

WESTERN EIM BENEFITS REPORT

Third Quarter 2018   

October 29, 2018

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EXECUTIVE SUMMARY

Gross benefits from EIM since November 2014

\$502.31 million

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

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

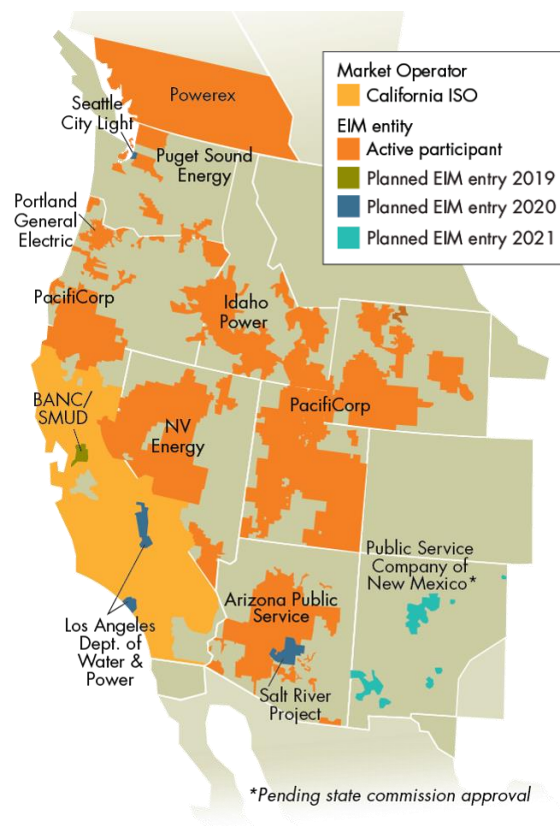
This analysis demonstrates the real-time market's ability to select the most economic resources across the EIM footprint.

Q3 2018 Gross Benefits by Participant

	(millions \$)
Arizona Public Service	\$20.78
California ISO	\$21.02
Idaho Power	\$13.31
NV Energy	\$11.09
PacifiCorp	\$17.82
Portland General Electric	\$9.47
Powerex	\$2.65
Puget Sound Energy	\$4.44
Total	\$100.58

*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>

2018
Q3 BENEFITS

ECONOMICAL

\$100.58M

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

ENVIRONMENTAL

8,146

Metric tons of CO₂** avoided curtailments

OPERATIONAL

48%

Average reduction in flexibility reserves across the footprint

■ 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 Q3 2018

Table 1 shows the estimated EIM gross benefits by each region per month². The monthly savings presented in the table show \$39.66 million for July, \$45.09 million for August, and \$15.83 million for September with a total estimated benefit of \$100.58 million. The benefits in Quarter 3 of this year were higher than usual due to more economical transfers in periods of high loads and higher electric prices following higher fuel prices. This was mainly observed in July and August; the estimated benefits dropped in September to typical ranges tracking lower load levels and fuel prices.

<i>Region</i>	July	August	September	Total
<i>APS</i>	\$9.48	\$9.34	\$1.96	\$20.78
<i>ISO</i>	\$9.93	\$7.85	\$3.24	\$21.02
<i>IPCO</i>	\$4.55	\$6.36	\$2.40	\$13.31
<i>NVE</i>	\$4.07	\$4.96	\$2.06	\$11.09
<i>PAC</i>	\$5.80	\$9.46	\$2.56	\$17.82
<i>PGE</i>	\$3.29	\$3.90	\$2.28	\$9.47
<i>PWRX</i>	\$0.93	\$1.20	\$0.52	\$2.65
<i>PSE</i>	\$1.61	\$2.02	\$0.81	\$4.44
Total	\$39.66	\$45.09	\$15.83	\$100.58

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

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

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 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.

