

WESTERN EIM BENEFITS REPORT

Second Quarter 2019 ■ ■ ■

July 31, 2019

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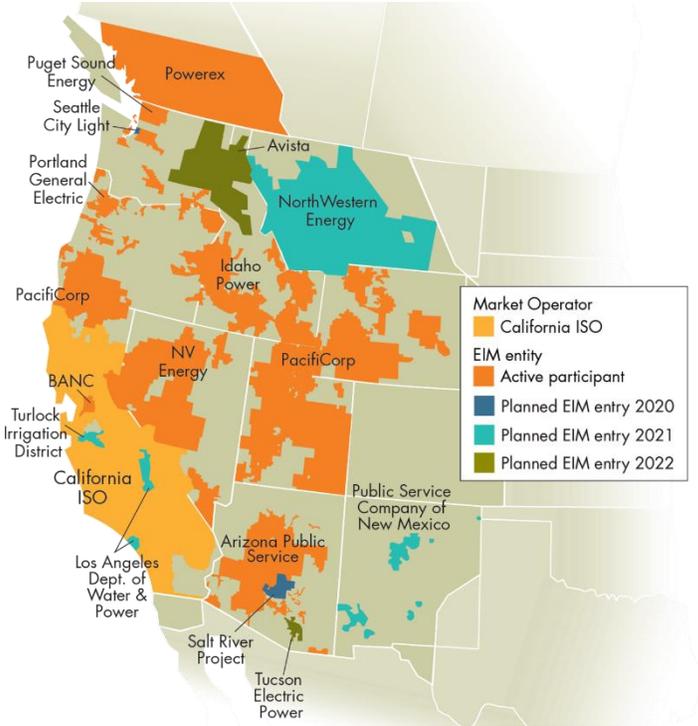
EXECUTIVE SUMMARY

Gross benefits from EIM since November 2014
\$736.26 million

This report presents the benefits associated with participation in the Western Energy Imbalance Market (EIM) for the second quarter of 2019. The benefits include cost savings and the use of surplus renewable energy.

The Western EIM is helping to displace less-clean energy supplies with surplus renewable energy that otherwise may have been curtailed.

This analysis demonstrates the benefit of economic dispatch in the real time market across a larger EIM footprint with more diverse resources and geography.



2019 Q2 BENEFITS

Q2 2019 Gross Benefits by Participant

	(millions \$)
Arizona Public Service	\$8.55
BANC	\$8.81
California ISO	\$23.53
Idaho Power	\$8.33
NV Energy	\$4.62
PacifiCorp	\$15.15
Portland General Electric	\$10.89
Powerex	\$3.06
Puget Sound Energy	\$3.06
Total	\$86.0

ECONOMICAL
\$86.0M
 Gross benefits realized due to more efficient inter- and intra-regional dispatch in the Fifteen-Minute Market (FMM) and Real-Time Dispatch (RTD)*

ENVIRONMENTAL
56,897
 Metric tons of CO₂** avoided curtailments

OPERATIONAL
45%
 Average reduction in flexibility reserves across the footprint

*EIM Quarterly Benefit Report Methodology, https://www.caiso.com/Documents/EIM_BenefitMethodology.pdf

**The GHG emission reduction reported is associated with the avoided curtailment only. The current market process and counterfactual methodology cannot differentiate the GHG emissions resulting from serving ISO load via the EIM versus dispatch that would have occurred external to the ISO without the EIM. For more details, see <http://www.caiso.com/Documents/GreenhouseGasEmissionsTrackingReport-FrequentlyAskedQuestions.pdf>

■ BACKGROUND

The Western EIM began financially binding operation on November 1, 2014 by optimizing resources across the ISO and PacifiCorp Balancing Authority Areas (BAAs). NV Energy began participating in December 2015, Arizona Public Service and Puget Sound Energy began participating on October 1, 2016, and Portland General Electric began participating on October 1, 2017. Idaho Power and Powerex began participating on April 4, 2018. Most recently, the Balancing Authority of Northern California (BANC)¹, began participating on April 3, 2019. The EIM footprint now includes portions of Arizona, California, Idaho, Nevada, Oregon, Utah, Washington, Wyoming, and extends to the border with Canada. The EIM facilitates renewable resource integration and increases reliability by sharing information between balancing authorities on electricity delivery conditions across the EIM region.

The ISO began publishing quarterly EIM benefit reports in April 2015. Prior reports can be accessed at <https://www.westerneim.com/Pages/About/QuarterlyBenefits.aspx>.

■ WESTERN EIM BENEFITS IN Q2 2019

Table 1 shows the estimated EIM gross benefits by each region per month². The monthly savings presented in the table show \$29.72 million for April, \$28.64 million for May, and \$27.64 million for June with a total estimated benefit of \$86 million for the quarter.

