California Independent System Operator Corporation

California ISO

Structural competiveness of the energy imbalance market:

Analysis of market power of the Berkshire Hathaway entities

June 29, 2017

Prepared by: Department of Market Monitoring

TABLE OF CONTENTS

1 Overview

FERC's November 19, 2015, Order found that the market power analyses submitted by PacifiCorp and NV Energy (referred to collectively in this report as Berkshire Hathaway entities) failed to demonstrate a lack of market power in the energy imbalance market (EIM).[1] The Commission therefore imposed special limitations on the Berkshire Hathaway entities (BHE), including a requirement that all bids submitted by BHE be at or below each unit's default energy bid. These default energy bids are cost-based bids calculated by the ISO that are designed to only be used when the ISO's automated procedures determine that units may have market power.

In July 2016, DMM completed its third report on the structural market competitiveness in the PacifiCorp balancing authority areas (BAAs).[2] DMM's July 2016 report provided analysis showing that the frequency of potential structural market power in the PacifiCorp areas had dramatically decreased with the additional transfer capacity that became available between the energy imbalance market areas and the ISO when NV Energy joined the energy imbalance market in December 2015. This structural competitiveness mitigates the potential for the exercise of market power through both economic and physical withholding during almost all intervals.

This report provides additional analysis of the structural competiveness of the energy imbalance market. This report focuses on the competitiveness of the combination of all three BHE balancing areas: PacifiCorp East, PacifiCorp West, and NV Energy. We describe a method to measure both demand and competitive supply in the energy imbalance market and to then test for structural market power based on these data. With this approach, the demand for real-time imbalance energy is aggregated across PacifiCorp East, PacifiCorp West, and NV Energy BAAs. This aggregated imbalance demand for these BHE areas is then compared to the amount of competitive supply that could be transferred into these BAAs from the ISO.

The report presents results of this pivotal supplier test applied to the BHE balancing areas in the energy imbalance market. Results of this analysis provide further evidence of the structural competiveness of the energy imbalance market, including the three BHE BAAs. Our conclusion is that the EIM market in the combined BHE area is structurally competitive during almost all intervals due to the amount of competitive supply that could be transferred into the BHE area from the ISO. As additional BAAs that are not affiliated with BHE join EIM, this additional transfer capacity and diversity of ownership should further increase the pool of competitive supply and make the EIM more competitive.

During the relatively small number of intervals when BHE may be pivotal and competitive supply from the ISO into any of the BHE BAAs may be limited by congestion, this potential structural market power is mitigated by the ISO's real-time bid mitigation procedures. When these procedures are triggered by

[1] *Order on Proposed Market-Based Tariff Changes*, November 19, 2015, 153 FERC 61,206, ER15-2281-000: https://www.ferc.gov/whats-new/comm-meet/2015/111915/E-5.pdf.

[2] *Report on Structural Competitiveness of Energy Imbalance Market*, Department of Market Monitoring, July 7, 2016: http://www.caiso.com/Documents/Jul8_2016_DepartmentMarketMonitoring_EIM_StructuralMarketPowerInformationalReport_ER14-1386.pdf.

congestion in the real-time market, bids of all supply within a BAA that is separated from the ISO are automatically subject to cost-based bid limits.

The ISO implemented enhancements to these bid mitigation procedures in the 15-mintue market in Q3 2016 and in the 5-minute market in Q2 2017. [3] With these enhancements, any potential market power can be effectively mitigated by these automated procedures. DMM will provide analysis on the effectiveness of these procedures in separate future reports.

[3] *2016 Annual Report on Market Issue and Performance*, Department of Market Monitoring, May 2017. pp. 20, 253-255, http://www.caiso.com/Documents/2016AnnualReportonMarketIssuesandPerformance.pdf

2 Background

This section describes a method for measuring imbalance demand and competitive supply in the EIM. In this analysis, the three BAAs corresponding to the Berkshire Hathaway entities (PacifiCorp West, PacifiCorp East and NV Energy) are treated as a single affiliated group for purposes of assessing their potential market power. In this report these entities are referred to collectively as the Berkshire Hathaway entities (BHE). The analysis in this report evaluates the combination of the three BHE areas as a single area, and assesses the competitiveness of this area based on the amount of competitive supply available to be transferred into this area in the EIM from the broader ISO footprint.

