

May 1, 2017

The Honorable Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

**Re: California Independent System Operator Corporation
Docket: ER15-2565-_____**
**Independent Assessment by the Department of Market Monitoring
December 2016 Energy Imbalance Market Transition Period
Report – Arizona Public Service**

Dear Secretary Bose:

The Department of Market Monitoring (DMM) hereby submits its independent assessment on the transition period of Arizona Public Service (APS) during its first six months of participation in the Energy Imbalance Market (EIM) for December 2016. APS entered the EIM on October 1, 2016, and the transition period will apply to its balancing authority area until April 1, 2017.

Please contact the undersigned directly with any questions or concerns regarding the foregoing.

Respectfully submitted,

By: /s/ Eric Hildebrandt

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California ISO

Report on energy imbalance market issues and performance: Arizona Public Service December 2016

May 1, 2017

Prepared by: Department of Market Monitoring

Executive summary

Pursuant to the Commission's October 29, 2015 Order on the ISO's Energy Imbalance Market (EIM), the ISO filed a report on April 4, 2017 covering the period from December 1 through December 31, 2016 (December report) for the Arizona Public Service area in the energy imbalance market.¹ This report provides a review by the Department of Market Monitoring (DMM) of energy imbalance market performance in the Arizona Public Service area during the period covered in the ISO's December report.

This report includes a summary of the frequency of the downward flexible ramping sufficiency test, along with discussion of impacts this test had on market outcomes including power balance constraint relaxations for excess energy. DMM recommends the ISO consider adding this analysis to its future monthly reports. DMM will continue to work with the ISO to ensure that data reported in this report coincides with data reported by the ISO. Key findings in this report include the following:

- During December, Arizona Public Service continued to frequently fail flexible ramping sufficiency tests in the downward direction (22 percent of hours). This contributed to power balance constraint relaxations when generation exceeded forecast demand during about 2 percent of 15-minute and 5-minute market intervals. Had transition period pricing not been in place, prices in both real-time markets would have been lower by about \$3/MWh (12 percent).
- Arizona Public Service 15-minute and 5-minute prices tracked just below Southern California Edison area prices within the ISO during most hours. For Arizona Public Service during December, prices averaged around \$28/MWh and \$29/MWh for the 15-minute and 5-minute markets, respectively, while prices in the Southern California Edison area averaged around \$34/MWh and \$35/MWh during the same period. This price difference was mostly driven by the \$5/MWh greenhouse gas (GHG) costs applicable to energy deemed delivered to California.
- The ISO implemented a number of software improvements in December that eliminated almost all of the invalid sufficiency test failures during the latter part of the month. As a result, there were very few invalid power balance constraint relaxations.
- The frequency of valid under-supply infeasibilities was relatively low during December as the number of intervals that Arizona Public Service failed the upward flexible ramping sufficiency test.
- Without special transition period pricing provisions in place, the frequency of intervals in which the load bias limiter would have triggered increased from the previous month in the 5-minute market. The majority of intervals that this occurred were intervals when supply exceeded demand, and thus prices with the load bias limiter would have been about \$0.70/MWh higher than prices without this feature.

Section 1 of this report provides a description of prices and power balance constraint impacts, section 2 discusses the load bias limiter, and section 3 discusses the flexible ramping sufficiency test.

¹ The ISO's December 2016 Report was filed at FERC and posted on the ISO website on April 4, 2017, http://www.caiso.com/Documents/Apr4_2017_EIMInformationalReport-TransitionPeriod_ArizonaPublicService_Dec2016_ER15-2565.pdf.

1 Energy imbalance market prices

Figure 1.1 and Figure 1.2 show hourly average 15-minute and 5-minute prices, respectively, during December in the Arizona Public Service and Southern California Edison areas, as well as the bilateral prices DMM used as an additional benchmark for energy imbalance market prices.

The bilateral price benchmark includes peak and off-peak prices at various trading hubs using day-ahead ICE indices that are representative of Arizona Public Service's pricing for settling imbalance prior to EIM implementation. The bilateral price benchmark reflects average prices at three major western trading hubs: Mead, Palo Verde, and Four Corners.