<i>Region</i>	April	May	June	Total
<i>APS</i>	\$2.68	\$2.10	\$3.77	\$8.55
<i>BANC</i>	\$4.55	\$1.99	\$2.27	\$8.81
<i>CISO</i>	\$8.30	\$9.58	\$5.65	\$23.53
<i>IPCO</i>	\$2.03	\$2.11	\$4.19	\$8.33
<i>NVE</i>	\$1.23	\$1.33	\$2.06	\$4.62
<i>PAC</i>	\$5.23	\$5.74	\$4.18	\$15.15
<i>PGE</i>	\$3.39	\$3.52	\$3.98	\$10.89
<i>PWRX</i>	\$1.28	\$1.15	\$0.63	\$3.06
<i>PSE</i>	\$1.03	\$1.12	\$0.91	\$3.06
Total	\$29.72	\$28.64	\$27.64	\$86.00

TABLE 1: Second quarter 2019 benefits in millions USD by month

¹ The benefits reflect the Sacramento Municipal Utility District as the participating resource within BANC.

² The EIM benefits reported here are calculated based on available data. Intervals without complete data are excluded in the calculation. The intervals excluded due to unavailable data are normally within a few percent of the total intervals.

■ INTER-REGIONAL TRANSFERS

A significant contributor to EIM benefits is transfers across balancing areas, providing access to lower cost supply, while factoring in the cost of compliance with greenhouse gas (GHG) emissions regulations when energy is transferred into the ISO. As such, the transfer volumes are a good indicator of a portion of the benefits attributed to the EIM. Transfers can take place in both the 15-Minute Market and Real-Time Dispatch (RTD).

Generally, transfer limits are based on transmission and interchange rights that participating balancing authority areas make available to the EIM, with the exception of the PacifiCorp West (PACW)-ISO transfer limit and the Portland General Electric (PGE)-ISO transfer limit in RTD. These RTD transfer capacities between PACW/PGE and the ISO are determined based on the allocated dynamic transfer capability driven by system operating conditions. This report does not quantify a BAA’s opportunity cost that the utility considered when using its transfer rights for the EIM.

Table 2 provides the 15-minute and 5-minute EIM transfer volumes with base schedule transfers excluded. The EIM entities submit inter-BAA transfers in their base schedules. The benefits quantified in this report are only attributable to the transfers that occurred through the EIM. The benefits do not include any transfers attributed to transfers submitted in the base schedules that are scheduled prior to the start of the EIM.

The transfer from BAA_x to BAA_y and the transfer from BAA_y to BAA_x are separately reported. For example, if there is a 100 Megawatt-Hour (MWh) transfer during a 5-minute interval, in addition to a base transfer from ISO to NVE, it will be reported as 100 MWh from_BAA ISO to_BAA NEVP, and 0 MWh from_BAA NEVP to_BAA ISO in the opposite direction. The 15-minute transfer volume is the result of optimization in the 15-minute market using all bids and base schedules submitted into the EIM. The 5-minute transfer volume is the result of optimization using all bids and base schedules submitted into EIM, based on unit commitments determined in the 15-minute market optimization. The maximum transfer capacities between EIM entities are shown in Graph 1 below.