2.1 Energy imbalance market

In the California ISO area, the majority of demand is met in the day ahead market. The ISO'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, 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 start from the base schedules for these BAAs just as it starts from the day ahead awards for the ISO, and then adjusts and optimizes to best meet the imbalance needs of the aggregate EIM area.

In the EIM entity areas, only a small portion of 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 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.

The EIM transfers allow competitively priced sources of power to flow between BAAs, providing access to the BAA for competitive resources from outside areas. The limits of the transfers cap the amount of competitive supply that can be offered in from outside the BAA. If the imbalance demand is greater than the transfer limits, some supply from within the BAA 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 areas of the energy imbalance market, this almost always means that 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 transfer limits, the EIM entity could theoretically set prices up to the $1,000 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.

2.2 Demand for imbalance energy

The relevant demand for each portion of the multi settlement ISO markets involves the sum of *changes* between two market solutions. In the ISO, 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 ISO. 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.

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 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:

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

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

The ISO 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.

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

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

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

3 Supply and demand in the energy imbalance market

For this report, DMM compiled the data described above for the period from December 2015 through September 2016. During this period, all three BHE balancing areas were EIM participants, and there were no other EIM BAAs outside of the ISO BAA. This allows us to keep a consistent 10-month data set in which the three BHE areas account for the total demand for imbalance energy in the EIM outside of the ISO.

3.1.1 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 combined BHE areas over this 10 month period (in MW). Figure 2 and Figure 4 highlight the distribution of imbalance energy demand in the 15-minute and 5-mintue markets over this 10 month as a percentage of total load in the combined 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 EIM on a 15-minute and 5-minute basis are roughly normally distributed. Imbalance demand in the 15-minute market averaged -46 MW per interval with a median value of -48 MW (see Table 1). The close values for the average and median suggest a symmetric distribution. Base schedules exceeded 15-minute schedules (indicating a net negative imbalance demand) on average and in more than half the intervals. Figure 2 shows that imbalance demand in the 5-minute market is slightly more skewed in the positive direction than in the 15-minute market.

As shown in Table 1, the demand for imbalance energy was positive during about 42 percent of 15-minute intervals. During intervals with positive imbalance demand, the average demand was about 176 MW. [4] Table 2 shows that in about 97 percent of 15-minute intervals, imbalance demand was less than 5 percent in absolute value of total demand. Median imbalance demand as a share of total load was about 1.3 percent in the 15-minute market.

[4] In a few intervals, imbalance demand in the 15-minute market was much larger than average, and even approached as much as 25 percent of total load. DMM's review of these extreme values indicate we have calculated this correctly according to ISO data. In some cases, systems issues may have prevented the ISO from receiving accurate data from the EIM entities. Whatever the cause, it is clear that even with these intervals in the dataset the instances of high levels of imbalance demand are extremely rare.

Figure 1: Demand for imbalance energy for the combined BHE areas (15-minute market, December 2015 to September 2016)

