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Low Carbon Grid Study: SWIP N Benefits

Additional submitted attachment is included below.

Low Carbon Grid Study: SWIP North Economic Benefits

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The report itself and the conclusions drawn are those of the authors alone and do not represent the views of Great Basin Transmission, NREL, the Low Carbon Grid Study, or CEERT

Abstract

This report provides new information derived from extensive previous modeling efforts to assist in determining the cost effectiveness of a new proposed transmission project connecting Southern Idaho with Eastern Nevada as a component of a policy driven plan by California and other Western states to significantly reduce carbon emissions associated with the production of electricity in the West. It finds that this transmission investment is indeed a cost effective piece of an overall investment portfolio to achieve this objective, and supports a decision to conduct formal Interregional Transmission Planning Studies to further define details of the proposed project.

Purpose and Introduction

The purpose of this report is to quantify WECC wide production cost savings that the proposed Southwest Intertie Project – North (SWIP-N) a new single circuit 500 kv AC transmission line from Midpoint (Idaho Power) to Robinson Summit (NV Energy) offers to ratepayers. SWIP-N represents the last missing link in a strong N-S 500 kv path down the Great Basin connecting the existing E-W pathways across the Cascades in the North and the Colorado River in the South. The loop thus formed with the existing strong N-S path along the Pacific Coast offers the potential to significantly improve transfer capabilities and circulation patterns throughout the West. When the project was submitted to the CAISO 2015-2016 ISO Transmission Planning Cycle request window, the CAISO concluded in its Draft Transmission Plan [1] that the project appeared to potentially offer material benefits to the achievement of California's recently enacted statute to reach a 50 percent renewable energy goal by 2030. CAISO recommended that the project be submitted to the Inter Regional Planning process and offered to participate in a three-party ITP with WestConnect and NTTG.

Throughout the Western Interconnection, loads and resources are changing at a rate unprecedented in modern history. In California alone, in addition to doubling the energy delivered by RPS eligible renewable resources from the current 25% to 50% over the next fourteen years, the state is adding

[1] CAISO Draft 2015-2016 Transmission Plan, Feb 1, 2016, p. 298

customer sited distributed rooftop solar photovoltaics at a pace that implies serving 10% of customer load from this non-RPS eligible renewable resource, retiring over 17 GW of gas/steam generation located in the coastal load pockets, and facing the potential retirement of its 2240 MW nuclear plant, Diablo Canyon when its operating licenses expire in less that ten years. Oregon recently passed legislation phasing out coal imports by 2030 and following California's lead with a 50% RPS standard by 2040.[2] Throughout the West, fueled by planned coal retirements, plummeting renewable energy costs, prospects for low priced abundant supplies of natural gas, a dramatic increase in customer sited distributed resources (primarily rooftop solar), and, through it all, a focus on reducing carbon emissions from the electric grid, these same trends are being felt.

In this report, we document the role that the SWIP-N line can make in this "low carbon grid" of the near future and quantify the production cost savings that SWIP-N offers. We note that, in this looming future, the missing transmission link filled by SWIP-N is a cost effective addition to the WECC grid topology. We rely on production cost modeling done for the Low Carbon Grid Study (LCGS)[3] and then perform additional runs to isolate the impact of SWIP-N on WECC-wide production costs to allow assessment of the costs and benefits of SWIP-N in a low carbon future.

SWIP-N and the Low Carbon Grid Study

The following discussion is provided not to tout the LCGS itself, but to explain the decision to include the SWIP-N project in Phase II of the LCGS and to provide context for the qualitative findings on the use of the SWIP-N project in a Western grid with high penetrations of renewable energy.

The LCGS is a peer-reviewed study of the California electric sector in 2030 that, between now and 2030, adds enough new California load serving renewable resources to cut California electric sector carbon emissions in half by 2030.

[2] Clearing Up, March 2, 2016

[3] www.lowcarbongrid2030.org. In particular, details of the modeling assumptions and data bases used can be found in "Low Carbon Grid Study: Analysis of a 50% Emission Reduction in California – Appendix: Modeling Assumptions and Results. Gregory Brinkman and Jennie Jorgenson (NREL) & Ali Ehlen and James H. Caldwell (CEERT).

Early in the LCGS process it was recognized that Wyoming wind is a cost effective element in virtually any cost effective resource portfolio designed to achieve California's carbon reduction targets. Over 2 GW of new Wyoming wind is included in all LCGS portfolios. Even more apparent was the importance of robust real time economic trading throughout the Western Interconnection. With the focus on California emission reductions but recognizing the importance of imports and exports and the likelihood of significant out of state renewable resources to serve California load, while keeping computer run times reasonable, the production cost model was configured to run with nodal transmission constraints within California and Balancing Area by Balancing Area zonal transmission transfer capacity constraints in the rest of the West. Each Balancing Authority provided its own ancillary services including operating and "flexibility" reserves and could trade imbalances from day ahead scheduled exchanges based on explicit forecast error distributions for load, wind and solar output. The study assumed a WECC-wide Energy Imbalance Market and three reserve sharing groups (Rocky Mountain, Southwest, and Northwest-Basin), as is roughly the common practice today.

In Phase I of the LCGS, published in 2014[4], the modeling platform was a modified version of the TEPPC 2020 Common Case. The Wyoming wind was brought to California by a "gen-tie" from Eastern Wyoming to Delta UT where it tied to the DC line to Los Angeles freed by the retirement of the IPP coal plant. A large compressed air energy storage (CAES) plant was co-located at Delta as proposed by Southern California Public Power Authority (SCPPA) members with an interest in WY wind. This arrangement worked fine for the scenario studied except the large quantities of energy flowing on the DC line destined for transfer to the CAISO exceeded ratings of existing connections between LADWP and the CAISO causing significant congestion in the Los Angeles Basin. Adding an AC:DC-DC:AC flow controller in the Southern Los Angeles Basin between the LADWP and CAISO systems solved this congestion.

In Phase II of the LCGS, the platform was updated to the TEPPC 2024 Common Case. The Common Case now included the IPCO/PAC Gateway West project from Windstar, WY to Hemingway, ID (near Midpoint), plus the PAC Gateway South project from Aeolus, WY to Mona, UT, plus the CAISO Harry Allen to El Dorado project in Nevada. It was easy to see that

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[4] lowcarbongrid2030.org/Phase I Results

the 2000 MW SWIP-N project including 1000 MW of scheduling rights to the CAISO could potentially provide, at reasonable cost, a direct path from WY to CA. It established the ability to dynamically schedule significant quantities of wind from WY to the CAISO potentially satisfying California's complex Product Content Category Rules for RPS eligibility[5]. In the Common Case topology, there are two other parallel paths for significant quantities of WY and potentially MT wind to CA, one through the IPP DC line and wheeling through LADWP and another through Gateway South and wheeling through NV Energy. However, some additional solution is required to provide a direct path for the large quantities of WY and potentially MT wind to serve California load. This arrangement of adding SWIP-N allowed dropping the expensive and un-sponsored flow controller in the Los Angeles Basin.