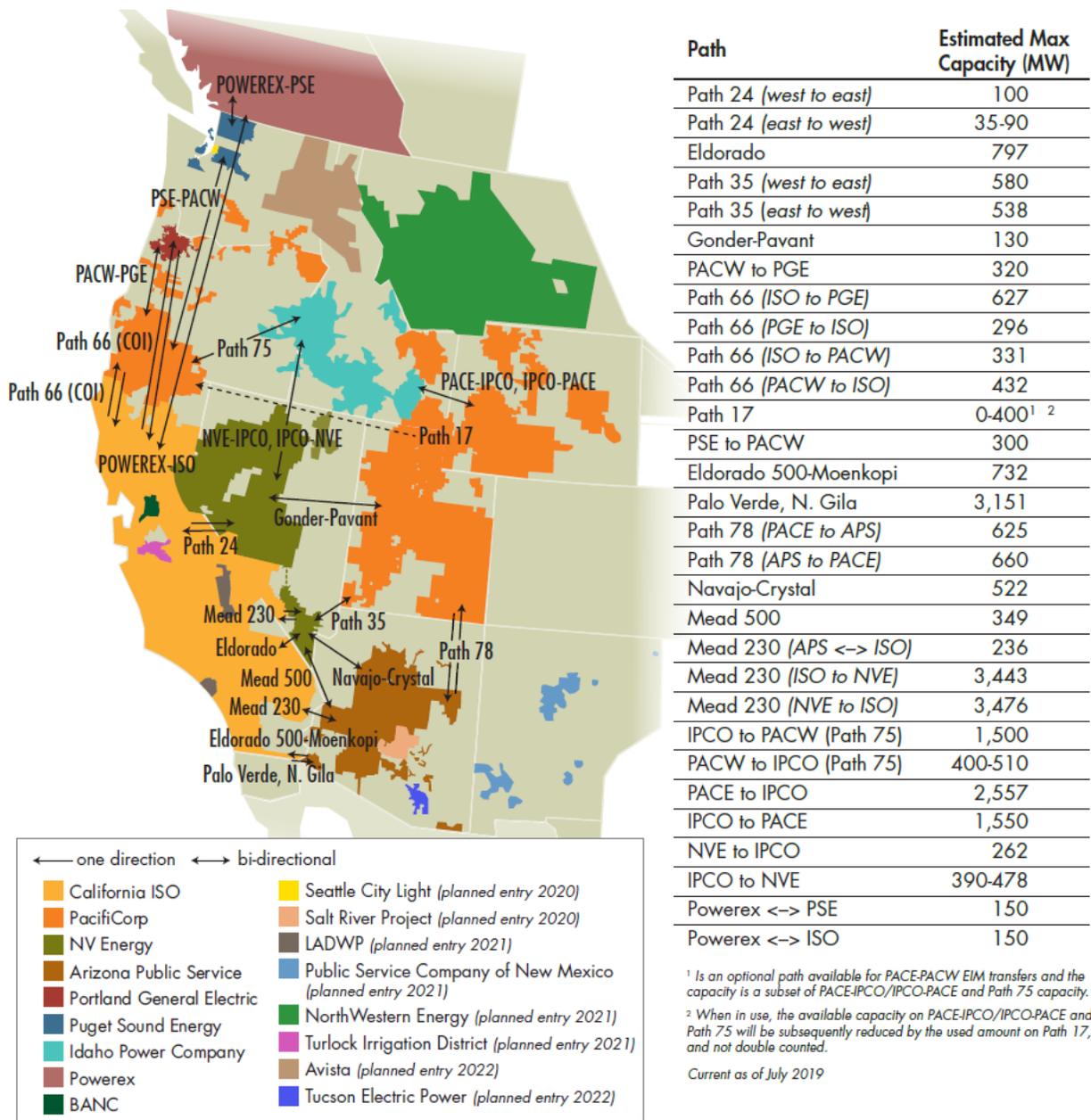
<i>Month</i>	From BAA	To BAA	15min EIM transfer	5min EIM transfer
			(15m - base)	(5m - base)
	AZPS	CISO	58,813	44,666
	AZPS	NEVP	2,788	5,799
	AZPS	PACE	173,316	197,864
	BANC	CISO	20,141	18,662
	PWRX	CISO	803	5,210
	PWRX	PSEI	1,613	2,153
	CISO	AZPS	202,343	217,429

<i>April</i>	CISO	BANC	24,835	29,317
	CISO	PWRX	123,099	132,834
	CISO	NEVP	165,005	173,555
	CISO	PACW	66,529	83,546
	CISO	PGE	41,419	71,539
	IPCO	NEVP	20,382	16,095
	IPCO	PACE	42,942	36,743
	IPCO	PACW	38,185	43,906
	NEVP	AZPS	3,681	4,357
	NEVP	CISO	72,934	42,996
	NEVP	IPCO	36,234	42,523
	NEVP	PACE	122,543	118,447
	PACE	AZPS	33,726	26,671
	PACE	IPCO	15,139	20,783
	PACE	NEVP	42,168	25,045
	PACE	PACW	21,040	24,391
	PACW	CISO	28,772	37,291
	PACW	IPCO	40,137	33,518
	PACW	PGE	15,839	11,958
	PACW	PSEI	28,305	32,131
	PGE	CISO	2,360	1,852
	PGE	PACW	78,012	90,067
	PSEI	PWRX	12,054	9,671
	PSEI	PACW	41,190	47,106
	AZPS	CISO	56,039	36,075
	AZPS	NEVP	5,714	7,275
	AZPS	PACE	246,067	260,039
	BANC	CISO	18,599	16,619
PWRX	CISO	106	1,253	

	PWRX	PSEI	1,648	3,240
	CISO	AZPS	259,128	258,904
	CISO	BANC	40,490	47,448
	CISO	PWRX	103,882	119,051
	CISO	NEVP	333,874	324,705
	CISO	PACW	98,939	117,606
	CISO	PGE	65,603	97,985
	IPCO	NEVP	13,475	8,633
	IPCO	PACE	95,965	95,716
May	IPCO	PACW	30,678	22,829
	NEVP	AZPS	3,406	2,419
	NEVP	CISO	39,421	22,304
	NEVP	IPCO	86,006	68,771
	NEVP	PACE	218,246	219,874
	PACE	AZPS	6,203	3,143
	PACE	IPCO	6,076	6,254
	PACE	NEVP	17,145	9,083
	PACE	PACW	17,208	13,713
	PACW	CISO	20,985	27,788
	PACW	IPCO	37,613	42,884
	PACW	PGE	13,686	11,499
	PACW	PSEI	14,475	17,139
	PGE	CISO	3,882	3,715
	PGE	PACW	82,643	96,278
	PSEI	PWRX	11,315	8,855
	PSEI	PACW	50,923	61,085
	AZPS	CISO	119,059	101,073
	AZPS	NEVP	18,398	18,633
	AZPS	PACE	137,156	146,704