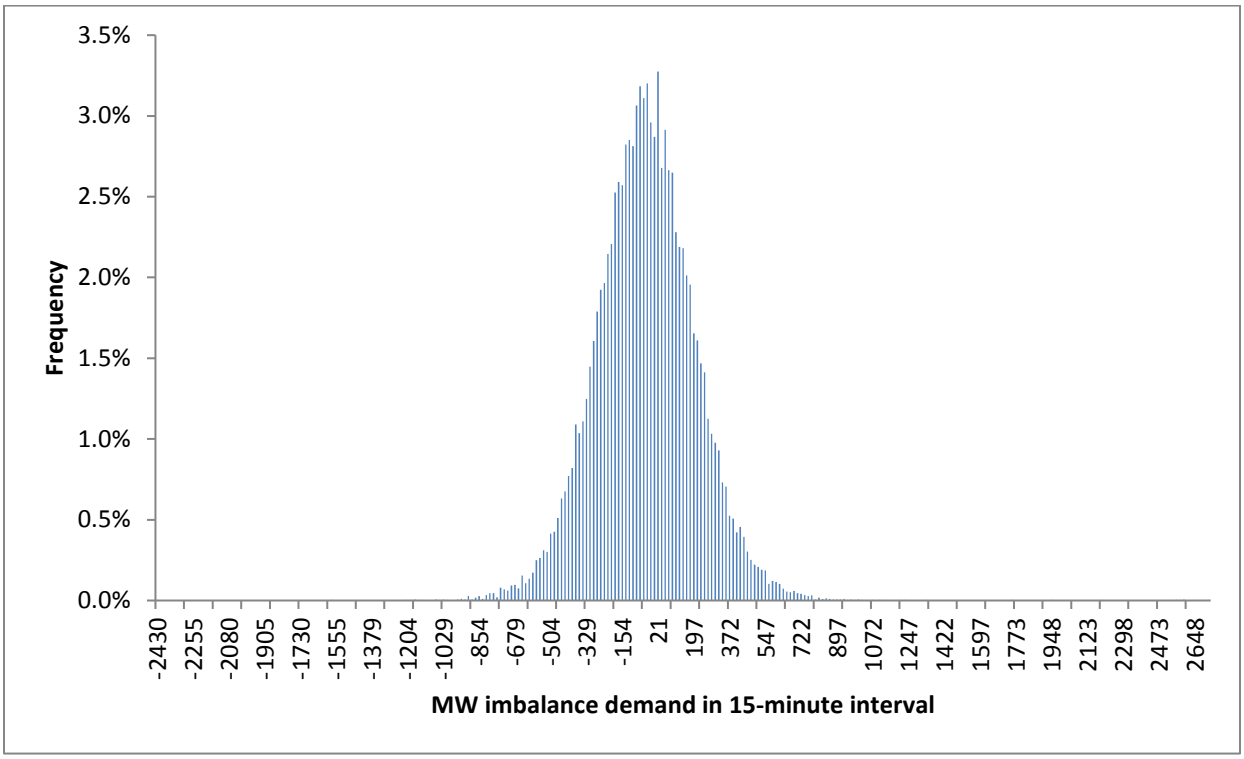


Figure 2. Imbalance energy demand compared to total load for the combined BHE areas (15-minute market, December 2015 to September 2016)

