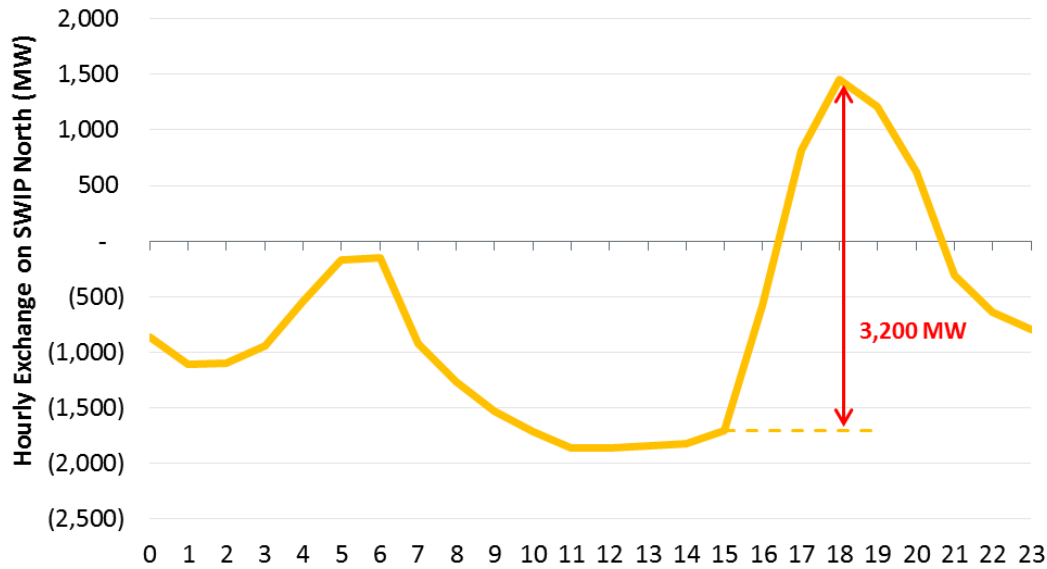


Figure 5 shows that an important future benefit of SWIP North based on the NREL LCGS results is its ability to provide access to over 3,000 MW of daily, 3-hour ramping capability during critical winter and spring days. The provision of this ramping capability allows SWIP North to support CAISO’s daily transitions from high solar generation at 3 p.m. in the afternoon (with 1,700 MW of south-to-north flow) to meeting the evening 6 p.m. peak load after sunset (with 1,500 MW of north-to-south flow). The ramping capability provided by the new path created by SWIP North will reduce the need for, and the costs of, flexible capacity procurement in the CAISO, which will provide benefits in addition to those estimated above based on historical market prices or the CEERT/NREL simulations.



**Figure 5: Average Daily Winter Utilization of SWIP North in Target Enhanced Scenario**



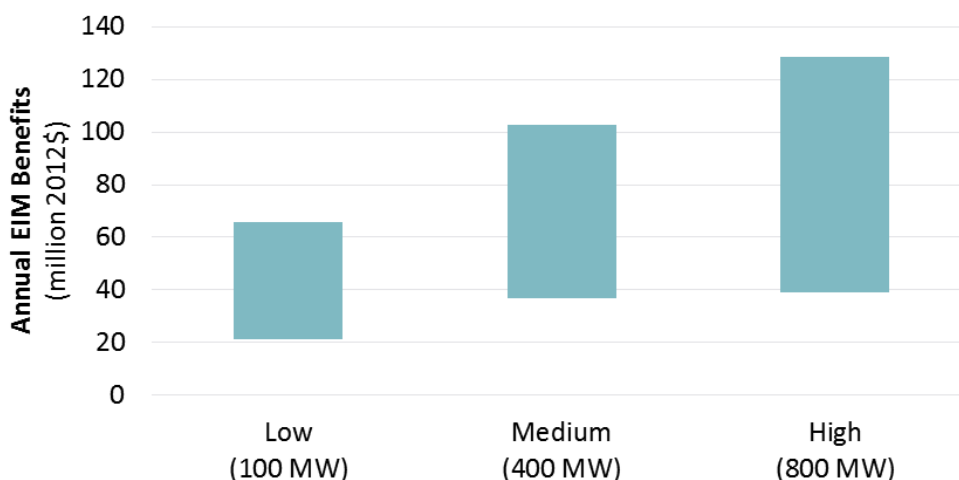
Source: Data provided by NREL from Brinkman, Jorgenson, Ehlen, Caldwell, Low Carbon Grid Study: Analysis of a 50% Emission Reduction in California, NREL/TP-6A20-64884, January 2016. Positive values indicate north-to-south flows

