

WESTERN EIM BENEFITS REPORT

Second Quarter 2018 

July 31, 2018

CONTENTS

EXECUTIVE SUMMARY	3
BACKGROUND	4
EIM BENEFITS IN Q2 2018	4
INTER-REGIONAL TRANSFERS	5
WHEEL THROUGH TRANSFERS.....	8
REDUCED RENEWABLE CURTAILMENT AND GHG REDUCTIONS.....	13
FLEXIBLE RAMPING PROCUREMENT DIVERSITY SAVINGS	14
CONCLUSION	17

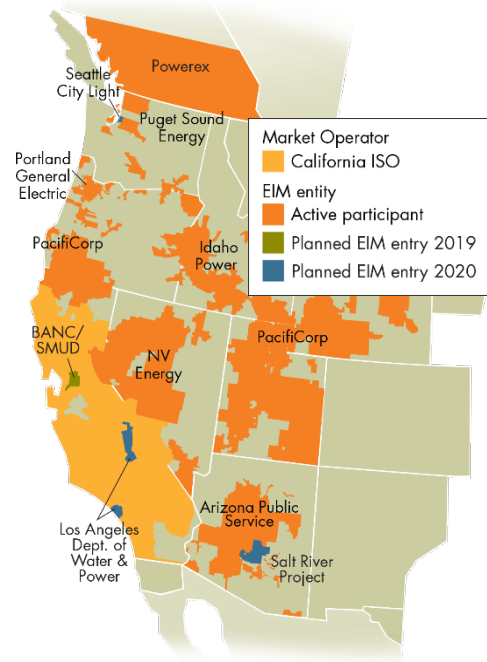
EXECUTIVE SUMMARY

Gross benefits from EIM since November 2014
\$401.73 million

This report presents the benefits associated with participation in the western Energy Imbalance Market (EIM) for the second quarter of 2018. The benefits include cost savings and the use of surplus renewable energy.

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

This analysis demonstrates the real-time market's ability to select the most economic resources across the EIM footprint.



2018 Q2 BENEFITS

ECONOMICAL

\$71.21M

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

ENVIRONMENTAL

55,267

Metric tons of CO₂** avoided curtailments

OPERATIONAL

46%

Average reduction in flexibility reserves across the footprint

Q2 2018 Gross Benefits by Participant

	(millions \$)
Arizona Public Service	\$8.59
California ISO	\$27.93
Idaho Power	\$7.75
NV Energy	\$5.34
PacifiCorp	\$11.67
Portland General Electric	\$5.34
Powerex	\$2.27
Puget Sound Energy	\$2.32
Total	\$71.21

*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 EIM began financially binding operation on November 1, 2014 by optimizing resources across the ISO and PacifiCorp BAAs. NV Energy began participating in December 2015, Arizona Public Service and Puget Sound Energy began operations October 1, 2016, and Portland General Electric began participation on October 1, 2017. Most recently, Idaho Power and Powerex began participation on April 4, 2018. 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 January 2015. Prior reports can be accessed at <https://www.westerneim.com/Pages/About/QuarterlyBenefits.aspx>

The benefits quantified in this report fall into three main categories and were described in earlier studies:¹

■ EIM BENEFITS IN Q2 2018

Table 1 shows the estimated EIM gross benefits by each region per month. The monthly savings presented in the table show \$26.34 million for April, \$25.18 million for May, and \$19.69 million for June with a total estimated benefit of \$71.21 million.

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.