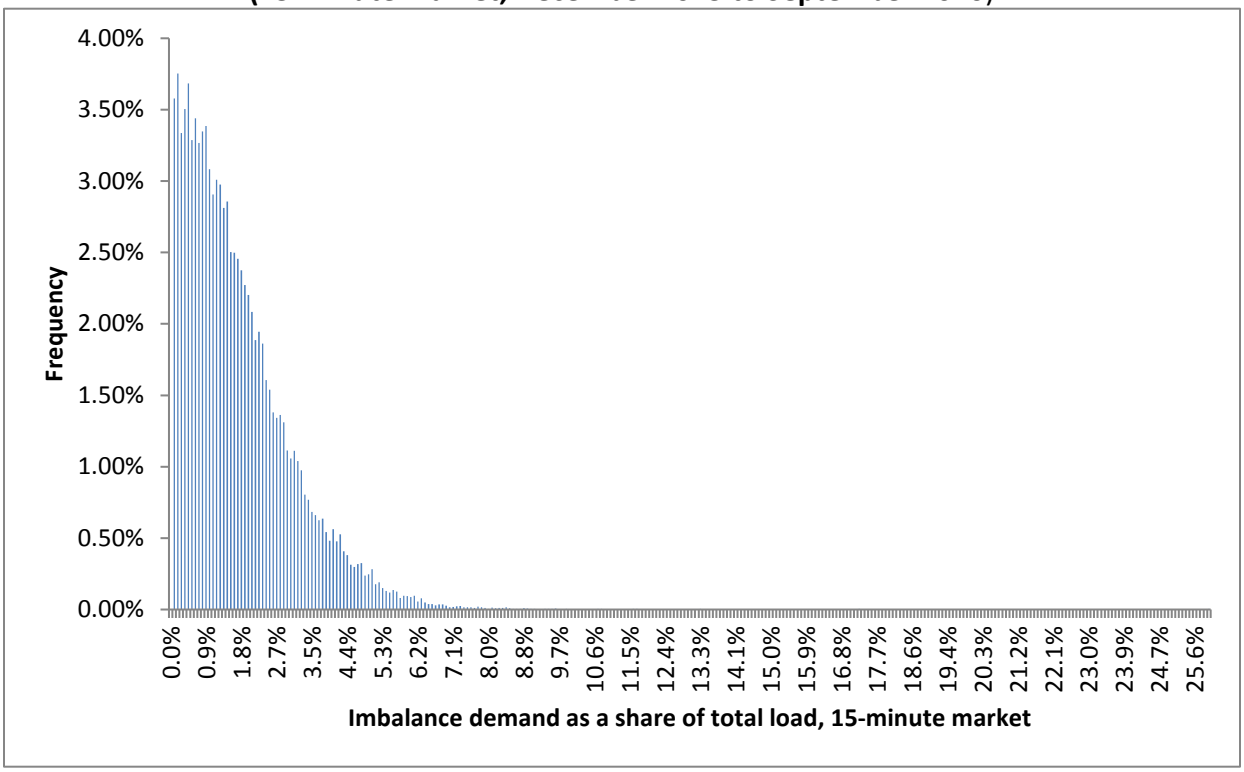


Figure 3: Demand for imbalance energy for the combined BHE areas (5-minute market, December 2015 to September 2016)

