California ISO

Western EIM Benefits Report

First Quarter 2018

April 30, 2018

Contents

Executive Summary

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

The estimated gross benefits for January, February and March 2018 are $42.08 million, bringing the total benefits of EIM to $330.52 million since the California Independent System Operator (ISO) expanded its real-time market to balancing authority areas outside the ISO in November 2014.

The report also shows that EIM is helping to displace less-clean energy supplies with surplus renewable energy that otherwise may have been curtailed.[1] In Q1, the EIM used 65,860 MWh of surplus renewable energy to displace 28,188 metric tons of CO_2 emissions.

The benefit calculation methodology is described in a separate document.[2] This analysis demonstrates the real-time market's ability to select the most economic resources across the ISO, PacifiCorp, NVE, APS, PSE and PGE balancing authority areas (BAAs), which comprise the EIM footprint. The benefits quantified in this report fall into three categories and were described in earlier studies:[3]

- ***More efficient dispatch, both inter-and intra-regional, in the Fifteen-Minute Market (FMM) and Real-Time Dispatch (RTD). Q1 estimated savings = $42.08 million.***
- ***Reduced renewable energy curtailment. Q1 estimated reduction = 65,860 MWh displacing approximately 28,188 metric tons of CO_2.***
- ***Reduced flexibility ramping reserves needed in all balancing authority areas. Q1 reduction = 387 MW – 492 MW in the upward direction and 490 MW – 542 MW in the downward direction.***

Background

The EIM began financially-binding operation on November 1, 2014 by optimizing resources across the ISO and PacifiCorp BAAs. NV Energy, operating in Nevada, 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. The EIM footprint now includes portions of Arizona, California, Idaho, Nevada, Oregon, Utah, Washington, and Wyoming. The EIM facilitates renewable resource integration and increases reliability by sharing information between balancing authorities on electricity delivery conditions across the EIM region.

[1] 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

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

[3] PacifiCorp-ISO, Energy Imbalance Market Benefits, http://www.caiso.com/Documents/PacifiCorp-ISOEnergyImbalanceMarketBenefits.pdf

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

EIM Benefits in Q1 2018

Table 1 shows the estimated EIM gross benefits by each region per month. The monthly savings presented in the table show $10.16 million for January, $15.86 million for February, and $16.06 million for March with a total estimated benefit of $42.08 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.

Region	January	February	March	Total
APS	$1.98	$1.84	$2.08	$5.90
ISO	$2.99	$5.74	$6.12	$14.85
NV Energy	$0.87	$2.07	$1.23	$4.17
PacifiCorp	$2.36	$4.00	$4.15	$10.51
PGE	$0.95	$1.21	$1.48	$3.64
PSE	$1.01	$1.00	$1.00	$3.01
Total	$10.16	$15.86	$16.06	$42.08

Table 1: First quarter 2018 benefits in millions USD

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.

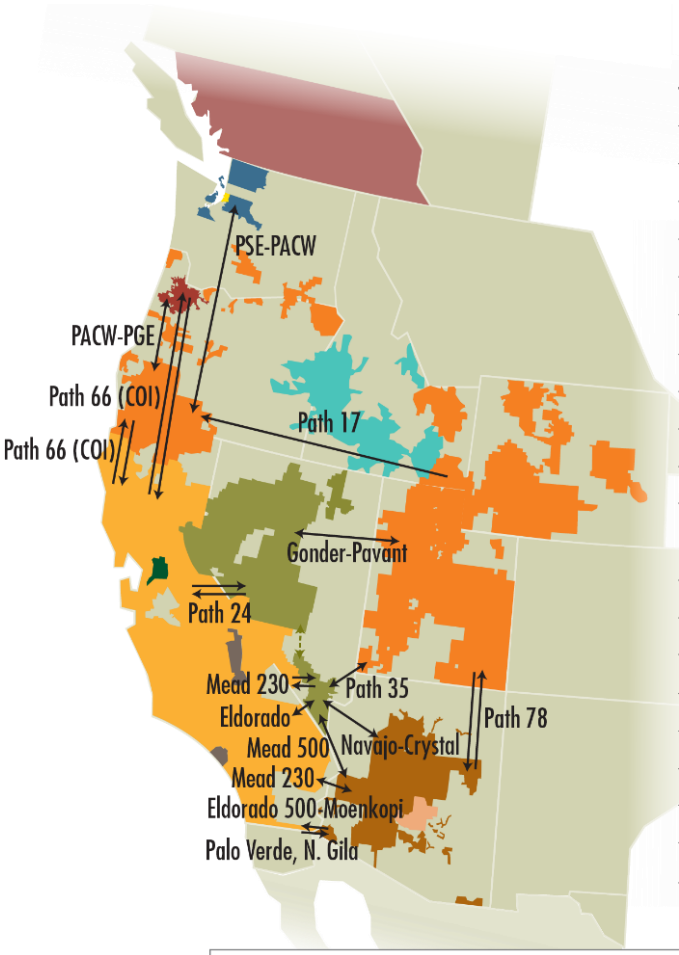
Table 2 provides the 15-minute and 5-minute EIM transfer volumes with base schedule transfers excluded. The EIM entities submit inter-BAA transfers in their base schedules. The benefits quantified in this report are only attributable to the transfers that occurred through the EIM. The benefits do not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