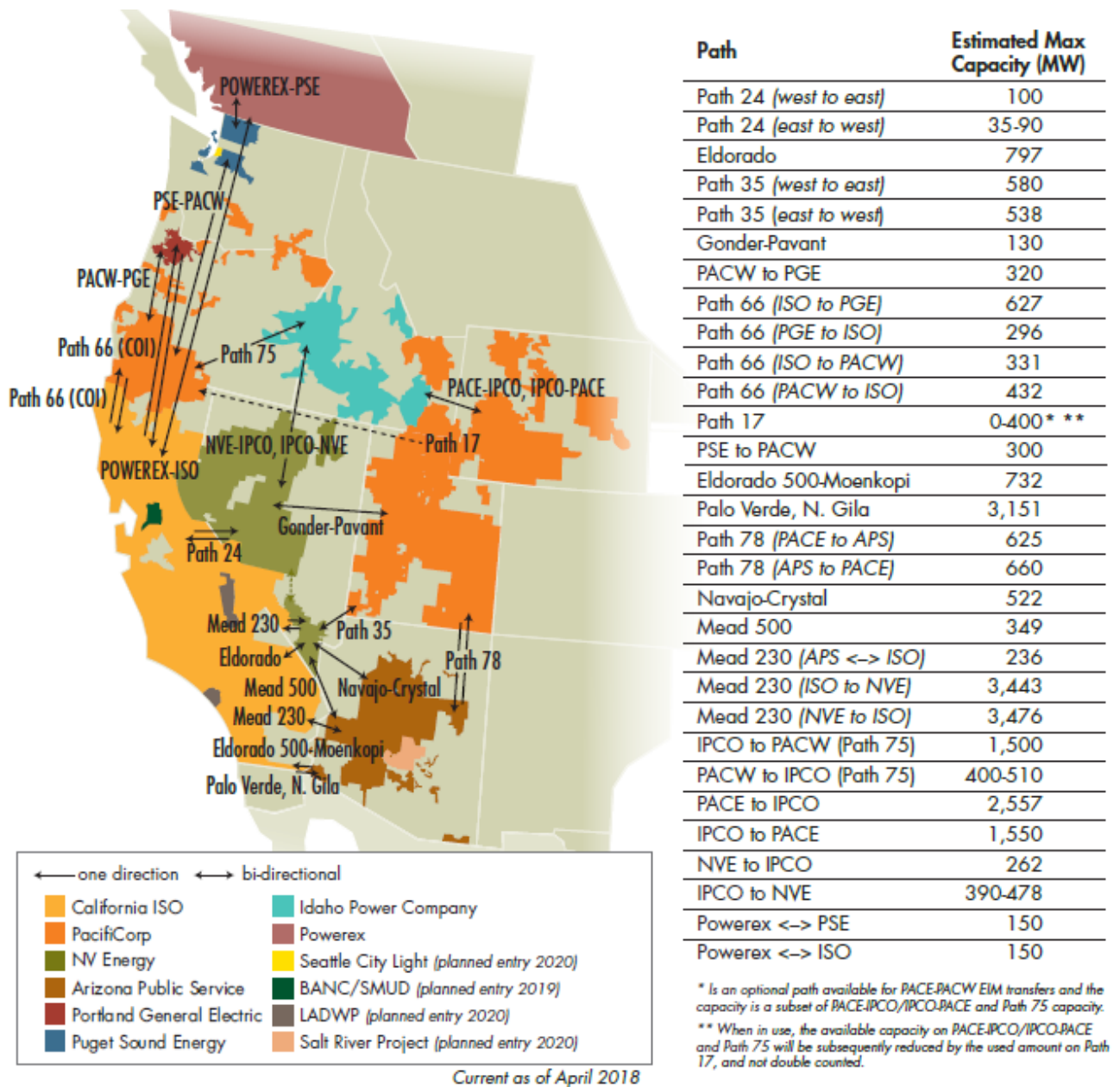
The transfer from BAA_x to BAA_y and the transfer from BAA_y to BAA_x are separately reported. For example, if there is a 100 MWh transfer during a 5-minute interval, in addition to a base transfer from ISO to NVE, it will be reported as 100 MWh from _BAA ISO to _BAA NEVP, and 0 MWh from _BAA NEVP to _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	308,299	279,306
	AZPS	NEVP	27,273	35,453
	AZPS	PACE	4,011	8,601
	PWRX	CISO	7,039	28,128
	PWRX	PSEI	9,400	6,692
	CISO	AZPS	20,542	26,108
	CISO	PWRX	6,801	34,025
	CISO	NEVP	38,074	63,089
	CISO	PACW	15,181	17,545
	CISO	PGE	13,349	18,579
	IPCO	NEVP	74,651	65,046

