California ISO

WESTERN EIM BENEFITS REPORT

Fourth Quarter 2019

January 30, 2020

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EXECUTIVE SUMMARY

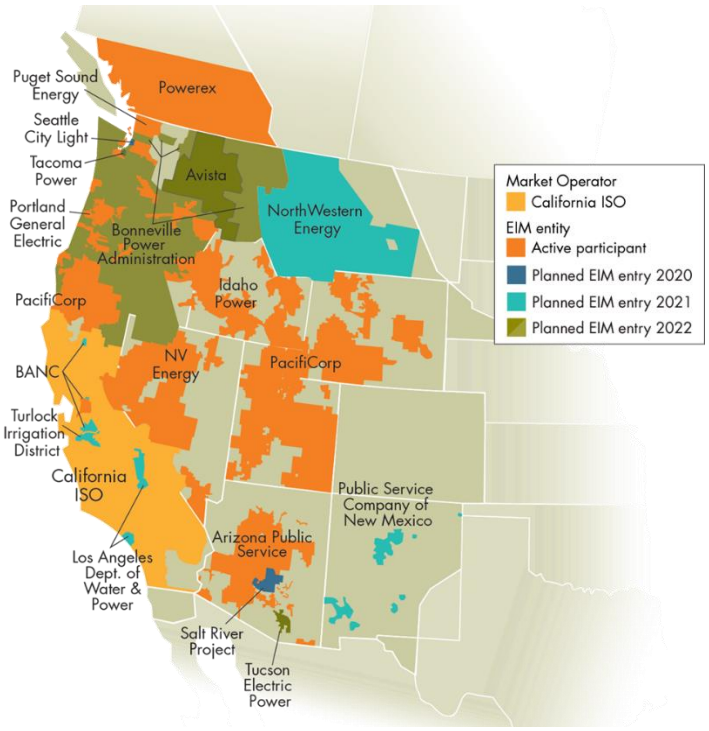
Gross benefits from EIM since November 2014

$861.79 million

This report presents the benefits associated with participation in the Western Energy Imbalance Market (EIM) for the Fourth 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.



Q4 2019 Gross Benefits by Participant

	(millions $)
Arizona Public Service	$17.37
BANC	$2.68
California ISO	$2.36
Idaho Power	$6.09
NV Energy	$6.62
PacifiCorp	$11.32
Portland General Electric	$10.76
Powerex	$0.61
Puget Sound Energy	$2.91
Total	$60.72

2019 Q4 BENEFITS

ECONOMICAL

$60.72M

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

ENVIRONMENTAL

15,089

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

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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 can be accessed at https://www.westerneim.com/Pages/About/QuarterlyBenefits.aspx.

WESTERN EIM ECONOMIC BENEFITS IN Q4 2019

Table 1 shows the estimated EIM gross benefits by each region per month[2]. The monthly savings presented show $21.26 million for October, $21.18 million for November, and $18.28 million for December with a total estimated benefit of $60.72 million for the quarter.

Region	October	November	December	Total
APS	$6.72	$4.98	$5.67	$17.37
BANC	$1.23	$1.12	$0.33	$2.68
CISO	$1.09	$0.89	$0.38	$2.36
IPCO	$2.47	$1.74	$1.88	$6.09
NVE	$2.47	$2.63	$1.52	$6.62
PAC	$3.05	$4.64	$3.63	$11.32
PGE	$3.30	$3.84	$3.62	$10.76
PWRX	$0.15	$0.25	$0.21	$0.61
PSE	$0.78	$1.09	$1.04	$2.91
Total	$21.26	$21.18	$18.28	$60.72

TABLE 1: Fourth 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.

