



California ISO

California Independent System Operator Corporation

California ISO

**Structural competitiveness of the energy
imbalance market:**

Arizona Public Service Balancing Area

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Department of Market Monitoring

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1 Introduction

This report provides an analysis of structural market power in the energy imbalance market (EIM) within the Arizona Public Service (APS) balancing authority area (BAA) using data from the 24 month period December 1, 2017 to November 30, 2019. The report assesses the competitiveness of the APS area based on the amount of competitive supply that may be transferred into the APS 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 APS BAA.¹

Results of this analysis show that the EIM in the APS 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 APS 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 the BAA for competitive resources from outside areas. The limits of the transfers cap the amount of competitive supply that can be supplied from outside the BAA. In the EIM's 15 minute market and 5 minute market, competitive supply available to meet incremental

¹ The report uses the same method to assess structural market power in the EIM as was used in DMM's August 2019 analysis of the BAAs of Portland General Electric, Puget Sound Energy, Idaho Power, and the Berkshire Hathaway entities.

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 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 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.

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:

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

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

The 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.

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

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

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

2 Supply and demand in the energy imbalance market

For this report, DMM compiled the data described above for the APS BAA in the 24 month period from December 2017 through November 2019.

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 APS BAA for this 24 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 APS BAA. Table 1 and Table 2 provide summary statistics for these data.

As seen in Figures 1 and 3, demand for imbalance energy in the APS BAA on a 15-minute and 5-minute basis are roughly normally distributed. Imbalance demand in the 15-minute market averaged 78 MW per interval with a median value of 77 MW (see Table 1). The close values for the average and median suggest a symmetric distribution.

As shown in Table 1, the demand for imbalance energy was positive during about 75 percent of 15-minute intervals. During intervals with positive imbalance demand, the average imbalance demand was about 132 MW. Table 2 shows that the median imbalance demand in the 15 minute market about 3.1 percent in absolute value of total demand. Median imbalance demand as a share of total load was about 1.5 percent in the 5-minute market.

Table 1. Imbalance demand (MW)

Market	average	median	Intervals demand positive	Average positive demand	Percentiles		
					90th	95th	97th
15 minute	78	77	75%	132	235	294	336
5 minute	-19	-17	39%	63	83	127	160

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

Market	Median	90th	95th	97th
15 minute	3.1%	7.2%	8.9%	10.1%
5 minute	1.5%	4.8%	6.3%	7.4%

Figure 1. Demand for imbalance energy for the APS BAA (15-minute market, December 2017 to November 2019)