July	IPCO	PACE	2,465	4,813
	IPCO	PACW	17,963	22,938
	NEVP	AZPS	2,320	9,577
	NEVP	CISO	115,574	93,098
	NEVP	IPCO	4,954	8,886
	NEVP	PACE	45,656	70,036
	PACE	AZPS	172,719	138,028
	PACE	IPCO	72,451	79,468
	PACE	NEVP	57,884	47,170
	PACE	PACW	58,997	68,577
	PACW	CISO	95,257	113,554
	PACW	IPCO	2,900	2,446
	PACW	PGE	88,242	87,902
	PACW	PSEI	85,520	70,970
	PGE	CISO	6,914	6,990
	PGE	PACW	22,942	24,336
	PSEI	PWRX	58,595	51,164
	PSEI	PACW	17,454	14,592
August	AZPS	CISO	336,838	283,392
	AZPS	NEVP	22,131	24,404
	AZPS	PACE	741	1,482
	PWRX	CISO	8,351	31,923
	PWRX	PSEI	10,750	5,366
	CISO	AZPS	11,866	19,684
	CISO	PWRX	6,057	30,432
	CISO	NEVP	38,398	74,357
	CISO	PACW	9,133	11,754
	CISO	PGE	3,567	9,171
	IPCO	NEVP	85,822	64,415
	IPCO	PACE	1,526	1,442
	IPCO	PACW	15,845	27,465
	NEVP	AZPS	1,203	669
	NEVP	CISO	124,984	92,743
	NEVP	IPCO	848	3,196
	NEVP	PACE	24,691	39,164
	PACE	AZPS	212,357	167,794
	PACE	IPCO	80,531	84,948
	PACE	NEVP	57,552	49,692
	PACE	PACW	46,273	69,641
	PACW	CISO	97,488	117,688
	PACW	IPCO	10,267	7,198

September	PACW	PGE	61,184	65,115
	PACW	PSEI	65,444	55,071
	PGE	CISO	7,118	10,097
	PGE	PACW	29,562	30,402
	PSEI	PWRX	56,383	56,670
	PSEI	PACW	30,585	30,024
	AZPS	CISO	233,913	205,634
	AZPS	NEVP	8,977	10,413
	AZPS	PACE	5,816	6,534
	PWRX	CISO	5,484	19,446
	PWRX	PSEI	9,140	4,692
	CISO	AZPS	31,025	35,535
	CISO	PWRX	12,416	44,696
	CISO	NEVP	46,338	62,393
	CISO	PACW	24,419	30,382
	CISO	PGE	16,475	27,210
	IPCO	NEVP	51,248	34,159
	IPCO	PACE	2,378	2,232
	IPCO	PACW	25,976	33,741
	NEVP	AZPS	1,138	1,100
	NEVP	CISO	147,864	113,253
	NEVP	IPCO	8,312	13,675
	NEVP	PACE	46,582	57,825
	PACE	AZPS	155,787	121,870
	PACE	IPCO	35,502	40,515
	PACE	NEVP	76,716	66,272
	PACE	PACW	29,513	39,796
	PACW	CISO	66,992	82,093
	PACW	IPCO	36,858	23,759
	PACW	PGE	47,967	47,583
	PACW	PSEI	64,917	46,803
	PGE	CISO	2,102	4,064
	PGE	PACW	22,931	21,154
	PSEI	PWRX	54,029	48,050
	PSEI	PACW	25,278	25,967

TABLE 2: Energy transfers (MWh) in the FMM and RTD markets for Q3 2018



GRAPH 1: Estimated maximum transfer capacity (EIM entities operating in Q3 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 will continue to track the volume of wheels through in the EIM market in the quarterly reports. In order to derive the wheels through for each EIM BAA, the ISO uses the following calculation for every real-time interval dispatch:

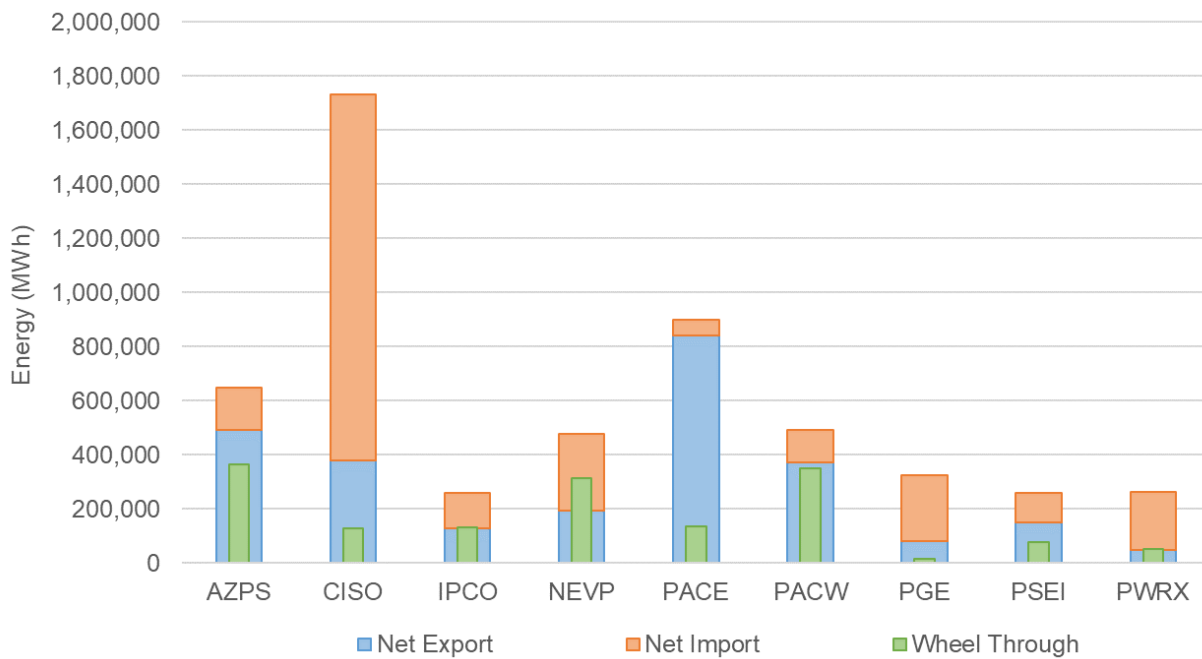
- Total import: summation of transfers above base transfers coming into the EIM BAA under analysis
- Total export: summation of all transfers above base transfers going out of the EIM BAA under analysis
- Net import: the maximum of zero or the difference between total imports and total exports
- Net 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 throughs are summed over both the month and the 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 Import</i>	<i>Net Export</i>	<i>Wheel Through</i>
<i>AZPS</i>	156,828	492,078	365,046
<i>CISO</i>	1,355,904	377,370	128,945
<i>IPCO</i>	133,902	126,231	130,799
<i>NEVP</i>	285,871	192,121	312,593
<i>PACE</i>	57,243	840,597	135,694
<i>PACW</i>	119,478	372,105	350,170
<i>PGE</i>	241,216	82,188	15,215
<i>PWRX</i>	215,351	46,284	50,323
<i>PSEI</i>	111,463	148,281	78,753