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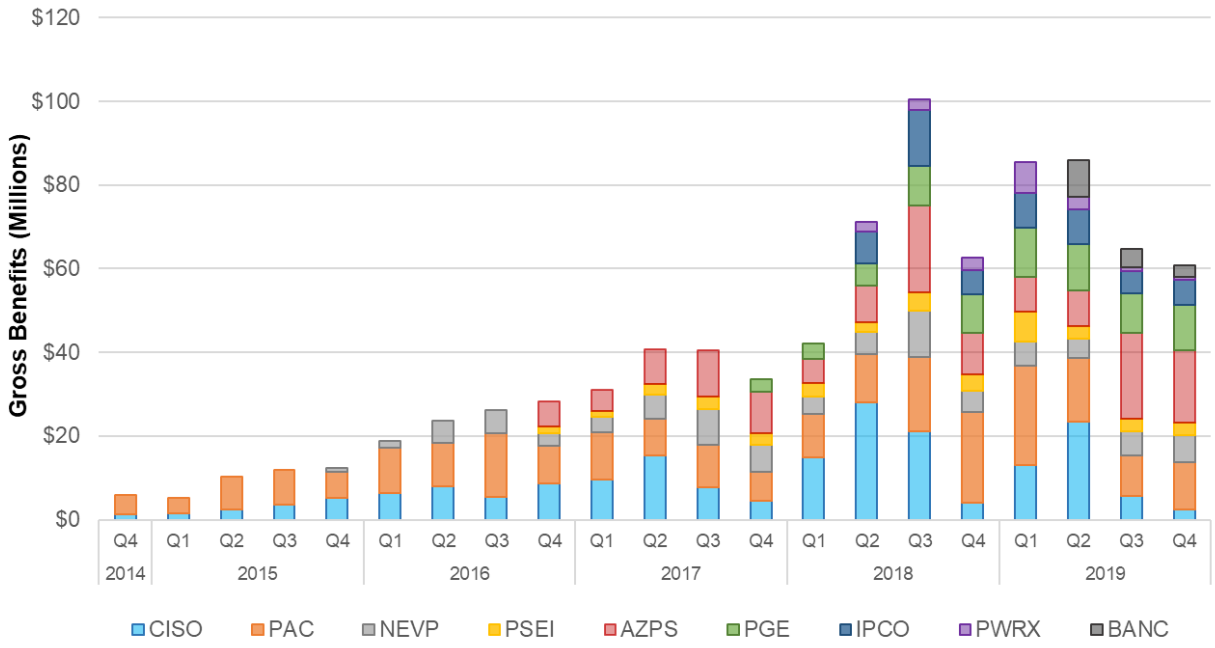
CUMULATIVE EIM BENEFITS SINCE INCEPTION

Since the start of the EIM in November 2014, the cumulative economic benefits have totaled $861.79 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.

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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	338,465	300,949
	AZPS	NEVP	11,727	14,266
	AZPS	PACE	22,330	22,309
	BANC	CISO	40,368	29,354
	PWRX	CISO	0	0
	PWRX	PSEI	15,776	17,742
	CISO	AZPS	13,407	17,763
	CISO	BANC	69,752	85,942
	CISO	PWRX	53,766	68,062
	CISO	NEVP	26,293	30,992
	CISO	PACW	52,232	73,166
	CISO	PGE	54,979	82,171
	IPCO	NEVP	42,462	28,519
	IPCO	PACE	4,481	2,991
	IPCO	PACW	49,171	52,037
	IPCO	PSEI	11,748	13,173
	NEVP	AZPS	4,339	2,546

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October	NEVP	CISO	159,172	123,909
	NEVP	IPCO	26,449	25,096
	NEVP	PACE	46,529	49,675
	PACE	AZPS	107,555	89,141
	PACE	IPCO	108,574	122,682
	PACE	NEVP	66,427	60,490
	PACE	PACW	43,547	50,397
	PACW	CISO	19	2,538
	PACW	IPCO	31,367	24,682
	PACW	PGE	61,944	55,164
	PACW	PSEI	51,127	53,304
	PGE	CISO	3,262	2,812
	PGE	PACW	28,364	34,748
	PGE	PSEI	641	760
	PSEI	PWRX	34,004	38,577
	PSEI	IPCO	3,603	2,795
	PSEI	PACW	16,152	17,572
	PSEI	PGE	316	336
	AZPS	CISO	170,089	146,335
	AZPS	NEVP	5,150	9,729
	AZPS	PACE	4,184	5,225
	BANC	CISO	28,561	21,568
	PWRX	CISO	0	0
	PWRX	PSEI	21,670	21,423
	CISO	AZPS	21,759	25,854
	CISO	BANC	49,868	62,514
	CISO	PWRX	22,792	34,233
	CISO	NEVP	17,512	31,175
	CISO	PACW	17,338	29,267
	CISO	PGE	24,934	39,601

