California ISO

WESTERN EIM BENEFITS REPORT

First Quarter 2020

April 30, 2020

CONTENTS

EXECUTIVE SUMMARY 3

BACKGROUND 4

WESTERN EIM ECONOMIC BENEFITS IN Q1 2020 4

CUMULATIVE EIM BENEFITS SINCE INCEPTION 5
INTER-REGIONAL TRANSFERS 5
WHEEL THROUGH TRANSFERS 10

REDUCED RENEWABLE CURTAILMENT AND GHG REDUCTIONS 15

FLEXIBLE RAMPING PROCUREMENT DIVERSITY SAVINGS 16

CONCLUSION 19

EXECUTIVE SUMMARY

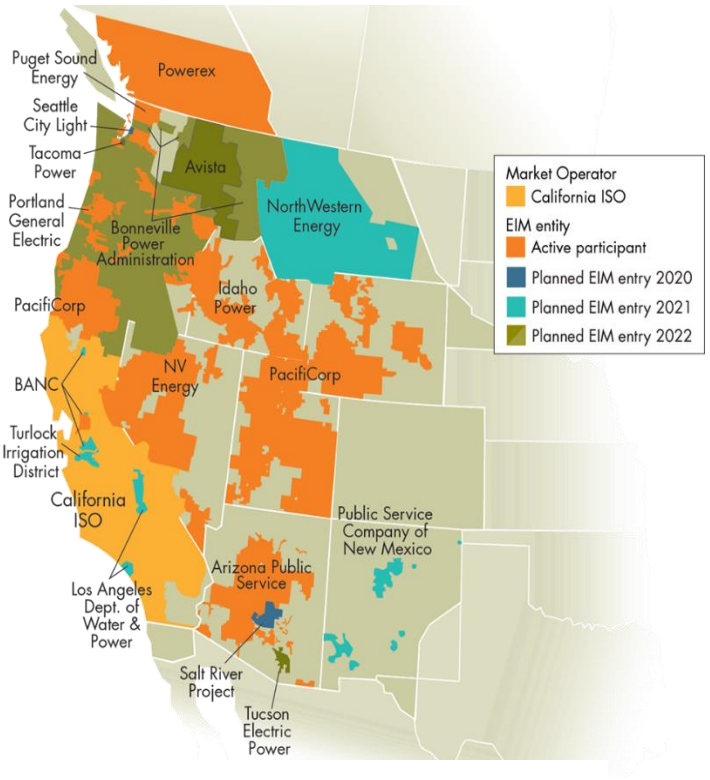
Gross benefits from EIM since November 2014

$919.69 million

This report presents the benefits associated with participation in the Western Energy Imbalance Market (EIM) for the first quarter of 2020.

The measured benefits of participation in the Western EIM include cost savings, increased integration of renewable energy, and improved operational efficiencies including the reduction of the need for real-time flexible reserves.

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



Q1 2020 Gross Benefits by Participant

	(millions $)
Arizona Public Service	$11.26
BANC	$7.07
California ISO	$9.57
Idaho Power	$5.15
NV Energy	$5.36
PacifiCorp	$7.80
Portland General Electric	$6.93
Puget Sound Energy	$3.67
Powerex	$1.09
Total	$57.90

2020 Q1 BENEFITS

ECONOMICAL

$57.90M

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

ENVIRONMENTAL

37,125

Metric tons of CO_2** avoided curtailments

OPERATIONAL

46%

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 in October 2016, and Portland General Electric began participating in October 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 ISO began publishing quarterly EIM benefit reports in April 2015. Prior reports are available at https://www.westerneim.com/Pages/About/QuarterlyBenefits.aspx.

WESTERN EIM ECONOMIC BENEFITS IN Q1 2020

Table 1 shows the estimated EIM gross benefits by each region per month[2]. The monthly savings presented show $17.21 million for January, $17.42 million for February, and $23.27 million for March with a total estimated benefit of $57.90 million for the quarter.