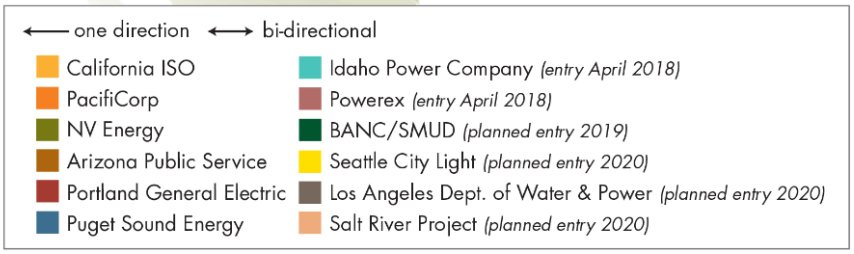
Year	Month	from_BAA	to_BAA	15m EIM transfer (15m - base)	5m EIM transfer (5m - base)
2018	January	AZPS	CISO	191,814	144,789
		AZPS	NEVP	1,438	2,861
		AZPS	PACE	15,678	22,271
		CISO	AZPS	34,466	45,218
		CISO	NEVP	29,687	53,184
		CISO	PACW	11,758	11,784
		CISO	PGE	4,023	7,410
		NEVP	AZPS	960	615
		NEVP	CISO	72,655	71,714
		NEVP	PACE	46,008	56,137
		PACE	AZPS	159,445	110,979
		PACE	NEVP	44,299	41,923
		PACE	PACW	12,995	28,616
		PACW	CISO	97,520	103,722
		PACW	PGE	20,398	20,841
		PACW	PSEI	11,894	12,463
		PGE	CISO	1,752	1,840
		PGE	PACW	63,201	60,706
		PSEI	PACW	64,692	75,999
2018	February	AZPS	CISO	209,446	124,273
		AZPS	NEVP	53	55
		AZPS	PACE	33,548	47,162
		CISO	AZPS	67,033	86,635
		CISO	NEVP	66,967	83,644
		CISO	PACW	24,640	24,025
		CISO	PGE	9,404	17,977
		NEVP	AZPS	66	67
		NEVP	CISO	39,800	68,386
		NEVP	PACE	78,854	76,194
		PACE	AZPS	197,289	103,736
		PACE	NEVP	18,969	37,663

		PACE	PACW	9,916	27,940
		PACW	CISO	71,067	73,959
		PACW	PGE	24,098	25,593
		PACW	PSEI	9,222	9,217
		PGE	CISO	1,197	907
		PGE	PACW	50,039	50,028
		PSEI	PACW	53,467	66,392
2018	**March**	AZPS	CISO	132,548	92,914
		AZPS	NEVP	1,154	2,682
		AZPS	PACE	54,397	82,432
		CISO	AZPS	89,217	115,543
		CISO	NEVP	137,375	182,029
		CISO	PACW	36,219	37,670
		CISO	PGE	20,357	37,870
		NEVP	AZPS	2,347	1,370
		NEVP	CISO	51,337	29,395
		NEVP	PACE	141,978	194,046
		PACE	AZPS	101,155	63,466
		PACE	NEVP	16,881	12,308
		PACE	PACW	18,849	48,633
		PACW	CISO	97,813	101,634
		PACW	PGE	24,143	27,427
		PACW	PSEI	15,340	17,993
		PGE	CISO	5,103	4,939
		PGE	PACW	65,506	61,422
		PSEI	PACW	70,834	80,567