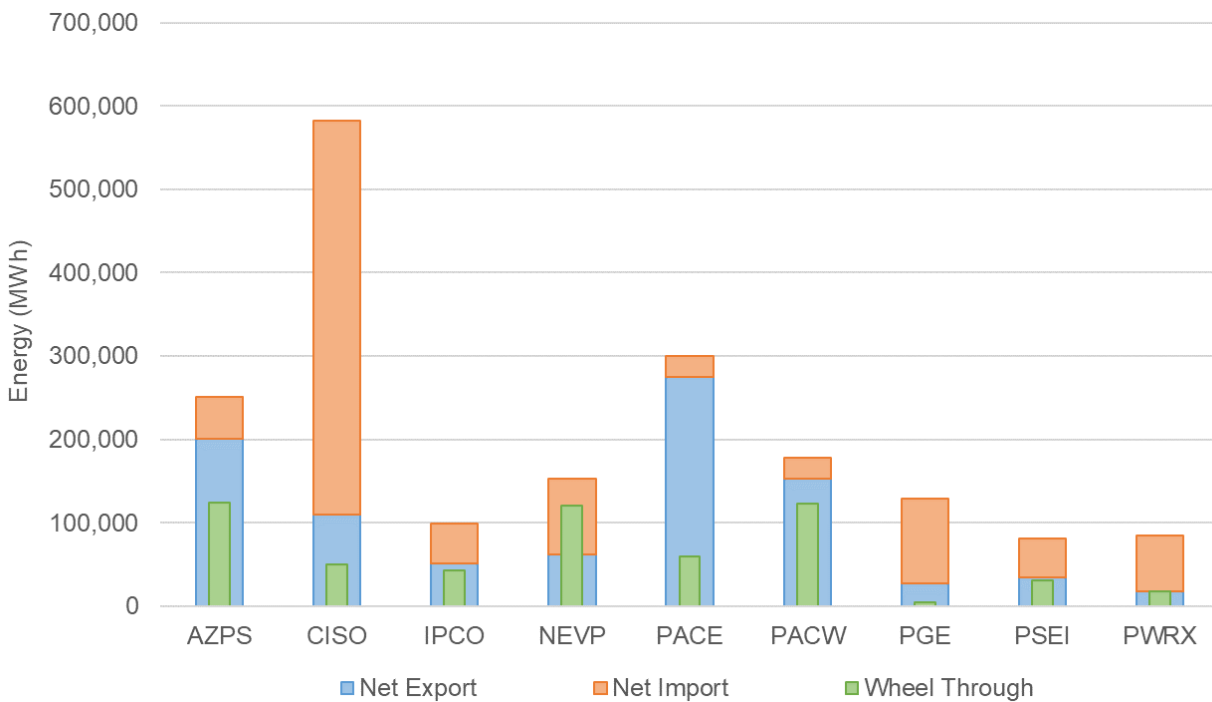
TABLE 3: Estimated wheel through transfers in Q3 2018



GRAPH 2: Estimated wheel through transfers in Q3 2018

<i>BAA</i>	Net Import	Net Export	Wheel Through
<i>AZPS</i>	50,085	200,290	123,922
<i>CISO</i>	472,764	110,109	49,683
<i>IPCO</i>	48,735	50,799	42,312
<i>NEVP</i>	91,011	61,971	120,253
<i>PACE</i>	24,685	274,731	59,127
<i>PACW</i>	25,294	152,402	123,123
<i>PGE</i>	102,186	26,739	4,649
<i>PWRX</i>	67,552	17,204	17,783
<i>PSEI</i>	46,489	34,555	31,347

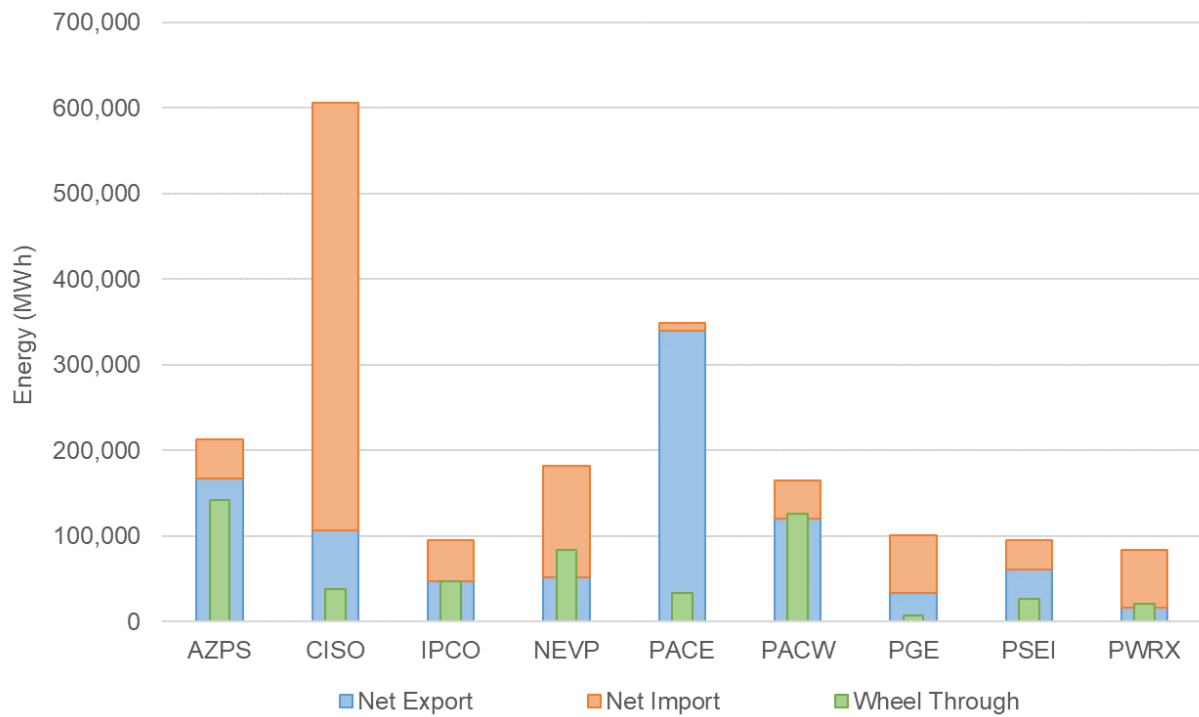
TABLE 4: Estimated wheel through transfers in July 2018