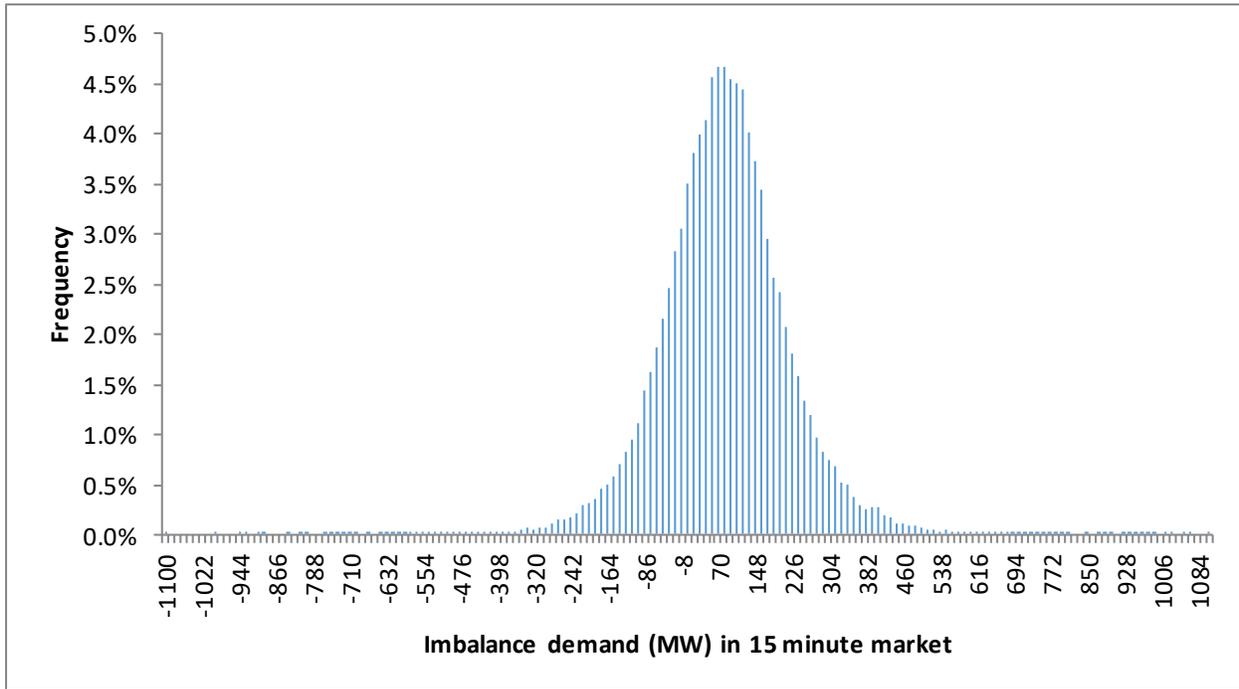


Figure 2. Imbalance energy demand compared to total load for the APS BAA (15-minute market, December 2017 to November 2019)

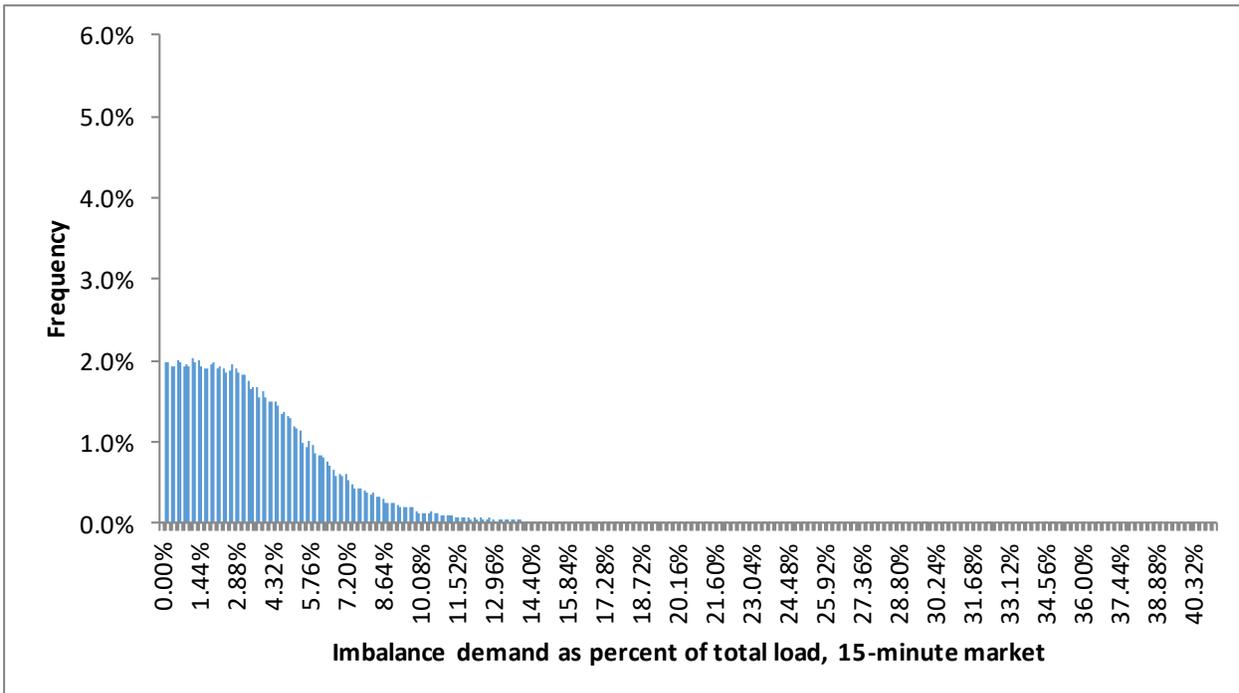


Figure 3. Demand for imbalance energy for the APS BAA (5-minute market, December 2017 to November 2019)