Table 2: Energy transfers (MWh) in the FMM and RTD for the First quarter 2018



Path	Estimated Max Capacity (MW)
Path 24 *(west to east)*	100
Path 24 *(east to west)*	35-90
Eldorado	797
Path 35 *(west to east)*	580
Path 35 *(east to west)*	538
Gonder-Pavant	130
PACW to PGE	320
Path 66 *(ISO to PGE)*	627
Path 66 *(PGE to ISO)*	296
Path 66 *(ISO to PACW)*	331
Path 66 *(PACW to ISO)*	432
Path 17	400
PSE to PACW	300
Eldorado 500-Moenkopi	732
Palo Verde, N. Gila	3,151
Path 78 *(PACE to APS)*	625
Path 78 *(APS to PACE)*	660
Navajo-Crystal	522
Mead 500	349
Mead 230 *(APS <–> ISO)*	236
Mead 230 *(ISO to NVE)*	3,443
Mead 230 *(NVE to ISO)*	3,476



Graph 1: Estimated maximum transfer capacity (EIM entities operating in Q1 2018)

Wheel through transfers

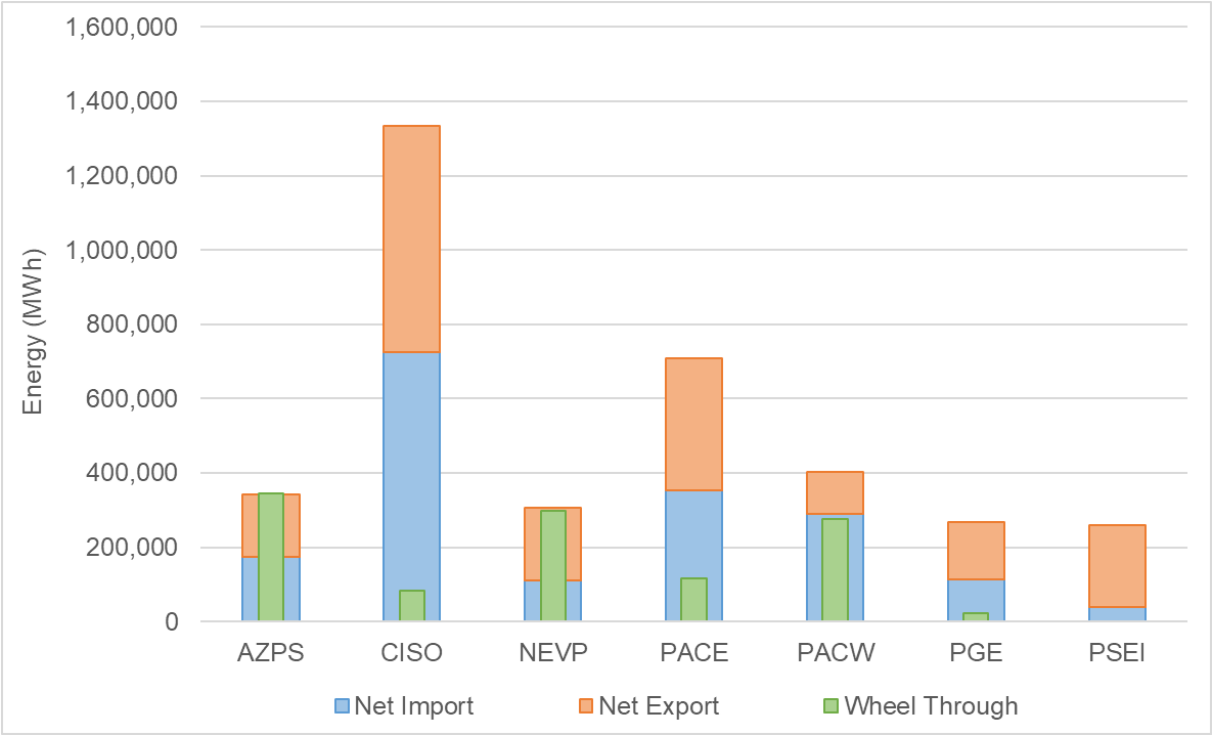
As the footprint of the EIM grows and continues to change, wheel through transfers may become more common. Currently, an EIM entity facilitating a wheel through receives no direct financial benefit for facilitating the wheel; only the sink and source directly benefit. As part of the EIM Consolidated 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.