GRAPH 3: Estimated wheel through transfers in July 2018

<i>BAA</i>	Net Import	Net Export	Wheel Through
<i>AZPS</i>	45,924	167,558	142,655
<i>CISO</i>	499,048	107,162	38,498
<i>IPCO</i>	48,770	46,917	46,736
<i>NEVP</i>	129,643	52,349	83,879
<i>PACE</i>	8,873	339,691	33,368
<i>PACW</i>	44,486	120,518	125,551
<i>PGE</i>	67,445	33,868	6,926
<i>PWRX</i>	66,773	16,744	20,656
<i>PSEI</i>	34,347	60,504	26,476

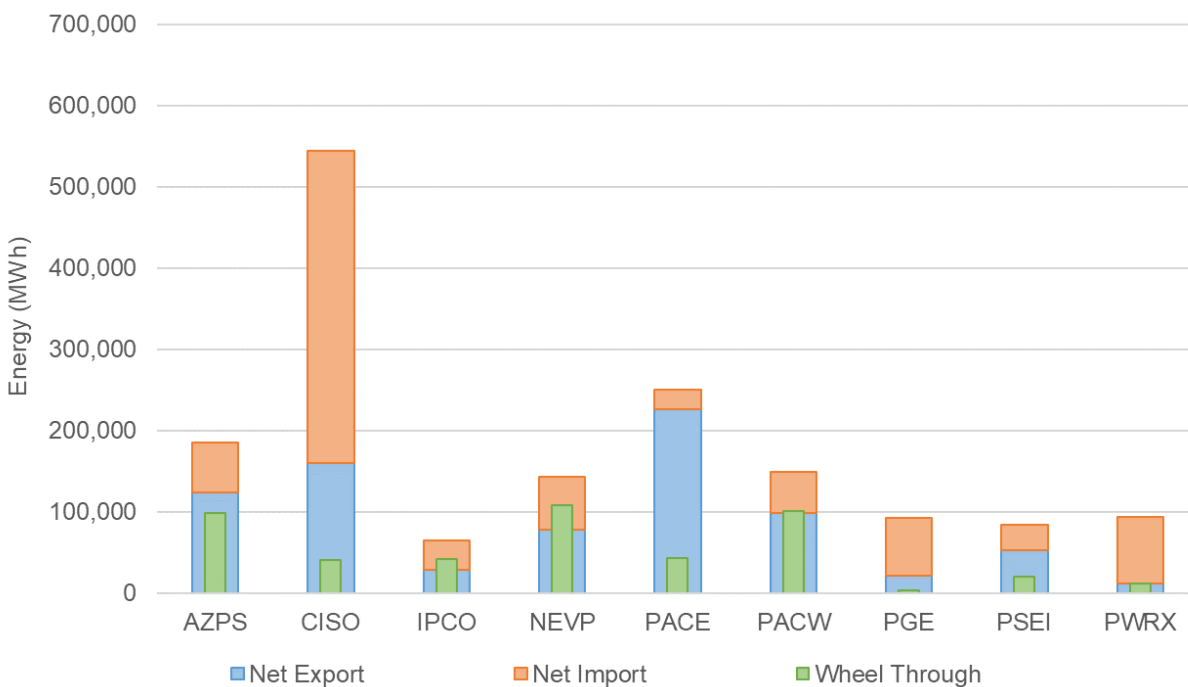
TABLE 5: Estimated wheel through transfers in August 2018