The Phase II results, published in early 2016[6], are consistent with Phase I results and were peer reviewed by the major CA utilities and energy agencies plus representatives from NV Energy and the Western Interstate Energy Board. Phase II examined two different CA renewable portfolios (termed "Target" for a geographic and technologically diverse portfolio and "High Solar" which more closely tracked current procurement trends) plus a counterfactual "Baseline" case freezing CA renewable investment at the 2020 level of 33%. It also included two rest-of-WECC renewable portfolios: (1), The default TEPPC 2024 resource case reflecting then current state-by-state RPS compliance and (2), a "High West" case that doubled the ex-CA WECC renewable penetration levels. These four resource portfolios were run with several sensitivities to form twenty-three scenarios/sensitivities that are summarized on a spreadsheet on the project website.[7] These results are not repeated here because our purpose is to discuss the role of the SWIP-N project, not deal with California climate policy. However the following qualitative observations about the Phase II body of results are relevant to the task at hand.

- California remains a net energy importer under all 2030 scenarios and sensitivities studied at roughly one-half of today's levels.

[5] See, e.g., California Public Utilities Commission decision D-11-12-052, December 15, 2011 at www.cpuc.ca.gov

[6] lowcarbongrid2030.org/Phase I Results

[7] lowcarebongrid2030.org/Phase II Results/"Low Carbon Grid Study: Analysis of a 50% Emission Reduction in California – Appendix: Modeling Assumptions and Results" NTRL/TP-6A20-64884-02 @ p. 29

- The trade is two-way with some physical exports of CA produced energy and/or, more likely, local sales of out of state produced energy contractually designated for CA import during light load hours of the year.
- The trade is almost exclusively in low/zero marginal cost renewables, hydro and nuclear rather than fossil based "economy energy" whether coal or gas derived.

These generic observations about the LCGS applied to the modeled interface between IPCO and NV Energy Balancing Authorities that includes SWIP-N are:

- The SWIP-N direct connection to PAC-East appears to the preferred path for WY wind to CAISO rather than the alternative of wheels through NV Energy or LADWP.
- SWIP-N flows are bi-directional both seasonably and diurnally and perform functions other than delivering WY wind to CA. For example, significant solar energy is delivered north during winter peak, significant hydro energy is distributed south during wet springs. Other flows have no obvious discernable purpose other than generic but principally renewable economy energy.

In the LCGS, these observations are qualitative because the model was not configured to capture the complexities of real world nodal dispatch at the interface between Idaho and Nevada, and there is no generic, easy counterfactual case to isolate the impact of removing SWIP-N from cases with several simultaneous variables that affect transmission flows in the region. In the next section, we discuss quantitative results from recent additional modeling done by the LCGS team to at least partially address these issues.

Production Cost Modeling of SWIP-N

Reflections on the above qualitative observations of the LCGS Phase II results caused the SWIP-N project developer to commission the LCGS team to perform additional production cost modeling using the LCGS platform to try to quantify production cost benefits of SWIP-N while improving the granularity of real time congestion at the interface between IPCO and NVE. The team chose the following scope of work:

- Use the LCGS platform and data base(s) but reconfigure the PLEXOS model to run nodal throughout WECC rather than nodal in CA and zonal elsewhere as was done for the LCGS.
- Represent SWIP-N as a new 2000 MW capacity 500 kv AC transmission line between Midpoint and Robinson Summit with appropriate reactance.
- In order to mimic transmission rights that Great Basin Transmission, LLC will receive upon construction of SWIP-N and plans to make available to CAISO and other Regions, the first 1000 MW of capacity on SWIP-N and Robinson Summit to Harry Allen and Harry Allen to Eldorado will have no hurdle rate. Flows greater than 1000 MW have the standard TEPPC Common Case IPCO/NVE hurdle rate of $2.60/MWH in both directions.
- Remove the LCGS additional "reinforcement" between Mona and Delta and the LCGS 1,200 CAES plant at Delta but keep the tie to the IPP DC line (IPP itself retired).
- Adjust the new 2,725 MW of WY wind's location to Aeolus. Leave Gateway West and Gateway South as represented in the TEPPC 2024 Common Case.
- Using the "Target Conventional" scenario from the LCGS,[8] construct a Base Case adding SWIP-N to the TEPPC Common Case transmission and a Sensitivity Case that adds SWIP-N but subtracts Gateway South from the TEPPC Common Case. Conduct four new hourly resolution modeling runs: with and without SWIP-N, and with and without Gateway South.

The Sensitivity Case was added to examine the impact of potential delays in construction of the Gateway South project. No such sensitivity to delays in the Gateway West project construction was conducted since that event would likely cascade to delays in Wyoming wind development which would then cascade to other required resource changes as well. These runs and the associated QA/QC were conducted during Feb/March 2016.

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[8] A full description of this scenario can be found at www.lowcarbongrid2030.org "Low Carbon Grid Study: Analysis of a 50% Emission Reduction in California" NREL/TP 6A20-64884, Jan 2016. In summary, this scenario adds a geographically and technologically diverse portfolio of new renewable resources including 2,725 MW of WY wind but no additional bulk storage over TEPPC 2024 Common Case levels, and configures CAISO grid operations (import/export rules, ancillary service provisions, frequency response obligations, local min gen capacity rules, etc.) as modeled in the TEPPC 2024 Common Case.

Modeling Results

Summary level production costs from the model are shown in Table 1. A SWIP-N flow duration curve (positive direction is N to S) for the Base Case with Gateway South is shown in Figure 1. Diurnal flow patterns averaged by season for the Base Case (positive direction is N to S) are shown in Figure 2. A more detailed breakdown of production costs along with other summary level statistics, and raw data for the flow duration curve and diurnal flow pattern charts for both the Base and Sensitivity Cases are included in the Appendix.

Table 1
WECC Wide Annual Production Costs

Scenario	Total Production Cost, $B/yr	Annual Savings from SWIP-N, $M/yr
Base Case	$18.96	
Base Case w/o SWIP-N	$19.02	$64.6
Sensitivity Case	$19.03	
Sensitivity Case w/o SWIP-N	$19.14	$107.4

Total production cost includes WECC wide fuel costs, variable O&M costs, and startup and shutdown costs, and California emission costs.[9]

[9] CO2 emissions to serve CA load are priced at projected 2030 CA cap and trade allowance price of $32.44/MT. Carbon from unspecified imports to CA is calculated using the CARB default emission factor of 0.432 MT/MWH. Carbon emissions outside of CA are recorded but not priced.

