California Independent System Operator Corporation

California ISO

Structural competitiveness of the energy imbalance market:

Balancing areas of the Berkshire Hathaway entities

June 26, 2019

Department of Market Monitoring

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1 Introduction

This report provides an analysis of structural market power in the combined energy imbalance market (EIM) areas of PacifiCorp and NV Energy (referred to collectively in this report as the Berkshire Hathaway entities). The analysis is conducted for the Berkshire Hathaway entities (BHE) BAAs considered as one EIM area using data from the 12 month period December 1, 2017 to November 30, 2018. The report assesses the competitiveness of the BHE area based on the amount of competitive supply that may be transferred into the BHE area in the EIM from the broader ISO/EIM footprint, compared to the amount of imbalance demand that is served by the EIM in the BHE area BAAs.[1]

Results of this analysis show that the EIM in the BHE area is structurally competitive in almost all intervals and has not been subject to any frequently binding transmission constraints. Furthermore, during the very limited intervals when the BHE area may be structurally non-competitive, the CAISO's market power mitigation processes provide highly effective mitigation of the potential to exercise market power.

1.1 Energy imbalance market

In the California ISO area, the majority of demand is met by supply procured or scheduled in the day ahead market. The CAISO's real time markets serve primarily to adjust and optimize unit commitments and dispatches in response to changes in system and market conditions and information.

In the EIM, however, almost all system load is served by resources identified in the base schedules of the EIM entities in each BAA. These base schedules are not determined by the automated market systems of the ISO and are not settled by the ISO or paid the EIM prices. The EIM is a real time market which starts from the base schedules for these BAAs and then adjusts and optimizes to best meet the imbalance needs of the aggregate EIM area.

In all EIM areas, only a small portion of total energy produced and consumed is settled by the ISO and paid based on EIM prices. Generating resources that receive or pay the EIM price are scheduled by the EIM entity. The only generation settled on EIM prices is the incremental amount scheduled in the EIM relative to each resource's base schedule. If market power is exercised in EIM, it is exercised on those EIM imbalance quantities. Any measure of competition or market power should be centered on those quantities as the measures of supply and demand.

For a seller to have structural market power in the EIM, some kind of barrier must limit supply from new or outside (third-party) entities. The limited nature of electric transmission can create potential market power in some regions. Any area that can be isolated by limited transmission can be subject to high prices and the effects of uncompetitive behavior if a single seller controls enough generation in the area behind the constraint.

Transfers in the 15-minute and 5-minute EIM processes allow competitively priced sources of power to flow between BAAs, providing access to competitive resources from outside areas. The limits of the transfers cap the amount of competitive supply that can be supplied from outside the area. In the EIM's

[1] The report uses a method to assess structural market power in the EIM similar to that used in DMM's June 2017 analysis of the BAAs of the Berkshire Hathaway Entities (BHE) and the April 2018 analysis of the Arizona Public Service (APS) BAA.

15-minute market and 5-minute market, competitive supply available to meet incremental demand is the transfer capacity that is incremental to the quantity of transfers occurring the prior market. If the imbalance demand in a given market is greater than the incrementally available import transfer capability, some supply from within the area is necessary to meet imbalance demand.

A market is not structurally competitive if a single producer can determine market outcomes. In a structurally competitive market, demand could be met without supply from that single producer. If demand cannot be met without that key producer, that producer is said to be *pivotal*. They can effectively dictate the market price. A *pivotal supplier* test compares demand to competitive supply in order to determine if the key supplier is pivotal. Competitive supply used in the pivotal supplier test consists of supply that can reach the market but is not controlled by the key supplier.

In most EIM areas, the additional imbalance needs that cannot be met by transfers from other areas would have to be met by the EIM entity's generation. In an interval where the imbalance demand is greater than the incremental transfer limits, the EIM entity could theoretically set prices up to the $1,000/MWh bid cap, knowing that they are pivotal and at least one of their resources would need to be dispatched to meet imbalance energy demand. In such intervals, the EIM entity could determine market outcomes and set market prices at extremely high levels in the absence of any special market power mitigation provisions.

1.2 Demand for imbalance energy

The relevant demand for each portion of the CAISO's multi settlement markets involves the sum of *changes* between two market solutions. In the CAISO, the 15-minute market demand is equal to (1) the sum of all generation in the 15-minute market *minus* (2) the sum of all generation in the day-ahead market. This represents the incremental energy dispatched by the 15-minute market. Using the changes to generation to quantify imbalance energy demand accurately captures the quantity of imbalance energy dispatched by the market. Using the load forecast in each market can underestimate or overestimate the actual market demand due to possible changes in self schedules, renewable output, resource outages, and other factors.

In the EIM, entities do not participate in the day-ahead market, but instead submit base schedules that are treated very much like day-ahead market schedules in the CAISO. For each EIM BAA, the quantity demanded in the 15-minute EIM market is equal to changes made by the market between base schedules and the final 15-minute schedules. For the BHE area, the total quantity demanded is the sum of the quantity demand in each of the BHE BAAs.