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November	IPCO	NEVP	43,233	19,439
	IPCO	PACE	8,061	2,492
	IPCO	PACW	25,069	34,235
	IPCO	PESI	205	306
	NEVP	AZPS	10,146	7,042
	NEVP	CISO	158,943	92,841
	NEVP	IPCO	24,472	29,309
	NEVP	PACE	28,984	34,260
	PACE	AZPS	121,074	90,011
	PACE	IPCO	66,192	95,610
	PACE	NEVP	88,079	66,881
	PACE	PACW	10,638	17,129
	PACW	CISO	21,528	44,847
	PACW	IPCO	37,768	26,707
	PACW	PGE	67,453	65,517
	PACW	PSEI	22,607	22,565
	PGE	CISO	5,333	5,078
	PGE	PACW	17,118	18,725
	PGE	PSEI	1,042	1,042
	PSEI	PWRX	28,157	30,419
	PSEI	IPCO	142	159
	PSEI	PACW	39,609	44,176
	PSEI	PGE	3,472	3,770
	AZPS	CISO	189,304	158,269
	AZPS	NEVP	7,394	13,123
	AZPS	PACE	11,571	16,493
	BANC	CISO	12,999	11,588
	PWRX	CISO	0	0
	PWRX	PSEI	17,365	15,736
	CISO	AZPS	24,355	37,395

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	CISO	BANC	70,648	80,427
	CISO	PWRX	25,550	39,767
	CISO	NEVP	34,629	53,473
	CISO	PACW	17,115	30,196
	CISO	PGE	22,812	42,681
	IPCO	NEVP	64,082	32,804
	IPCO	PACE	22,565	9,512
	IPCO	PACW	23,004	32,697
	IPCO	PSEI	31	28
December	NEVP	AZPS	12,467	11,469
	NEVP	CISO	127,330	67,351
	NEVP	IPCO	26,448	33,904
	NEVP	PACE	45,676	52,564
	PACE	AZPS	133,207	107,352
	PACE	IPCO	51,608	68,680
	PACE	NEVP	54,606	39,802
	PACE	PACW	16,011	22,646
	PACW	CISO	36,551	63,404
	PACW	IPCO	54,722	37,853
	PACW	PGE	74,486	72,685
	PACW	PSEI	25,909	28,138
	PGE	CISO	25,554	24,562
	PGE	PACW	10,903	15,026
	PGE	PSEI	1,411	1,770
	PSEI	PWRX	33,655	36,337
	PSEI	IPCO	0	0
	PSEI	PACW	42,893	47,617
	PSEI	PGE	3,118	3,281