Figure 1
Flow Duration Curve for Base Case

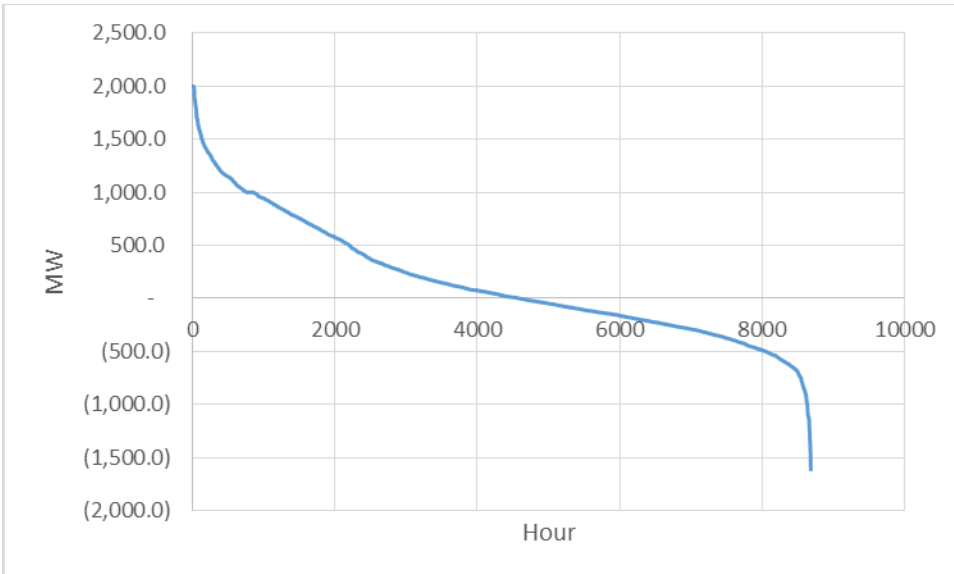
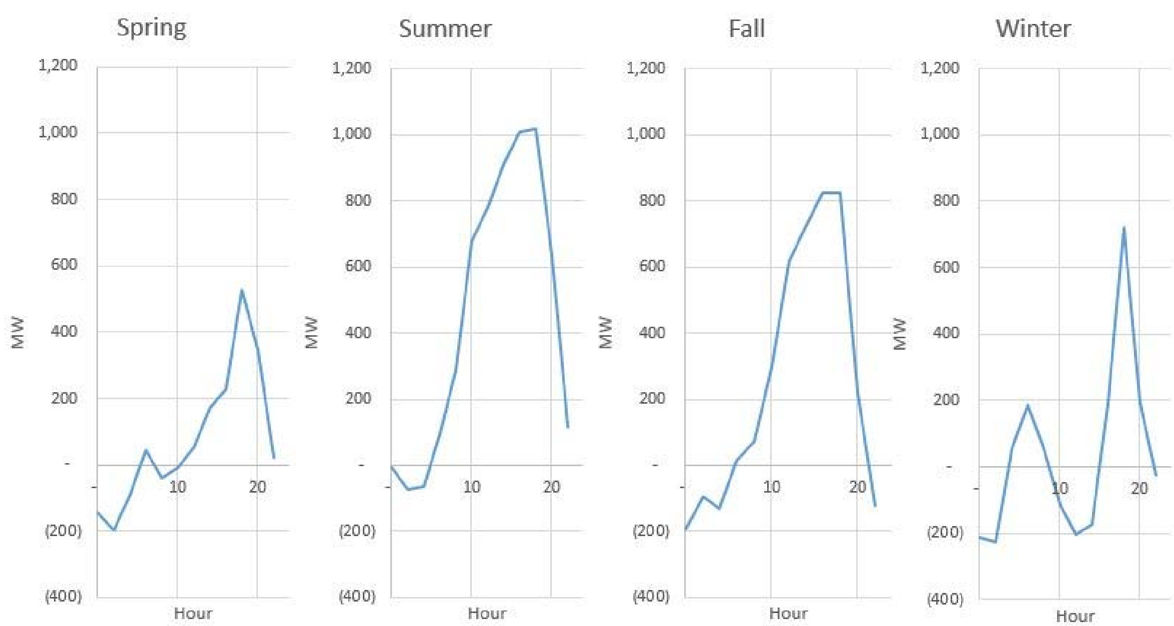


Figure 2
SWIP-N Average Base Case Diurnal Flow Patterns



Discussion

In this report, we modeled one plausible scenario for the year 2030 with one possible pathway for California to meet its renewable resource targets at one gas price and one set of loads and resources for the rest of WECC that reflect forecasts and plans included in the 2024 TEPPC Common Case. SWIP-N performed well in that scenario. Based on a qualitative assessment of these cases, there is every reason to believe that SWIP-N will be cost effective prior to major Wyoming wind development, which is its primary purpose in this study, or in other likely future scenarios. No power flow modeling was conducted, no Path Rating studies were performed, and no engineering of interconnection facilities or system upgrades was performed to allow firming up project cost estimates. All of these are clearly worth the effort going forward.

The LCGS study is a snapshot in time for the year 2030. LCGS added the SWIP-N line as a conduit to bring Wyoming wind to California to help meet California's next tranche of renewable development of 50% RPS by 2030 plus plug the gap left by retirement of Diablo Canyon. The portfolios and grid topology in LCGS were specifically designed to be building blocks for further carbon emission reductions post 2030. LCGS also captures a major trend towards distributed generation with at least 10% of WECC load met with rooftop solar. The likely growth of micro-grids and local generation is not incompatible with a stiff bulk grid capable of moving energy around the Western Interconnection from areas of temporal surplus to areas of temporal shortage that vary by time of day and season. Although significant investments in energy efficiency are likely to hold load growth to near zero in the near future, by 2030, electrification of transportation, building space conditioning and potentially water heating are likely to cause California and potentially WECC-wide load growth to match levels from what today seems like by-gone history.

Because SWIP-N is the missing link in a high voltage loop around all of WECC, it can serve as much more than a simple gen tie from WY to CA. In examining the interface flows with and without SWIP-N, it is clear that every major interface throughout the entire interconnection is affected at least to some degree by the presence or absence of SWIP-N in the scenario modeled. In the LCGS, although the resolution was not sufficient to precisely quantify the production cost benefits isolated to this specific project, the same pattern is apparent. Scenarios with more or less hydro production, more or less renewable development in non-CA WECC, in an alternate world of low gas prices and high carbon prices to flip dispatch and put coal on the margin rather than gas, all showed robust flows on SWIP-N.

Allocation of SWIP-N benefits to the Regions in the West was not undertaken as part of this study. Although it appears that much of the benefits of SWIP-N accrue to California or regions that contract with California, the broad reach of interface flow changes that the presence of SWIP-N makes in all of the scenarios studied suggests that this task be undertaken as part of the Region's ongoing Transmission Planning cycles.