In the Arizona Public Service area during the month, prices averaged about \$28/MWh and \$29/MWh in the 15-minute and 5-minute market, respectively. In comparison, Southern California Edison load aggregation area 15-minute prices averaged around \$34/MWh while 5-minute prices averaged around \$35/MWh during the month.

Average 15-minute and 5-minute prices in Arizona Public Service during the month were about \$5/MWh less than prices in the ISO during almost all hours of the day. When energy from Arizona Public Service is deemed delivered into the ISO, the greenhouse gas costs cause prices to be about \$5/MWh lower in Arizona Public Service than in the ISO, which explains most of the price differences observed in the real-time markets. Additional price deviations occurred mostly when export capability was limited during intervals when that area failed the downward flexible ramping sufficiency test. In the 15-minute market this was noticeable during times when load was low and the average prices in the ISO were lowest, during hours ending 5 and 14.

Figure 1.1 Average hourly 15-minute price – Arizona Public Service

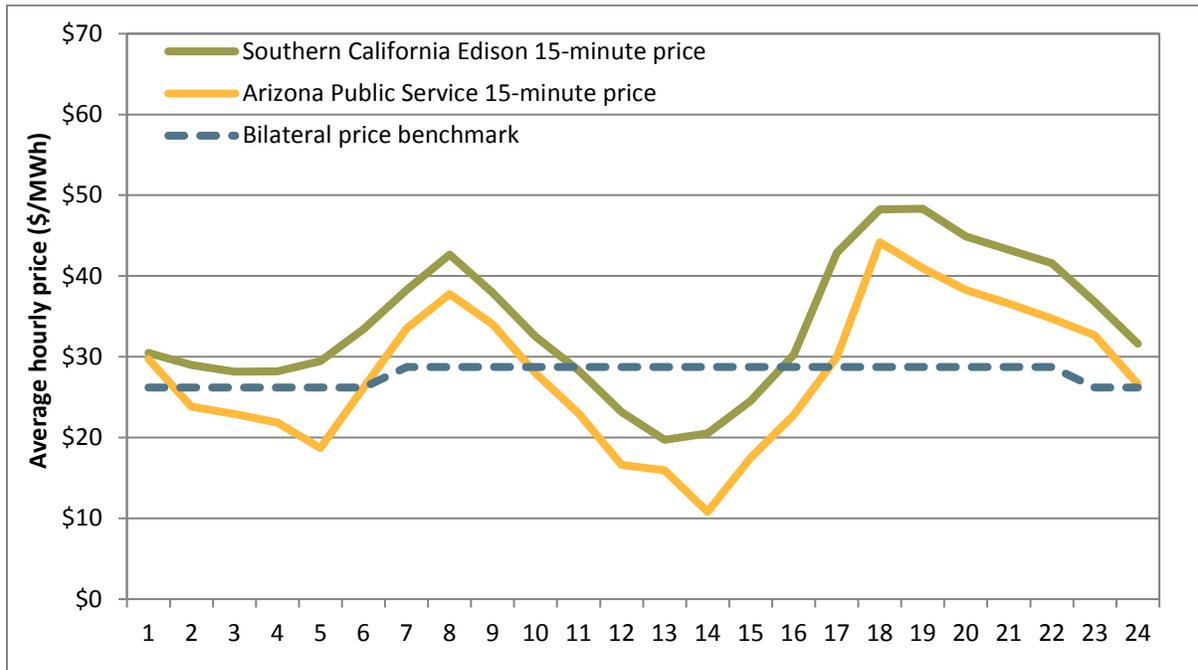
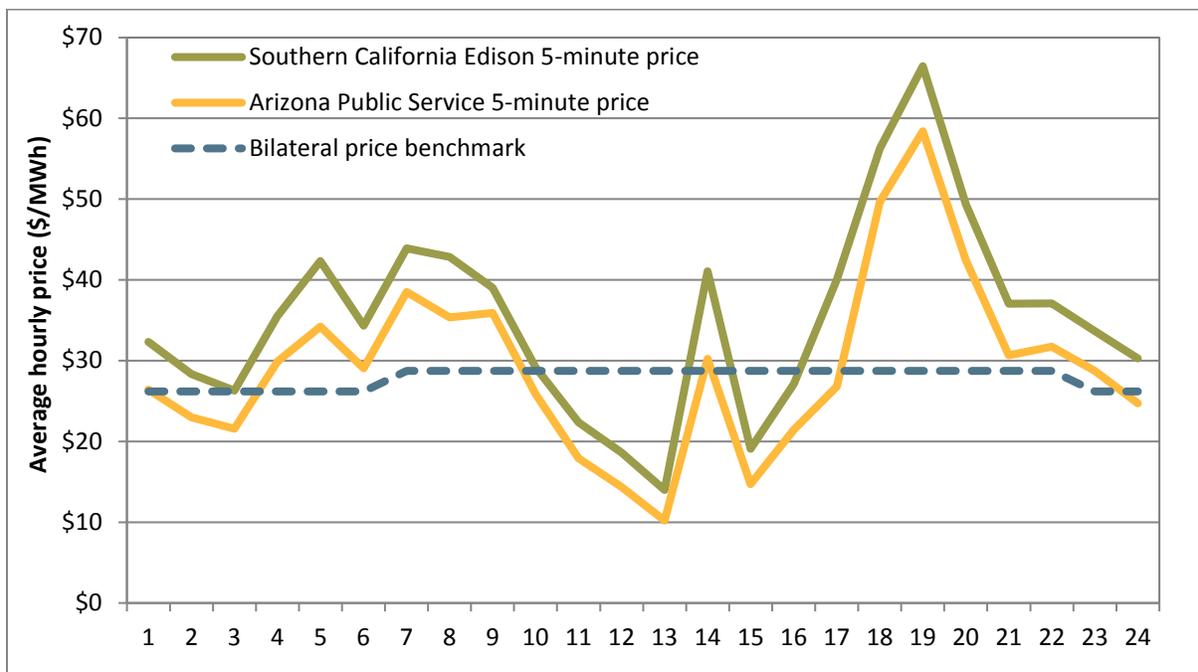