June	BANC	CISO	36,111	35,831
	PWRX	CISO	0	0
	PWRX	PSEI	3,820	5,747
	CISO	AZPS	132,869	152,001
	CISO	BANC	46,488	45,366
	CISO	PWRX	70,481	84,559
	CISO	NEVP	216,668	241,982
	CISO	PACW	64,429	80,061
	CISO	PGE	34,510	53,783
	IPCO	NEVP	14,928	13,946
	IPCO	PACE	37,786	42,831
	IPCO	PACW	34,178	30,864
	NEVP	AZPS	2,115	1,452
	NEVP	CISO	55,771	38,658
	NEVP	IPCO	56,279	59,229
	NEVP	PACE	199,862	213,750
	PACE	AZPS	34,806	24,181
	PACE	IPCO	20,129	24,469
	PACE	NEVP	26,639	15,919
	PACE	PACW	24,279	20,929
	PACW	CISO	41,120	50,682
	PACW	IPCO	23,525	25,814
	PACW	PGE	16,480	13,139
	PACW	PSEI	22,584	23,510
	PGE	CISO	1,439	2,231
	PGE	PACW	90,669	97,208
	PSEI	PWRX	11,941	10,703
	PSEI	PACW	43,407	54,294

TABLE 2: Energy transfers (MWh) in the FMM and RTD markets for Q2 2019



GRAPH 1: Estimated maximum transfer capacity (EIM entities operating in Q2 2019)

■ WHEEL THROUGH TRANSFERS

As the footprint of the Western EIM grows and continues to change, wheel-through transfers may become more common. Currently, an EIM entity facilitating a wheel through receives no direct financial benefit for facilitating the wheel; only the sink and source directly benefit. As part of the Western EIM Consolidated Initiatives stakeholder process, the ISO committed to monitoring the wheel through volumes to assess whether, after the addition of new EIM entities, there is a potential future need to pursue a market solution to address the equitable sharing of wheeling benefits. The ISO will continue to track the volume of wheel-through transfers in the EIM market in the quarterly reports. In order to derive the wheel-through transfers for each EIM BAA, the ISO uses the following calculation for every real-time interval dispatch:

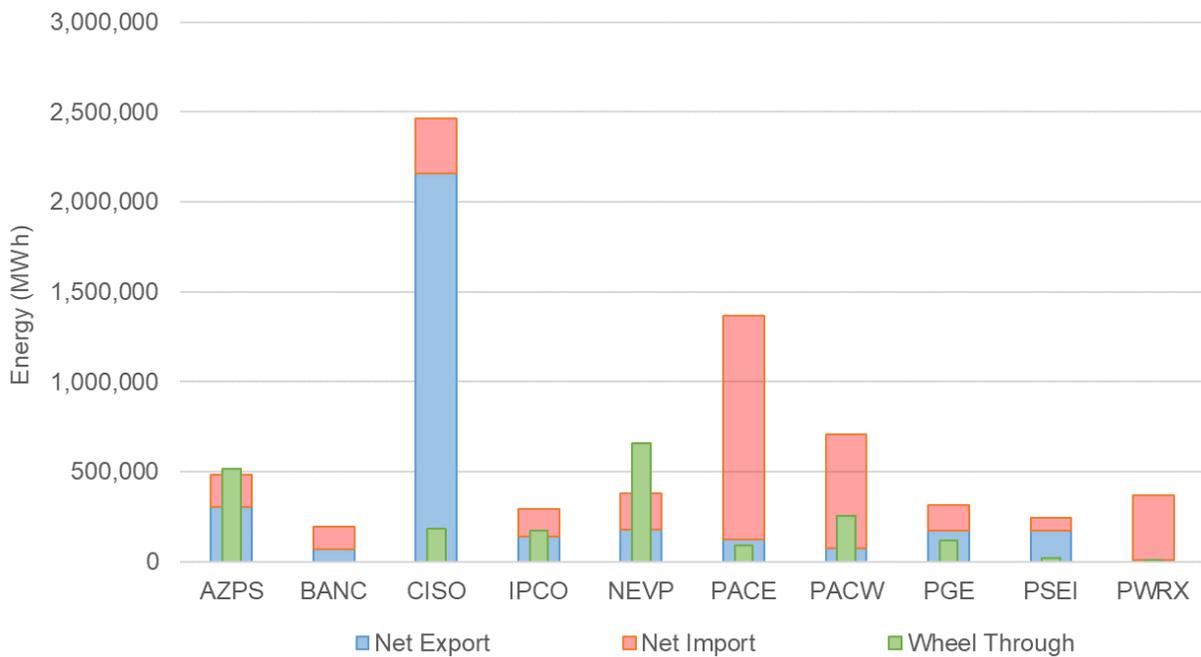
- Total import: summation of transfers above base transfers coming into the EIM BAA under analysis
- Total export: summation of all transfers above base transfers going out of the EIM BAA under analysis
- Net import: the maximum of zero or the difference between total imports and total exports
- Net export: the maximum of zero or the difference between total exports and total imports
- Wheel through: the minimum of the EIM transfers into (total import) or EIM transfer out (total export) of a BAA for a given interval