<i>Region</i>	April	May	June	Total
<i>APS</i>	\$3.63	\$2.95	\$2.01	\$8.59
<i>PWRX</i>	\$0.89	\$0.77	\$0.61	\$2.27
<i>ISO</i>	\$9.73	\$9.99	\$8.21	\$27.93
<i>IPCO</i>	\$2.57	\$2.54	\$2.64	\$7.75
<i>NV Energy</i>	\$2.55	\$1.98	\$0.81	\$5.34
<i>PacifiCorp</i>	\$4.43	\$4.58	\$2.66	\$11.67
<i>PGE</i>	\$1.48	\$1.79	\$2.07	\$5.34
<i>PSE</i>	\$1.06	\$0.58	\$0.68	\$2.32
Total	\$26.34	\$25.18	\$19.69	\$71.21

TABLE 1: Second quarter 2018 benefits in millions USD by month

¹ PacifiCorp-ISO, Energy Imbalance Market Benefits, <http://www.caiso.com/Documents/PacifiCorp-ISOEnergyImbalanceMarketBenefits.pdf>

■ 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 Fifteen-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.

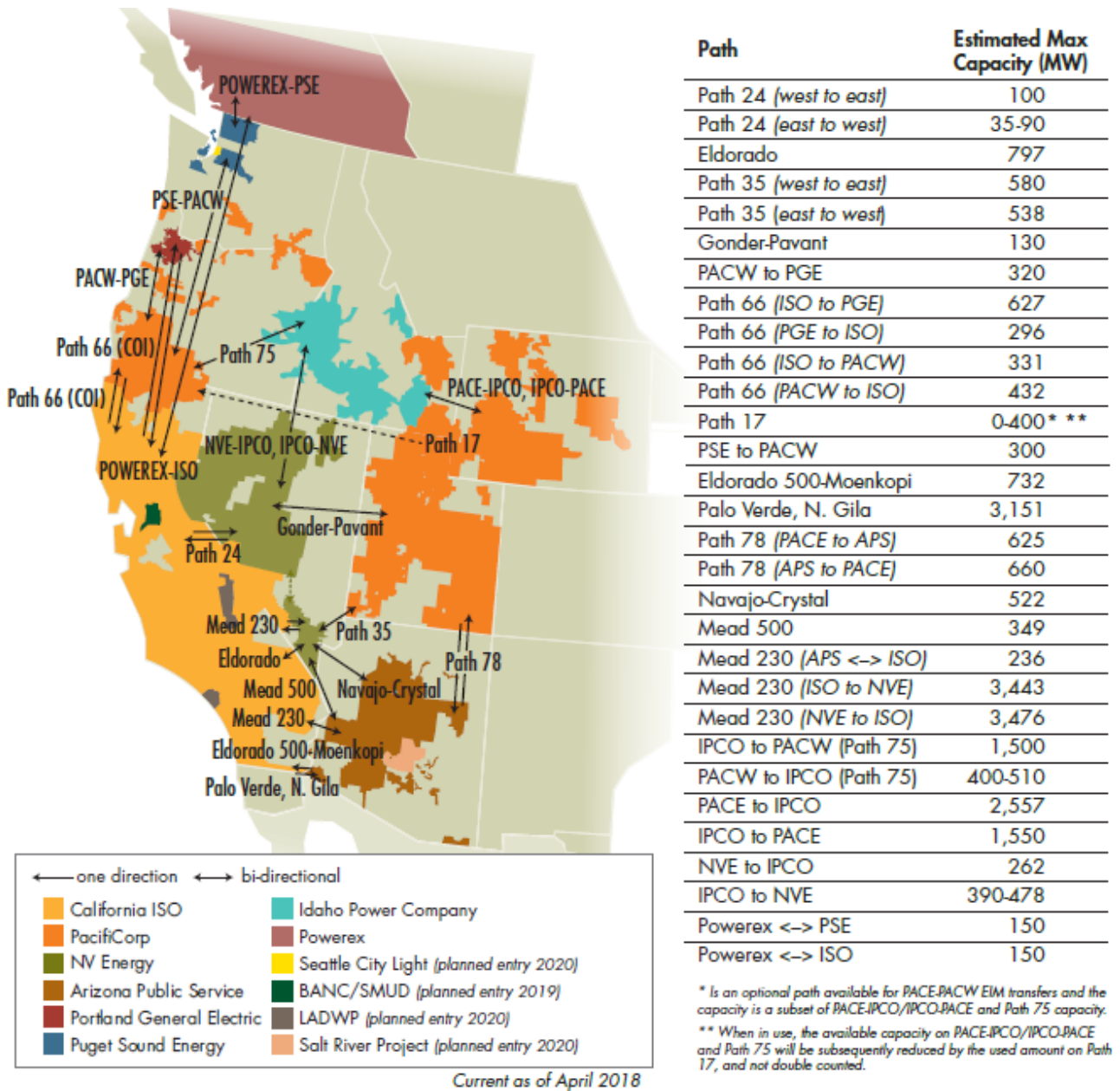
The transfer from BAA_x to BAA_y and the transfer from BAA_y to BAA_x are separately reported. For example, if there is a 100 MWh transfer during a 5-minute interval, in addition to a base transfer from ISO to NVE, it will be reported as 100 MWh from_BAA ISO to_BAA NEVP, and 0 MWh from_BAA NEVP to_BAA 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	89,259	52,854
	AZPS	NEVP	8,471	11,814
	AZPS	PACE	52,935	61,497
	PWRX	CISO	2,016	7,222
	PWRX	PSEI	4,273	4,938
	CISO	AZPS	142,487	166,250
	CISO	PWRX	34,857	68,950
	CISO	NEVP	233,565	350,928
	CISO	PACW	41,529	44,198
	CISO	PGE	17,533	37,415
	IPCO	NEVP	12,169	8,221