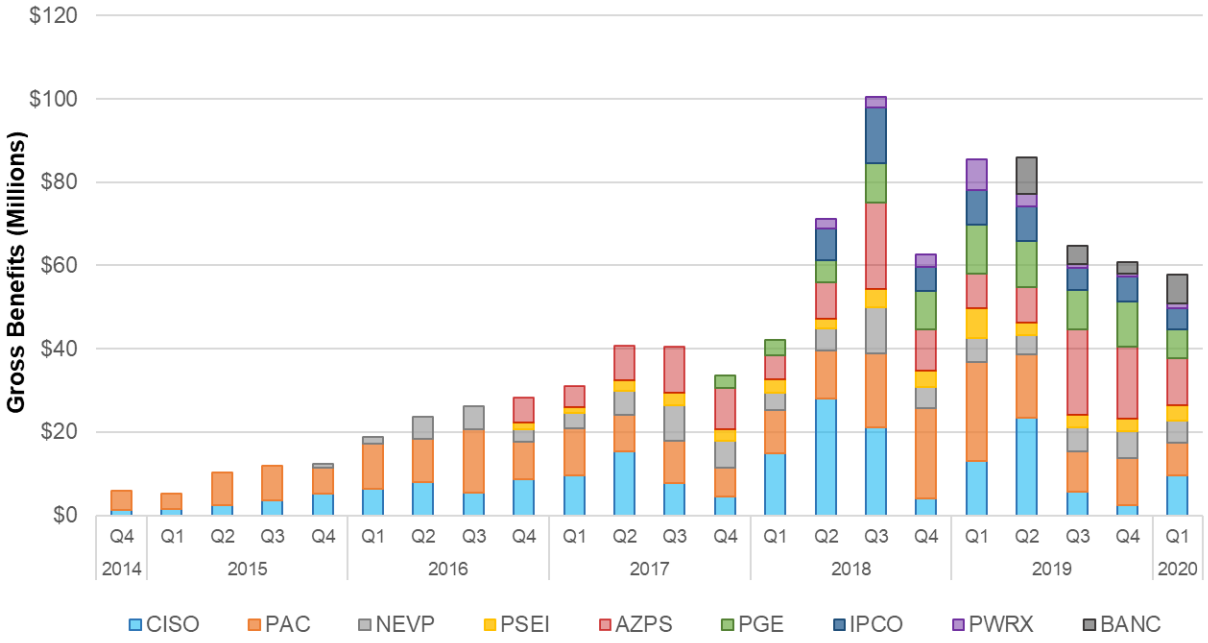
Region	January	February	March	Total
APS	$4.10	$3.48	$3.68	$11.26
BANC	$1.66	$1.26	$4.15	$7.07
CISO	$2.57	$2.91	$4.09	$9.57
IPCO	$1.66	$1.43	$2.06	$5.15
NVE	$1.10	$1.80	$2.46	$5.36
PAC	$2.22	$2.46	$3.12	$7.80
PGE	$2.46	$2.34	$2.13	$6.93
PSE	$1.16	$1.23	$1.28	$3.67
PWRX	$0.28	$0.51	$0.30	$1.09
Total	$17.21	$17.42	$23.27	$57.90

TABLE 1: First Quarter 2020 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.

CUMULATIVE EIM BENEFITS SINCE INCEPTION

Since the start of the EIM in November 2014, the cumulative economic benefits have totaled $919.69 million. The quarterly benefits have grown over time as a result of the participation of new Balancing Authority Areas (BAA) in the market, which results in additional benefits for both the individual BAA but also compounds the benefits to adjacent BAA's by enabling further transfers. Graph 1 illustrates the gross economic benefits of the EIM by quarter for each participating BAA.



GRAPH 1: Cumulative gross benefits since the inception of the EIM

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 2 below.

