Western EIM Benefits Report

First Quarter 2017

May 1, 2017

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Executive Summary

This report presents the benefits associated with participation in the western Energy Imbalance Market (EIM) for the first quarter of 2017. 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 2017 are $31.1 million, bringing the total benefits of EIM to $173.72 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 52,651 MWh of surplus renewable energy to displace 22,535 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 and PSE 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 = $31.1 million.***
- ***Reduced renewable energy curtailment. Q1 estimated reduction = 52,651 MWh displacing approximately 22,535 metric tons of CO_2.***
- ***Reduced flexibility ramping reserves needed in all balancing authority areas. Q1 reduction = 377 MW – 399 MW in the upward direction and 474 MW – 488 MW in the downward direction.***

[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 Markets Benefits, http://www.caiso.com/Documents/PacifiCorp-ISOEnergyImbalanceMarketBenefits.pdf

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. 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.

To the extent an entity base schedule is already optimized, the benefits may be lessened when compared to an entity that has not submitted optimized base schedules.

The ISO began publishing quarterly EIM benefit reports in January 2015. Prior reports can be accessed at http://www.caiso.com/informed/Pages/EIMOverview/Default.aspx.

EIM Benefits in Q1 2017

Table 1 shows the estimated EIM gross benefits by each region per month. The monthly savings presented in the table show $8.08 million for January, $10.44 million for February, and $12.58 million for March with a total estimated benefit of $31.1 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	$ 1.71	$ 1.71	$ 1.81	$5.23
ISO	$ 2.15	$ 3.17	$ 4.18	$ 9.50
NV Energy	$ 1.07	$ 1.31	$ 1.12	$ 3.50
PacifiCorp	$ 2.74	$ 3.84	$ 4.89	$ 11.47
PSE	$ 0.41	$ 0.41	$ 0.58	$ 1.40
Total	$ 8.08	$ 10.44	$ 12.58	$ 31.10

Table 1: First quarter 2017 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 in RTD. The RTD transfer capacities between PACW 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.

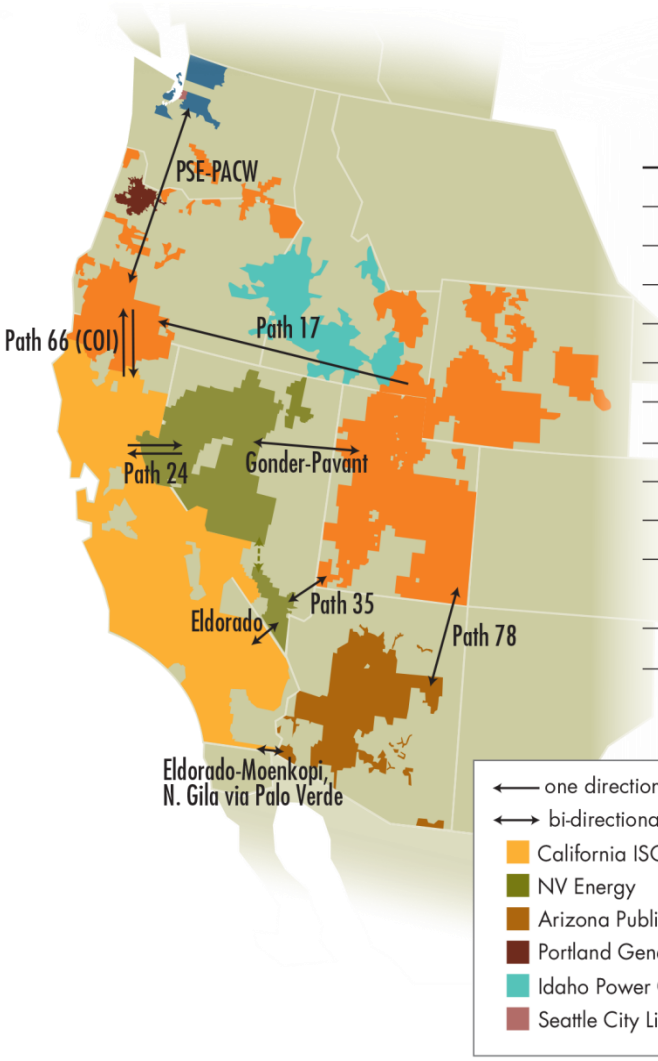
Table 2 provides the 15-minute and 5-minute EIM transfer volumes with base schedule transfers excluded. The EIM entities submit inter-BAA transfers in their base schedules. The benefits quantified in this report are only attributable to the transfers that occurred through the EIM. The benefits do not 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 on page 7.