<i>April</i>	IPCO	PACE	91,356	101,309
	IPCO	PACW	9,646	15,893
	NEVP	AZPS	5,406	5,671
	NEVP	CISO	53,947	27,912
	NEVP	IPCO	26,035	41,257
	NEVP	PACE	204,274	274,597
	PACE	AZPS	64,107	39,919
	PACE	IPCO	7,718	9,562
	PACE	NEVP	25,087	13,176
	PACE	PACW	42,094	58,876
	PACW	CISO	71,122	71,143
	PACW	IPCO	53,734	52,491
	PACW	PACE	4,861	4,664
	PACW	PGE	14,535	15,530
	PACW	PSEI	28,039	22,234
	PGE	CISO	1,308	932
	PGE	PACW	51,560	54,636
	PSEI	PWRX	41,984	34,794
	PSEI	PACW	64,692	75,999
	<i>May</i>	AZPS	CISO	79,186
AZPS		NEVP	6,799	9,669
AZPS		PACE	147,558	167,836
PWRX		CISO	2,187	15,366
PWRX		PSEI	13,495	12,808
CISO		AZPS	233,548	262,529
CISO		PWRX	4,853	42,926
CISO		NEVP	293,407	376,027
CISO		PACW	76,019	79,156
CISO		PGE	18,466	35,840
IPCO		NEVP	10,415	6,581
IPCO		PACE	100,808	128,040
IPCO		PACW	10,955	14,188
NEVP		AZPS	7,585	7,654
NEVP		CISO	39,997	22,674
NEVP		IPCO	44,642	64,778
NEVP		PACE	221,644	259,597
PACE		AZPS	43,829	28,075
PACE		IPCO	11,255	9,077
PACE		NEVP	14,271	7,871
PACE	PACW	61,697	79,721	