### C. BENEFITS RELATED TO EIM AND CAISO-PACIFICORP INTEGRATION

The 2013 analysis of the Energy Imbalance Market (EIM) between the CAISO and PacifiCorp found that the benefits of the EIM depend on the transfer capability between the two systems. The addition of SWIP North, which creates at least 1,000 MW of additional transfer capability between the PacifiCorp and CAISO balancing areas, will consequently increase EIM benefits. For example, Figure 6 below shows that the 2013 analysis of EIM benefits found that increasing transfer capability from 400 MW to 800 MW increases annual benefits by up to \$26 million per year.<sup>23</sup>

<sup>23</sup> E3, PacifiCorp-ISO Energy Imbalance Market Benefits, March 13, 2013, Table 2, p. 9.

**Figure 6: Impact of CAISO-PAC Transfer Capability on Annual EIM Benefits**



Source: E3, PacifiCorp-ISO Energy Imbalance Market Benefits, March 13, 2013, Table 2, p. 9.

In addition to these EIM benefits, SWIP North would very likely provide significantly higher benefits if PacifiCorp and CAISO succeeded in their efforts to create a regional market. Based on the ISO-PacifiCorp integration study, the transfer capability between the two regions is currently projected to be limited to 776 MW from CAISO to PacifiCorp and to 982 MW from PacifiCorp to CAISO.<sup>24</sup> SWIP North would create at least an additional 1,000 MW of transfer capability between the two regions and increase the integration benefits by reducing dispatch costs, allowing greater reserve sharing, and avoid generation capacity costs.

Analysis of the benefits of APS and NV Energy joining the EIM do not specifically highlight limitations due to transfer capability between their respective systems.<sup>25</sup> However, the additional path between PacifiCorp, NV Energy, and CAISO will likely bring additional EIM-related benefits to both existing and future EIM participants.

#### **D. LOAD DIVERSITY BENEFITS AND CAPACITY COST SAVINGS**

The new transmission path created by SWIP North, ON Line, and Harry Allen to Eldorado offers potential load diversity benefits to NTTG, WestConnect, and CAISO. Although it has been determined that the line will shift approximately 300 MW of power flows away from the congested COI path, it has not been determined the extent to which SWIP North will increase the transfer capability into CAISO. Nevertheless, the line interconnects regions with divergent load patterns that would make it possible to reduce resources adequacy needs.

<sup>24</sup> E3, Regional Coordination in the West: Benefits of PacifiCorp and California ISO Integration, Technical Appendix, October 2015, p. 2.

<sup>25</sup> See EIM benefit studies posted here:  
<https://www.caiso.com/informed/Pages/EIMOverview/Default.aspx>

We analyzed the potential for balancing areas on either end of SWIP North to share resource adequacy capacity due to differences in the timing of peak load. We specifically reviewed the load diversity savings potential between the CAISO and PacifiCorp, CAISO and Idaho Power, and between a broader pool of balancing areas including CAISO, PacifiCorp, Idaho Power, NV Energy, LA Department of Water & Power (LADWP), and Salt River Project (SRP). Our analysis finds that the regional coincident peak tends to be closely aligned with the CAISO peak in most years, such that most of the reduced resource adequacy requirement due to the shift from each entity's own non-coincident peak to the coincident peak shared with CAISO is realized by the utilities in NTTG and WestConnect.