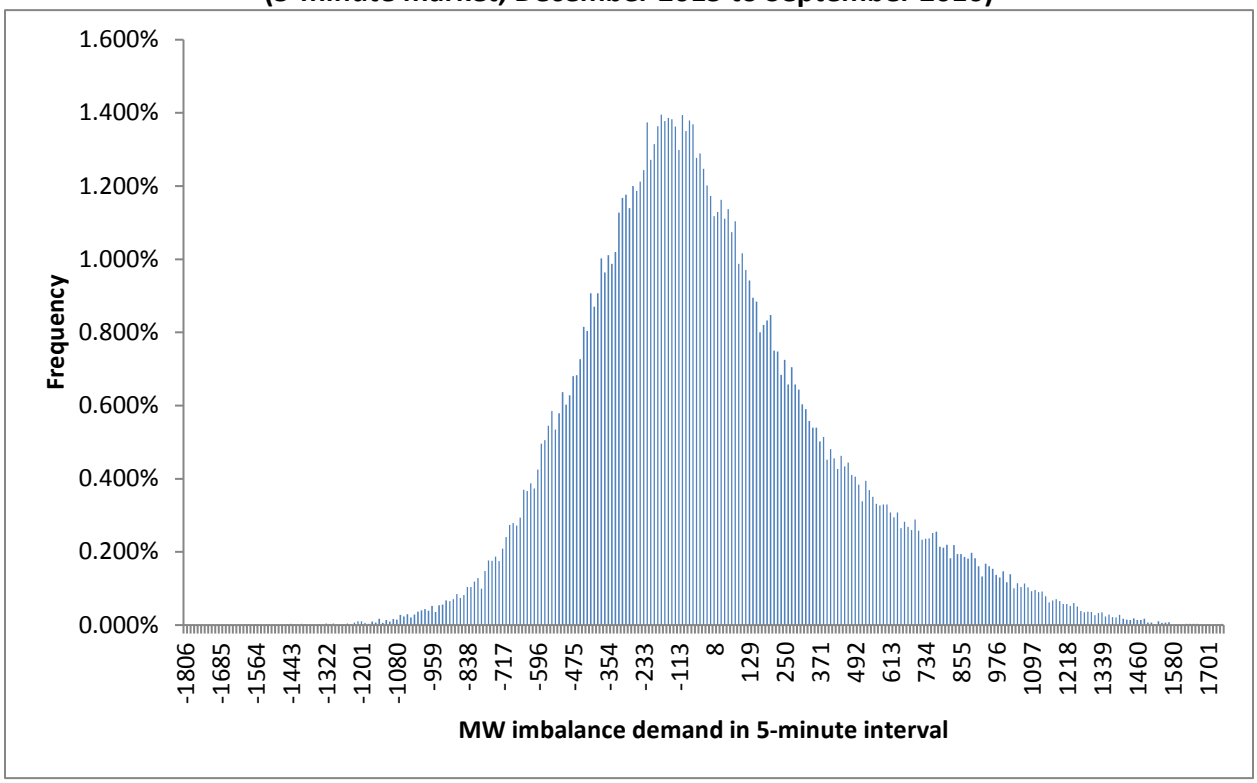


Figure 4: Imbalance energy demand compared to total load for the combined BHE areas (5-minute market, December 2015 to September 2016)

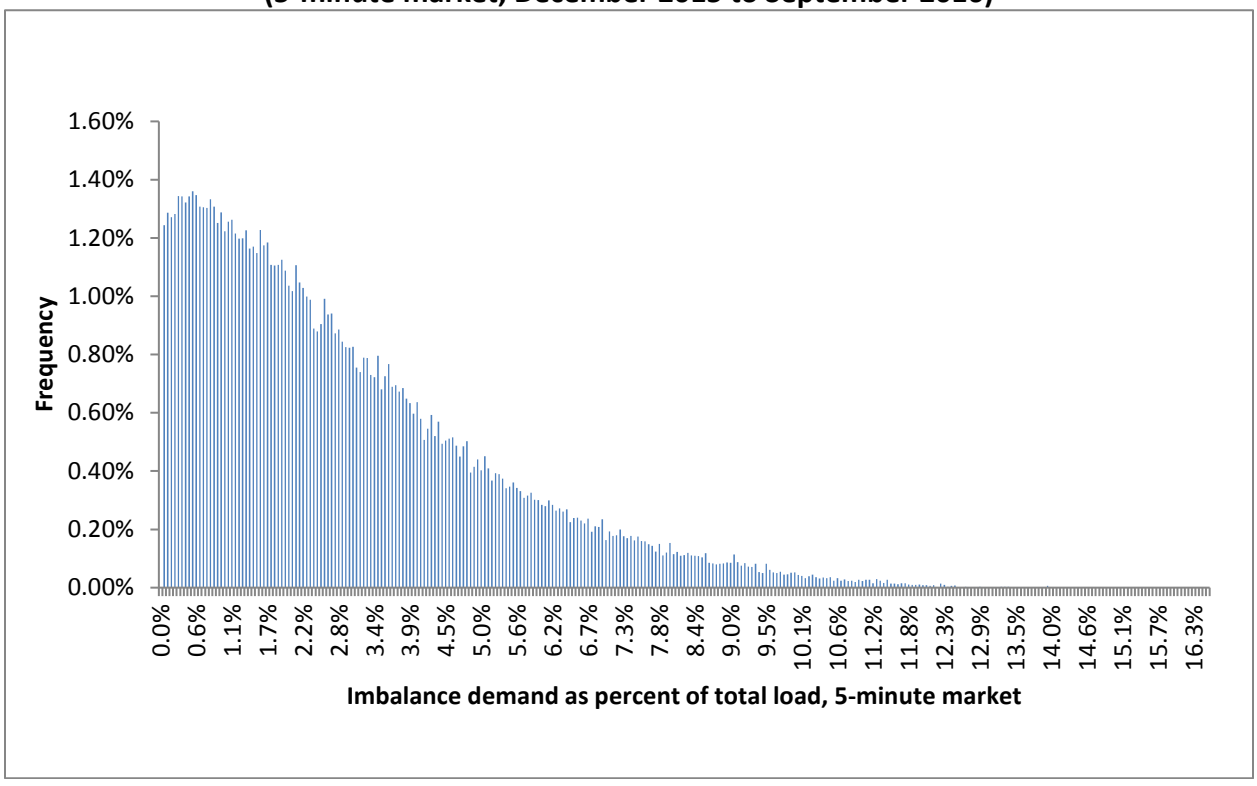


Table 1: Imbalance demand (MW)