Review of the flow patterns generated by the study suggests that the presence of SWIP-N would allow substantial incremental path flows on at least the California Oregon Intertie (COI) and Path 26. Neither capacity benefits from this incremental addition to California Maximum Import Capability (MIC) nor reliability benefits to the entire WECC region were quantified as part of this report

Finally, we note the issue of the proposed integration of the CAISO and PacifiCorp and speculate on the potential impact of that event on the cost/benefit of SWIP-N. All of the modeling here and in the LCGS assumed that CAISO, PAC-E and PAC-W were separate Balancing Authorities that did not operate an integrated transmission grid with a common congestion management scheme, or conduct a common day ahead unit commitment process, and were coordinated in real time only by an Energy Imbalance Market. SWIP-N was cost effective under that "business as usual" scenario.

Clearly, cost and benefit allocation and path rating issues would be materially simplified should CAISO and PAC achieve full integration. Perhaps more importantly, the significant temporal and spatial diversity of loads and resources between and among CAISO, PAC-E and PAC-W Balancing Authorities offers significant additional capacity benefits, lower Frequency Response Obligation costs, more efficient unit commitment and real time dispatch decisions, etc. if and only if sufficient transmission capacity exists between and among the former separate BAs. While integration itself is likely to provide at least some material increase in utilization efficiency of existing transmission assets by eliminating the contractual seams between the systems, there is no substitute for physical transfer capability increases provided by a strong 500 kv connection across the entire geography of the new consolidated BA. This is what SWIP-N provides. The authors believe that SWIP-N cost/benefit ratio would improve if CAISO and PAC were to integrate.

Appendix

This appendix contains examples of raw data from the production cost modelling. "SWIP_Gateway" represents the Base Case. "SWIP_NoGateway" represents the Sensitivity. "NoGateway" implies "No Gateway South transmission project". Gateway West transmission project is modelled in all cases. For more detailed data or questions, email Liz Anthony at liz@ceert.org.

	Calculation of Annual Cost Savings: WECC-Wide Reduction									
scenario	WECC Fuel Cost ($000)	Gas Fuel Cost ($000)	Coal Fuel Cost ($000)	Other Fuel Cost (Biomass, Nuclear, Other) ($000)	WECC Start & Shutdown Cost ($000)	WECC VO&M Cost ($000)	CA Emissions Cost ($000)	CA Import Emissions (0.432MT/MWh * Unspec. Imports * Carbon Cost) ($000)	TPC ($000)	Annual Savings (from SWIP) ($000)
SWIP_NoGateway	15,983,937	9,616,372	4,843,250	1524314.809	301,691	1,361,081	1,348,755	32,729	19,028,193	
NoSWIP_NoGateway	16,044,002	9,680,991	4,842,975	1520036.662	329,177	1,365,137	1,359,277	38,047	19,135,640	107,447
SWIP_Gateway	15,942,699	9,616,372	4,881,432	1504255.723	292,035	1,355,203	1,319,832	45,176	18,954,945	
NoSWIP_Gateway	15,983,873	9,680,991	4,835,470	1493567.626	316,208	1,352,296	1,329,061	38,094	19,019,532	64,587

	Curtailment		
scenario	%CA RE Curtailment	%NonCA Curtailment	% Total WECC Curtailment
SWIP_NoGateway	4.4%	0.2%	3.0%
NoSWIP_NoGateway	4.5%	0.2%	3.1%
SWIP_Gateway	5.0%	0.2%	3.5%
NoSWIP_Gateway	5.1%	0.3%	3.6%

	CA Imports and Exports							
scenario	Net Imports (TWh)	Imports from NW (TWh)	Exports (TWh)	Imports (TWh)	Specified Imports (TWh)	Not Imported Specified Imports (TWh)	Imported Specified Imports (TWh)	Unspecified Imports (TWh)
SWIP_NoGateway	54.99	9.9	0	54.99	49.48	4.75	44.7	10.26
NoSWIP_NoGateway	54.18	8.5	0	54.18	49.44	4.76	44.7	9.50
SWIP_Gateway	53.54	9.1	0	53.54	49.48	4.75	44.7	10.52
NoSWIP_Gateway	52.59	8.7	0	52.59	49.44	4.76	44.7	9.70

	Carbon Accounting					
scenario	CO2 from Unspecified Imports (MMT)	CO2 from CA Gas (MMT)	CO2 Credited To Exports, and Umimported Spec. Imports	Net CO2 assigned to CA load (MMT)	OOS CO2 For All of WECC (includes AB, BC, Mex) (MMT)	Total CO2 in WECC, including AB, MC, Mex) (MMT)
SWIP_NoGateway	1.01	45.90	(2.1)	44.9	299.9	345.8
NoSWIP_NoGateway	1.17	46.27	(2.1)	45.4	299.9	346.1
SWIP_Gateway	1.39	45.90	(2.1)	45.2	299.9	345.8
NoSWIP_Gateway	1.17	46.27	(2.1)	45.4	299.9	346.1

	CA Gas Fleet Statistics										
scenario	**Heat Rate CHP-QF**	**Heat Rate Gas CC**	**Heat Rate Gas CT**	**Capacity Factor CHP-QF**	**Capacity Factor Gas CC**	**Capacity Factor Gas CT**	**Online Capacity Factor CHP-QF**	**Online Capacity Factor Gas CC**	**Online Capacity Factor Gas CT**	**Max Gas Gen Level (MW)**	**Min Gas Gen Level (MW)**
SWIP_NoGateway	9060.9	7166.5	8635.3	87.7	24.4	4.6	91.0	73.5	77.2	27290.7	3717.9
NoSWIP_NoGateway	9064.4	7171.2	8650.1	87.6	24.9	4.7	91.0	73.0	76.8	27567.8	5292.0
SWIP_Gateway	9112.2	7176.1	8646.8	86.5	23.8	5.3	90.1	71.6	80.3	27274.0	5128.2
NoSWIP_Gateway	9110.1	7180.9	8725.1	86.5	24.3	5.7	90.1	74.0	78.8	27690.5	4566.1

	WECC Gas Fleet Statistics							
scenario	**Capacity Factor Coal**	**Capacity Factor Gas CC**	**Capacity Factor Gas CT**	**Online Factor Coal**	**Online Factor Gas CC**	**Online Factor Gas CT**	**Max Therm Gen Level (MW)**	**Min Therm Gen Level (MW)**
SWIP_NoGateway	80.4	19.5	4.9	96.2	78.2	82.9	81459.6	7892.5
NoSWIP_NoGateway	80.5	19.5	4.8	96.2	76.8	80.5	81392.9	15961.2
SWIP_Gateway	81.1	19.9	6.4	96.3	77.4	80.3	81078.1	23028.6
NoSWIP_Gateway	80.3	19.8	6.0	96.5	79.4	81.8	81515.5	5168.3

Seasonal Exchange (GWh) for each scenario for each line.