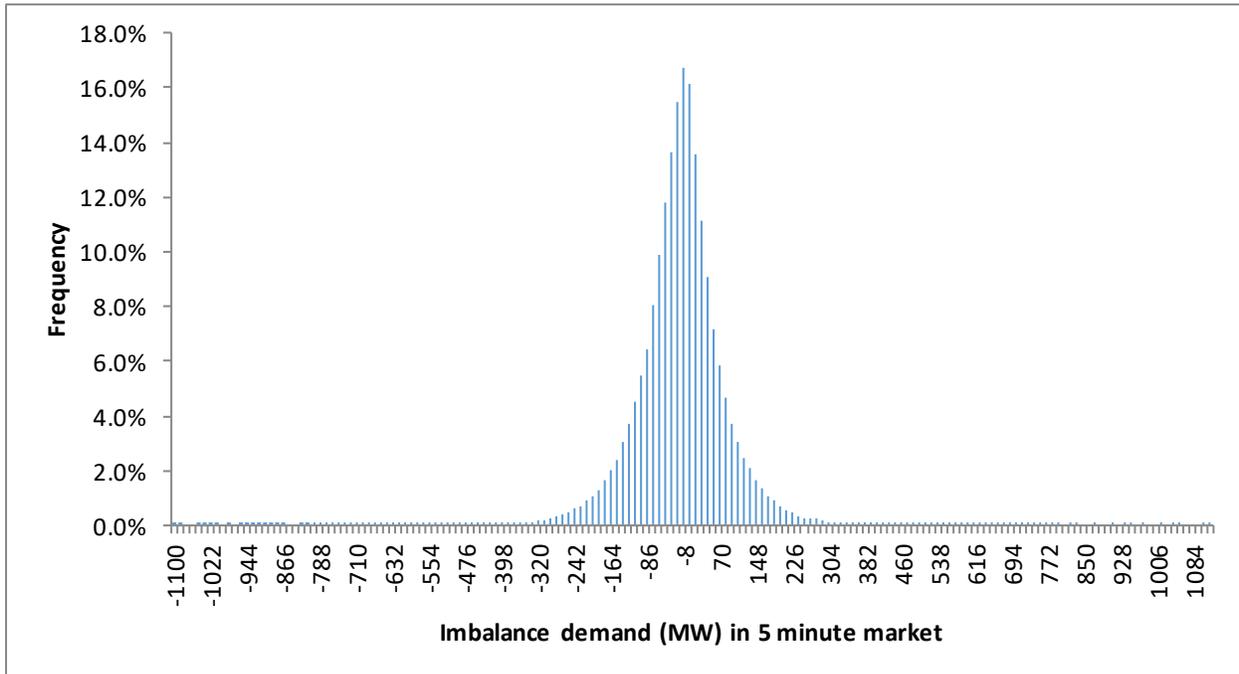
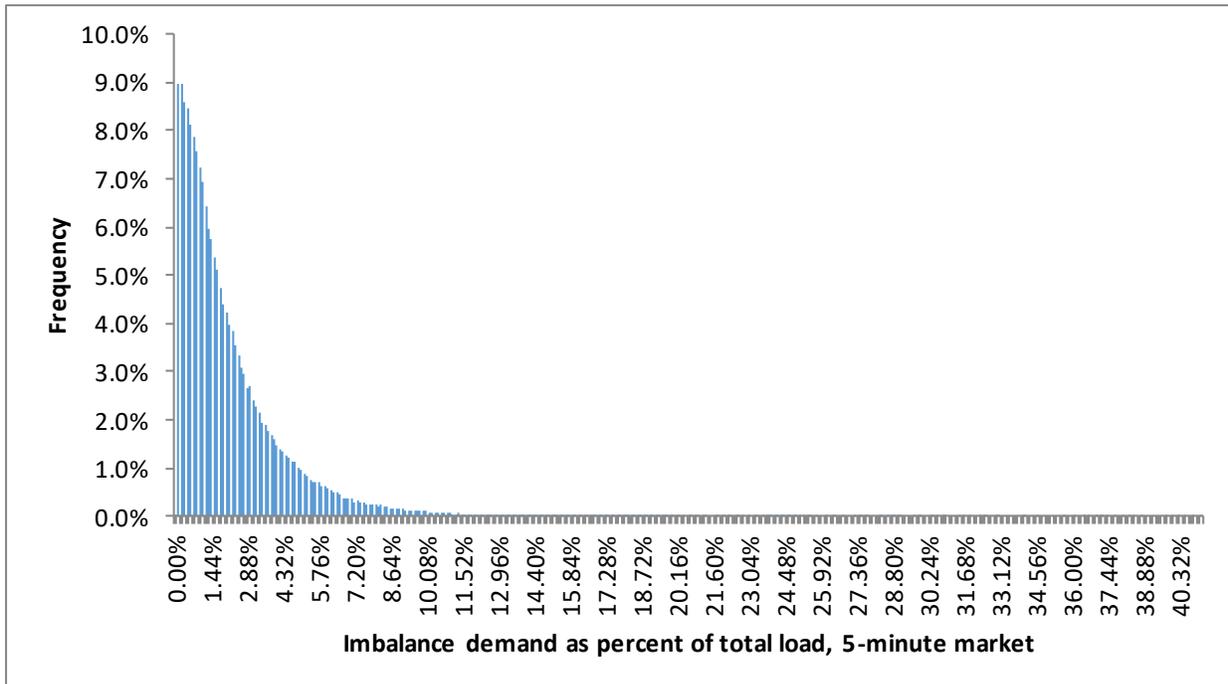