GRAPH 4: Estimated wheel through transfers in August 2018

<i>BAA</i>	Net Import	Net Export	Wheel Through
<i>AZPS</i>	60,818	124,230	98,469
<i>CISO</i>	384,092	160,099	40,763
<i>IPCO</i>	36,396	28,515	41,751
<i>NEVP</i>	65,217	77,801	108,461
<i>PACE</i>	23,685	226,175	43,199
<i>PACW</i>	49,697	99,185	101,496
<i>PGE</i>	71,585	21,580	3,640
<i>PWRX</i>	81,026	12,336	11,884
<i>PSEI</i>	30,627	53,222	20,930

TABLE 6: Estimated wheel through transfers in September 2018



GRAPH 5: Estimated wheel through transfers in September 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 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 Q3 2018 was calculated to be 5,206 MWh (July) + 5,879 MWh (August) + 7,947 MWh (September) = 19,032 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 8,146 metric tons of CO₂ for Q3 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
	3	19,032	8,146
	Total	734,437	314,258

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	July	AZPS	up	0	199
		CISO	up	0	1,499
		NEVP	up	0	170
		PACE	up	0	319
		PACW	up	0	161
		PGE	up	0	147
		PSEI	up	0	152
		PWRX	up	0	296
		IPCO	up	0	222
		ALL EIM	up	0	1,630
		AZPS	down	0	180
		CISO	down	0	1,294
		NEVP	down	0	152
		PACE	down	0	269
		PACW	down	0	192
		PGE	down	0	189
		PSEI	down	0	127
		PWRX	down	0	198
		IPCO	down	0	209
		ALL EIM	down	0	1,492
2018	August	AZPS	up	0	199
		CISO	up	0	1,499
		NEVP	up	0	170
		PACE	up	0	319
		PACW	up	0	179
		PGE	up	0	147
		PSEI	up	0	152
		PWRX	up	0	279
		IPCO	up	0	222
		ALL EIM	up	0	1,630
		AZPS	down	0	180
		CISO	down	0	1,316
		NEVP	down	0	152
		PACE	down	0	269
		PACW	down	0	192
		PGE	down	0	189
		PSEI	down	0	127
		PWRX	down	0	198
		IPCO	down	0	209
		ALL EIM	down	0	1,492

2018	September	AZPS	up	36	199
		CISO	up	0	1,499
		NEVP	up	39	170
		PACE	up	83	319
		PACW	up	46	143
		PGE	up	53	138
		PSEI	up	26	152
		PWRX	up	71	279
		IPCO	up	45	222
		ALL EIM	up	250	1,630
		AZPS	down	35	180
		CISO	down	231	1,316
		NEVP	down	27	152
		PACE	down	82	269
		PACW	down	31	188
		PGE	down	35	189
		PSEI	down	29	127
		PWRX	down	65	198
		IPCO	down	20	203
		ALL EIM	down	300	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.

	July		August		September	
<i>Direction</i>	Up	Down	Up	Down	Up	Down
<i>Average MW saving</i>	864	877	807	845	741	798
<i>Sum of BAA requirements</i>	1,757	1,754	1,722	1,758	1,652	1,714
<i>Percentage savings</i>	49%	50%	47%	48%	45%	47%

Table 9: Flexible ramping procurement diversity savings for third 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

With \$502.31 million in gross benefits to date, the realized savings are in line with analysis conducted by each EIM entity before they joined EIM. Sharing resources across a larger geographic area, even if it's just in real-time, 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 GHG quantified benefits from avoided curtailments of 314,258 metric tons from 2015 to date is roughly equivalent to avoiding the emissions from 66,071 passenger cars driven for one year. These reports also reflect variability from month to month and quarter to quarter, caused by seasonal conditions. Growing participation in the western EIM demonstrates that utilities can realize cost benefits and reduced carbon emissions with increased coordination and optimization in the west.