BAA	Net Import	Net Export	Wheel Through
AZPS	174,467	168,577	346,612
CISO	726,508	608,416	84,704
NEVP	111,993	194,672	297,957
PACE	354,583	354,084	115,898
PACW	291,135	112,592	275,903
PGE	113,930	154,775	22,280
PSEI	39,802	219,302	

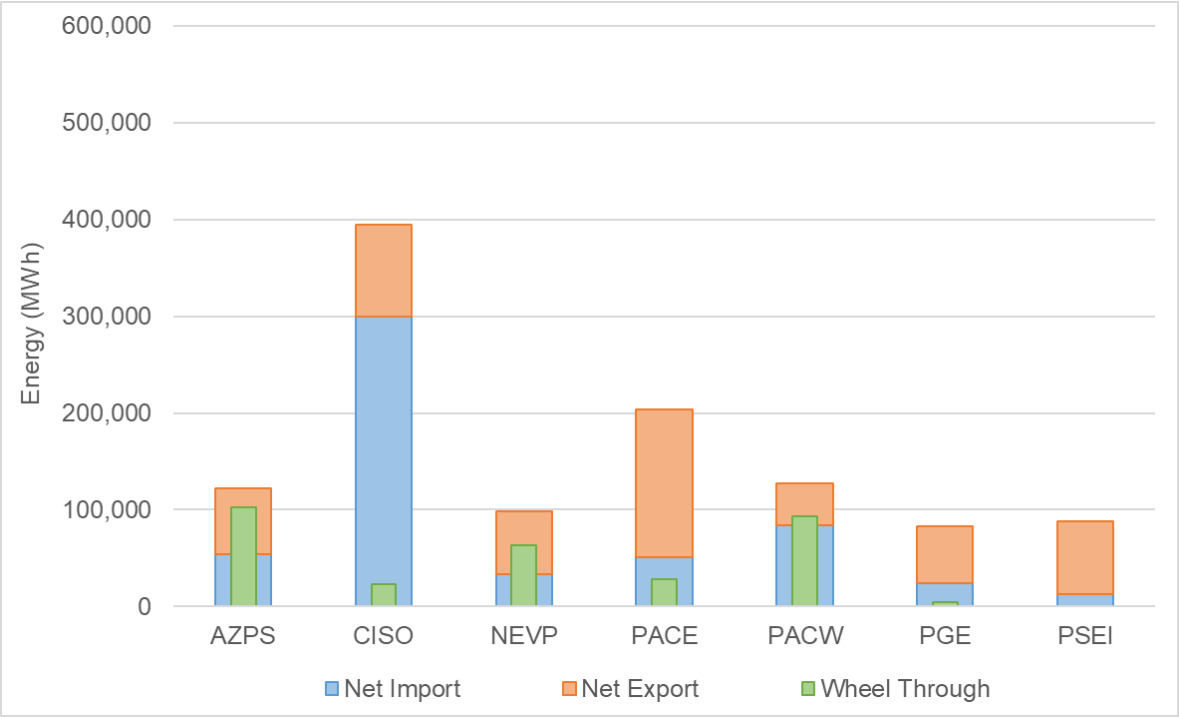
Table 3: Estimated wheel through transfers in Q1 2018



Graph 2: Estimated wheel through transfers in Q1 2018

BAA	Net Import	Net Export	Wheel Through
AZPS	54,548	67,667	102,482
CISO	299,586	94,769	22,986
NEVP	33,630	65,155	63,842
PACE	50,876	153,133	28,024
PACW	83,912	43,750	93,545
PGE	24,104	58,498	4,156
PSEI	12,463	76,145	