All wheel-through transfers are summed over both the month and the quarter. This volume reflects the total wheel-through transfers for each EIM BAA, regardless of the potential paths used to wheel through. The net imports and exports estimated in this section reflect the overall volume of net imports and exports; in contrast, the imports and exports provided in Table 2 reflect the gross transfers between two EIM BAAs.

The metric is measured as energy in MWh for each month and the corresponding calendar quarter, as shown in Tables 3 through 6 and Figures 2 through 5.

<i>BAA</i>	<i>Net Export</i>	<i>Net Import</i>	<i>Wheel Through</i>
<i>AZPS</i>	305,752	178,346	514,915
<i>BANC</i>	71,261	122,721	-
<i>CISO</i>	2,158,797	306,124	182,083
<i>IPCO</i>	139,127	151,739	173,400
<i>NEVP</i>	177,602	204,565	659,897
<i>PACE</i>	122,388	1,243,723	92,681
<i>PACW</i>	75,296	633,406	252,686
<i>PGE</i>	173,894	142,630	118,114
<i>PSEI</i>	174,881	66,700	17,354
<i>PWRX</i>	11,295	360,341	6,409

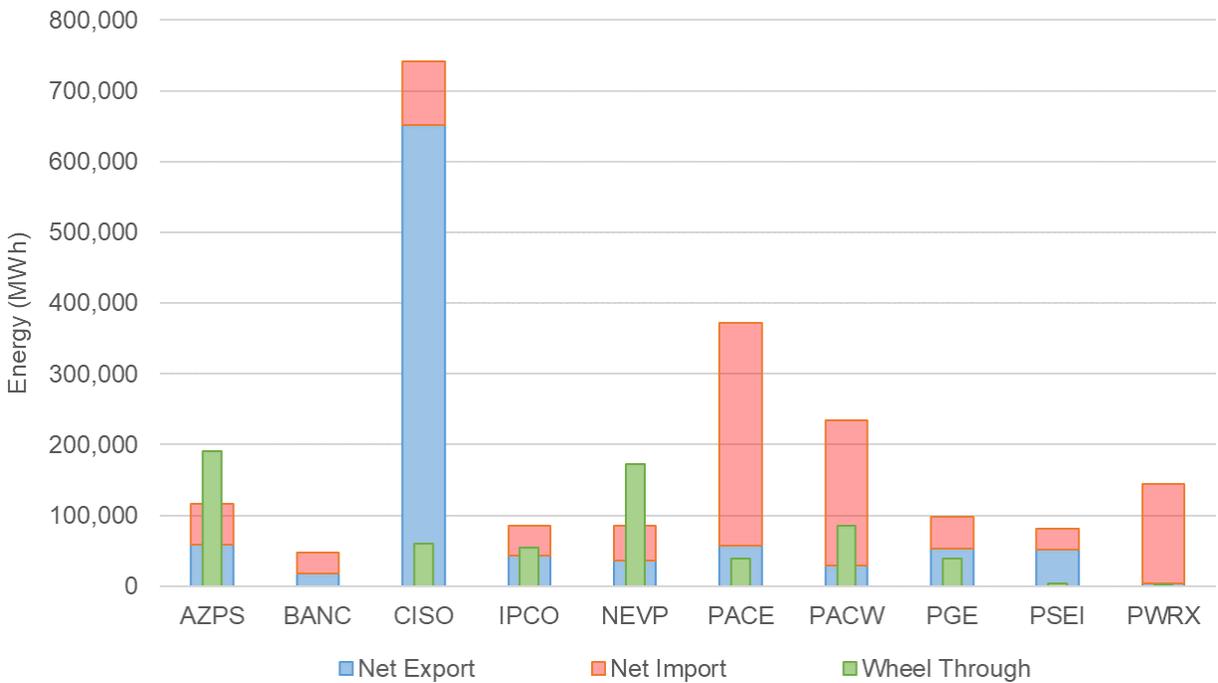
TABLE 3: Estimated wheel-through transfers in Q2 2019



GRAPH 2: Estimated wheel-through transfers in Q2 2019

<i>BAA</i>	Net Export	Net Import	Wheel-Through
<i>AZPS</i>	58,189	58,376	191,095
<i>BANC</i>	18,676	29,432	-
<i>CISO</i>	651,169	90,743	60,069
<i>IPCO</i>	42,949	43,091	54,092
<i>NEVP</i>	36,358	48,632	172,854
<i>PACE</i>	57,526	315,192	39,491
<i>PACW</i>	29,488	204,354	85,584
<i>PGE</i>	53,331	44,946	38,805
<i>PSEI</i>	52,262	29,600	4,704
<i>PWRX</i>	4,533	140,115	2,848