	PACW	CISO	25,955	26,488
	PACW	IPCO	65,804	79,229
	PACW	PACE	5,410	5,163
	PACW	PGE	21,139	19,376
	PACW	PSEI	27,037	19,023
	PGE	CISO	2,320	1,849
	PGE	PACW	39,492	47,397
	PSEI	PWRX	21,036	18,951
	PSEI	PACW	37,571	45,165
	AZPS	CISO	96,903	75,340
	AZPS	NEVP	18,885	16,349
	AZPS	PACE	45,446	66,710
	PWRX	CISO	2,795	32,103
	PWRX	PSEI	19,098	15,222
	CISO	AZPS	127,789	163,425
	CISO	PWRX	1,973	25,658
	CISO	NEVP	240,113	309,317
	CISO	PACW	48,425	49,982
	CISO	PGE	16,217	24,100
	IPCO	NEVP	25,190	20,322
	IPCO	PACE	60,239	81,078
	IPCO	PACW	24,550	27,811
<i>Jun</i>	NEVP	AZPS	7,139	7,097
	NEVP	CISO	41,304	24,735
	NEVP	IPCO	29,033	50,693
	NEVP	PACE	193,873	241,623
	PACE	AZPS	61,089	43,344
	PACE	IPCO	36,671	26,880
	PACE	NEVP	17,686	8,911
	PACE	PACW	67,636	81,623
	PACW	CISO	60,915	62,106
	PACW	IPCO	46,573	56,249
	PACW	PACE	5,013	5,035
	PACW	PGE	19,898	18,725
	PACW	PSEI	28,862	21,731
	PGE	CISO	3,417	3,218
	PGE	PACW	67,546	72,302
	PSEI	PWRX	26,390	27,641
	PSEI	PACW	47,045	45,385

TABLE 2: Energy transfers (MWh) in the FMM and RTD markets for Q2 2018



GRAPH 1: Estimated maximum transfer capacity (EIM entities operating in Q2 2018)

WHEEL THROUGH TRANSFERS

As the footprint of the 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 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 committed to tracking the volume of wheels through in the EIM market in this quarterly

report. In order to derive the wheels through for each EIM BAA, the ISO uses the following calculation for every real-time interval dispatch:

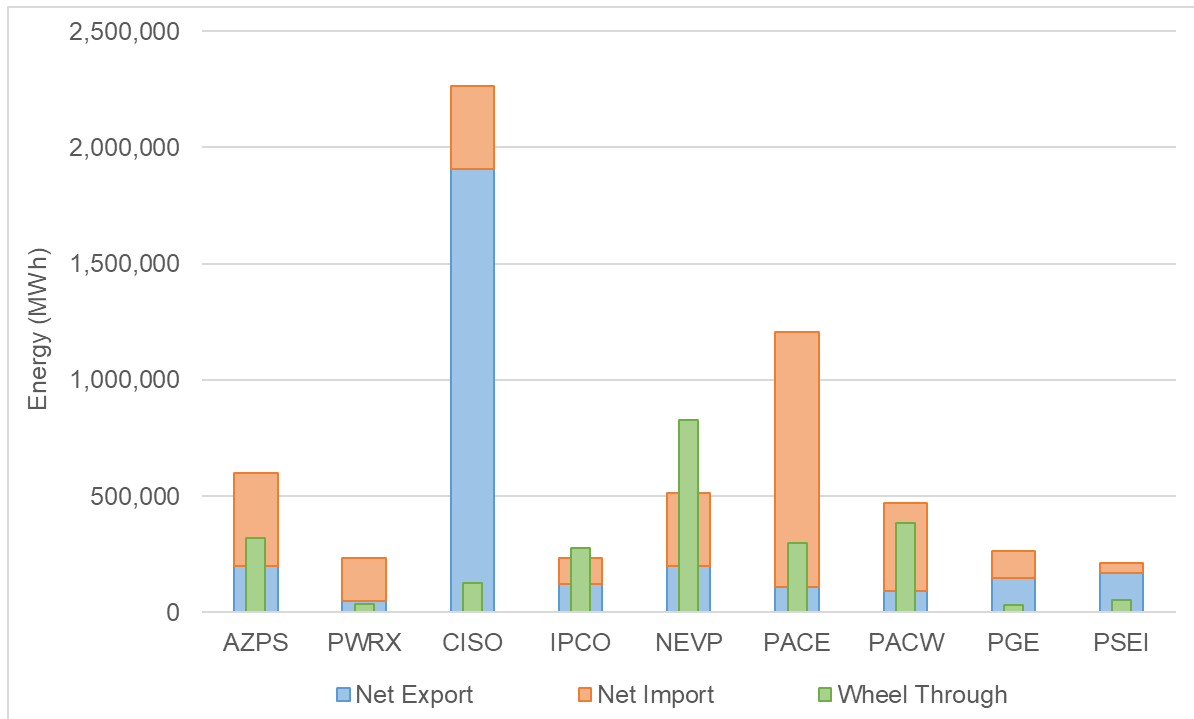
- Total import: summation of transfers above base transfers coming into the EIM BAA under analysis
- Total export: summation of all transfers above base transfers leaving the EIM BAA under analysis
- Net import: the maximum of zero or the difference between total imports and total exports
- Net export: 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 wheels through are summed over the month or quarter. This volume reflects the total wheels through 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>	199,014	402,296	321,667
<i>PWRX</i>	50,635	181,896	37,024
<i>CISO</i>	1,909,497	355,349	127,205
<i>IPCO</i>	124,228	111,192	279,214
<i>NEVP</i>	200,007	312,017	828,282
<i>PACE</i>	108,331	1,099,203	298,704
<i>PACW</i>	92,398	380,002	386,788
<i>PGE</i>	146,556	117,205	33,778
<i>PSEI</i>	170,138	43,973	51,982