Our analysis of the potential capacity savings for PacifiCorp due to the new transmission path provided by SWIP North finds that capacity savings are likely beyond the existing 776 MW contract path assumed in the PacifiCorp-ISO integration study.<sup>26</sup> The additional transfer capability on the path created by SWIP North will allow PacifiCorp to reduce its reserve margin requirements by an additional 390 MW in 2020 and 450 MW in 2030. We estimate the potential capital cost savings of avoided capacity costs for PacifiCorp to be \$15 million in 2020 and \$45 million in 2030, assuming capacity costs of \$38/kW-year can be avoided in 2020 and higher capacity costs of \$100/kW-year can be avoided in 2030.<sup>27</sup>

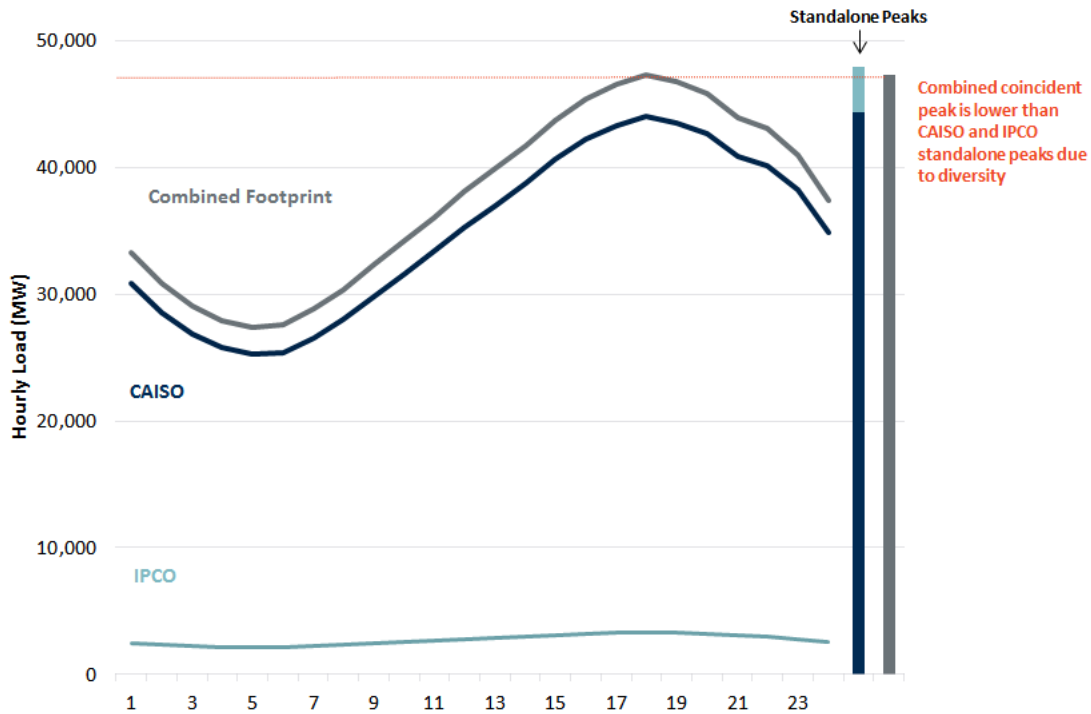
We analyzed the potential for CAISO and Idaho Power to reduce resource adequacy needs due to load diversity since the two balancing areas are not directly interconnected today. Our analysis finds that due to the differences between their coincident and non-coincident peaks, the addition of SWIP North would allow for the sharing of 600 MW of capacity between CAISO and Idaho Power. The associated benefit, which would mostly accrue to Idaho Power, has not been quantified in this study. Figure 7 below shows how the combined non-coincident, or standalone, peaks are greater than the coincident peak across the combined footprint. While there is currently significant regional transfer capacity through balancing areas that are physically located between CAISO and Idaho Power, the addition of SWIP North will provide the first direct connection between them, which should facilitate capturing these benefits.