Analyzing market power in the EIM requires measuring supply and demand in the EIM. Exercising market power involves changing prices, so for this analysis we are able to leave out the changes to generation in the EIM BAAs that cannot have any impact on price. Since only changes made by the market software can set price, non-participating resources and self-scheduled resources that have no bids in the market do not need to be counted when measuring demand for market power evaluation.

When a resource has a self-schedule and has economic bids above the self-schedule, any dispatch into the economic bid range will be part of the market demand. Below we present a mathematical representation of this approach, using the following variables:

$E_{15,A}$ 15-minute market demand in BAA A

$E_{5,A}$ 5-minute market demand in BAA A

$Dispatch_{15,A}$ Total 15-minute schedules within BAA A

$Dispatch_{5,A}$ Total 5-minute schedules within BAA A

$schedule_{B,A}$ total base schedule for BAA A

$schedule_{I,A}$ total IFM schedule for BAA A

$gen_{h,p}$ output from economically bid participating resources p for market h

For a given EIM BAA A, 15-minute demand is:

$$E_{15,A} = \sum Dispatch_{15,A} - \sum schedule_{B,A}$$

This demand includes changes to generation schedules as well as net energy transfers out of each BAA through the EIM since transfers into and out of each BAA can be adjusted by the EIM dispatch as part of the 15-minute EIM. Mathematically, the two pieces of demand can be broken down to:

$$Dispatch_{15,A} = \sum_{p.np \in A} \left(gen_{15,p}\right) + in\ transfers_{15,A} + out\ transfers_{15,A}$$

$$Schedule_{B,A} = \sum_{p.np \in A} \left(gen_{B,p}\right) + in\ transfers_{B,A} + out\ transfers_{B,A}$$

The CAISO differs from EIM BAAs because we consider the day-ahead schedule instead of the base schedule as the starting point. Because 15-minute intertie transactions into and out of the ISO can be adjusted by the real time market, these transactions area also included in the analysis as imports and exports:

$$E_{15,ISO} = \sum Dispatch_{15,ISO} - \sum schedule_{I,ISO}$$

$$Dispatch_{15,ISO} = \sum_{p \in ISO} (gen_p) + in\ transfers_{15,ISO} + out\ transfers_{15,ISO} + imports_{15,ISO} + exports_{15,ISO}$$

$$Schedule_{I.ISO} = \sum_{p \in ISO} (gen_p) + imports_{I,ISO} + exports_{I,ISO}$$

Total demand for the 15-minute EIM is the sum of the EIM demand in the ISO and in each of the other BAAs participating in EIM:

$$E_{15} = E_{15,ISO} + \sum_{A \in EIM} E_{15,A}$$

In the 5-minute market, imbalance demand is the difference between 5-minute dispatches and 15-minute dispatches. For the 5-minute market, all EIM BAAs and the ISO have the same formulation.

$$E_{5,A} = \sum Dispatch_{5,A} - \sum Dispacth_{15,A}$$

$$Dispatch_{5,A} = \sum_{p.np \in A} (gen_{5,p}) + in\ transfers_{5,A} + out\ transfers_{5,A}$$

$$E_5 = E_{5,ISO} + \sum_{A \in EIM} E_{5,A}$$

For both the 15-minute and 5-minute market, the total imbalance demand for any group of individual BAAs can be calculated by summing imbalance demand for each individual BAA within the group.

2 Supply and demand in the energy imbalance market

For this report, DMM compiled the data described above for the BHE area in the 12 month period from December 2017 through November 2018.

2.1 Demand for imbalance energy

Figures 1 and 3 show the distribution of the demand for imbalance energy in the 15-minute and 5-minute markets in the BHE area for this 12 month period (in MW). Figure 2 and Figure 4 highlight the distribution of imbalance energy demand in the 15-minute and 5-minute markets over this period as a percentage of total load in the BHE area. Table 1 and Table 2 provide summary statistics for these data.

As seen in Figures 1 and 3, demand for imbalance energy in the BHE area on a 15-minute and 5-minute basis are roughly normally distributed. Imbalance demand in the 15-minute market averaged 64 MW per interval with a median value of 79 MW (see Table 1). The close values for the average and median suggest a symmetric distribution. Base schedules were exceeded by 15-minute schedules (indicating a net positive imbalance demand) in more than half of the intervals.

As shown in Table 1, the demand for imbalance energy was positive during about 63 percent of 15-minute intervals. During intervals with positive imbalance demand in the 15-minute market, the average imbalance demand was about 172 MW. Demand for imbalance energy was positive in only 52 percent of intervals in the 5-minute market. During intervals with positive imbalance demand in the 5-minute market, the average imbalance demand was about 139 MW. Table 2 shows that the median imbalance demand in the 15-minute market was about 1.2 percent in absolute value of total demand and the 5-minute market was about 0.9 percent in absolute value of total demand.