Figure 1.2 Average hourly 5-minute price – Arizona Public Service



When any energy imbalance market area fails the downward flexible ramping sufficiency test, exports are limited to base schedules, and for Arizona Public Service this frequently contributed to power balance constraint relaxations for excess supply during December.²

Figure 1.3 through Figure 1.6 show the frequency of power balance constraint relaxations in the 15-minute and 5-minute markets by week. All power balance constraint relaxations that occurred in December are subject to the six-month transition period pricing that expired in April 2017. This feature sets prices equal to the last economic unit dispatched instead of the \$1,000/MWh penalty parameter while relaxing the constraint for shortages or the -\$155/MWh penalty parameter while relaxing the constraint for excess energy. Power balance constraint relaxations in Arizona Public Service during December can be grouped in the following categories:

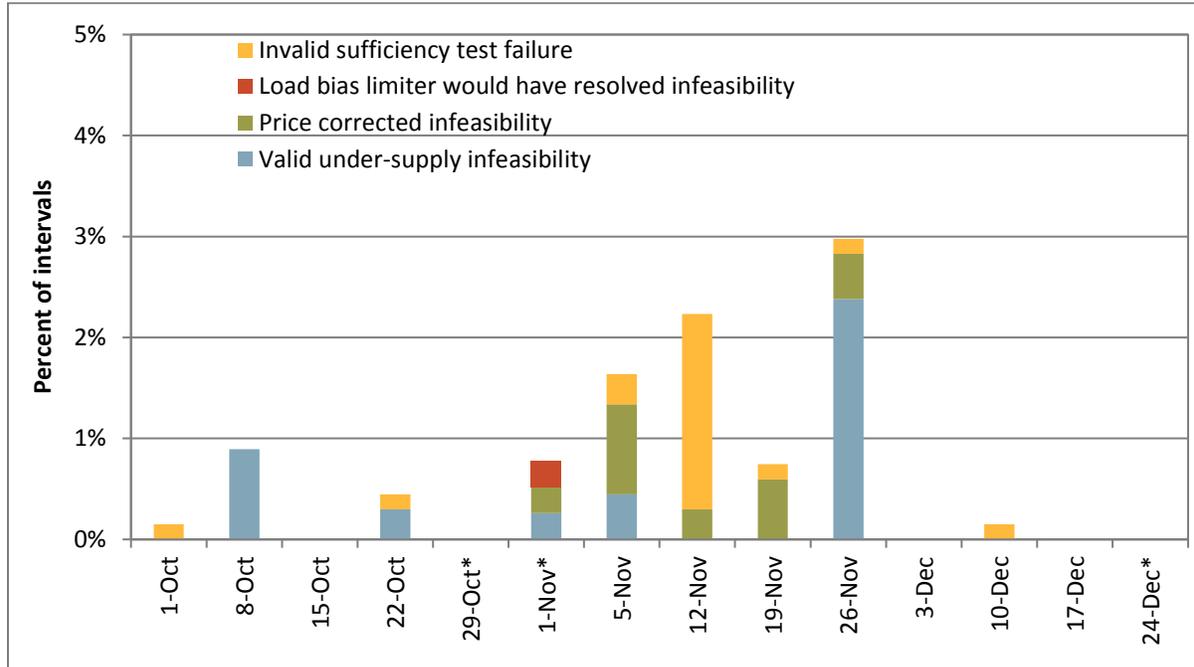
- **Valid under-supply infeasibility** (power balance constraint shortage). These occurred when the power balance constraint was relaxed because load exceeded available generation. The ISO validated that ISO software was working appropriately during these instances.
- **Valid over-supply infeasibility** (power balance constraint excess). These occurred when the power balance constraint was relaxed because generation exceeded load. The ISO validated that ISO software was working appropriately during these instances.
- **Load bias limiter would have resolved infeasibility.** These occurred when a load adjustment entered by Arizona Public Service operators exceeded the amount of power balance constraint relaxation and the load adjustment was in the same direction. During the transition period, the impacts of the load bias limiter did not change price outcomes because transition period pricing was applied during these intervals. However, in these cases, the load bias limiter would have reduced the operator adjustment in the pricing run to prevent the infeasibility had transition period pricing not been in effect.
- **Invalid sufficiency test failure.** These occurred when the ISO software relaxed the power balance constraint during an hour when the area also failed the flexible ramping sufficiency test (either upward or downward). However, unlike valid infeasibilities, the ISO later identified the result as invalid because of an underlying issue with the accuracy of the test, such as incorrect accounting of the area's flexible capability.³
- **Price corrected infeasibility.** These occurred when a power balance constraint was relaxed, and the resulting prices were corrected by the ISO afterwards under Section 35 of the ISO tariff.⁴

² When a balancing area fails the flexible ramping sufficiency test, energy imbalance area transfers are limited. When an area fails the downward flexible ramping sufficiency test for a specific hour, exports are limited to the higher of the base schedule or the optimal transfer from the prior hour. If an area fails the upward flexible ramping sufficiency test, imports are limited similarly. These rules were implemented to prevent any energy imbalance market area from leaning on other areas for ramping resources.