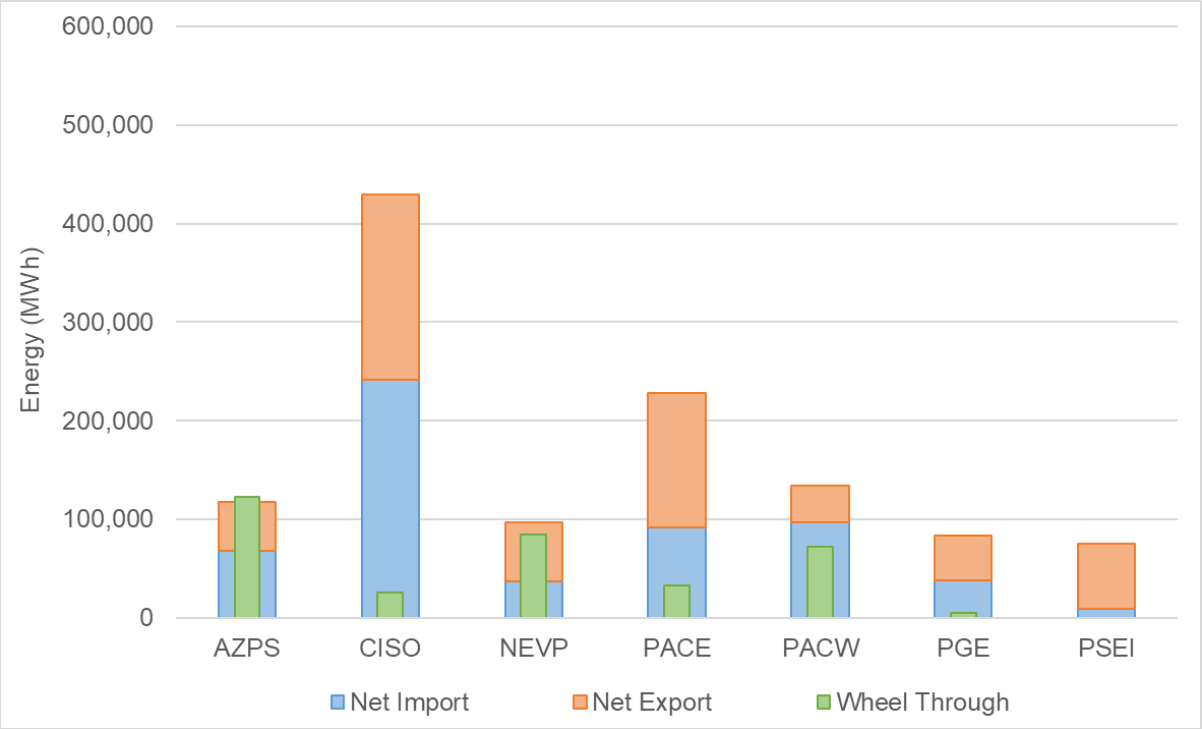
Table 4: Estimated wheel through transfers in January 2018



Graph 3: Estimated wheel through transfers in January 2018

BAA	Net Import	Net Export	Wheel Through
AZPS	68,520	49,245	122,781
CISO	241,914	187,983	25,730
NEVP	36,686	60,133	85,106
PACE	91,808	136,791	32,643
PACW	96,794	36,950	71,970
PGE	38,160	45,638	5,491
PSEI	9,269	66,411	

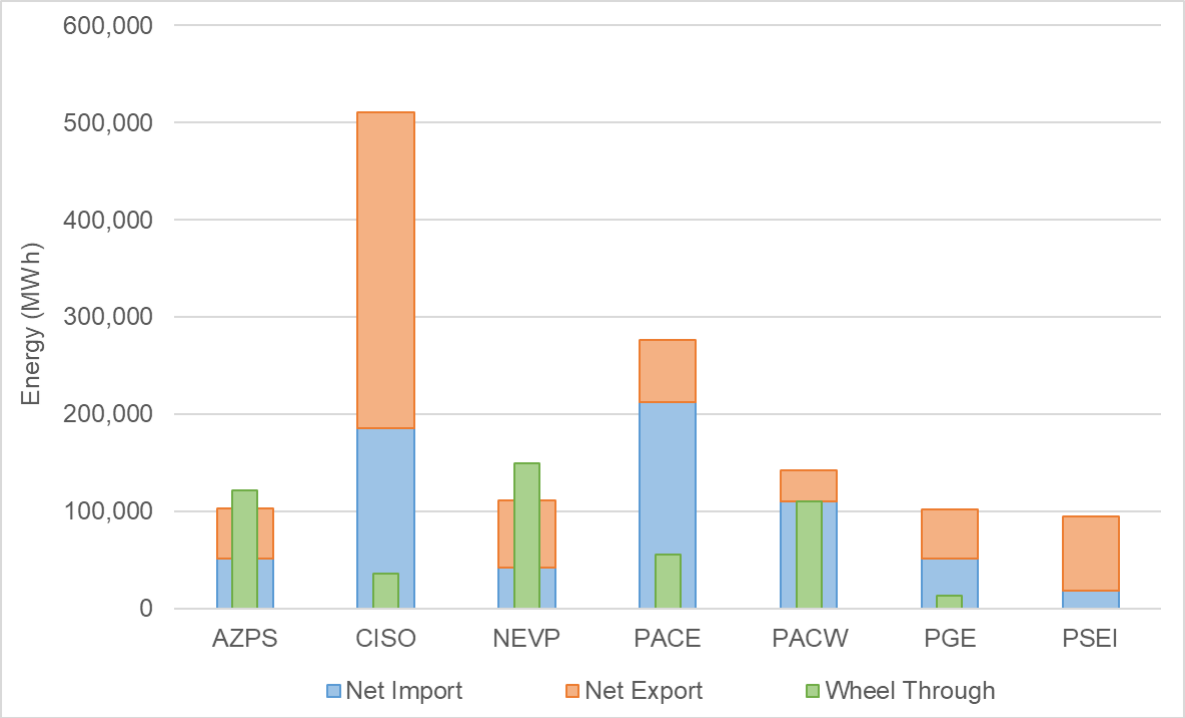
Table 5: Estimated wheel through transfers in February 2018