			AZ to CAISO	AZ to IID	AZ to LDWP	AZ to NM	CAISO to BANC
NoSWIP_Gateway	Spring	Backward	(139.4)	(115.7)	(2.1)	(271.2)	(307.0)
NoSWIP_Gateway	Spring	Forward	754.5	9.9	1,326.9	1,079.8	296.3
NoSWIP_Gateway	Summer	Backward	(497.5)	(108.4)	(2.9)	(140.2)	(378.2)
NoSWIP_Gateway	Summer	Forward	411.1	8.0	1,120.3	1,360.3	121.7
NoSWIP_Gateway	Fall	Backward	(148.5)	(102.2)	(1.7)	(361.0)	(153.1)
NoSWIP_Gateway	Fall	Forward	960.6	9.8	1,586.6	896.1	391.1
NoSWIP_Gateway	Winter	Backward	(46.3)	(135.4)	(3.0)	(577.3)	(116.4)
NoSWIP_Gateway	Winter	Forward	1,057.5	4.5	1,754.0	719.0	584.0
SWIP_Gateway	Spring	Backward	(116.4)	(116.0)	(7.8)	(279.6)	(390.4)
SWIP_Gateway	Spring	Forward	735.1	8.4	1,311.7	1,017.2	375.3
SWIP_Gateway	Summer	Backward	(411.9)	(113.0)	(14.2)	(168.0)	(677.6)
SWIP_Gateway	Summer	Forward	403.3	7.6	1,070.5	1,170.1	57.3
SWIP_Gateway	Fall	Backward	(139.1)	(104.6)	(1.6)	(381.2)	(232.5)
SWIP_Gateway	Fall	Forward	943.9	10.3	1,591.9	830.5	412.8
SWIP_Gateway	Winter	Backward	(30.0)	(135.6)	(0.0)	(602.3)	(188.8)
SWIP_Gateway	Winter	Forward	1,087.4	2.7	1,820.6	674.7	643.4

			AZ to CAISO	AZ to IID	AZ to LDWP	AZ to NM	CAISO to BANC
NoSWIP_NoGateway	Spring	Backward	(133.7)	(115.6)	(1.2)	(278.0)	(299.8)
NoSWIP_NoGateway	Spring	Forward	767.9	10.1	1,365.4	1,044.9	316.0
NoSWIP_NoGateway	Summer	Backward	(488.5)	(107.7)	(4.5)	(152.3)	(372.4)
NoSWIP_NoGateway	Summer	Forward	420.1	7.9	1,135.9	1,351.0	132.1
NoSWIP_NoGateway	Fall	Backward	(156.8)	(104.0)	(4.7)	(367.6)	(144.3)
NoSWIP_NoGateway	Fall	Forward	940.4	9.8	1,566.0	846.9	400.2
NoSWIP_NoGateway	Winter	Backward	(37.7)	(138.0)	(0.2)	(562.7)	(112.3)
NoSWIP_NoGateway	Winter	Forward	1,060.5	3.6	1,788.3	705.9	593.5
SWIP_NoGateway	Spring	Backward	(106.8)	(114.7)	(4.0)	(291.0)	(405.6)
SWIP_NoGateway	Spring	Forward	761.8	8.8	1,351.1	982.1	373.6
SWIP_NoGateway	Summer	Backward	(391.4)	(112.1)	(4.8)	(198.9)	(683.5)
SWIP_NoGateway	Summer	Forward	424.1	7.0	1,113.4	1,069.4	47.2
SWIP_NoGateway	Fall	Backward	(136.5)	(102.7)	(2.5)	(382.7)	(231.4)
SWIP_NoGateway	Fall	Forward	942.6	10.5	1,560.3	804.5	381.3
SWIP_NoGateway	Winter	Backward	(28.3)	(135.7)	(0.1)	(650.7)	(215.0)
SWIP_NoGateway	Winter	Forward	1,092.0	3.0	1,803.4	631.3	575.4

			CAISO to CFE	Canada to NW	IID to CAISO	IPCO to NV	IPCO to NW
NoSWIP_Gateway	Spring	Backward	(14.0)	(435.6)	-	(386.1)	(73.9)
NoSWIP_Gateway	Spring	Forward	639.7	671.5	5,356.0	69.8	3,466.4
NoSWIP_Gateway	Summer	Backward	(26.1)	(167.9)	-	(553.4)	(251.1)
NoSWIP_Gateway	Summer	Forward	302.5	2,499.7	4,879.8	16.8	1,831.1
NoSWIP_Gateway	Fall	Backward	(18.8)	(120.6)	-	(373.7)	(24.5)
NoSWIP_Gateway	Fall	Forward	351.2	2,651.3	5,050.7	66.8	3,891.5
NoSWIP_Gateway	Winter	Backward	(28.8)	(171.4)	-	(320.6)	(52.8)
NoSWIP_Gateway	Winter	Forward	344.0	2,598.9	5,229.9	93.0	3,760.7
SWIP_Gateway	Spring	Backward	(8.9)	(410.6)	-	(468.4)	(235.3)
SWIP_Gateway	Spring	Forward	695.6	691.9	5,396.0	210.2	3,906.0
SWIP_Gateway	Summer	Backward	(28.4)	(168.1)	-	(345.0)	(1,024.9)
SWIP_Gateway	Summer	Forward	306.6	2,454.9	4,840.9	208.5	1,604.3
SWIP_Gateway	Fall	Backward	(14.9)	(83.0)	-	(458.1)	(119.2)
SWIP_Gateway	Fall	Forward	387.2	2,622.0	5,063.3	147.9	4,236.3
SWIP_Gateway	Winter	Backward	(22.7)	(136.0)	-	(419.7)	(75.6)
SWIP_Gateway	Winter	Forward	365.6	2,630.6	5,247.1	231.8	4,115.5

			CAISO to CFE	Canada to NW	IID to CAISO	IPCO to NV	IPCO to NW
NoSWIP_NoGateway	Spring	Backward	(4.7)	(429.2)	-	(365.2)	(61.0)
NoSWIP_NoGateway	Spring	Forward	666.8	663.4	5,397.5	80.1	3,668.5
NoSWIP_NoGateway	Summer	Backward	(23.3)	(183.8)	-	(522.9)	(211.6)
NoSWIP_NoGateway	Summer	Forward	309.8	2,490.7	4,884.8	25.0	1,969.7
NoSWIP_NoGateway	Fall	Backward	(24.6)	(118.1)	-	(360.2)	(19.7)
NoSWIP_NoGateway	Fall	Forward	329.2	2,659.5	5,070.2	71.8	4,084.3
NoSWIP_NoGateway	Winter	Backward	(41.3)	(171.2)	-	(305.8)	(7.2)
NoSWIP_NoGateway	Winter	Forward	333.7	2,560.3	5,241.9	92.5	3,873.6
SWIP_NoGateway	Spring	Backward	(9.0)	(407.9)	-	(438.3)	(226.1)
SWIP_NoGateway	Spring	Forward	698.3	691.9	5,404.3	236.2	3,868.4
SWIP_NoGateway	Summer	Backward	(20.2)	(146.9)	-	(275.0)	(995.2)
SWIP_NoGateway	Summer	Forward	300.7	2,471.5	4,888.1	250.4	1,612.6
SWIP_NoGateway	Fall	Backward	(40.2)	(158.4)	-	(388.0)	(194.0)
SWIP_NoGateway	Fall	Forward	365.9	2,592.9	5,078.7	183.2	3,960.9
SWIP_NoGateway	Winter	Backward	(35.4)	(137.4)	-	(331.2)	(66.2)
SWIP_NoGateway	Winter	Forward	355.5	2,601.8	5,250.6	302.1	3,741.5