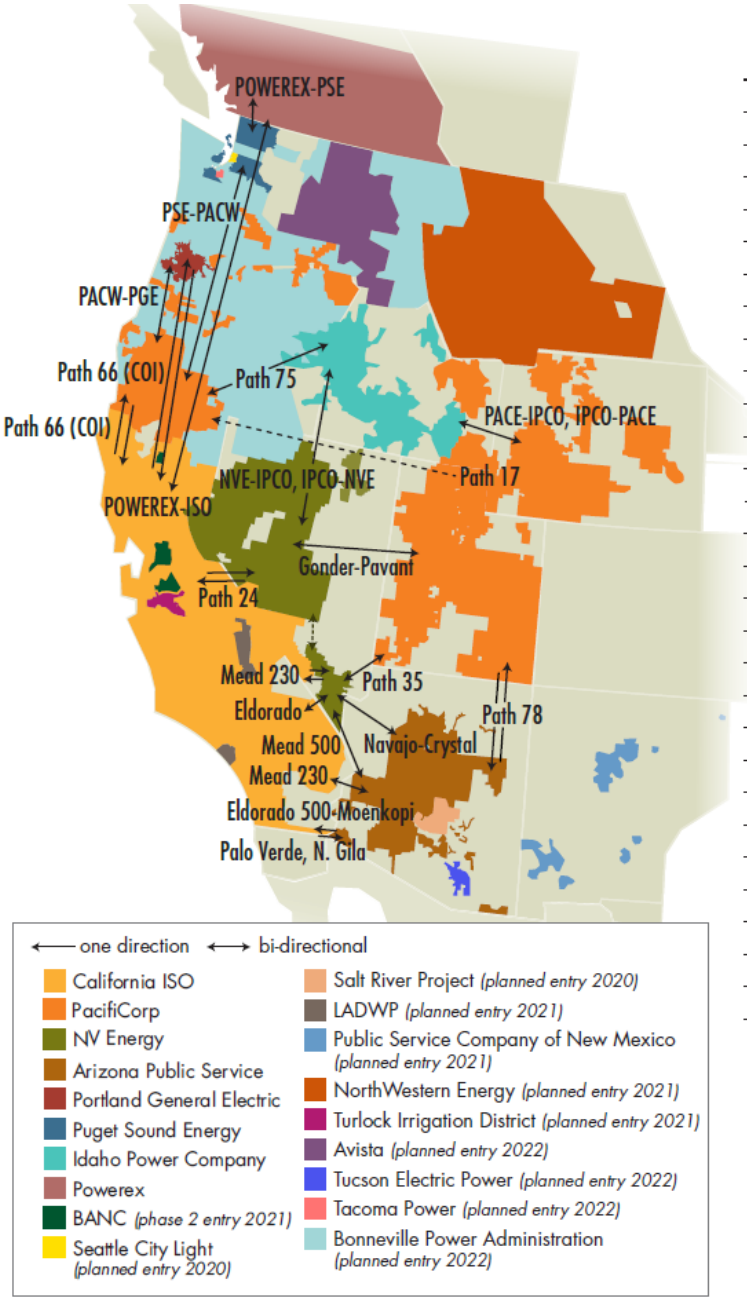
Month	**From BAA**	**To BAA**	**15min EIM transfer**	**5min EIM transfer**
			(15m - base)	**(5m - base)**
	AZPS	CISO	146,580	118,035
	AZPS	NEVP	4,396	7,516
	AZPS	PACE	31,022	34,140
	BANC	CISO	5,218	3,705
	CISO	AZPS	51,059	62,838
	CISO	BANC	102,749	115,280
	CISO	PWRX	33,513	49,461
	CISO	NEVP	70,572	94,165
	CISO	PACW	24,582	41,224
	CISO	PGE	23,995	48,442
	IPCO	NEVP	36,003	19,786
	IPCO	PACE	11,976	10,826
	IPCO	PACW	32,504	40,927
	IPCO	PSEI	0	0
	NEVP	AZPS	6,365	4,578
	NEVP	CISO	82,274	40,914
	NEVP	IPCO	26,080	28,996
January	NEVP	PACE	91,058	100,398
	PACE	AZPS	94,262	72,968
	PACE	IPCO	52,866	63,932
	PACE	NEVP	45,373	30,234