Table 1. Imbalance demand (MW)

Market	average	median	Intervals demand positive	Average positive demand	Percentiles 90th	95th	97th
15 minute	64	79	63%	172	384	491	563
5 minute	3	6	52%	139	223	301	362

Table 2: Imbalance demand as share of total load (absolute value)

Market	Median	90th	95th	97th
15 minute	1.2%	3.4%	4.1%	4.6%
5 minute	0.9%	2.6%	3.3%	3.8%

Figure 1. Demand for imbalance energy for the BHE area (15-minute market, December 2017 to November 2018)

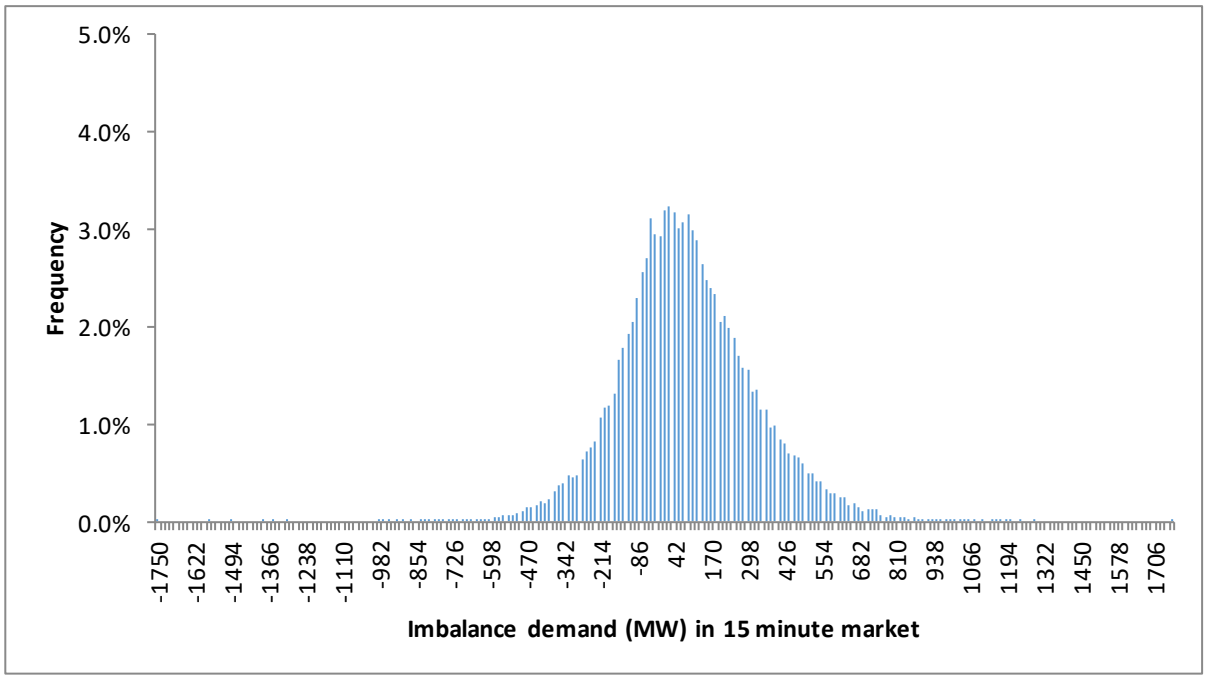


Figure 2. Imbalance energy demand compared to total load for the BHE area (15-minute market, December 2017 to November 2018)