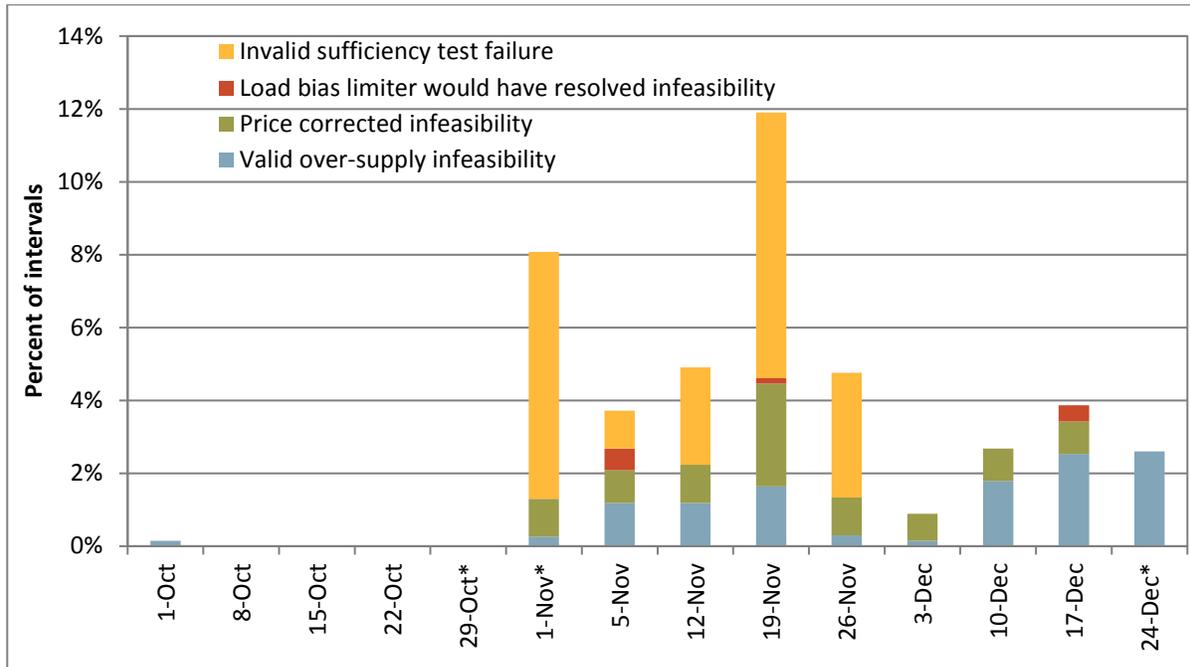
³ The ISO maintains that some invalid sufficiency test failures do not necessarily invalidate power balance constraint relaxations. In particular, several consecutive hours of invalid sufficiency test failures on November 12 resulted in under-supply infeasibilities in the 15-minute and 5-minute markets. These infeasibilities were flagged as valid by the ISO because they would have been essentially infeasible regardless of the result of the sufficiency test. DMM treats all power balance constraint relaxations during hours with invalid sufficiency test failures as invalid infeasibilities throughout this report.

⁴ Section 35 of the ISO tariff provides the ISO authority to correct prices if it detects an invalid market solution or prices because of issues including data input failure, occurrence of hardware or software failure, or a result inconsistent with the ISO tariff.

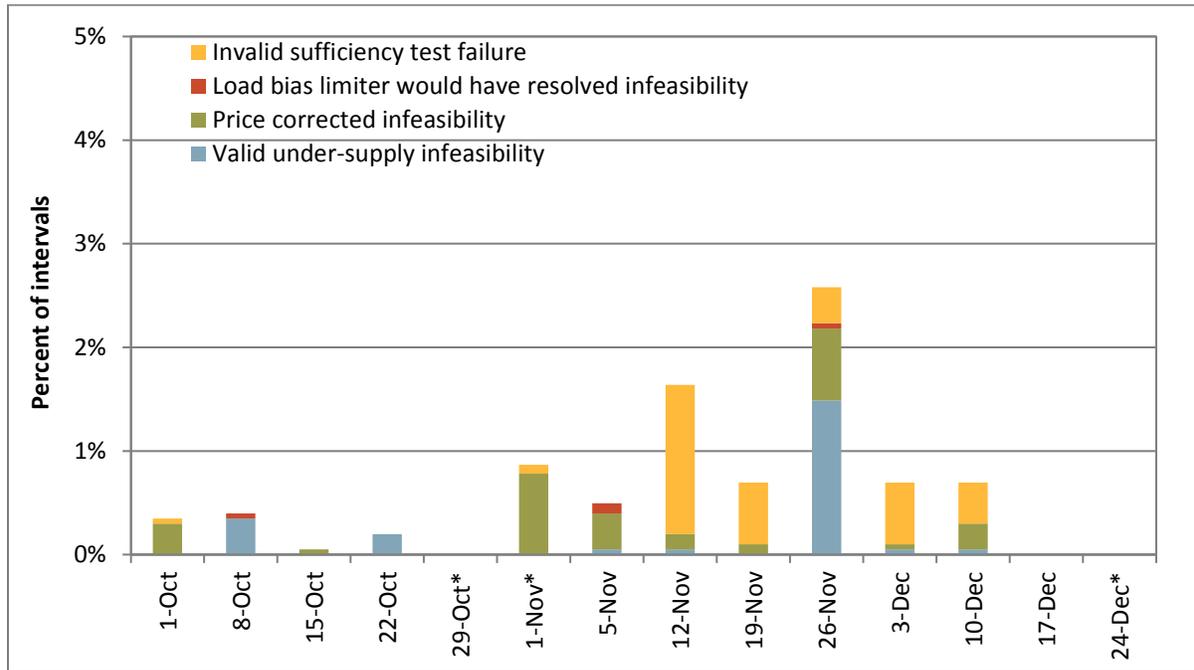
**Figure 1.3 Frequency of under-supply power balance infeasibilities by week
Arizona Public Service (15-minute market)**



