California ISO

Western EIM Benefits Report

Second Quarter 2017

July 31, 2017

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Executive Summary

This report presents the benefits associated with participation in the western Energy Imbalance Market (EIM) for the second 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 April, May and June 2017 are $40.71 million, bringing the total benefits of EIM to $214.43 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 Q2, the EIM used 67,055 MWh of surplus renewable energy to displace 28,700 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). Q2 estimated savings = $40.71 million.***
- ***Reduced renewable energy curtailment. Q2 estimated reduction = 67,055 MWh displacing approximately 28,700 metric tons of CO_2.***
- ***Reduced flexibility ramping reserves needed in all balancing authority areas. Q2 reduction = 426 MW – 482 MW in the upward direction and 504 MW – 521 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.

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 Q2 2017

Table 1 shows the estimated EIM gross benefits by each region per month. The monthly savings presented in the table show $13.73 million for April, $13.71 million for May, and $13.27 million for June with a total estimated benefit of $40.71 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	April	May	June	Total
APS	$2.87	$2.54	$2.84	$8.25
ISO	$3.42	$5.23	$6.66	$15.31
NV Energy	$2.37	$2.25	$1.08	$5.70
PacifiCorp	$3.94	$2.97	$1.89	$8.80
PSE	$1.13	$0.72	$0.80	$2.65
Total	$13.73	$13.71	$13.27	$40.71

Table 1: Second 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.

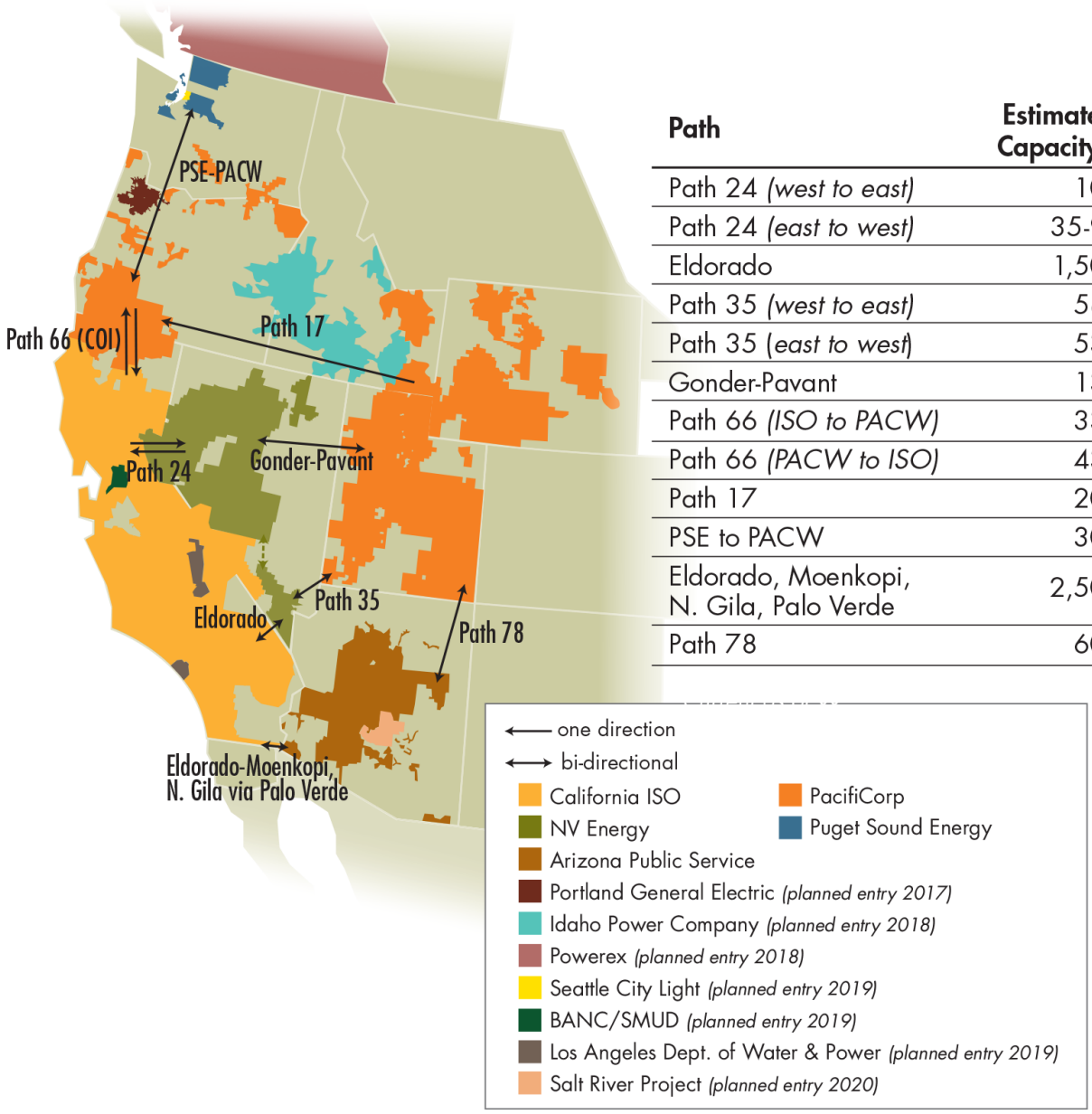
Table 2 provides the 15-minute and 5-minute EIM transfer volumes with base schedule transfers excluded. The EIM entities submit inter-BAA transfers in their base schedules. The benefits quantified in this report are only attributable to the transfers that occurred through the EIM. The benefits do not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