			LDWP to CAISO	MT to NW	MT to PACE	MT to WY	NV to AZ	NV to CAISO
NoSWIP_Gateway	Spring	Backward	(41.8)	(42.0)	(276.5)	(57.1)	(149.1)	(563.8)
NoSWIP_Gateway	Spring	Forward	0.1	2,834.4	210.9	116.3	-	0.1
NoSWIP_Gateway	Summer	Backward	(11.6)	(26.2)	(32.5)	(2.5)	(223.7)	(910.2)
NoSWIP_Gateway	Summer	Forward	50.8	2,514.4	481.8	245.1	-	-
NoSWIP_Gateway	Fall	Backward	(9.8)	(15.3)	(371.7)	(76.6)	(159.6)	(547.4)
NoSWIP_Gateway	Fall	Forward	32.9	3,061.2	50.8	22.6	-	-
NoSWIP_Gateway	Winter	Backward	(25.6)	(24.5)	(346.5)	(75.6)	(141.6)	(521.6)
NoSWIP_Gateway	Winter	Forward	10.8	2,931.9	86.1	41.6	0.0	2.0
SWIP_Gateway	Spring	Backward	(40.7)	(17.8)	(337.2)	(66.6)	(150.1)	(541.2)
SWIP_Gateway	Spring	Forward	5.7	2,950.5	233.0	119.1	-	-
SWIP_Gateway	Summer	Backward	(4.9)	(37.0)	(44.2)	(3.2)	(218.5)	(873.3)
SWIP_Gateway	Summer	Forward	27.6	2,338.2	564.4	259.8	-	-
SWIP_Gateway	Fall	Backward	(7.5)	(6.4)	(435.1)	(89.8)	(163.8)	(552.1)
SWIP_Gateway	Fall	Forward	63.3	3,133.5	76.5	24.8	-	-
SWIP_Gateway	Winter	Backward	(27.4)	(3.3)	(401.5)	(86.3)	(147.2)	(512.0)
SWIP_Gateway	Winter	Forward	54.3	3,036.4	103.8	43.4	-	0.0

			LDWP to CAISO	MT to NW	MT to PACE	MT to WY	NV to AZ	NV to CAISO
NoSWIP_NoGateway	Spring	Backward	(41.5)	(38.3)	(300.5)	(62.7)	(151.5)	(580.1)
NoSWIP_NoGateway	Spring	Forward	1.8	2,876.3	187.3	103.0	-	0.0
NoSWIP_NoGateway	Summer	Backward	(19.0)	(29.6)	(47.4)	(4.0)	(223.5)	(911.2)
NoSWIP_NoGateway	Summer	Forward	51.8	2,566.3	440.0	226.2	0.1	-
NoSWIP_NoGateway	Fall	Backward	(10.7)	(13.2)	(413.0)	(85.5)	(157.9)	(545.2)
NoSWIP_NoGateway	Fall	Forward	23.4	3,084.0	62.5	25.3	-	0.5
NoSWIP_NoGateway	Winter	Backward	(36.6)	(20.7)	(354.3)	(74.1)	(142.9)	(536.1)
NoSWIP_NoGateway	Winter	Forward	15.6	2,929.4	65.4	34.0	-	0.0
SWIP_NoGateway	Spring	Backward	(42.4)	(17.5)	(341.0)	(67.8)	(149.6)	(533.9)
SWIP_NoGateway	Spring	Forward	4.9	2,967.2	219.0	111.2	-	-
SWIP_NoGateway	Summer	Backward	(7.1)	(27.8)	(51.6)	(4.2)	(219.4)	(882.3)
SWIP_NoGateway	Summer	Forward	26.0	2,431.9	532.7	244.5	-	0.0
SWIP_NoGateway	Fall	Backward	(10.2)	(98.7)	(422.1)	(89.8)	(159.0)	(507.1)
SWIP_NoGateway	Fall	Forward	46.5	2,992.8	83.4	26.6	0.0	2.6
SWIP_NoGateway	Winter	Backward	(28.4)	(5.3)	(344.7)	(69.2)	(142.3)	(486.1)
SWIP_NoGateway	Winter	Forward	25.3	2,983.3	94.2	37.4	-	-

			NW to LDWP	NW to NV	P26 N - S CA	P46 WOR	PACE to AZ	PACE to IPCO
NoSWIP_Gateway	Spring	Backward	(95.0)	(309.7)	(2,132.4)	(74.9)	(123.7)	(79.1)
NoSWIP_Gateway	Spring	Forward	3,364.4	1.0	1,068.8	9,402.2	85.9	4,164.2
NoSWIP_Gateway	Summer	Backward	(0.0)	(257.9)	(320.3)	(42.3)	(50.2)	(24.2)
NoSWIP_Gateway	Summer	Forward	4,832.1	1.5	3,457.2	7,876.9	167.4	3,802.5
NoSWIP_Gateway	Fall	Backward	(10.0)	(365.3)	(1,009.5)	-	(60.3)	(25.6)
NoSWIP_Gateway	Fall	Forward	3,121.3	0.5	2,913.9	10,145.3	178.9	5,440.5
NoSWIP_Gateway	Winter	Backward	(114.7)	(311.1)	(1,824.3)	-	(172.3)	(47.1)
NoSWIP_Gateway	Winter	Forward	2,709.5	0.5	1,871.2	10,280.0	67.2	5,252.9
SWIP_Gateway	Spring	Backward	(14.7)	(333.3)	(1,919.1)	(7.4)	(160.7)	(9.0)
SWIP_Gateway	Spring	Forward	3,559.5	7.2	1,000.9	9,365.6	230.6	4,581.4
SWIP_Gateway	Summer	Backward	(0.0)	(211.2)	(331.5)	(2.8)	(20.3)	(17.1)
SWIP_Gateway	Summer	Forward	4,967.1	10.6	3,485.6	8,195.5	520.4	4,055.5
SWIP_Gateway	Fall	Backward	(0.0)	(409.0)	(835.1)	-	(84.7)	(1.2)
SWIP_Gateway	Fall	Forward	3,458.3	2.1	3,157.6	9,735.3	270.3	5,745.4
SWIP_Gateway	Winter	Backward	(11.4)	(338.1)	(1,561.4)	-	(191.9)	(0.2)
SWIP_Gateway	Winter	Forward	2,934.0	7.7	1,880.2	10,118.1	140.1	5,600.7