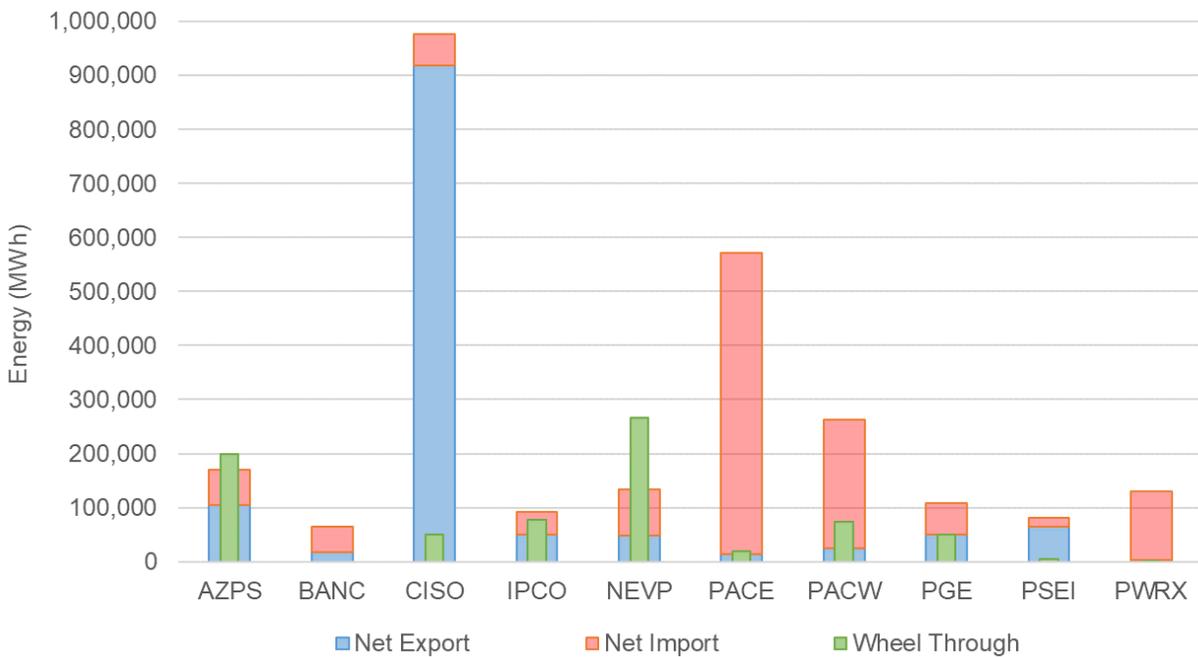
TABLE 4: Estimated wheel-through transfers in April 2019



GRAPH 3: Estimated wheel-through transfers in April 2019

<i>BAA</i>	Net Export	Net Import	Wheel- Through
<i>AZPS</i>	104,103	65,357	199,970
<i>BANC</i>	16,659	47,598	-
<i>CISO</i>	918,466	57,377	50,518
<i>IPCO</i>	50,872	41,725	76,566
<i>NEVP</i>	48,069	85,136	266,052
<i>PACE</i>	13,125	557,873	19,094
<i>PACW</i>	24,934	237,649	74,541
<i>PGE</i>	49,642	59,181	50,636
<i>PSEI</i>	65,100	15,493	4,937
<i>PWRX</i>	2,944	126,525	1,616