	PACE	PACW	21,566	29,096
	PACW	CISO	85,524	104,694
	PACW	IPCO	45,622	29,565
	PACW	PGE	42,483	44,254
	PACW	PSEI	21,578	23,446
	PGE	CISO	3,272	3,010
	PGE	PACW	57,741	60,642
	PGE	PSEI	1,947	2,309
	PSEI	PWRX	36,840	38,452
	PSEI	IPCO	0	0
	PSEI	PACW	52,512	53,785
	PSEI	PGE	2,755	2,883
	PWRX	CISO	0	0
	PWRX	PSEI	12,029	15,666
February	AZPS	CISO	110,197	84,590
	AZPS	NEVP	1,243	2,031
	AZPS	PACE	49,481	67,028
	BANC	CISO	15,318	12,762
	CISO	AZPS	62,791	90,838
	CISO	BANC	53,241	62,792
	CISO	PWRX	50,290	61,234
	CISO	NEVP	125,094	129,734
	CISO	PACW	24,058	38,847
	CISO	PGE	26,134	48,985
	IPCO	NEVP	26,689	17,026
	IPCO	PACE	39,221	30,664
	IPCO	PACW	29,334	35,149
	IPCO	PESI	1,300	2,160
	NEVP	AZPS	17,018	12,257
	NEVP	CISO	120,880	74,392
	NEVP	IPCO	41,426	40,715
	NEVP	PACE	100,130	103,027
	PACE	AZPS	61,353	46,796

	PACE	IPCO	13,289	13,872
	PACE	NEVP	35,684	19,018
	PACE	PACW	9,754	17,294
	PACW	CISO	67,058	79,157
	PACW	IPCO	29,470	20,974
	PACW	PGE	17,822	17,247
	PACW	PSEI	13,828	18,807
	PGE	CISO	2,545	2,104
	PGE	PACW	85,897	88,355
	PGE	PSEI	3,293	4,241
	PSEI	PWRX	31,655	32,500
	PSEI	IPCO	3,941	2,749
	PSEI	PACW	57,737	60,498
	PSEI	PGE	2,481	2,588
	PWRX	CISO	0	0
	PWRX	PSEI	8,880	10,174
	AZPS	CISO	92,088	73,985
	AZPS	NEVP	1,721	4,264
	AZPS	PACE	50,487	64,233
	BANC	CISO	19,643	15,780
	CISO	AZPS	57,988	73,220
	CISO	BANC	62,205	68,134
	CISO	PWRX	42,058	54,981
	CISO	NEVP	96,890	108,966
	CISO	PACW	30,926	44,195
	CISO	PGE	26,517	56,148
	IPCO	NEVP	32,182	23,767
	IPCO	PACE	24,923	26,958
	IPCO	PACW	37,485	54,883
	IPCO	PSEI	0	0
March	NEVP	AZPS	6,574	5,579
	NEVP	CISO	125,012	89,517
	NEVP	IPCO	35,922	47,472

	NEVP	PACE	83,215	83,860
	PACE	AZPS	38,155	29,430
	PACE	IPCO	17,877	24,656
	PACE	NEVP	30,556	17,372
	PACE	PACW	33,457	46,451
	PACW	CISO	66,383	75,005
	PACW	IPCO	35,194	24,962
	PACW	PGE	31,274	31,354
	PACW	PSEI	26,528	33,045
	PGE	CISO	6,300	5,556
	PGE	PACW	46,068	49,875
	PGE	PSEI	5,073	6,446
	PSEI	PWRX	18,503	22,492
	PSEI	IPCO	2,501	1,944
	PSEI	PACW	51,373	49,594
	PSEI	PGE	4,752	5,350
	PWRX	CISO	0	0
	PWRX	PSEI	25,899	25,663