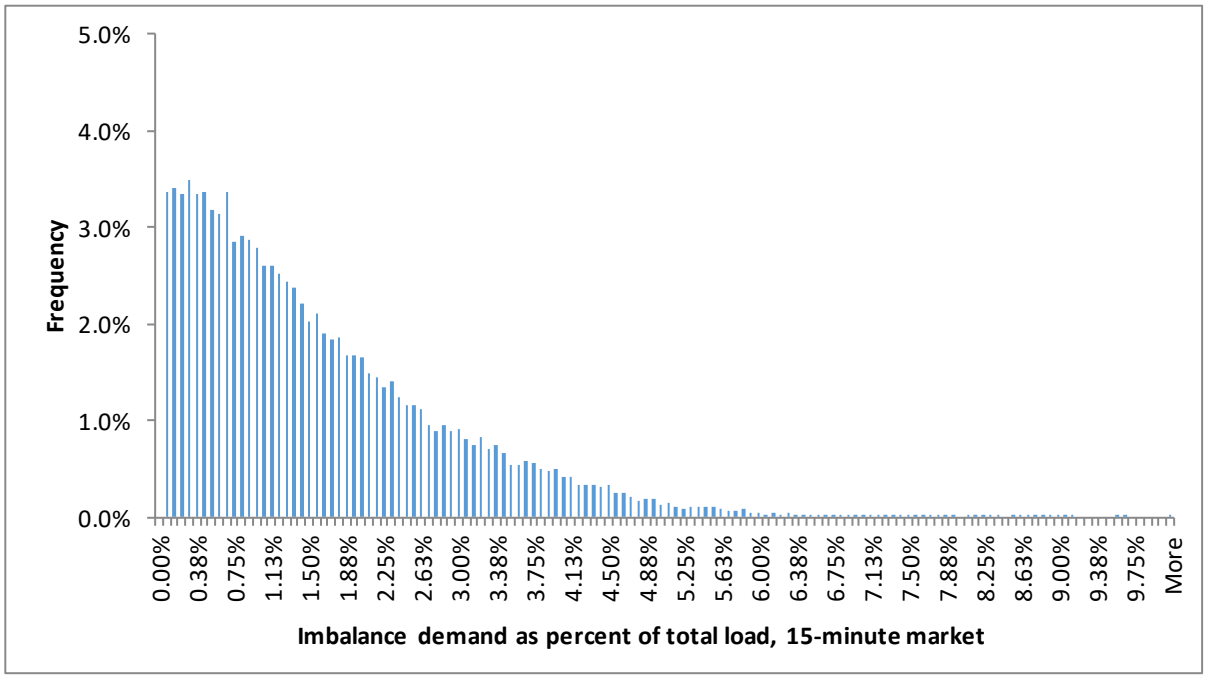


Figure 3. Demand for imbalance energy for the BHE area (5-minute market, December 2017 to November 2018)

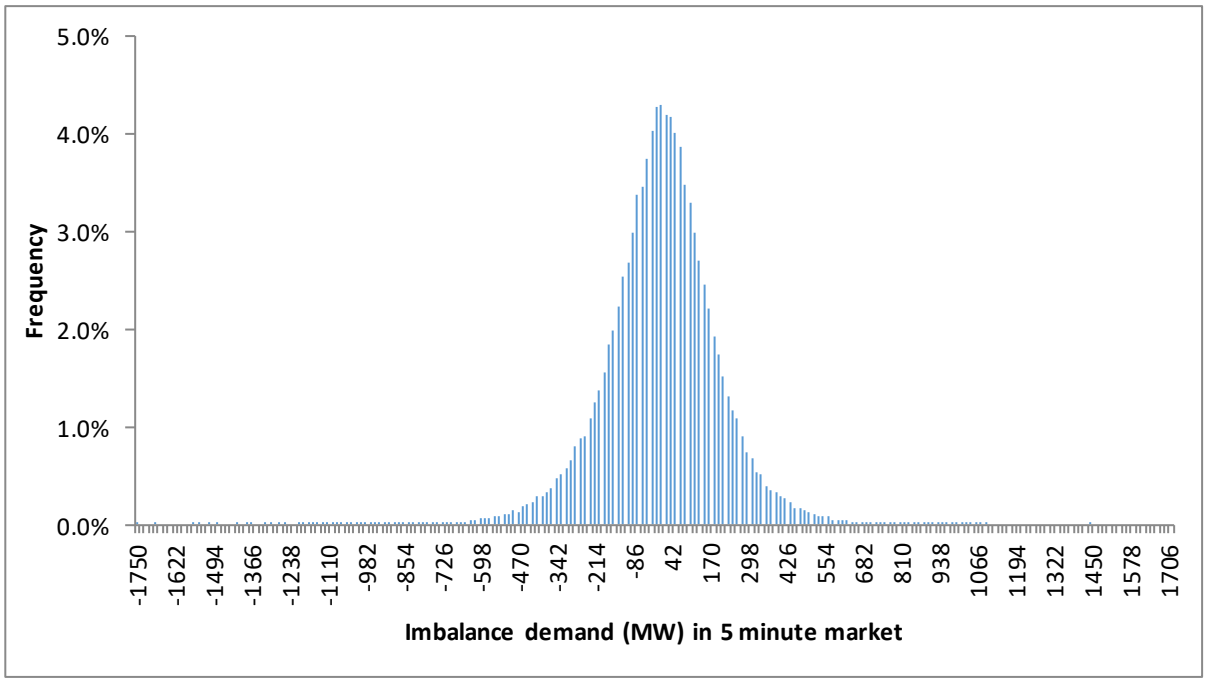
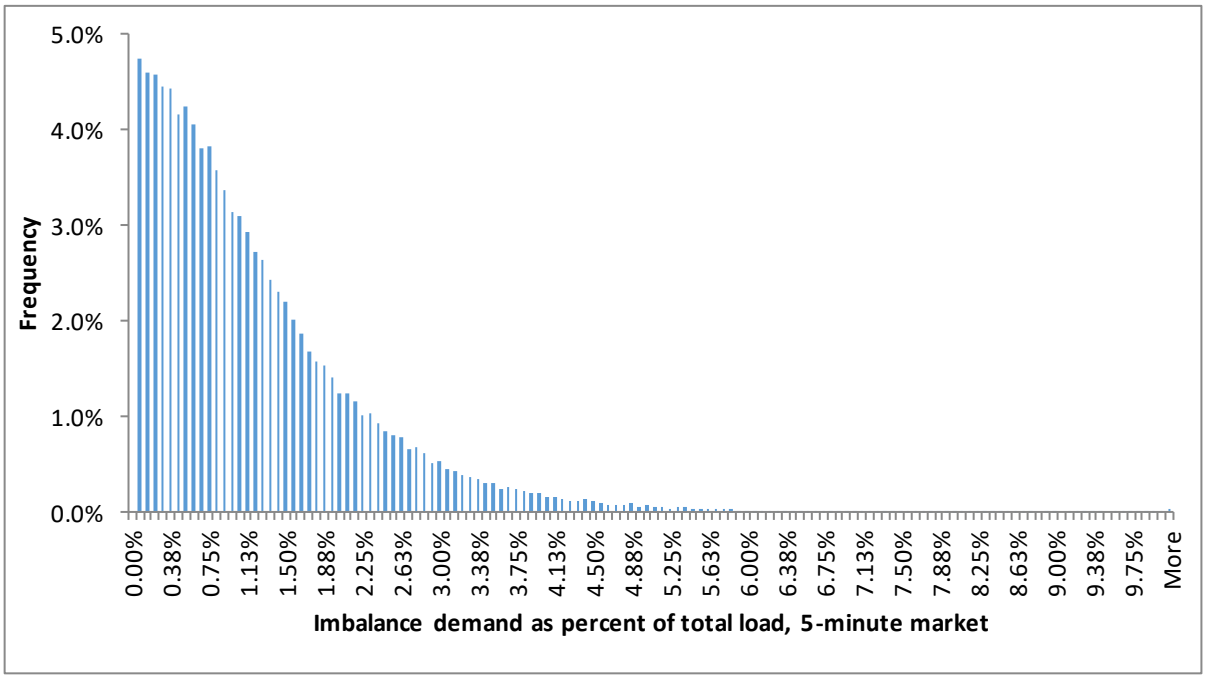