TABLE 2: Energy transfers (MWh) in the FMM and RTD markets for Q4 2019

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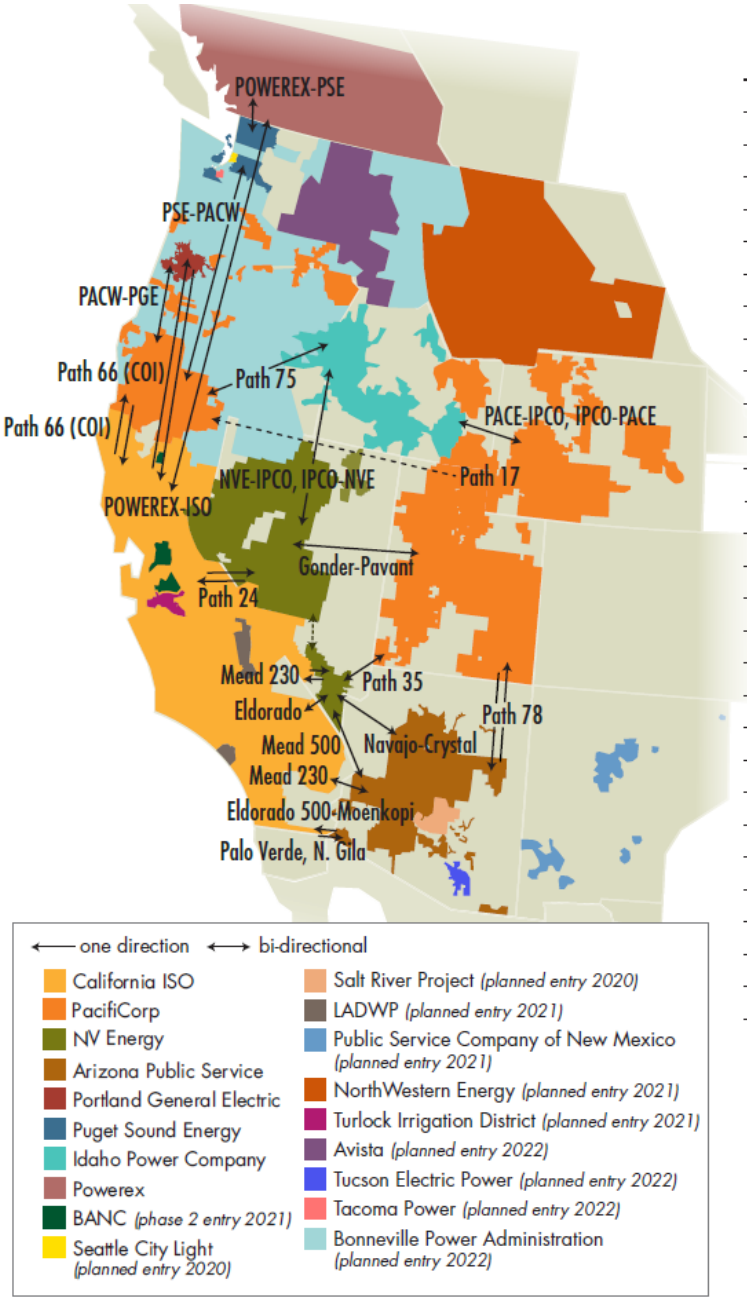

Path	Estimated Max Capacity (MW)
Path 24 *(west to east)*	100
Path 24 *(east to west)*	35-90
Eldorado	797
Path 35 *(west to east)*	580
Path 35 *(east to west)*	538
Gonder-Pavant	130
PACW to PGE	320
Path 66 *(ISO to PGE)*	627
Path 66 *(PGE to ISO)*	296
Path 66 *(ISO to PACW)*	331
Path 66 *(PACW to ISO)*	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 Q4 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:

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- 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	479,837	182,083	207,189
BANC	62,585	229,577	-
CISO	551,855	781,781	314,935
IPCO	76,690	310,181	151,938
NEVP	255,003	124,640	275,689
PACE	688,208	60,370	135,262
PACW	194,144	213,094	303,638
PGE	57,996	319,543	46,331
PSEI	141,074	93,407	82,627
PWRX	36,075	228,792	18,729