TABLE 2: Energy transfers (MWh) in the FMM and RTD markets for Q1 2020



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	0-400[1] [2]
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
IPCO to PACW (Path 75)	1,500
PACW to IPCO (Path 75)	400-510
PACE to IPCO	2,557
IPCO to PACE	1,550
NVE to IPCO	262
IPCO to NVE	390-478
Powerex <–> PSE	150
Powerex <–> ISO	150

[1] *Is an optional path available for PACE-PACW EIM transfers and the capacity is a subset of PACE-IPCO/IPCO-PACE and Path 75 capacity.*

[2] *When in use, the available capacity on PACE-IPCO/IPCO-PACE and Path 75 will be subsequently reduced by the used amount on Path 17, and not double counted.*

Current as of October 2019

GRAPH 2: Estimated maximum transfer capacity (EIM entities operating in Q1 2020)

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:

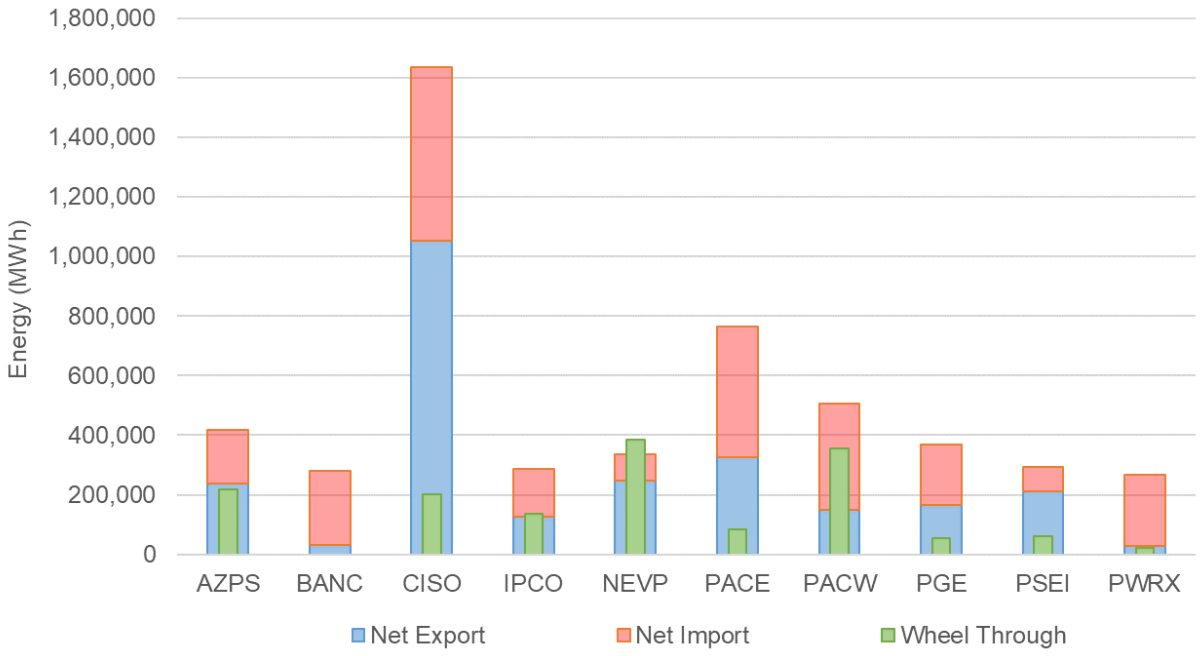
- *Total import*: summation of transfers above base transfers coming into the EIM BAA under analysis
- *Total export*: summation of all transfers above base transfers going out of the EIM BAA under analysis
- *Net import*: the maximum of zero or the difference between total imports and total exports
- *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 Graphs 3 through 6.