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<sup>26</sup> “For PacifiCorp, potential capacity cost savings are limited by transmission constraints, assumed here to be 776 MW.” E3, *Regional Coordination in the West: Benefits of PacifiCorp and California ISO Integration*, October 2015, p. 20.

<sup>27</sup> We assumed a 2020 capacity value of \$38/kW-year based on recent resource adequacy contracts in California as reported in the E3 PAC Integration study. For 2030, we applied an avoided cost of capacity of \$100/kW-year, as a conservatively low estimate of the net cost of new entry for a gas combined-cycle unit. E3, “Regional Coordination in the West: Benefits of PacifiCorp and California ISO Integration,” Technical Appendix October 2015, p. 12.

**Figure 7: Potential Capacity Savings between CAISO and Idaho Power**



Source: Brattle analysis of Velocity Suite, ABB load data on July 31, 2014.

Similar load diversity analysis of a wider footprint around SWIP North that includes CAISO, PacifiCorp, Idaho Power, NV Energy, LADWP, and SRP finds that there is potential for capacity savings through 2,900 MW of load diversity benefit across these balancing areas. The addition of SWIP North has the potential to ease sharing and increase transfer capabilities between entities at the southern end of the new path created by SWIP North and Desert Link (CAISO, LADWP, SRP), with those entities with access at the northern end of SWIP North (Idaho Power and PacifiCorp). This transfer capability will facilitate the realization of load diversity benefits for NV Energy who has access to multiple points on this path. These benefits have not been quantified in this study.

In addition to load diversity benefits, the additional transfer capability created by SWIP North between NTTG and WestConnect may reduce generation capacity costs by either: (1) providing access to temporary amounts of excess generation in the other region; or (2) allowing more new generation capacity to be built in the lowest-cost locations of the combined footprint. For example, the capital cost for new combined-cycle plants in Arizona are estimated to be 18% lower than in PacifiCorp.<sup>28</sup> To the extent SWIP North creates additional simultaneous transfer

<sup>28</sup> Combined-cycle capital cost estimates of \$988/kW for APS and \$1,202/kW for PacifiCorp are based on values included in each utility's Integrated Resource Plan analysis. E3, Capital Cost Review of Power Generation Technologies: Recommendations for WECC's 10- and 20-Year Studies. March 2014, p. 18. Available at:

capability into the CAISO footprint, such generation capacity cost savings would benefit the CAISO.

## **E. INSURANCE VALUE**

Transmission investments offer “insurance value” by providing additional flexibility that allows the grid to respond more cost-effectively to both short-term operational and long-term planning uncertainties. The addition of SWIP North will mitigate the adverse impacts of both short-term extreme events and long-term challenges on electricity market participants and retail customer rates. More specifically, transmission projects provide such insurance value with respect to two types of uncertainties:<sup>29</sup>

1. Short-term uncertainties, such as extreme (but temporary) contingencies, constrained fuel supplies, and weather conditions that can lead to spikes in load, hydro variations, renewable generation output, or generation and transmission outages.
2. Long-term uncertainties, such as 5–10 year changes in fuel prices, technology costs, environmental regulations, and/or public policy goals that, in the absence of the transmission project, would impose substantial costs on market participants and retail customers.

For example, we found in our analysis of market prices across SWIP North that applying the absolute real-time price difference between Malin and Eldorado from 2010 through 2015 to a 1,000 MW of additional transfer capability yields a 6-year average annual value of \$65 million per year. However, this average value is substantially influenced by the conditions in a single year: in 2012, the value of 1,000 MW transfers was \$127 million, while the average for the other five years was only \$53 million. Thus, more challenging market conditions resulted in benefits that in one year were significantly more than twice the “normal” \$53 million 5-year average, yielding a six-year average that was 23% above the five-year average.