			NW to LDWP	NW to NV	P26 N - S CA	P46 WOR	PACE to AZ	PACE to IPCO
NoSWIP_NoGateway	Spring	Backward	(70.6)	(319.2)	(2,047.9)	(75.3)	(204.0)	(62.3)
NoSWIP_NoGateway	Spring	Forward	3,552.9	0.7	1,128.2	9,395.6	44.0	4,390.4
NoSWIP_NoGateway	Summer	Backward	(6.9)	(264.6)	(291.9)	(37.6)	(89.0)	(22.3)
NoSWIP_NoGateway	Summer	Forward	4,791.4	1.0	3,539.3	7,960.4	136.6	4,033.8
NoSWIP_NoGateway	Fall	Backward	(7.7)	(375.1)	(963.2)	-	(101.4)	(17.8)
NoSWIP_NoGateway	Fall	Forward	3,297.2	0.3	3,051.5	10,005.3	152.1	5,654.2
NoSWIP_NoGateway	Winter	Backward	(115.1)	(315.2)	(1,795.3)	-	(300.9)	(3.0)
NoSWIP_NoGateway	Winter	Forward	2,829.0	0.4	1,968.5	10,256.4	24.3	5,355.4
SWIP_NoGateway	Spring	Backward	(7.3)	(328.0)	(1,947.2)	(8.3)	(205.8)	(7.3)
SWIP_NoGateway	Spring	Forward	3,674.1	7.0	1,000.0	9,553.6	186.5	4,723.0
SWIP_NoGateway	Summer	Backward	(6.2)	(203.6)	(343.6)	(2.2)	(13.7)	(1.4)
SWIP_NoGateway	Summer	Forward	4,997.1	11.2	3,483.1	8,333.7	506.4	4,392.7
SWIP_NoGateway	Fall	Backward	(75.0)	(385.0)	(931.8)	-	(127.4)	(57.0)
SWIP_NoGateway	Fall	Forward	3,469.2	2.7	3,083.3	10,202.4	248.8	5,647.1
SWIP_NoGateway	Winter	Backward	(8.4)	(303.9)	(1,647.5)	-	(239.5)	(0.1)
SWIP_NoGateway	Winter	Forward	3,069.0	7.8	1,863.1	10,397.7	106.3	5,592.1

			PACE to LDWP	PACE to NV	PACE to WY	PSCO to NM	SWIP	WY to AZ	WY to NM	WY to PSCO

NoSWIP_Gateway	Spring	Backward	(28.0)	(120.0)	(114.2)	(121.3)	-	(139.9)	(183.2)	-
NoSWIP_Gateway	Spring	Forward	816.0	254.7	643.6	39.1	-	15.0	36.1	3,714.0
NoSWIP_Gateway	Summer	Backward	(7.7)	(182.5)	(417.8)	(34.6)	-	(82.4)	(101.9)	(0.0)
NoSWIP_Gateway	Summer	Forward	832.9	284.3	215.1	91.6	-	33.3	78.5	3,128.3
NoSWIP_Gateway	Fall	Backward	(7.8)	(44.7)	(291.9)	(78.5)	-	(86.4)	(109.5)	(1.6)
NoSWIP_Gateway	Fall	Forward	1,232.5	492.9	496.2	95.9	-	41.0	84.7	2,853.8
NoSWIP_Gateway	Winter	Backward	(41.8)	(62.8)	(69.3)	(170.8)	-	(166.7)	(252.3)	(20.3)
NoSWIP_Gateway	Winter	Forward	942.2	374.0	1,011.3	41.4	-	13.4	25.5	3,567.0
SWIP_Gateway	Spring	Backward	(4.6)	(62.6)	(136.1)	(124.6)	(387.9)	(125.7)	(163.7)	-
SWIP_Gateway	Spring	Forward	502.7	301.6	690.7	64.8	553.8	35.4	78.1	3,656.2
SWIP_Gateway	Summer	Backward	(23.0)	(54.6)	(411.6)	(18.6)	(121.5)	(37.1)	(38.2)	(0.0)
SWIP_Gateway	Summer	Forward	391.7	419.5	261.7	171.6	1,101.8	104.3	218.4	2,847.8
SWIP_Gateway	Fall	Backward	(0.6)	(14.5)	(361.3)	(71.0)	(328.2)	(74.1)	(95.1)	(2.7)
SWIP_Gateway	Fall	Forward	1,092.3	536.5	461.1	120.4	443.8	66.5	133.5	2,690.6
SWIP_Gateway	Winter	Backward	(9.6)	(28.4)	(83.9)	(160.9)	(347.0)	(147.1)	(221.6)	-
SWIP_Gateway	Winter	Forward	717.3	428.5	968.6	52.8	431.1	23.5	44.6	3,532.2

			PACE to LDWP	PACE to NV	PACE to WY	PSCO to NM	SWIP	WY to AZ	WY to NM	WY to PSCO
NoSWIP_NoGateway	Spring	Backward	(32.5)	(167.6)	(90.8)	(126.3)	-	(139.8)	(185.8)	-
NoSWIP_NoGateway	Spring	Forward	490.9	168.1	721.0	37.9	-	11.4	29.0	3,706.6
NoSWIP_NoGateway	Summer	Backward	(16.5)	(224.9)	(398.4)	(31.2)	-	(78.0)	(96.8)	(0.0)
NoSWIP_NoGateway	Summer	Forward	707.6	244.3	227.8	99.3	-	36.5	84.8	3,081.9
NoSWIP_NoGateway	Fall	Backward	(7.1)	(70.7)	(264.1)	(85.0)	-	(94.7)	(123.9)	(1.9)
NoSWIP_NoGateway	Fall	Forward	856.8	414.5	663.3	91.4	-	38.6	79.1	2,828.1
NoSWIP_NoGateway	Winter	Backward	(37.3)	(118.7)	(32.6)	(191.0)	-	(185.4)	(289.5)	-
NoSWIP_NoGateway	Winter	Forward	466.6	217.3	1,170.6	35.7	-	4.7	10.9	3,751.0
SWIP_NoGateway	Spring	Backward	(9.6)	(99.1)	(108.3)	(125.9)	(329.4)	(126.0)	(167.6)	-
SWIP_NoGateway	Spring	Forward	192.2	206.4	795.6	68.6	609.3	37.1	81.2	3,663.5
SWIP_NoGateway	Summer	Backward	(17.0)	(54.8)	(396.2)	(13.9)	(71.1)	(23.9)	(22.4)	(0.1)
SWIP_NoGateway	Summer	Forward	236.7	390.9	259.6	194.7	1,238.9	127.3	261.7	2,770.4
SWIP_NoGateway	Fall	Backward	(21.9)	(53.7)	(267.3)	(79.1)	(261.0)	(88.4)	(117.2)	(10.4)
SWIP_NoGateway	Fall	Forward	664.9	425.5	650.0	117.1	554.3	66.6	132.2	2,679.9
SWIP_NoGateway	Winter	Backward	(13.1)	(54.9)	(56.0)	(164.7)	(227.0)	(142.9)	(219.1)	-
SWIP_NoGateway	Winter	Forward	200.1	263.5	1,127.6	56.4	585.7	19.4	40.6	3,534.6