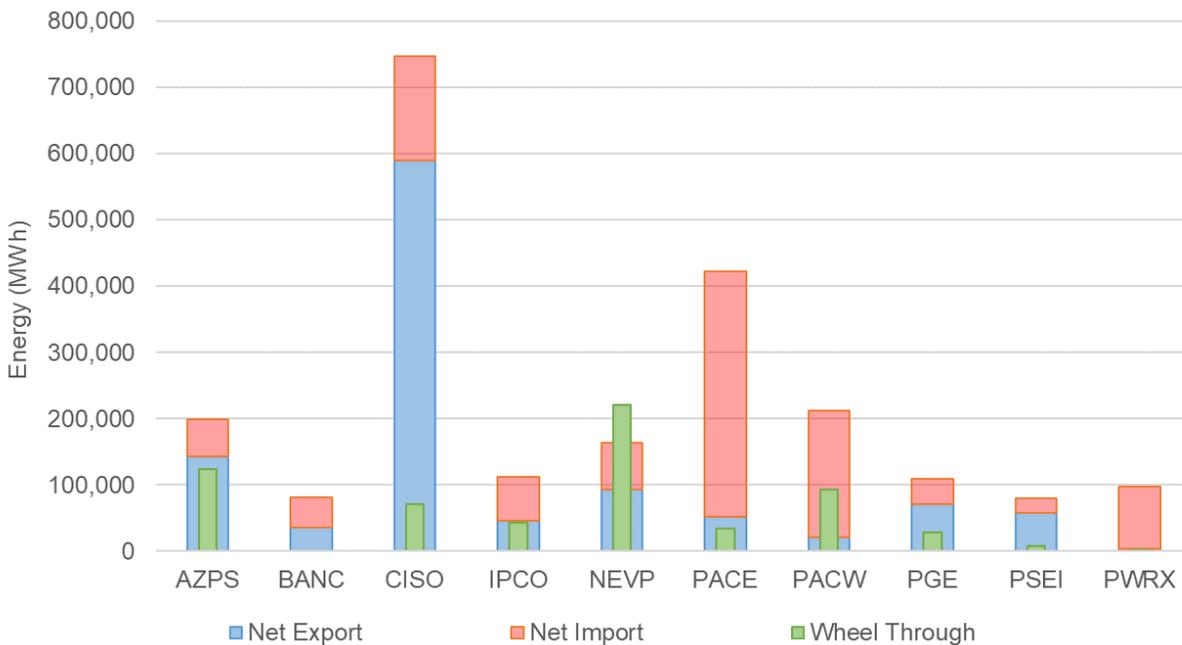
TABLE 5: Estimated wheel-through transfers in May 2019



GRAPH 4: Estimated wheel-through transfers in May 2019

<i>BAA</i>	Net Export	Net Import	Wheel Through
<i>AZPS</i>	143,460	54,612	123,851
<i>BANC</i>	35,926	45,691	-
<i>CISO</i>	589,162	158,004	71,496
<i>IPCO</i>	45,306	66,923	42,742
<i>NEVP</i>	93,175	70,797	220,992
<i>PACE</i>	51,737	370,658	34,097
<i>PACW</i>	20,875	191,403	92,561
<i>PGE</i>	70,921	38,504	28,673
<i>PSEI</i>	57,519	21,607	7,713
<i>PWRX</i>	3,819	93,700	1,945

TABLE 6: Estimated wheel-through transfers in June 2019



GRAPH 5: Estimated wheel-through transfers in June 2019

REDUCED RENEWABLE CURTAILMENT AND GHG REDUCTIONS

The Western EIM benefit calculation includes the economic benefits that can be attributed to avoided renewable curtailment within the ISO footprint. If not for energy transfers facilitated by the EIM, some renewable generation located within the ISO would have been curtailed via either economic or exceptional dispatch. The total avoided renewable curtailment volume in MWh for Q2 2019 was calculated to be 46,812 MWh (April) + 59,422 MWh (May) + 26,703 MWh (June) = 132,937 MWh total.

The environmental benefits of avoided renewable curtailment are significant. Under the assumption that avoided renewable curtailments displace production from other resources at a default emission rate of 0.428 metric tons CO₂/MWh, avoided curtailments displaced an estimated 56,897 metric tons of CO₂ for Q2 2019. Avoided renewable curtailments also may have contributed to an increased volume of renewable credits that would otherwise have been unavailable. This report does not quantify the additional value in dollars associated with this benefit. Total estimated reductions in the curtailment of renewable energy along with the associated reductions in CO₂ are shown in Table 7.

Year	Quarter	MWh	Eq. Tons CO2
2015	1	8,860	3,792
	2	3,629	1,553
	3	828	354
	4	17,765	7,521
2016	1	112,948	48,342
	2	158,806	67,969
	3	33,094	14,164
	4	23,390	10,011
2017	1	52,651	22,535
	2	67,055	28,700
	3	23,331	9,986
	4	18,060	7,730
2018	1	65,860	28,188
	2	129,128	55,267
	3	19,032	8,146
	4	23,425	10,026
2019	1	52,254	22,365
	2	132,937	56,897
Total		943,053	403,546

TABLE 7: Total reduction in curtailment of renewable energy and the associated reductions in CO2

■ FLEXIBLE RAMPING PROCUREMENT DIVERSITY SAVINGS

The Western EIM facilitates procurement of flexible ramping capacity in the FMM to address variability that may occur in the RTD. Because variability across different BAAs may happen in opposite directions, the flexible ramping requirement for the entire EIM footprint can be less than the sum of individual BAA's requirements. This difference is known as flexible ramping procurement diversity savings. Starting in November 2016, the ISO replaced the flexible ramping constraint with flexible ramping products that provide both upward and downward ramping. The minimum and maximum flexible ramping requirements for each BAA and for each direction are listed in Table 8.