BAA	*Net Export*	*Net Import*	*Wheel Through*
AZPS	237,528	181,011	218,657
BANC	32,285	246,733	-
CISO	1,051,716	583,098	201,248
IPCO	125,432	162,999	137,416
NEVP	248,060	89,481	385,682
PACE	326,984	438,008	84,689
PACW	148,313	357,286	354,935
PGE	167,047	201,921	55,808
PSEI	212,129	80,877	61,317
PWRX	29,587	237,667	22,007

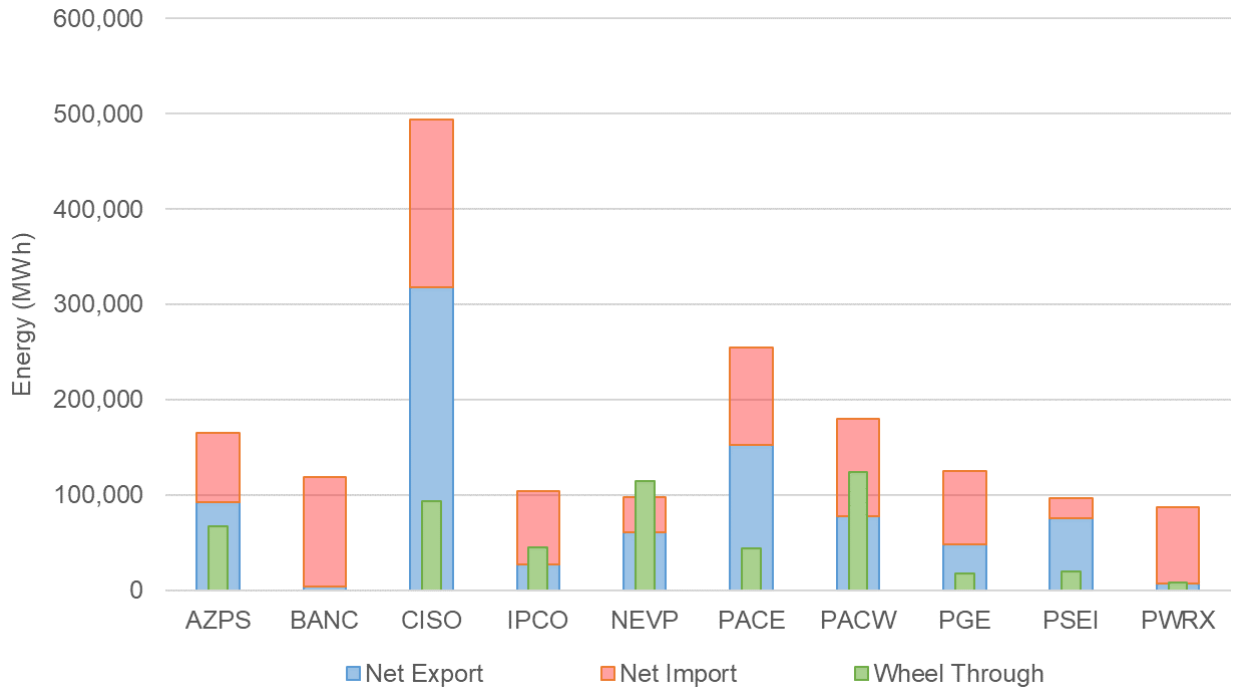
TABLE 3: Estimated wheel-through transfers in Q1 2020



GRAPH 3: Estimated wheel-through transfers in Q1 2020

BAA	Net Export	Net Import	Wheel-Through
AZPS	92,296	73,054	67,396
BANC	3,721	115,327	-
CISO	317,916	176,457	93,950
IPCO	26,753	77,760	44,810
NEVP	60,510	37,207	114,600
PACE	152,580	101,859	43,690
PACW	77,837	101,686	124,232
PGE	47,800	77,483	18,189
PSEI	75,354	21,614	19,853
PWRX	7,416	79,735	8,260