Year	Month	from_BAA	to_BAA	15m EIM transfer (15m - base)	5m EIM transfer (5m - base)
2017	April	AZPS	CISO	83,470	41,168
		AZPS	NEVP	6,541	6,549
		AZPS	PACE	62,978	68,357
		CISO	AZPS	132,803	126,281
		CISO	NEVP	162,592	183,217
		CISO	PACW	28,768	34,942
		NEVP	AZPS	4,209	5,612
		NEVP	CISO	29,482	30,579
		NEVP	PACE	90,185	102,465
		PACE	AZPS	72,276	32,182
		PACE	NEVP	25,229	27,159
		PACE	PACW	15,028	23,442
		PACW	CISO	34,792	47,432
		PACW	PSEI	61,724	62,992
		PSEI	PACW	4,652	6,597

Year	Month	from_BAA	to_BAA	15m EIM transfer (15m - base)	5m EIM transfer (5m - base)
2017	May	AZPS	CISO	89,639	46,813
		AZPS	NEVP	12,384	6,173
		AZPS	PACE	52,991	58,765
		CISO	AZPS	135,289	157,734
		CISO	NEVP	177,020	219,990
		CISO	PACW	30,233	30,333
		NEVP	AZPS	3,199	6,206
		NEVP	CISO	20,393	24,108
		NEVP	PACE	120,252	144,687
		PACE	AZPS	91,860	45,628
		PACE	NEVP	20,979	18,093
		PACE	PACW	8,861	22,925
		PACW	CISO	37,958	45,026
		PACW	PSEI	30,053	32,338
		PSEI	PACW	11,706	13,584
2017	June	AZPS	CISO	114,534	74,825
		AZPS	NEVP	24,814	18,801
		AZPS	PACE	44,383	49,111
		CISO	AZPS	110,592	119,260
		CISO	NEVP	155,376	212,704
		CISO	PACW	27,734	26,913
		NEVP	AZPS	2,273	3,845
		NEVP	CISO	22,169	24,238
		NEVP	PACE	135,951	168,554
		PACE	AZPS	113,054	72,227
		PACE	NEVP	9,866	7,823
		PACE	PACW	15,598	22,526
		PACW	CISO	31,535	43,313
		PACW	PSEI	15,723	18,140
		PSEI	PACW	29,323	33,838

Table 2: Energy transfers (MWh) in the FMM and RTD for the second 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 Q2 2017 was calculated to be 24,753 MWh (April) + 22,517 MWh (May) + 19,785 MWh (June) = 67,055 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 28,700 metric tons of CO_2 for Q2 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
	2	67,055	28,700
	Total	479,026	204,941

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	April	AZPS	up	18	235
		CISO	up	108	1,000
		NEVP	up	4	197
		PACE	up	88	300
		PACW	up	36	150
		PSEI	up	0	135
		ALL EIM	up	0	1,799
		AZPS	down	30	241
		CISO	down	92	1,000
		NEVP	down	7	207
		PACE	down	99	300
		PACW	down	40	175
		PSEI	down	0	135
		ALL EIM	down	3	1,200
2017	May	AZPS	up	30	260
		CISO	up	81	1,000
		NEVP	up	14	155
		PACE	up	124	300
		PACW	up	8	150
		PSEI	up	0	135
		ALL EIM	up	0	1,756
		AZPS	down	18	241
		CISO	down	124	1,000
		NEVP	down	0	157
		PACE	down	84	300
		PACW	down	47	175
		PSEI	down	24	135
		ALL EIM	down	51	1,200
2017	June	AZPS	up	23	243
		CISO	up	171	1,000
		NEVP	up	17	221
		PACE	up	80	300
		PACW	up	8	150
		PSEI	up	16	135
		ALL EIM	up	10	1,800
		AZPS	down	7	228
		CISO	down	200	1,000
		NEVP	down	0	228
		PACE	down	63	300
		PACW	down	33	175
		PSEI	down	18	135
		ALL EIM	down	91	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.

	April		May		June	
Direction	Up	Down	Up	Down	Up	Down
Average MW saving	426	509	469	521	482	504
Sum of BAA requirements	1,210	1,303	1,242	1,319	1,245	1,275
Percentage savings	35%	39%	38%	39%	39%	39%

Table 5: Flexible ramping procurement diversity savings for Second 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 $214.43 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 204,941 metric tons from 2015 to date is roughly equivalent to avoiding the emissions from 43,088 passenger cars driven for one year.

[4] See footnote 1 on page 3.