TABLE 3: Estimated wheel-through transfers in Q4 2019

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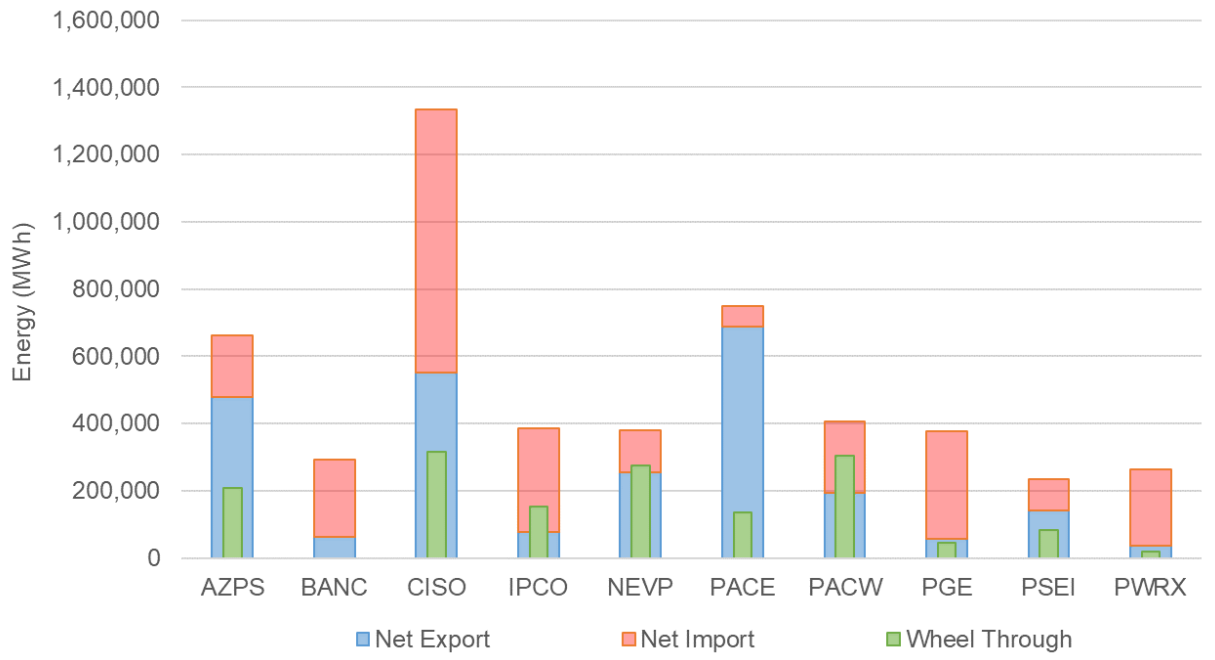

GRAPH 3: Estimated wheel-through transfers in Q4 2019

BAA	Net Export	Net Import	Wheel-Through
AZPS	262,038	33,897	75,698
BANC	29,356	86,364	-
CISO	207,496	308,071	151,804
IPCO	20,905	99,469	76,049
NEVP	101,214	34,329	100,249
PACE	275,113	26,985	48,075
PACW	33,847	126,490	102,114
PGE	20,186	119,835	18,215
PSEI	23,989	49,727	35,398
PWRX	9,870	98,846	7,935

TABLE 4: Estimated wheel-through transfers in October 2019

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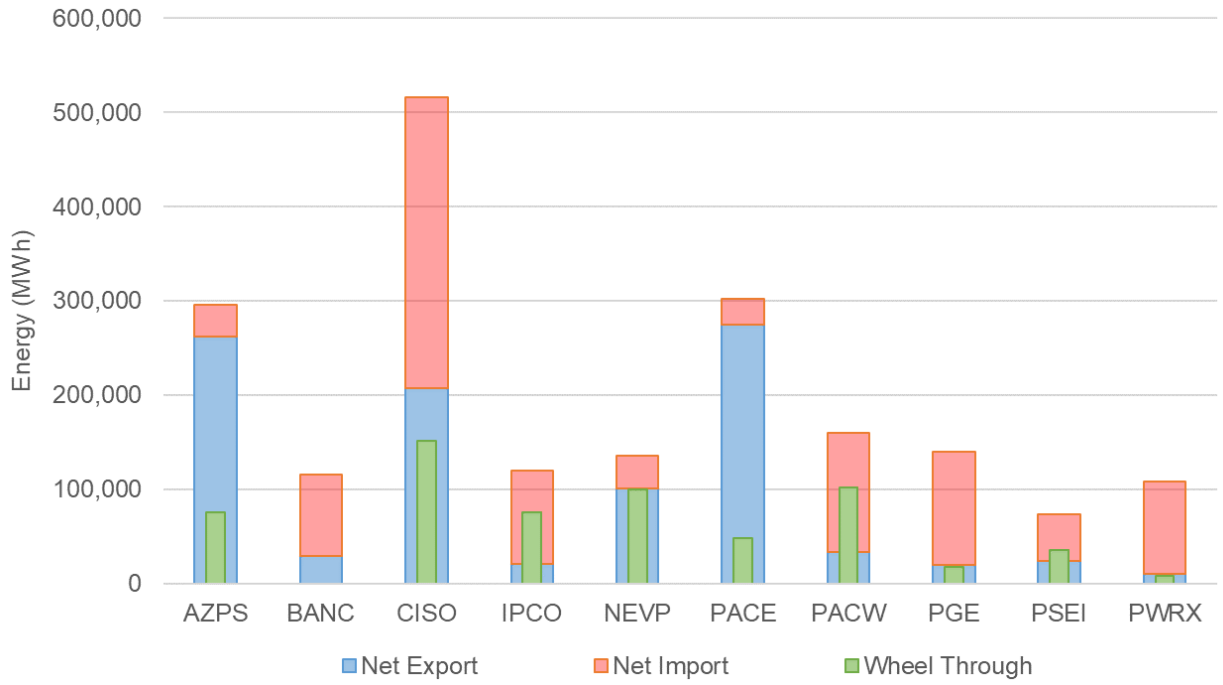