Figure 4. Imbalance energy demand compared to total load for the BHE area (5-minute market, December 2017 to November 2018)



2.2 Competitive supply of imbalance energy

The competitive supply available to meet EIM internal demand consists of supply that is not controlled by the generation arm of the EIM entity for that BAA or one of its affiliates. In EIM areas, all or most of the available competitive supply is from outside the EIM BAA in the form of EIM transfers. EIM transfer limits are determined in the import and export directions for both the 15-minute and 5-minute markets.

To determine additional competitive supply available in each market to meet imbalance demand in that market, this analysis considers the portion of each market's EIM transfer limit that is incremental to the transfers occurring in the prior market. Specifically, we consider the portion of each market's import transfer limit that is incremental to the prior market's scheduled imports as the competitive supply available to serve imbalance demand. [2] This approach appropriately accounts for base transfers, and allows for direct comparison of imbalance demand in a given market to the ability to increase import transfers over the level of the prior market to meet imbalance demand. The calculation of competitive supply into the BHE area is calculated for each BAA in the BHE area (PacifiCorp East, PacifiCorp West, and NV Energy), excluding import transfer capability from other BHE BAAs. The values are then summed to arrive at a value for the broader BHE area.

As shown in Table 3, during more than 95 percent of intervals, total incremental transfer capacity into the BHE area from any combination of other EIM BAAs was approximately ten times the 97th percentile of BHE's imbalance demand in the 15-minute market. Further, the extensive amount of import transfer capacity into the BHE area is sourced from several unaffiliated entities, limiting the ability of any one entity to restrict capacity. Similar results appear in the 5-minute market, with combined incremental transfer capacity into PSE exceeding the 97th percentile of imbalance demand by more than twelve times times during 95 percent of intervals. This analysis of total incremental import transfer capability demonstrates that considerable amounts of transfers have consistently been available relative to imbalance demand.

[2] Supply that may be transferred into area in the 15-minute EIM is the difference between the 15-minute transfer limit less any transmission needed between outside EIM areas for base schedules. Supply that may be transferred into an area in the 5-minute EIM is the difference between the 5-minute transfer limit less any transmission needed with outside EIM areas for final 15-minute EIM schedules.

Table 3. Competitive supply from EIM into BHE area (MW)

	Percentiles: 15 minute market				
Source	5th	10th	25th	median	90th
Total	5,676	5,878	6,228	7,494	8,766
AZPS	326	704	995	1,200	1,487
ISO	3,310	3,576	4,009	4,283	4,721
PGE	160	320	320	320	415
PSEI	300	300	300	300	300
IPCO	685	1,215	1,753	2,229	2,574

	Percentiles: 5 minute market				
Source	5th	10th	25th	median	90th
Total	4,480	4,996	5,465	6,813	8,335
AZPS	299	406	787	1,050	1,437
ISO	2,546	3,101	3,587	3,944	4,443
PGE	78	146	243	320	415
PSEI	73	127	210	300	300
IPCO	543	1,035	1,637	2,089	2,516

3 Structural market competitiveness

3.1 Pivotal supplier test

The pivotal supplier test for structural market power in EIM asks this question: could imbalance demand within an EIM area have been met by transfers from other unaffiliated BAAs, without using generation controlled by the EIM entity or its affiliates? If so, then the EIM entity was not pivotal in that interval and could not have successfully raised prices at that time. In a structurally competitive market the exercise of market power would be difficult and opportunities to do so would be rare.