Market	average	median	Intervals demand positive	Average positive demand	Percentiles 90th	95th	97th
15-minute	-46	-48	41.8%	176	252	347	415
5-minute	-16	-73	42.5%	375	581	811	944

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

Market	median	90th	95th	97th
15-minute	1.3%	3.5%	4.3%	4.8%
5-minute	2.3%	6.2%	7.6%	8.5%

3.2 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 BAA or one of its affiliates. In all EIM areas, all or most of the available competitive supply is from outside the EIM BAA. In the case of the three BHE BAAs in the EIM, a very small amount of generation in these BAAs that is controlled by one other entity has been offered in the EIM. We have excluded these resources in this analysis since this is a relatively small amount of generation and is controlled by a single entity. When these resources do participate in the EIM, this means more competitive supply was available than we calculate here.

In both the 15-minute and 5-minute markets, a significant amount of competitive supply from the ISO was available to be transferred into the BHE BAAs during the period of this analysis. As shown in Table 3, during 90 percent of 15-minute market intervals, the potential supply that could be transferred from the ISO into the BHE BAAs ranged from 1,117 MW up to 1,228 MW. This represents less than a 5 percent up or down deviation from the median.

In the 5-minute market the variation was wider. Transfer constraints in the 5-minute market more explicitly depend on interactions with surrounding BAAs. The interactions lead to slightly lower on average capacity and more variability.

Table 3: Competitive supply from ISO into BHE (MW)

Market	Percentiles 5th	50th	95th	97th
15-minute	1117	1178	1228	1228
5-minute	862	947	1147	1203

4 Structural market competitiveness

4.1 Pivotal supplier test

The pivotal supplier test for structural market power in EIM asks this question: could imbalance demand within the 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.

For the case of the BHE sellers, we test all three BAAs together by aggregating imbalance demand across the PacifiCorp East, PacifiCorp West, and NV Energy BAAs. The aggregated imbalance demand is compared to possible supply that could be transferred into these area from the ISO BAA.

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 combined BHE areas. When the level of competitive supply exceeds imbalance demand, BHE would be pivotal. Table 4 shows results of this analysis for each of the 10 months examined in this report.