Average Hourly Exchange (MW) for all lines in Summer for “SWIP- No Gateway S”. For the full set of Average Hourly Exchange for each scenario and season, email Liz Anthony at liz@ceert.org.

scenario	Quarter	Hour	AZ to CAISO	AZ to IID	AZ to LDWP	AZ to NM	CAISO to BANC
SWIP_NoGateway	Summer	0	89	(47)	232	(10)	(244)
SWIP_NoGateway	Summer	2	108	(49)	257	7	(100)
SWIP_NoGateway	Summer	4	93	(48)	251	47	(74)
SWIP_NoGateway	Summer	6	43	(34)	247	111	42
SWIP_NoGateway	Summer	8	(33)	(11)	179	216	(28)
SWIP_NoGateway	Summer	10	(88)	(2)	112	258	(157)
SWIP_NoGateway	Summer	12	(124)	0	84	257	(250)
SWIP_NoGateway	Summer	14	(117)	(4)	75	214	(333)
SWIP_NoGateway	Summer	16	(46)	(10)	89	85	(448)
SWIP_NoGateway	Summer	18	18	(19)	147	37	(722)
SWIP_NoGateway	Summer	20	41	(28)	172	(16)	(652)
SWIP_NoGateway	Summer	22	51	(37)	185	(10)	(531)

scenario	Quarter	Hour	CAISO to CFE	Canada to NW	IID to CAISO	IPCO to NV	IPCO to NW	LDWP to CAISO
SWIP_NoGateway	Summer	0	204	727	2,229	(43)	407	(0)
SWIP_NoGateway	Summer	2	156	735	2,121	(71)	437	(0)
SWIP_NoGateway	Summer	4	111	702	2,125	(153)	417	(0)
SWIP_NoGateway	Summer	6	107	572	2,387	(286)	276	(0)
SWIP_NoGateway	Summer	8	140	523	2,365	(396)	55	(0)
SWIP_NoGateway	Summer	10	178	979	2,320	(193)	(176)	(1)
SWIP_NoGateway	Summer	12	192	1,242	2,375	(104)	(224)	(7)
SWIP_NoGateway	Summer	14	179	1,608	2,297	50	(257)	(11)
SWIP_NoGateway	Summer	16	39	1,528	2,025	306	(243)	2
SWIP_NoGateway	Summer	18	12	1,506	2,012	483	(222)	19
SWIP_NoGateway	Summer	20	59	1,298	2,335	299	34	50
SWIP_NoGateway	Summer	22	164	1,352	2,269	(26)	345	0

scenario	Quarter	Hour	MT to NW	MT to PACE	MT to WY	NV to AZ	NV to CAISO	NV to LDWP
SWIP_NoGateway	Summer	0	861	1	60	(21)	(339)	(657)
SWIP_NoGateway	Summer	2	876	(44)	50	(20)	(315)	(687)
SWIP_NoGateway	Summer	4	828	(44)	54	(20)	(340)	(653)
SWIP_NoGateway	Summer	6	684	22	76	(22)	(324)	(414)
SWIP_NoGateway	Summer	8	511	199	119	(25)	(354)	(200)
SWIP_NoGateway	Summer	10	356	402	159	(27)	(406)	(10)
SWIP_NoGateway	Summer	12	268	455	168	(30)	(481)	(28)
SWIP_NoGateway	Summer	14	188	467	163	(32)	(528)	(51)
SWIP_NoGateway	Summer	16	274	433	146	(30)	(517)	(40)
SWIP_NoGateway	Summer	18	359	393	135	(25)	(412)	(106)
SWIP_NoGateway	Summer	20	602	277	112	(24)	(385)	(271)
SWIP_NoGateway	Summer	22	798	83	79	(24)	(450)	(585)

scenario	Quarter	Hour	NW to CAISO	NW to LDWP	NW to NV	P26 N - S CA	P46 WOR	PACE to AZ	PACE to IPCO
SWIP_NoGateway	Summer	0	16	2,263	(157)	1,342	3,434	51	2,896
SWIP_NoGateway	Summer	2	15	1,827	(163)	1,333	3,422	35	2,935
SWIP_NoGateway	Summer	4	13	1,540	(162)	1,453	3,497	33	2,812
SWIP_NoGateway	Summer	6	6	1,070	(135)	223	4,190	61	2,335
SWIP_NoGateway	Summer	8	2	2,007	(115)	(280)	4,352	95	1,687
SWIP_NoGateway	Summer	10	3	2,425	(61)	393	3,954	155	1,135
SWIP_NoGateway	Summer	12	6	2,626	(43)	1,194	3,555	162	940
SWIP_NoGateway	Summer	14	8	2,708	(15)	1,695	3,245	166	914
SWIP_NoGateway	Summer	16	10	2,762	(3)	3,043	3,649	182	1,404
SWIP_NoGateway	Summer	18	9	2,747	7	2,481	4,177	185	1,851
SWIP_NoGateway	Summer	20	13	2,771	(61)	2,334	4,567	146	2,438
SWIP_NoGateway	Summer	22	16	2,676	(149)	2,039	3,736	84	2,783

scenario	Quarter	Hour	PACE to LDWP	PACE to NV	PACE to WY	PSCO to NM	SWIP	WY to AZ	WY to NM	WY to PSCO
SWIP_NoGateway	Summer	0	169	279	(267)	56	137	36	89	801
SWIP_NoGateway	Summer	2	102	303	(265)	50	54	25	70	828
SWIP_NoGateway	Summer	4	23	285	(156)	35	11	7	41	1,050
SWIP_NoGateway	Summer	6	2	211	(19)	37	179	(9)	20	1,314
SWIP_NoGateway	Summer	8	6	69	138	51	326	(23)	4	1,623
SWIP_NoGateway	Summer	10	16	(14)	279	82	749	8	53	1,807
SWIP_NoGateway	Summer	12	13	(64)	292	91	854	30	82	1,858
SWIP_NoGateway	Summer	14	48	(58)	282	93	974	50	110	1,794
SWIP_NoGateway	Summer	16	180	86	(86)	138	1,103	120	222	1,371
SWIP_NoGateway	Summer	18	194	214	(366)	172	1,069	158	289	965
SWIP_NoGateway	Summer	20	310	265	(350)	124	746	119	227	908
SWIP_NoGateway	Summer	22	144	271	(231)	65	215	48	109	902