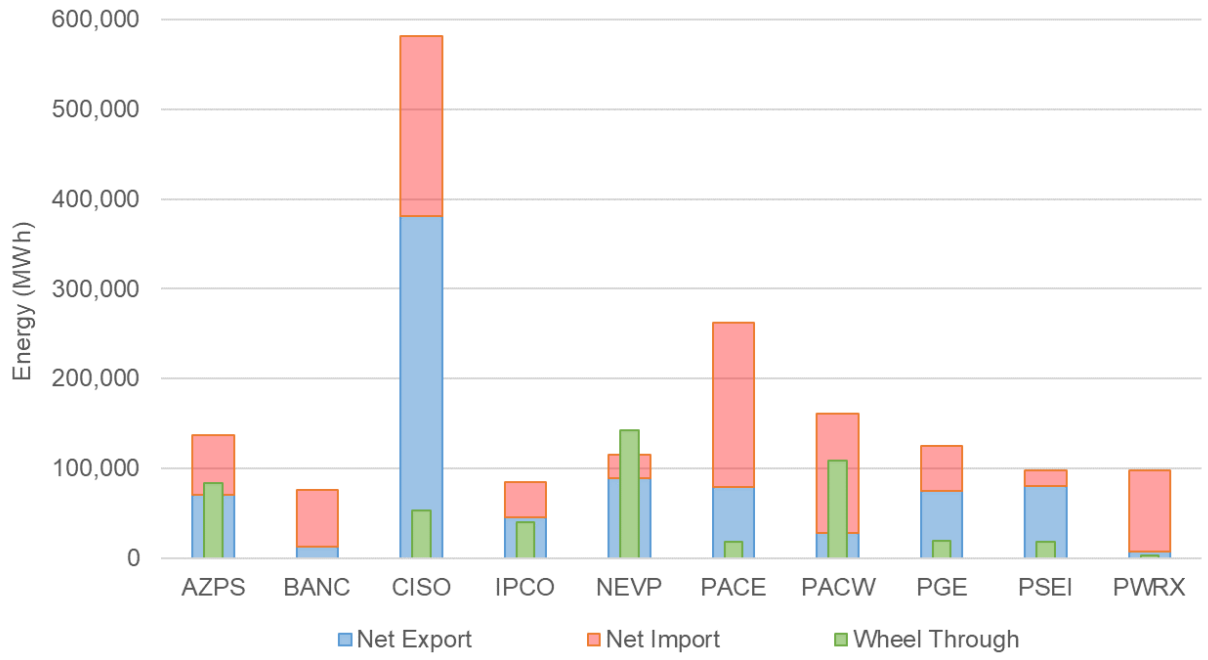
TABLE 4: Estimated wheel-through transfers in January 2020



GRAPH 4: Estimated wheel-through transfers in January 2020

BAA	Net Export	Net Import	Wheel- Through
AZPS	70,052	67,031	83,672
BANC	12,783	63,100	-
CISO	380,979	200,112	53,045
IPCO	45,710	38,732	39,677
NEVP	88,845	25,773	142,277
PACE	78,731	183,309	18,336
PACW	27,994	132,460	108,367
PGE	75,164	49,265	19,663
PSEI	80,430	17,110	18,302
PWRX	7,185	90,982	3,019

TABLE 5: Estimated wheel-through transfers in February 2020



GRAPH 5: Estimated wheel-through transfers in February 2020

BAA	Net Export	Net Import	Wheel Through
AZPS	75,180	40,926	67,589
BANC	15,781	68,306	-
CISO	352,821	206,528	54,252
IPCO	52,969	46,507	52,928
NEVP	98,705	26,500	128,805
PACE	95,672	152,839	22,663
PACW	42,481	123,140	122,336
PGE	44,082	75,174	17,956
PSEI	56,345	42,152	23,162
PWRX	14,986	66,951	10,728

TABLE 6: Estimated wheel-through transfers in March 2020

GRAPH 6: Estimated wheel-through transfers in March 2020

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 Q1 2020 was calculated to be 23,977 MWh (January) + 33,575 MWh (February) + 29,188 MWh (March) = 86,740 MWh total.