CAISO has previously studied the insurance value of similar transmission projects. For example, its 2004 study of the Palo Verde to Devers No. 2 (PVD2) line illustrated this point.<sup>30</sup> The

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[https://www.wecc.biz/Reliability/2014 TEPPC Generation CapCost Report E3.pdf](https://www.wecc.biz/Reliability/2014%20TEPPC%20Generation%20CapCost%20Report%20E3.pdf)

<sup>29</sup> For a broader discussion of the insurance value of transmission, see: Pfeifenberger, Chang, and Sheilendranath, “Toward More Effective Transmission Planning: Addressing the Costs and Risks of an Insufficiently Flexible Electricity Grid, Prepared for WIRES, April 2015. Posted at: [http://www.brattle.com/system/publications/pdfs/000/005/154/original/Toward More Effective Transmission Planning Addressing the Costs and Risks of an Insufficiently Flexible Electricity Grid.pdf?1429801687](http://www.brattle.com/system/publications/pdfs/000/005/154/original/Toward_More_Effective_Transmission_Planning_Addressing_the_Costs_and_Risks_of_an_Insufficiently_Flexible_Electricity_Grid.pdf?1429801687)

<sup>30</sup> See Pfeifenberger, Chang, and Sheilendranath, “Toward More Effective Transmission Planning: Addressing the Costs and Risks of an Insufficiently Flexible Electricity Grid, Prepared for WIRES, April 2015, Section III.B and Appendix A. Posted at:

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CAISO's production cost simulations under base-case conditions estimated production cost savings of \$55 million per year. When considering savings beyond production cost savings, the total cost savings increased to \$100 million per year. However, when considering the probability of infrequent but high-cost events, the probability-weighted average increased by 20% to \$120 million per year. This increase in the probability-weighted average greatly understates the substantial cost savings the project was estimated to provide under the most challenging market conditions. The CAISO's study found that, without the proposed line, there was a 10% chance (comparable to once in 10 years) that the annual cost would be at least \$300 million (and possibly up to \$750 million) higher without PVD2. The high end of this range is associated with a long-term outage of the SONGS nuclear stations, which was considered as an extreme contingency in this 2004 study. This example documents the importance of "insurance value" by showing that under certain circumstances the cost savings offered by a transmission project can exceed "base case" savings estimates by a factor of ten.

A very recent example of unforeseen events in which transmission provides insurance value is the natural gas leakage issues at Aliso Canyon near Los Angeles. The ongoing issues with natural gas leaking from the storage facility may result in limited gas supply in the summer of 2016. Because of such gas supply shortages, there is potential for short-term electricity system operability and reliability issues.<sup>31</sup> In circumstances such as these, additional transmission provides the system with more flexibility to respond to the limited fuel supply availability by relying on a wider range of generation facilities and fuel types.

SWIP North will provide insurance value to protect against the loss of significant transfer capacity on the few existing north-south lines in WECC. A disturbance of this nature could result in very high system costs and large economic losses across the region due to power outages to businesses until the system can be restored. The potential of such events occurring is understood by WECC, which has developed operational schemes to separate the northwestern and southwestern portion of the region in the case of the loss of certain elements of the Pacific Intertie.<sup>32</sup> The additional interregional transmission path could greatly mitigate the potential impact of such an event and avoid the need for significant operational actions to maintain system operation. The impending retirements due to once-through-cooling requirements and the potential retirement of Diablo Canyon are additional near-time examples in which additional transmission infrastructure could help mitigate potentially very high cost outcomes.