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

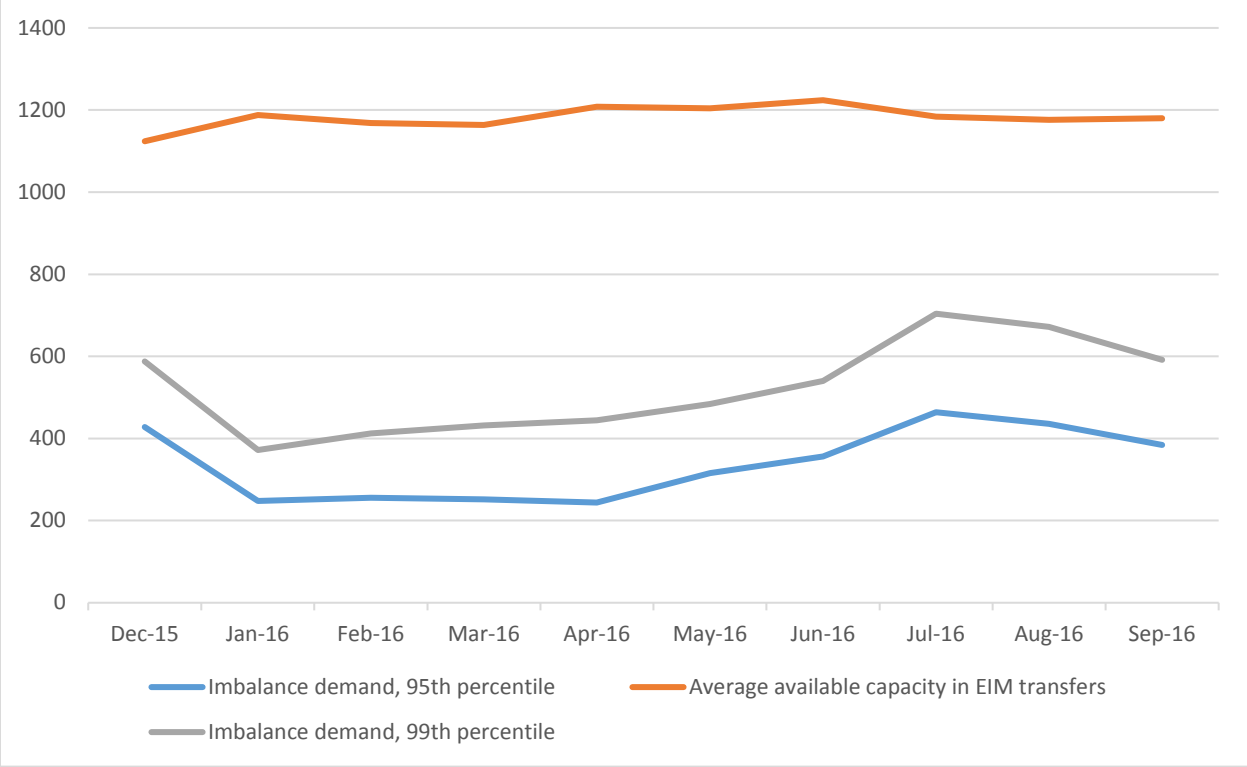
Month	Share of intervals with imbalance demand greater than transfer capacity	
	15-minute market	5-minute market
Dec-15	0.3%	1.8%
Jan-16	0.0%	2.6%
Feb-16	0.0%	0.3%
Mar-16	0.0%	2.0%
Apr-16	0.0%	3.0%
May-16	0.0%	1.8%
Jun-16	0.0%	2.8%
Jul-16	0.2%	1.6%
Aug-16	0.0%	1.6%
Sep-16	0.3%	0.3%

We can also summarize the structural competitiveness of the BHE BAAs in the EIM based on statistical values of supply and demand. Figure 5 and Figure 6 provide a comparison between average transfer capacity, representing competitive supply, and the 95th percentile of imbalance demand.[5]

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. In most months, average competitive supply is about three times as large as the 95th percentile of imbalance demand. For 7 of the 10 months in the study period, there were no 15-minute market intervals where imbalance demand was larger than available competitive supply. During the 3 months where this did occur, less than 0.3 percent of the intervals in each month contained conditions that could have led to the exercise of market power.

These results show that supply and demand conditions in the 15-minute market were competitive during more than 99% 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.