Figure 4. Imbalance energy demand compared to total load for the APS BAA (5-minute market, December 2017 to November 2019)



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.

As shown in Table 3, during more than 90 percent of intervals, total incremental transfer capacity into APS from any combination of other EIM BAAs was nearly ten times the 97th percentile of APS's imbalance demand in the 15-minute market. Similar results appear in the 5-minute market, with combined incremental transfer capacity into APS significantly exceeding the 97th percentile of imbalance demand in more than 90 percent of intervals. The analysis of total incremental import transfer capability demonstrates that considerable amounts of transfers have consistently been available relative to imbalance demand, with a majority of incremental import transfer capability coming from the CAISO area.

Table 3. Competitive supply from EIM into APS (MW)

Percentiles: 15 minute market					
Source	5th	10th	25th	median	90th
Total	1,274	1,512	1,912	2,407	3,261
ISO	670	831	1,158	1,508	2,117
NEVP	0	0	349	522	813
PACE	0	0	252	435	680

Percentiles: 5 minute market					
Source	5th	10th	25th	median	90th
Total	868	1,169	1,611	2,164	3,083
ISO	533	726	1,066	1,432	2,060
NEVP	0	0	342	516	809
PACE	0	0	0	226	569

² Supply that may be transferred into a BAA in the 15-minute EIM is the difference between the 15-minute transfer limit less any transmission needed between EIM areas for base schedules. Supply that may be transferred into a BAA in the 5-minute EIM is the difference between the 5-minute transfer limit less any transmission needed between EIM areas for final 15-minute EIM schedules.

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 the EIM BAA 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 APS is compared to additional competitive supply that could be transferred into the APS BAA from the CAISO area and other EIM BAAs that are not affiliated with APS.

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 APS BAA. When the level of competitive supply is below imbalance demand, APS would be pivotal. Table 4 shows results of this analysis for each of the 24 months examined in this report. The frequency of intervals where imbalance demand is greater than supply is generally quite low.

Table 4. Frequency that APS is pivotal in APS EIM BAA

Month	Share of intervals with imbalance demand greater than incremental transfer capacity	
	15-minute market	5-minute market
Dec-17	0.0%	0.0%
Jan-18	0.0%	0.0%
Feb-18	0.3%	1.1%
Mar-18	0.1%	0.7%
Apr-18	0.0%	0.2%
May-18	0.4%	1.1%
Jun-18	0.0%	0.2%
Jul-18	0.0%	0.1%
Aug-18	0.5%	0.2%
Sep-18	1.9%	0.8%
Oct-18	0.0%	0.0%
Nov-18	5.6%	0.0%
Dec-18	5.3%	0.0%
Jan-19	0.0%	0.0%
Feb-19	0.2%	0.2%
Mar-19	0.0%	0.0%
Apr-19	0.0%	0.0%
May-19	0.2%	0.0%
Jun-19	0.0%	0.0%
Jul-19	0.1%	0.1%
Aug-19	0.0%	0.0%
Sep-19	0.1%	0.0%
Oct-19	0.0%	0.0%
Nov-19	0.0%	0.0%

The structural competitiveness of the APS BAA 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

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 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 nine times as large as the 95th percentile of imbalance demand. In the closest months, average available supply is about four 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 APS 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 comparable to the 15-minute market. On average competitive supply still meets the 95th and 99th percentile of demand in all months of the study period. Competitive supply exceeded imbalance demand in the vast majority of 5-minute intervals. In more than 98 percent of 5-minute intervals in each month, the amount of incremental import transfer capacity from the EIM exceeded total imbalance demand in the APS area.