To perform this test, the imbalance demand in the BHE area is compared to additional competitive supply that could be transferred into the BHE area from the CAISO area and other EIM BAAs that are not affiliated with BHE.

The pivotal supplier test can be performed for individual intervals using historical data by calculating how often competitive supply was able to meet imbalance demand in the BHE area. When the level of competitive supply is below imbalance demand, BHE would be pivotal. Table 4 shows results of this analysis for each of the 12 months examined in this report. The frequency of intervals where imbalance demand is greater than supply is extremely low.

Table 4. Frequency that BHE is pivotal in BHE EIM area

	Share of intervals with imbalance demand greater than transfer capacity	
Month	15-minute market	5-minute market
Dec-17	0.0%	0.0%
Jan-18	0.0%	0.0%
Feb-18	0.0%	0.3%
Mar-18	0.0%	0.0%
Apr-18	0.0%	0.0%
May-18	0.0%	0.1%
Jun-18	0.0%	0.0%
Jul-18	0.0%	0.0%
Aug-18	0.0%	0.0%
Sep-18	0.1%	0.2%
Oct-18	0.0%	0.0%
Nov-18	0.0%	0.1%

The structural competitiveness of the BHE area in the EIM can also be summarized based on statistical values of supply and demand. Figure 5 and Figure 6 provide a comparison between average incremental import transfer capacity, representing competitive supply, and the 95th and 99th percentile of imbalance demand.[3]

Figure 5 shows a comparison of average available supply to the 95th percentile and the 99th percentile of demand for the 15-minute market. In the 15-minute market, average competitive supply exceeded both the 95th and 99th percentile of imbalance demand during each month of the study period. Average competitive supply is on average 16 times as large as the 95th percentile of imbalance demand. In the closest months, average available supply is about 8 times the volume of the 99th percentile of imbalance demand.

These results show that supply and demand conditions in the 15-minute market were competitive during more than 99 percent of the study period. Transfer capacity allowed resources from other parts of EIM to compete with resources controlled by BHE in almost all intervals of the 15-minute market.

Fundamental supply and demand conditions in the 5-minute market are also competitive. Figure 6 shows that these conditions are slightly tighter than in the 15-minute market, but that average competitive supply still far exceeds the 95th and 99th percentile of imbalance demand in all months of the study period. Competitive supply exceeded imbalance demand in all but a very small fraction of 5-minute intervals. In more than 99 percent of intervals in each month, the amount of incremental import transfer capacity from the EIM exceeded total imbalance demand in the BHE area.

[3] If we use the average demand over some period of time to compare to average transfer capacity, we will include the negative intervals and may provide an underestimate of the size of the market. Therefore, instead of comparing average competitive supply to average demand, we compare average competitive supply to imbalance demand during intervals with particularly tight supply conditions.

Figure 5: BHE area imbalance demand and competitive supply (15-minute market)