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[http://www.brattle.com/system/publications/pdfs/000/005/154/original/Toward More Effective Transmission Planning Addressing the Costs and Risks of an Insufficiently Flexible Electricity Grid.pdf?1429801687](http://www.brattle.com/system/publications/pdfs/000/005/154/original/Toward_More_Effective_Transmission_Planning_Addressing_the_Costs_and_Risks_of_an_Insufficiently_Flexible_Electricity_Grid.pdf?1429801687)

<sup>31</sup> Colbert, Cathleen, Aliso Canyon Gas Electric Coordination, Issue Paper Stakeholder Call, March 23, 2016. Available at:

[http://www.caiso.com/Documents/Agenda\\_Presentation\\_AlisoCanyonGasElectricCoordination.pdf](http://www.caiso.com/Documents/Agenda_Presentation_AlisoCanyonGasElectricCoordination.pdf)

<sup>32</sup> WECC RAS #18, Major WECC Remedial Action Schemes (RAS), Used in Standard PRC-004-WECC-1, Revised September 19, 2007.

We recommend that, in the context of the interregional planning process, the value of SWIP North be evaluated for a plausible range of such uncertainties to capture at least a portion of the insurance value of the line.

## **F. RELIABILITY BENEFITS**

The addition of the 500kV SWIP North transmission line will have positive reliability benefits in the area in which the line is located. The transmission system in northern Nevada is based on a network of 345 kV lines that has limited transfer capability. For example, the 345 kV system limits the capability of the existing ON Line to approximately 1,000 MW north-to-south and 600 MW south-to-north.<sup>33</sup> Adding the 500 kV SWIP North line across northern Nevada adds at least 1,000 MW of transfer capability to ON Line, reinforces the local 345 kV network, and increases the reliability of the local system. In addition, shifting flows off of existing 345 kV lines will reduce the potential for reliability violations and the need for reliability upgrades as the system load increases over time.

The new 500 kV intertie and associated increased transmission intertie capacity into the Idaho Power and PacifiCorp systems in the north and the CAISO, LADWP, and SRP systems in the south will provide regional reliability benefits to NTTG, WestConnect, and CAISO members.

The additional transmission capability in southern Idaho and northern Nevada will provide operational flexibility during periods of maintenance on the existing transmission system and generating plants. Taking transmission lines out of service for maintenance often must occur in the spring or fall to avoid creating significant congestion on the system. The addition of the new path will provide greater flexibility in choosing when maintenance can be performed and limiting reliability concerns and cost increases when the maintenance occurs.

## **G. INCREASED WHEELING REVENUES**

Creating a new north-to-south transmission path with at least 1,700 MW transfer capability between Midpoint, Robinson, Harry Allen, and Eldorado offers substantial opportunities for increased electricity trading throughout the West. Utilities with transmission rights at Midpoint (PacifiCorp and Idaho Power) will be able to increase wheeling revenues associated with transfers out of and across their transmission system (*e.g.*, from the Mid-C trading hub to Midpoint) for any transactions (*e.g.*, to Nevada, California, or Arizona) that utilize the new transfer capabilities created by SWIP North.

For example, under PacifiCorp's Open Access Transmission Tariff (OATT) the charge for an annual reservation for point-to-point transmission service is currently \$28,472/MW-year.<sup>34</sup> At

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<sup>33</sup> Transfer capability limits on existing lines provided by LS Power.

<sup>34</sup> PacifiCorp, PacifiCorp Transmission Rates, December 1, 2015. Available at: [http://www.oasis.oati.com/PPW/PPWdocs/Rate\\_Table\\_20151201.pdf](http://www.oasis.oati.com/PPW/PPWdocs/Rate_Table_20151201.pdf)

this rate, each 1,000 MW of “out” or “through-and-out” transmission reservations sold by NTTG or WestConnect utilities, including NV Energy on its 700 MW portion of SWIP North, would generate incremental wheeling revenues of \$28 million per year. Any such incremental wheeling revenues would be a real and tangible benefit associated with the new trading opportunities created by SWIP North.