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

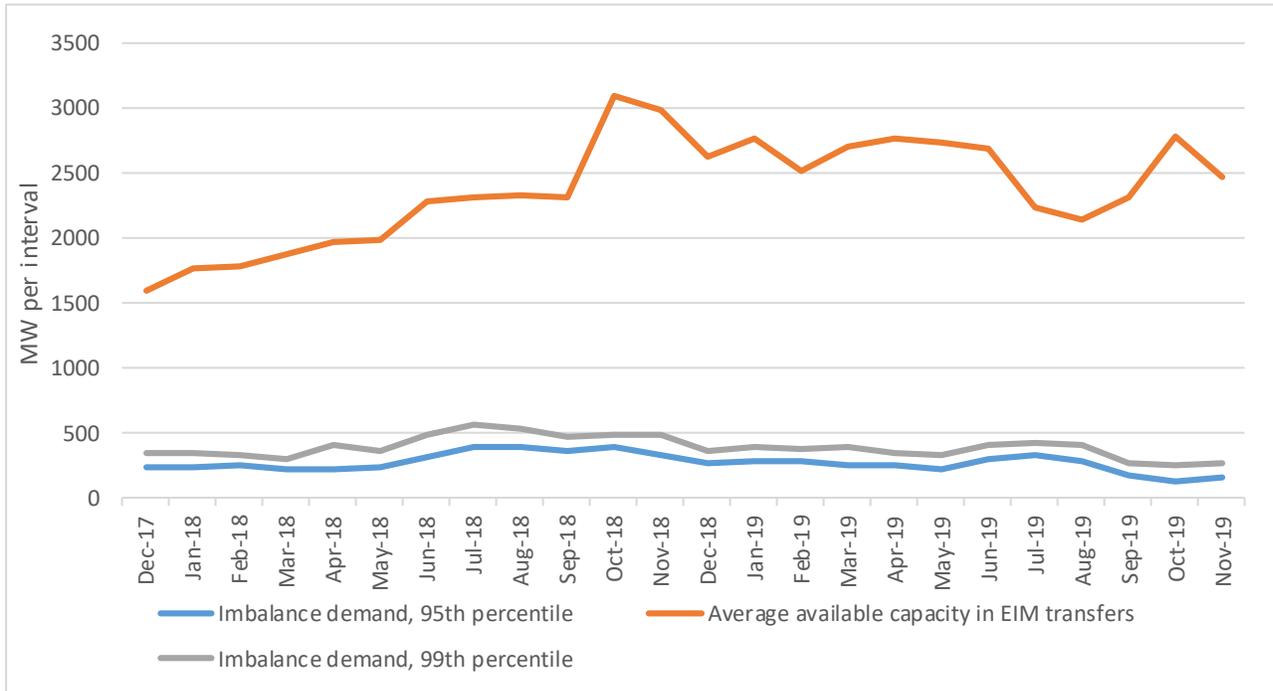
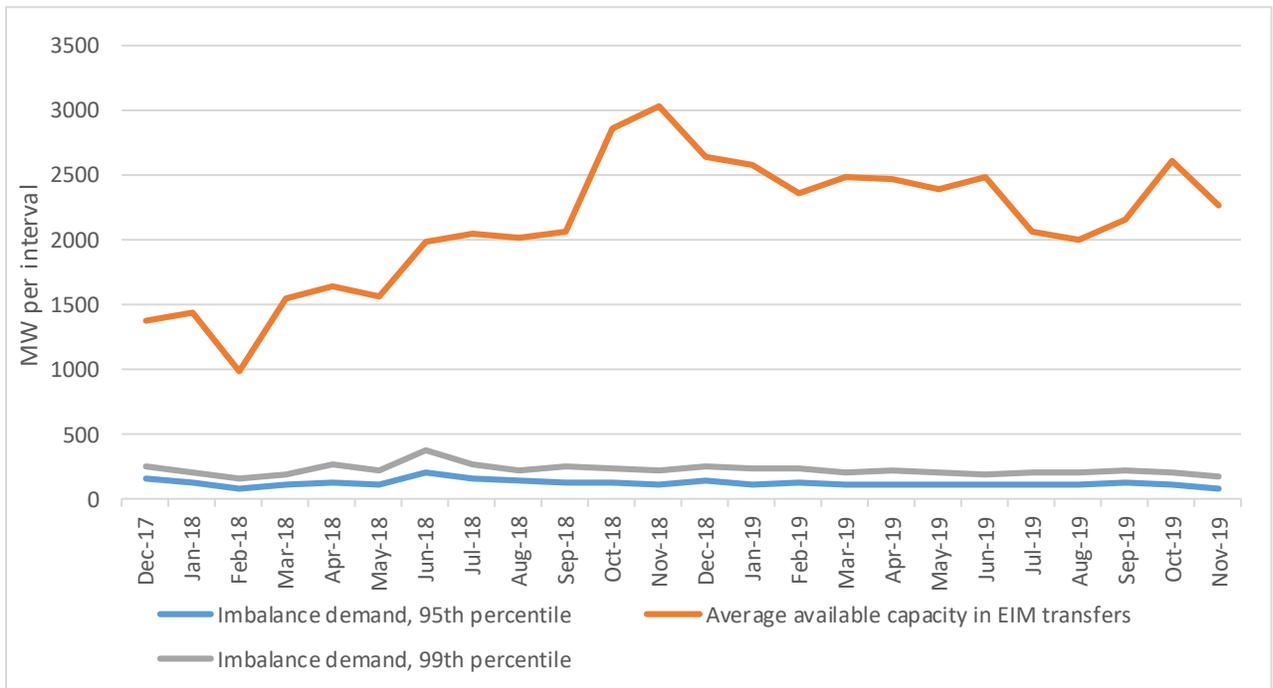