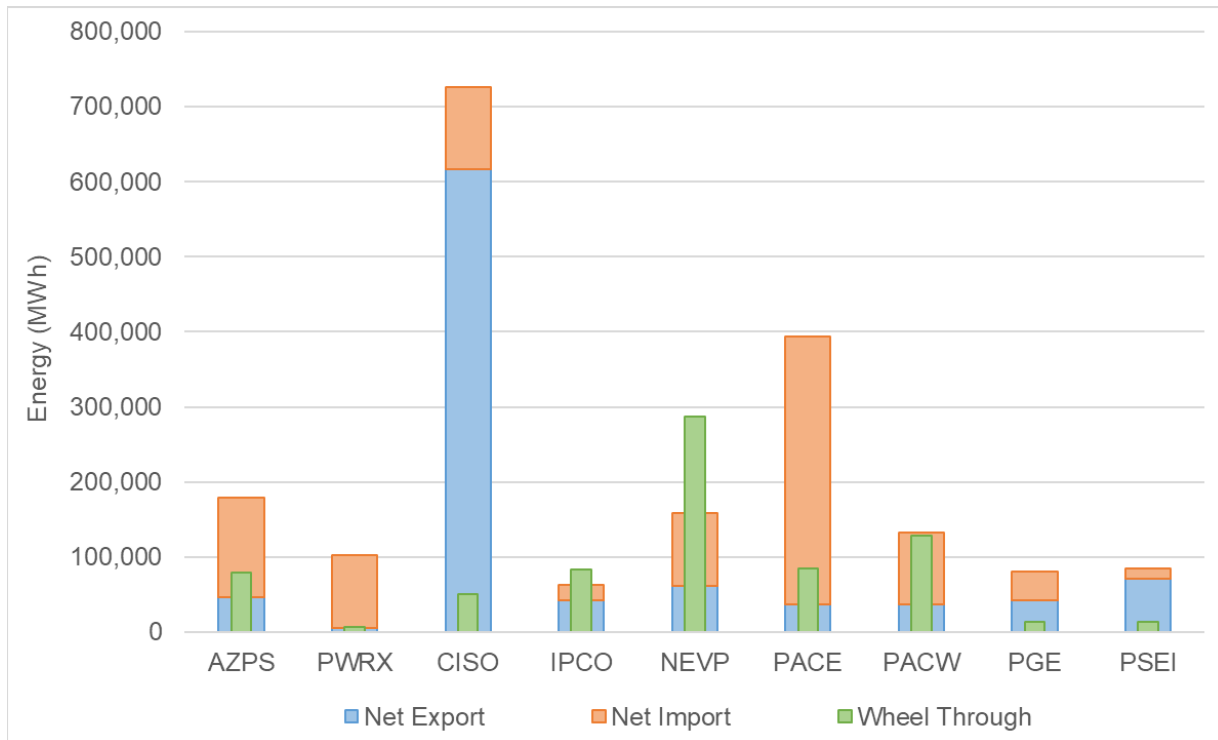
TABLE 3: Estimated wheel through transfers in Q2 2018