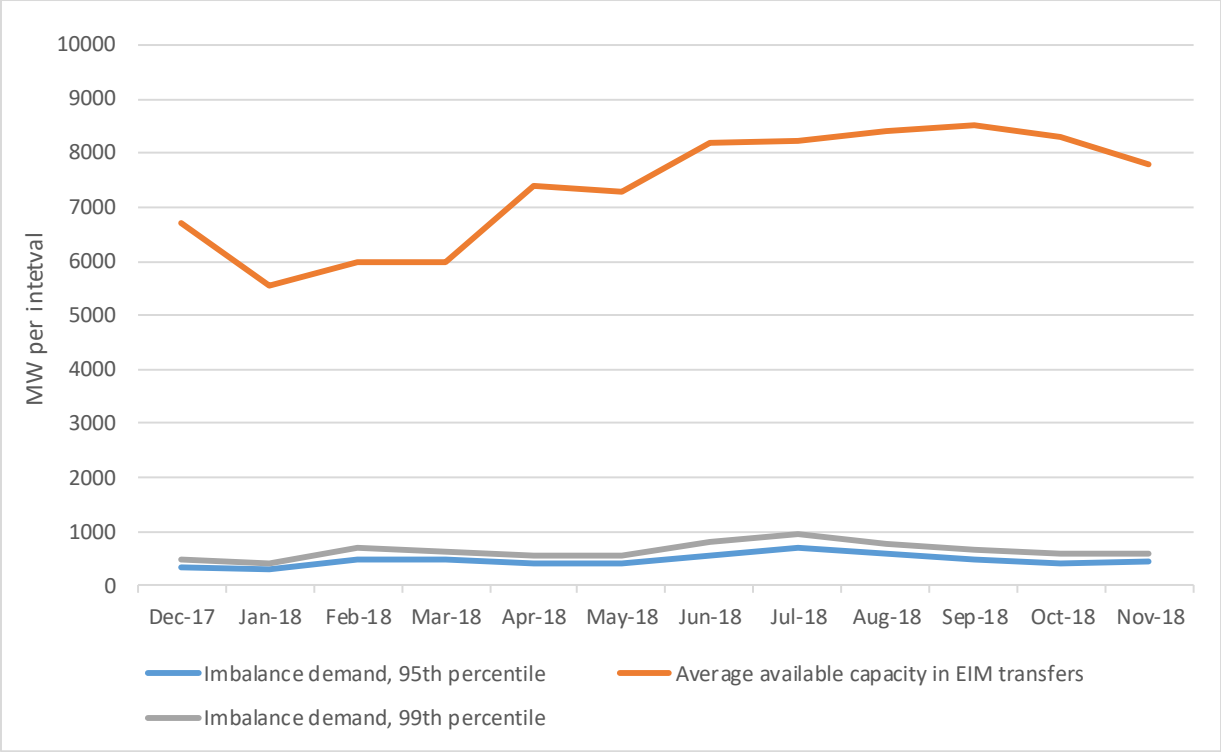
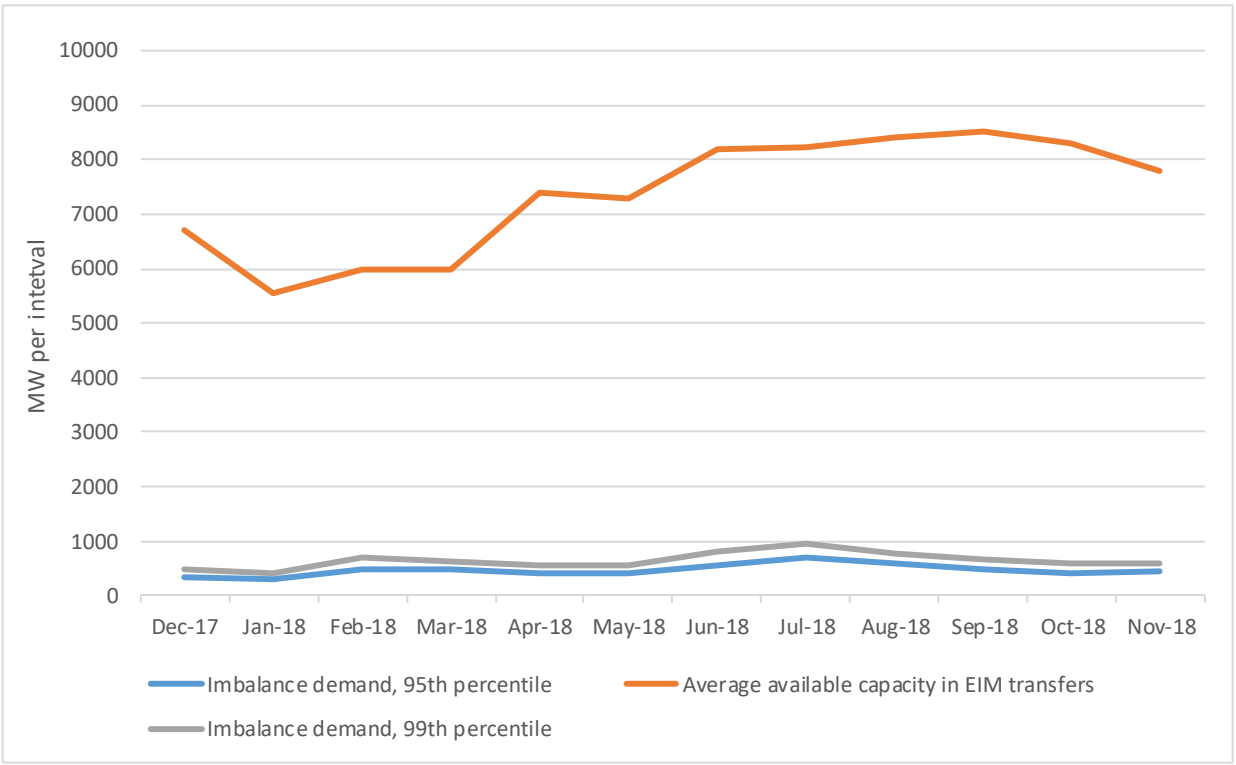


Figure 6: BHE area imbalance demand and competitive supply (5-minute market)



3.2 Market separation due to congestion

Another indicator that is often used to assess the structural competitiveness of a market (or a potential sub-market within a larger market) is the frequency with which an area is separated by congestion from other markets or a larger market. In an LMP market, such congestion results in *price separation,* which reflects higher LMPs within a congested area due to the positive congestion component of LMPs in that area.