<i>Month</i>	BAA	Direction	Minimum requirement	Maximum requirement
<i>April</i>	<i>AZPS</i>	up	35	185
	<i>BANC</i>	up	5	60
	<i>CISO</i>	up	215	1701
	<i>IPCO</i>	up	45	157
	<i>NEVP</i>	up	0	152
	<i>PACE</i>	up	105	298
	<i>PACW</i>	up	56	137
	<i>PGE</i>	up	54	129
	<i>PSEI</i>	up	36	106
	<i>PWRX</i>	up	68	234
	ALL EIM	up	287	1,823
	<i>AZPS</i>	down	23	190
	<i>BANC</i>	down	4	69
	<i>CISO</i>	down	343	1,349
	<i>IPCO</i>	down	53	153
	<i>NEVP</i>	down	0	152
	<i>PACE</i>	down	82	321
	<i>PACW</i>	down	19	119
	<i>PGE</i>	down	35	146
	<i>PSEI</i>	down	43	145
	<i>PWRX</i>	down	54	230
	ALL EIM	down	418	1,484
<i>May</i>	<i>AZPS</i>	up	27	185
	<i>BANC</i>	up	5	72
	<i>CISO</i>	up	167	1,701
	<i>IPCO</i>	up	44	157
	<i>NEVP</i>	up	0	152
	<i>PACE</i>	up	68	298

	<i>PACW</i>	up	61	137
	<i>PGE</i>	up	58	129
	<i>PSEI</i>	up	38	106
	<i>PWRX</i>	up	63	234
	ALL EIM	up	260	1,823
	<i>AZPS</i>	down	21	190
	<i>BANC</i>	down	4	69
	<i>CISO</i>	down	286	1,349
	<i>IPCO</i>	down	45	153
	<i>NEVP</i>	down	0	152
	<i>PACE</i>	down	73	321
	<i>PACW</i>	down	37	119
	<i>PGE</i>	down	52	146
	<i>PSEI</i>	down	40	145
	<i>PWRX</i>	down	57	230
	ALL EIM	down	428	1,484
<i>June</i>	<i>AZPS</i>	up	38	185
	<i>BANC</i>	up	4	72
	<i>CISO</i>	up	293	1,701
	<i>IPCO</i>	up	41	157
	<i>NEVP</i>	up	32	152
	<i>PACE</i>	up	65	298
	<i>PACW</i>	up	60	137
	<i>PGE</i>	up	37	129
	<i>PSEI</i>	up	18	106
	<i>PWRX</i>	up	59	234
	ALL EIM	up	380	1,823
	<i>AZPS</i>	down	21	190
	<i>BANC</i>	down	5	72
	<i>CISO</i>	down	227	1,349

<i>IPCO</i>	down	45	153
<i>NEVP</i>	down	21	152
<i>PACE</i>	down	66	321
<i>PACW</i>	down	27	119
<i>PGE</i>	down	47	146
<i>PSEI</i>	down	27	145
<i>PWRX</i>	down	60	230
ALL EIM	down	337	1,484

Table 8: Flexible ramping requirements

The flexible ramping procurement diversity savings for all the intervals averaged over the month are shown in Table 9. The percentage savings is the average MW savings divided by the sum of the four individual BAA requirements.

	April		May		June	
<i>Direction</i>	Up	Down	Up	Down	Up	Down
<i>Average MW saving</i>	827	881	844	880	853	880
<i>Sum of BAA requirements</i>	1,861	1,959	1,867	1,934	1,953	1,879
<i>Percentage savings</i>	44%	45%	45%	45%	44%	47%

Table 9: Flexible ramping procurement diversity savings in Q2 2019

Flexible ramping capacity may be used in RTD to handle uncertainties in the future interval. The RTD flexible ramping capacity is prorated to each BAA. Flexible ramping surplus MW is defined as the awarded flexible ramping capacity in RTD minus its share, and the flexible ramping surplus cost is defined as the flexible ramping surplus MW multiplied by the flexible ramping EIM-wide marginal price. A positive flexible ramping surplus MW is the capacity that a BAA provided to help other BAAs, and a negative flexible ramping surplus MW is the capacity that a BAA received from other BAAs. The EIM dispatch cost for a BAA with positive flexible ramping surplus MW is increased because some capacities are used to help other BAAs. The flexible ramping surplus cost is subtracted from the BAA's EIM dispatch cost to reflect the true dispatch cost of a BAA. Please see the Benefit Report Methodology for more details.

■ CONCLUSION

The first real-time wholesale power market of its kind in the western United States, the EIM uses state-of-the-art technology to find and deliver low-cost energy to meet real-time demand across eight western states and a Canadian province. Since launching in November 2014, the Western EIM has produced gross economic benefits of \$736.26 million, demonstrating that utilities can realize cost benefits and reduce carbon emissions through increased coordination and optimization in the West.

Sharing resources across a larger geographic area continues to have a positive effect of reducing greenhouse gas emissions by using renewable generation that otherwise would have been turned off. Use of this energy to meet demand across the EIM footprint is likely replacing less clean energy sources. The quantified benefits from avoided curtailments of renewable generation from 2015 to-date reached 403,546 metric tons of CO₂, roughly the equivalent of avoiding the emissions from 84,844 passenger cars driven for one year.