GRAPH 2: Estimated wheel through transfers in Q2 2018

<i>BAA</i>	Net Export	Net Import	Wheel Through
<i>AZPS</i>	46,859	132,535	79,305
<i>PWRX</i>	5,561	97,145	6,599
<i>CISO</i>	616,706	109,027	51,036
<i>IPCO</i>	42,444	20,332	82,978
<i>NEVP</i>	61,681	96,382	287,757
<i>PACE</i>	36,403	356,937	85,130
<i>PACW</i>	37,409	95,134	128,653
<i>PGE</i>	41,956	39,333	13,612
<i>PSEI</i>	71,540	13,733	13,439

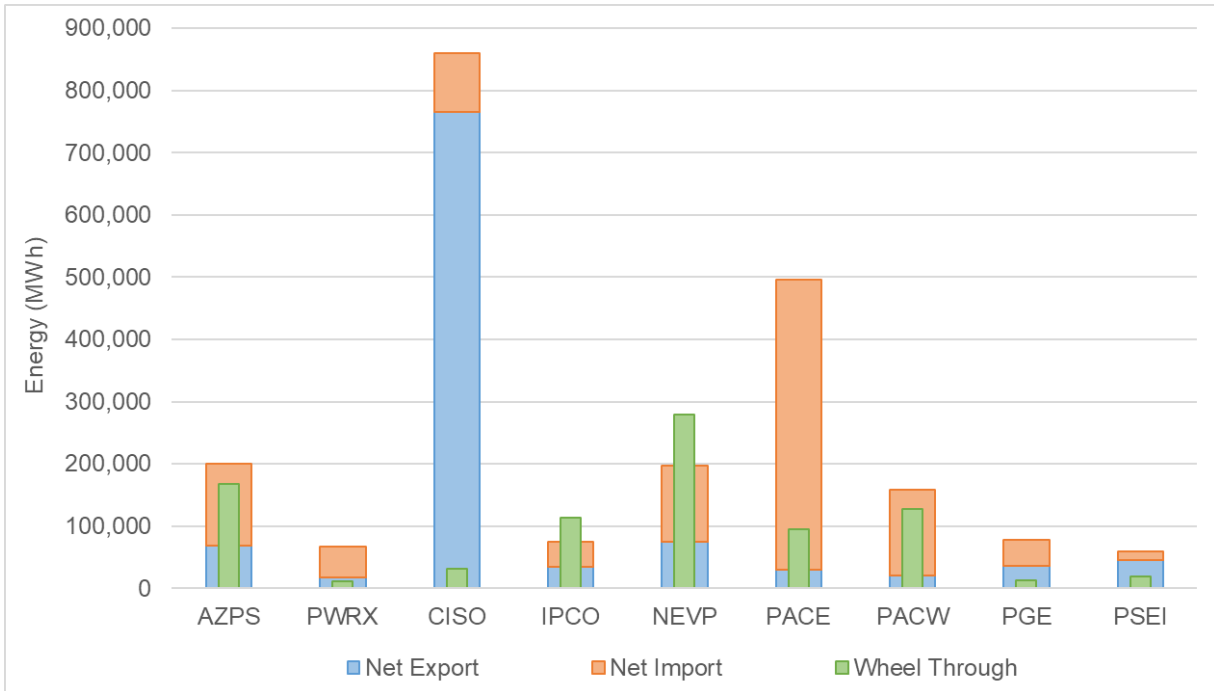
TABLE 4: Estimated wheel through transfers in April 2018