Graph 4: Estimated wheel through transfers in February 2018

BAA	Net Import	Net Export	Wheel Through
AZPS	51,399	51,665	121,349
CISO	185,008	325,664	35,988
NEVP	41,676	69,383	149,009
PACE	211,898	64,159	55,231
PACW	110,429	31,891	110,388
PGE	51,666	50,638	12,634
PSEI	18,071	76,746	

Table 6: Estimated wheel through transfers in March 2018



Graph 5: Estimated wheel through transfers in March 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 Q1 2018 was calculated to be 5,644 MWh (January) + 20,905 MWh (February) + 39,311 MWh (March) = 65,860 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 CO_2/MWh, avoided curtailments displaced an estimated 28,188 metric tons of CO_2 for Q1 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 CO_2 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
	Total	586,277	250,845

Table 7: Total reduction in curtailment of renewable energy along with the associated reductions in CO_2

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	January	AZPS	up	0	210
		CISO	up	0	1,000
		NEVP	up	0	204
		PACE	up	20	300
		PACW	up	16	150
		PGE	up	0	150
		PSEI	up	0	135
		ALL EIM	**up**	**0**	**1,800**
		AZPS	down	5	257
		CISO	down	0	1,000
		NEVP	down	0	250
		PACE	down	48	300
		PACW	down	8	175
		PGE	down	0	175
		PSEI	down	12	135
		ALL EIM	**down**	**0**	**1,200**
2018	February	AZPS	up	0	255
		CISO	up	0	1,000
		NEVP	up	6	209
		PACE	up	68	300
		PACW	up	21	150
		PGE	up	8	150
		PSEI	up	0	135
		ALL EIM	**up**	**0**	**1,800**
		AZPS	down	3	257
		CISO	down	46	1,000
		NEVP	down	0	250
		PACE	down	29	300
		PACW	down	0	175
		PGE	down	0	175
		PSEI	down	10	135
		ALL EIM	**down**	**0**	**1,200**
2018	March	AZPS	up	0	255
		CISO	up	0	1,000
		NEVP	up	0	219
		PACE	up	0	300
		PACW	up	0	150
		PGE	up	0	150
		PSEI	up	0	135
		ALL EIM	**up**	**0**	**1,800**
		AZPS	down	0	204
		CISO	down	0	1,000
		NEVP	down	0	250

		PACE	down	0	300
		PACW	down	0	175
		PGE	down	0	175
		PSEI	down	0	135
		ALL EIM	**down**	**0**	**1,200**

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.

	January		February		March	
Direction	Up	Down	Up	Down	Up	Down
Average MW saving	387	490	426	530	492	542
Sum of BAA requirements	1,109	1,157	1,177	1,241	1,374	1,368
Percentage savings	35%	42%	36%	43%	36%	40%

Table 9: Flexible ramping procurement diversity savings for first 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 $330.52 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 due to avoided curtailments[4] of 250,845 metric tons from 2015 to date is roughly equivalent to avoiding the emissions from 52,739 passenger cars driven for one year.

[4] See footnote 1 on page 3.