Year	Month	from_BAA	to_BAA	15m EIM transfer (15m - base)	5m EIM transfer (5m - base)
2017	January	AZPS	CISO	164,684	136,893
		AZPS	NEVP	100	104
		AZPS	PACE	11,125	4,430
		CISO	AZPS	28,140	21,353
		CISO	NEVP	57,564	61,678
		CISO	PACW	27,915	32,814
		NEVP	AZPS	501	498
		NEVP	CISO	110,834	110,364
		NEVP	PACE	76,010	77,327
		PACE	AZPS	125,345	113,873
		PACE	NEVP	55,559	57,460
		PACE	PACW	27,580	52,527
		PACW	CISO	64,399	73,405
		PACW	PSEI	54,839	66,376
		PSEI	PACW	20,606	19,685

Year	Month	from_BAA	to_BAA	15m EIM transfer (15m - base)	5m EIM transfer (5m - base)
2017	February	AZPS	CISO	124,235	86,271
		AZPS	NEVP	2,361	1,494
		AZPS	PACE	40,237	32,748
		CISO	AZPS	51,172	39,324
		CISO	NEVP	69,298	74,994
		CISO	PACW	29,145	35,440
		NEVP	AZPS	4,183	3,334
		NEVP	CISO	57,699	74,871
		NEVP	PACE	71,436	68,727
		PACE	AZPS	106,862	76,000
		PACE	NEVP	36,285	50,780
		PACE	PACW	21,232	38,238
		PACW	CISO	50,181	57,750
		PACW	PSEI	35,834	44,050
		PSEI	PACW	22,704	23,964
2017	March	AZPS	CISO	86,043	64,935
		AZPS	NEVP	2,059	3,202
		AZPS	PACE	76,789	67,993
		CISO	AZPS	84,536	76,533
		CISO	NEVP	128,482	129,614
		CISO	PACW	30,489	37,671
		NEVP	AZPS	1,723	2,079
		NEVP	CISO	29,398	26,100
		NEVP	PACE	51,874	58,080
		PACE	AZPS	61,606	44,832
		PACE	NEVP	47,084	49,026
		PACE	PACW	14,348	27,877
		PACW	CISO	40,916	54,575
		PACW	PSEI	46,552	52,598
		PSEI	PACW	15,329	17,051

Table 2: Energy transfers (MWh) in the FMM and RTD for the first quarter 2017



Path	Estimated Max Capacity (MW)*
Path 24 *(west to east)*	100
Path 24 *(east to west)*	35-90
Eldorado	1,500
Path 35 *(west to east)*	580
Path 35 *(east to west)*	538
Gonder-Pavant	130
Path 66 *(ISO to PACW)*	331
Path 66 *(PACW to ISO)*	432
Path 17	200
PSE to PACW	300
Eldorado, Moenkopi, N. Gila, Palo Verde	2,500
Path 78	600

Graph 1: Estimated maximum transfer capacity

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 2017 was calculated to be 10,316 MWh (January) + 12,621 MWh (February) + 29,714 MWh (March) = 52,651 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 22,535 metric tons of CO_2 for Q1 2017. 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 3.

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
	Total	411,971	176,241

Table 3: 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 4.

Year	Month	BAA	Direction	Minimum requirement	Maximum requirement
2017	January	AZPS	up	0	400
		CISO	up	0	1,000
		NEVP	up	0	179
		PACE	up	45	300
		PACW	up	26	150
		PSEI	up	5	135
		ALL EIM	up	0	1,800
		AZPS	down	0	305
		CISO	down	0	1,000
		NEVP	down	3	250
		PACE	down	72	300
		PACW	down	24	175
		PSEI	down	0	135
		ALL EIM	down	0	1,200
2017	February	AZPS	up	0	400
		CISO	up	35	1,000
		NEVP	up	0	197
		PACE	up	49	300
		PACW	up	22	150
		PSEI	up	0	135
		ALL EIM	up	0	1,800
		AZPS	down	12	305
		CISO	down	0	1,000
		NEVP	down	6	250
		PACE	down	71	300
		PACW	down	26	175
		PSEI	down	0	135
		ALL EIM	down	0	1,200
2017	March	AZPS	up	0	261
		CISO	up	87	1,000
		NEVP	up	0	197
		PACE	up	70	300
		PACW	up	36	150
		PSEI	up	0	135
		ALL EIM	up	43	1,800
		AZPS	down	13	305
		CISO	down	85	1,000
		NEVP	down	7	240
		PACE	down	62	300
		PACW	down	34	175
		PSEI	down	0	135
		ALL EIM	down	0	1,200

Table 4: Flexible ramping requirements

The flexible ramping procurement diversity savings for all the intervals averaged over a month are shown in Table 5. 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	377	474	379	486	399	488
Sum of BAA requirements	1,205	1,165	1,191	1,192	1,181	1,245
Percentage savings	31%	41%	32%	41%	34%	39%

Table 5: Flexible ramping procurement diversity savings for first quarter 2017

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 $173.72 million in gross benefits to date, the realized savings are in line with analysis conducted before the market expansion launched in November 2014. 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 replacing less clean energy sources. The GHG quantified benefits due to avoided curtailments[4] of 176,241 metric tons from 2015 to date is roughly equivalent to avoiding the emissions from 37,054 passenger cars driven for one year.

[4] See footnote 1 on page 3.