GRAPH 3: Estimated wheel through transfers in April 2018

<i>BAA</i>	Net Export	Net Import	Wheel Through
<i>AZPS</i>	68,824	130,965	167,293
<i>PWRX</i>	16,831	50,534	11,342
<i>CISO</i>	765,499	94,009	30,980
<i>IPCO</i>	34,847	39,312	113,962
<i>NEVP</i>	75,036	121,594	279,666
<i>PACE</i>	29,434	466,084	95,311
<i>PACW</i>	21,217	137,839	128,062
<i>PGE</i>	36,146	42,112	13,101
<i>PSEI</i>	45,799	13,514	18,317

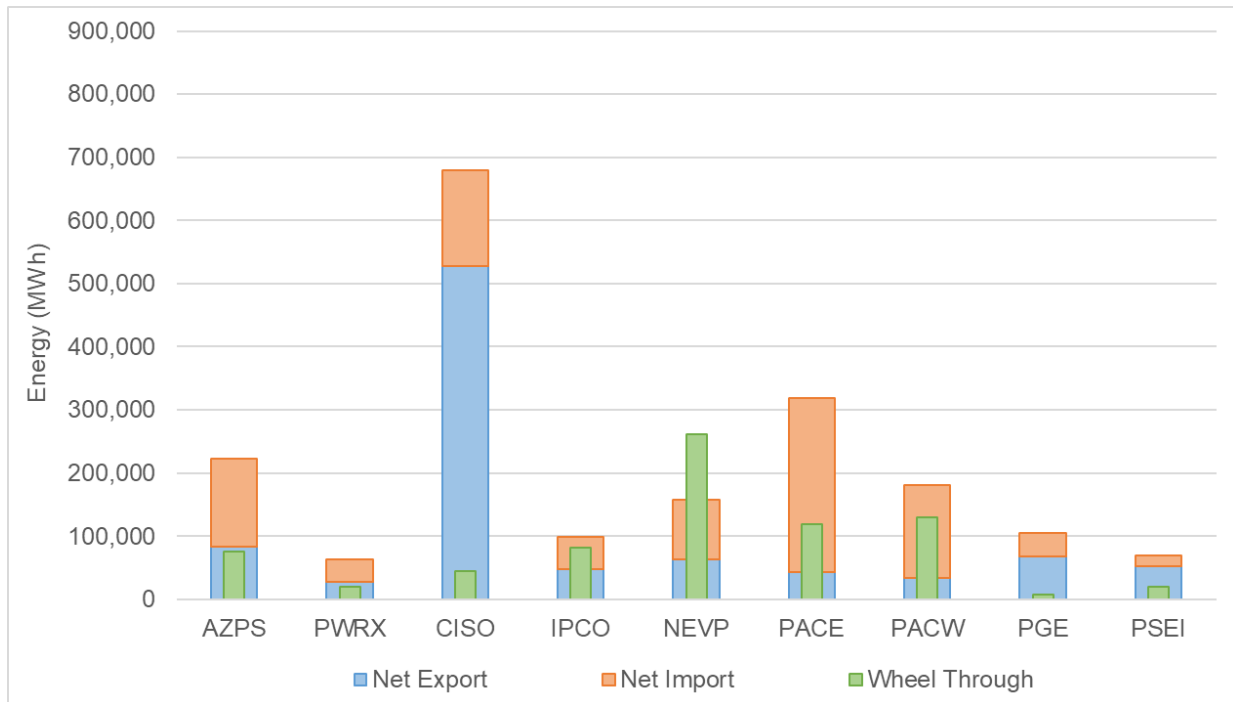
TABLE 5: Estimated wheel through transfers in May 2018



GRAPH 4: Estimated wheel through transfers in May 2018

BAA	Net Export	Net Import	Wheel Through
<i>AZPS</i>	83,330	138,796	75,069
<i>PWRX</i>	28,243	34,216	19,082
<i>CISO</i>	527,292	152,312	45,189
<i>IPCO</i>	46,937	51,548	82,274
<i>NEVP</i>	63,289	94,041	260,859
<i>PACE</i>	42,494	276,182	118,263
<i>PACW</i>	33,772	147,030	130,073
<i>PGE</i>	68,455	35,760	7,065
<i>PSEI</i>	52,799	16,726	20,227