Figure 6: APS imbalance demand and competitive supply (5-minute market)



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 the APS BAA was separated by congestion from the rest of the EIM, such that prices within the APS BAA were higher due to congestion on EIM transfer constraints between the APS 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 APS BAA 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 the APS BAAs is low. Only 2.9 percent of intervals in the 15-minute market and 2.2 percent of intervals in the 5-minute market show price separation between APS and CAISO. 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

Table 5. Frequency of price separation (December 2017 to November 2019)

	Share of intervals exhibiting price separation	
	15-minute market	5-minute market
AZPS	2.9%	2.2%

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. Under-prediction of congestion into APS in the 5-minute market occurred in 3 percent of intervals, and only 2.2 percent of intervals had price separation in APS in the 5-minute market. This implies that 3 percent of 2.2 percent of total intervals ($.03 * .022 = .00066 = 0.066\%$) were unmitigated and potentially had prices set by an unmitigated bid. The values are comparable in the 15-minute market, which has more accurate prediction of congestion and a slightly higher frequency of price separation.

3.3 Energy bid mitigation

During the relatively small portion of intervals when APS may be pivotal and competitive supply from the CAISO and broader EIM into the APS 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. The percentage of missed mitigation intervals in the APS BAA is among the lowest of all EIM areas.

**Table 6: Accuracy of congestion prediction by region on EIM transfers, 15-minute market
December 1, 2017 – November 30, 2019⁷**

	Accurately predicted	Predicted but resolved	Under predicted
PACE	93%	4%	2%
PACW	92%	5%	3%
PGE	91%	6%	4%
BCHA	90%	7%	4%
PSEI	90%	6%	4%
IPCO	92%	5%	3%
NEVP	95%	3%	3%
AZPS	94%	4%	2%
BANC	88%	7%	5%

⁷ Data for BCHA and BANC begin in April 2018, corresponding with the dates that these entities began participation in EIM.

**Table 7: Accuracy of congestion prediction by region on EIM transfers, 5-minute market
December 1, 2017 – November 30, 2019⁸**

	Accurately predicted	Predicted but resolved	Under predicted
PACE	63%	33%	4%
PACW	63%	26%	10%
PGE	60%	30%	10%
BCHA	64%	30%	7%
PSEI	61%	30%	9%
IPCO	64%	30%	7%
NEVP	57%	38%	5%
AZPS	55%	42%	3%
BANC	63%	30%	7%

4 Conclusion

This report provides analysis by DMM evaluating the potential for market power in existing EIM areas. This analysis indicates that the APS BAA 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 APS 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 APS BAA is effectively mitigated when the APS area is separated by congestion from the CAISO and other EIM areas.

⁸ Data for BCHA and BANC begin in April 2018, corresponding with the dates that these entities began participation in EIM.