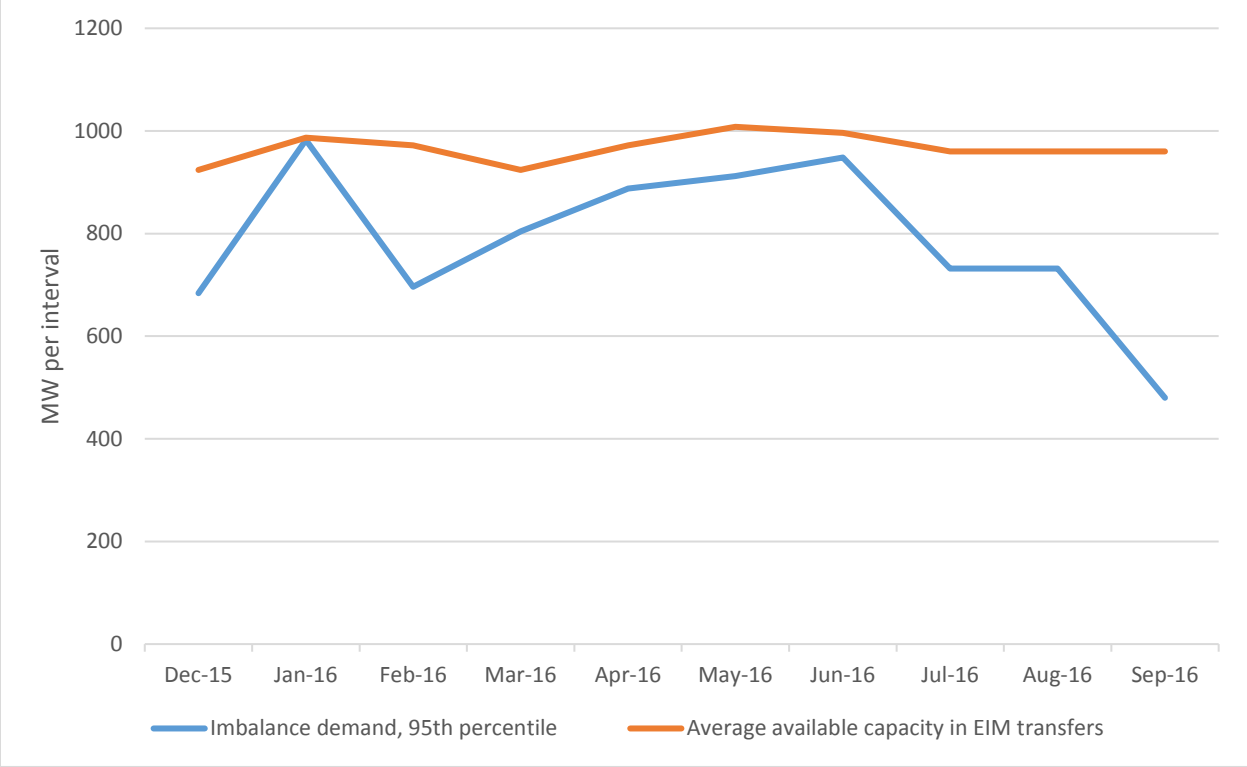
Figure 5: BHE imbalance demand and competitive supply (15-minute market)



[5] 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 in intervals with particularly tight supply conditions.

Fundamental supply and demand conditions in the 5-minute market are also competitive. Figure 6 shows that these conditions are tighter than in the 15-minute market, but that average competitive supply still meets the 95th percentile of demand in all months of the study period. Competitive supply exceeded imbalance demand in the vast majority of 5-minute intervals. In at least 97 percent of intervals in each month, the amount of EIM transfer capacity from the ISO exceeded total imbalance demand in the BHE area.

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



4.2 Market separation due to congestion

Another indicator that is often used to assess the structural competiveness 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 different BHE BAAs were separated by congestion from the ISO portion of the EIM, such that prices within the BHE BAAs were higher due to congestion on EIM transfer constraints between these areas and the ISO. [6] As shown in Figure 5, the frequency of price separation due to congestion limiting transfers into the BHE BAAs is extremely low. These results provide further evidence of the structural competitiveness of BHE BAAs.

Table 5: Frequency of price separation

	Share of intervals exhibiting price separation	
BAA	15-minute market	5-minute market
PACE	2.5%	2.3%
PACW	1.7%	4.1%
NEVP	2.4%	2.1%

4.3 Energy bid mitigation

During the relatively small number of intervals when BHE may be pivotal and competitive supply from the ISO into any of the BHE BAAs may be limited by congestion, this potential structural market power is mitigated by the ISO's real-time bid mitigation procedures. When these procedures are triggered by congestion in the real-time market, bids of all supply within a BAA that is separated from the ISO are automatically subject to cost-based bid limits.

The ISO 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. [7] With these enhancements, any potential market power can be effectively mitigated by these automated procedures. DMM will provide analysis the effectiveness of these procedures in separate future reports.

[6] 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.

[7] *2016 Annual Report on Market Issue and Performance*, Department of Market Monitoring, May 2017. pp. 20, 253-255, http://www.caiso.com/Documents/2016AnnualReportonMarketIssuesandPerformance.pdf

5 Conclusion

This paper describes a method used by DMM to evaluate the potential for market power in existing EIM areas. Our conclusion is that the combined BHE area is structurally competitive during almost all intervals in the EIM due to the amount of competitive that could be transferred into the BHE area from the ISO. As additional BAAs that are not affiliated with BHE join EIM, this additional transfer capacity and diversity of supply ownership should further increase the pool of competitive supply and make the EIM even more competitive.