There are environmental benefits of avoided renewable curtailment as well. 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 37,125 metric tons of CO_2 for Q1 2020. 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
	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
	3	33,843	14,485
	4	35,254	15,089
2020	1	86,740	37,125
	Total	1,098,890	470,245

TABLE 7: Total reduction in curtailment of renewable energy and the associated reductions in CO_2

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 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.

Month	**BAA**	**Direction**	**Minimum requirement**	**Maximum requirement**
	AZPS	up	21	230
	BANC	up	3	58
	CISO	up	37	1716

	IPCO	up	28	143
	NEVP	up	0	291
	PACE	up	78	252
	PACW	up	46	162
	PGE	up	35	206
	PSEI	up	27	158
	PWRX	up	51	231
January	**ALL EIM**	**up**	**36**	**1,962**
	AZPS	down	11	275
	BANC	down	8	95
	CISO	down	171	1,530
	IPCO	down	54	196
	NEVP	down	0	267
	PACE	down	80	291
	PACW	down	19	146
	PGE	down	46	217
	PSEI	down	39	155
	PWRX	down	69	224
	ALL EIM	**down**	**303**	**1,957**
	AZPS	up	23	235
	BANC	up	4	53
	CISO	up	81	1,634
	IPCO	up	28	131
	NEVP	up	23	257
	PACE	up	75	291
	PACW	up	55	197
	PGE	up	24	206
	PSEI	up	27	158
	PWRX	up	52	228
February	**ALL EIM**	**up**	**119**	**1,935**
	AZPS	down	12	202
	BANC	down	7	81
	CISO	down	91	1,616

	IPCO	down	59	210
	NEVP	down	17	259
	PACE	down	79	269
	PACW	down	30	140
	PGE	down	42	238
	PSEI	down	39	163
	PWRX	down	73	286
	ALL EIM	**down**	**320**	**1,957**
March	*AZPS*	up	27	235
	BANC	up	3	53
	CISO	up	201	1,652
	IPCO	up	48	152
	NEVP	up	22	257
	PACE	up	81	269
	PACW	up	71	197
	PGE	up	40	206
	PSEI	up	38	158
	PWRX	up	63	228
	ALL EIM	**up**	**277**	**1,935**
	AZPS	down	23	227
	BANC	down	6	81
	CISO	down	95	1,616
	IPCO	down	64	210
	NEVP	down	19	284
	PACE	down	79	301
	PACW	down	45	140
	PGE	down	48	238
	PSEI	down	46	178
	PWRX	down	71	289
	ALL EIM	**down**	**249**	**1,957**

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.

	January		February		March	
Direction	Up	Down	Up	Down	Up	Down
Average MW saving	715	769	806	821	830	814
Sum of BAA requirements	1,606	1,731	1,699	1,781	1,807	1,770
Percentage savings	44%	44%	47%	46%	46%	46%

Table 9: Flexible ramping procurement diversity savings in Q1 2020

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

Using state-of-the-art technology to find and deliver low-cost energy to meet real-time demand across eight western states and extending to the border with Canada, the Western EIM has proven extensive financial and operational benefits for participants. Since its inception in November 2014, the cumulative gross economic benefits have reached $919.69 million.

The Western EIM provides significant environmental benefits through the reduction of renewable curtailments during periods of oversupply. Sharing resources across a larger geographic area reduces greenhouse gas emissions by using renewable generation that otherwise would have been turned off.

The quantified environmental benefits from avoided curtailments of renewable generation from 2015 to-date reached 470,245 metric tons of CO2, roughly the equivalent of avoiding the emissions from 98,867 passenger cars driven for one year.

The Western EIM demonstrates that utilities can realize cost benefits and reduce carbon emissions through increased coordination and optimization in the West.