GRAPH 4: Estimated wheel-through transfers in October 2019

BAA	Net Export	Net Import	Wheel- Through
AZPS	100,677	62,648	60,372
BANC	21,626	62,645	-
CISO	144,233	232,150	78,894
IPCO	19,852	109,197	36,692
NEVP	77,589	40,243	86,104
PACE	228,027	8,601	33,253
PACW	65,164	45,514	94,169
PGE	17,575	102,249	6,793
PSEI	54,331	22,615	22,573
PWRX	14,607	57,819	6,654

TABLE 5: Estimated wheel-through transfers in November 2019

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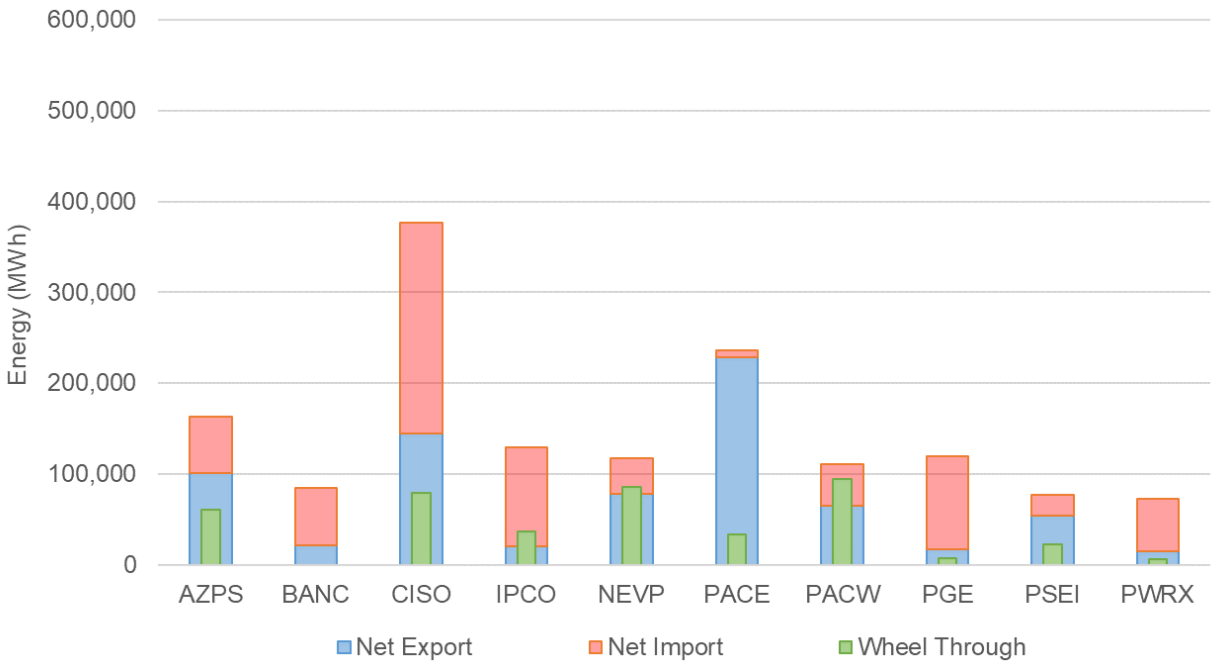