Table 5 shows the portion of intervals that each of the BHE area BAAs was separated by congestion from the rest of the EIM, such that prices within the BAA were higher due to congestion on EIM transfer constraints between the BAA and CAISO. [4] Although price separation implies relatively higher prices compared to other EIM BAAs, intervals with congestion on the transfer constraints in to an EIM BAA are precisely the intervals in which CAISO's local market power mitigation procedures are designed to be triggered. Therefore, given the high degree of accuracy in the prediction of congestion for local market power mitigation, nearly all intervals with price separation in the BHE area BAAs will still have a competitive price set either by the cost-based default energy bid of a mitigated resource or the CAISO system energy price. [5]

Figure 5 shows that the frequency of price separation due to congestion limiting transfers into each of the BHE area BAAs is low. In the PacifiCorp East (PACE) BAA and the NV Energy (NEVP) BAA, only 2 to 3 percent of intervals in any EIM market show price separation from CAISO. In the PacifiCorp West (PACW) BAA, values are similar in the 15-minute market, and increase but remain low at 7.1 percent in the 5-minute market. These results, combined with highly accurate prediction of congestion in market power mitigation, imply that less than 1 percent of intervals in either the 15-minute or 5-minute market may have separated prices set by an unmitigated bid.[6]

[4] In the EIM, price separation can also occur due to the greenhouse gas (GHG) component of LMPs and congestion on constraints within each EIM BAA. Therefore, this analysis is based only on price separation due to congestion on transfer constraints between EIM areas. Additionally, price separations of less than one cent are not considered as intervals with price separation in this analysis. Such instances are typically the result of modeling parameters that add fractional amounts less than one cent to the objective functions associated with some individual ETSRs in order to ensure an optimal transfer solution.

[5] When mitigation is triggered, bids are limited by the higher of the unit's cost-based default energy bid or the competitive LMP for the resource's node (which is usually about equal to the system marginal energy price for the CAISO system)

[6] See Table 6 below. The highest frequency of price separation among the BHE area BAAs occurs in PACW in the 5-minute market. Under-prediction of congestion into PACW in the 5-minute market occurred in 9 percent of intervals, and only 7.1 percent of intervals had price separation in PACW in the 5-minute market. This implies that 9 percent of 7.1 percent of total intervals (.09*.071 = .0064 = 0.64%) were unmitigated and potentially had prices set by an unmitigated bid. The values are considerably smaller in other markets and BHE area BAAs, which have even more accurate prediction of congestion and lower frequency of price separation.

Table 5. Frequency of price separation (December 2017 to November 2018)

	Share of intervals exhibiting price separation	
	15-minute market	5-minute market
NEVP	2.7%	2.0%
PACE	2.4%	2.8%
PACW	2.7%	7.1%

3.3 Energy bid mitigation

During the relatively small portion of intervals when BHE may be pivotal and competitive supply from the CAISO and broader EIM into a BHE area BAA may be limited by congestion (as shown in Table 5), this potential structural market power is mitigated by the CAISO's real-time market power mitigation procedures. These bid mitigation procedures are triggered when congestion is projected in the real-time market. When bid mitigation is triggered, bids of all supply within a BAA that is separated from the ISO are automatically subject to bid limits based on each resource's marginal cost and competitive system prices in the CAISO area. Thus, even when price separation occurs, effective market power mitigation ensures that the resulting price is still typically competitive.

The CAISO implemented enhancements to its real-time bid mitigation procedures in the 15-minute market in Q3 2016 and in the 5-minute market in Q2 2017. DMM analysis shows that with these enhancements, CAISO's market power mitigation processes have a high degree of accuracy of congestion estimation for all EIM transfer constraints. This reduces the possibilities of missed mitigation to a very low level for each of the EIM BAAs in both the 15-minute and 5-minute market, as shown in Table 6 and Table 7.

Table 6: Accuracy of congestion prediction by region on EIM transfers, 15-minute market

	Accurately predicted	Predicted but resolved	Under predicted
PACE	90%	6%	4%
PACW	91%	6%	3%
PGE	92%	5%	3%
BCHA	90%	7%	3%
PSEI	90%	6%	4%
IPCO	91%	6%	3%
NEVP	93%	4%	2%
AZPS	92%	5%	4%

Table 7: Accuracy of congestion prediction by region on EIM transfers, 5-minute market

	Accurately predicted	Predicted but resolved	Under predicted
PACE	75%	20%	6%
PACW	71%	20%	9%
PGE	72%	19%	9%
BCHA	67%	28%	5%
PSEI	67%	25%	9%
IPCO	76%	18%	6%
NEVP	77%	19%	4%
AZPS	72%	23%	4%

4 Conclusion

This report provides analysis by DMM evaluating the potential for market power in existing EIM areas. This analysis show that the BHE area is structurally competitive during almost all intervals in the EIM due to the amount of competitive supply in each market that could be transferred into the area from the rest of the EIM. The report also shows that CAISO's real-time market power mitigation procedures provide assurance that any potential market power in the BHE BAAs is effectively mitigated when the BHE BAAs are separated by congestion from the CAISO and other EIM areas.