TABLE 6: Estimated wheel through transfers in June 2018



GRAPH 5: Estimated wheel through transfers in June 2018

■ REDUCED RENEWABLE CURTAILMENT AND GHG REDUCTIONS

The EIM benefit calculation includes the economic benefits that can be attributed to avoided renewable curtailment within the ISO. 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 2018 was calculated to be 46,921 MWh (April) + 57,349 MWh (May) + 24,859 MWh (June) = 129,128 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 55,267 metric tons of CO₂ for Q2 2018. 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
	Total	715,405	306,112

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

■ FLEXIBLE RAMPING PROCUREMENT DIVERSITY SAVINGS

The 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.

Year	Month	BAA	Direction	Minimum requirement	Maximum requirement
2018	April	AZPS	up	25	252
		CISO	up	246	1,530
		NEVP	up	24	218
		PACE	up	85	319
		PACW	up	53	179
		PGE	up	43	150
		PSEI	up	41	152
		PWRX	up	65	288
		IPCO	up	56	92
		ALL EIM	up	339	1,932
	AZPS	down	17	196	
	CISO	down	166	1,055	
	NEVP	down	15	242	
	PACE	down	69	300	
	PACW	down	41	152	
	PGE	down	53	189	
	PSEI	down	23	135	
	PWRX	down	66	399	
	IPCO	down	50	96	
	ALL EIM	down	288	1,568	
2018	May	AZPS	up	0	199
		CISO	up	235	1,530
		NEVP	up	26	170
		PACE	up	107	319
		PACW	up	60	179
		PGE	up	43	147
		PSEI	up	31	152
		PWRX	up	60	166
		IPCO	up	60	92
		ALL EIM	up	314	2,291
	AZPS	down	0	180	
	CISO	down	166	1,055	
	NEVP	down	17	152	
	PACE	down	89	269	
	PACW	down	36	185	
	PGE	down	61	189	
	PSEI	down	26	127	
	PWRX	down	69	145	
	IPCO	down	54	96	
	ALL EIM	down	366	1,568	

2018	June	AZPS	up	28	199
		CISO	up	127	1,467
		NEVP	up	32	170
		PACE	up	93	319
		PACW	up	63	179
		PGE	up	45	147
		PSEI	up	35	152
		PWRX	up	66	296
		IPCO	up	55	92
		ALL EIM	up	220	1,467
	AZPS	down	27	180	
	CISO	down	242	1,308	
	NEVP	down	16	152	
	PACE	down	97	269	
	PACW	down	29	192	
	PGE	down	52	189	
	PSEI	down	34	127	
	PWRX	down	67	198	
	IPCO	down	33	96	
	ALL EIM	down	254	1,492	

Table 8: Flexible ramping requirements

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

<i>Direction</i>	April		May		June	
	Up	Down	Up	Down	Up	Down
<i>Average MW saving</i>	736	771	758	748	790	804
<i>Sum of BAA requirements</i>	1,656	1,681	1,609	1,695	1,649	1,704
<i>Percentage savings</i>	44%	46%	47%	44%	48%	47%

Table 9: Flexible ramping procurement diversity savings for second quarter 2018

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 in the Appendix for more details.

■ CONCLUSION

Participation in the western EIM continues to show that utilities can realize cost benefits and reduced carbon emissions. With \$401.73 million in gross benefits to date, the realized savings are in line with analysis conducted by each EIM entity before they joined EIM. The EIM resource sharing also continues to have a positive effect on 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 GHG quantified benefits from avoided curtailments of 306,112 metric tons from 2015 to date is roughly equivalent to avoiding the emissions from 64,359 passenger cars driven for one year.