GRAPH 5: Estimated wheel-through transfers in November 2019

BAA	Net Export	Net Import	Wheel Through
AZPS	117,123	85,538	71,119
BANC	11,603	80,568	-
CISO	200,126	241,559	84,238
IPCO	35,933	101,515	39,196
NEVP	76,200	50,069	89,337
PACE	185,068	24,784	53,935
PACW	95,133	41,090	107,354
PGE	20,235	97,460	21,323
PSEI	62,754	21,064	24,656
PWRX	11,597	72,127	4,140

TABLE 6: Estimated wheel-through transfers in December 2019

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GRAPH 6: Estimated wheel-through transfers in December 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 Q4 2019 was calculated to be 15,286 MWh (October) + 11,405 MWh (November) + 8,563 MWh (December) = 35,254 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 15,089 metric tons of CO_2 for Q4 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 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

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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
	Total	1,012,150	433,120

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.

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Month	BAA	Direction	Minimum requirement	Maximum requirement
October	*AZPS*	up	25	263
	BANC	up	4	66
	CISO	up	316	1592
	IPCO	up	43	229
	NEVP	up	23	279
	PACE	up	73	313
	PACW	up	44	194
	PGE	up	56	213
	PSEI	up	29	169
	PWRX	up	60	231
	ALL EIM	**up**	**332**	**1,620**
	AZPS	down	33	370
	BANC	down	59	71
	CISO	down	123	1,305
	IPCO	down	54	232
	NEVP	down	27	268
	PACE	down	94	328
	PACW	down	25	128
	PGE	down	39	242
	PSEI	down	30	205
	PWRX	down	59	270
	ALL EIM	**down**	**193**	**1,521**
November	*AZPS*	up	0	321
	BANC	up	0	58
	CISO	up	0	1,556
	IPCO	up	0	229
	NEVP	up	0	272
	PACE	up	0	321

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	PACW	up	0	194
	PGE	up	0	213
	PSEI	up	0	169
	PWRX	up	0	231
	ALL EIM	**up**	**0**	**1,867**
	AZPS	down	0	370
	BANC	down	0	68
	CISO	down	0	1,399
	IPCO	down	0	228
	NEVP	down	0	226
	PACE	down	0	316
	PACW	down	0	154
	PGE	down	0	242
	PSEI	down	0	205
	PWRX	down	0	270
	ALL EIM	**down**	**0**	**1,717**
December	*AZPS*	up	7	210
	BANC	up	3	58
	CISO	up	139	1,716
	IPCO	up	33	229
	NEVP	up	14	291
	PACE	up	53	321
	PACW	up	45	194
	PGE	up	38	206
	PSEI	up	33	156
	PWRX	up	61	230
	ALL EIM	**up**	**196**	**1,905**
	AZPS	down	31	275
	BANC	down	5	72
	CISO	down	213	1,527

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IPCO	down	55	228
NEVP	down	18	248
PACE	down	80	248
PACW	down	14	146
PGE	down	36	242
PSEI	down	52	143
PWRX	down	62	270
ALL EIM	**down**	**299**	**1,740**

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.

	October		**November**		**December**	
Direction	Up	Down	Up	Down	Up	Down
Average MW saving	808	813	770	772	686	735
Sum of BAA requirements	1,712	1,663	1,615	1,670	1,576	1,681
Percentage savings	47%	49%	48%	46%	44%	44%

Table 9: Flexible ramping procurement diversity savings in Q4 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.

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CONCLUSION

The first real-time wholesale power market of its kind in the western United States, the Western EIM uses state-of-the-art technology to find and deliver low-cost energy to meet real-time demand across eight western states and extends to the border with Canada. The Western EIM has proven extensive financial and operational benefits since its inception in November 2014, and cumulative gross economic benefits now total $861.79 million.

Additionally, the EIM proves the cooperative efforts of participants provided 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 433,120 metric tons of CO2, roughly the equivalent of avoiding the emissions from 91,062 passenger cars driven for one year.

Nine entities are currently participating in the EIM, and eleven more are committed to joining by 2022. As new entities join, the quarterly benefits are anticipated to grow from the resulting individual benefits and the compounded benefits across the footprint as transfers are enabled. The Western EIM demonstrates that utilities can realize cost benefits and reduce carbon emissions through increased coordination and optimization in the West.

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