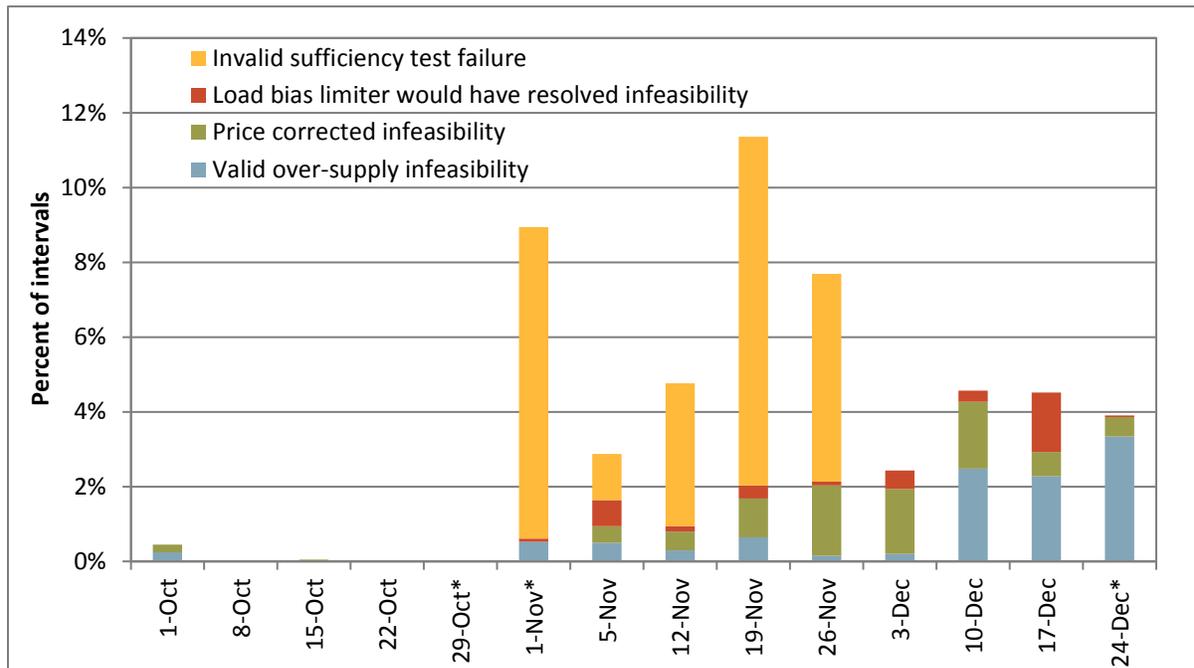
**Figure 1.4 Frequency of over-supply power balance infeasibilities by week
Arizona Public Service (15-minute market)**



**Figure 1.5 Frequency of under-supply power balance infeasibilities by week
Arizona Public Service (5-minute market)**



**Figure 1.6 Frequency of over-supply power balance infeasibilities by week
Arizona Public Service (5-minute market)**



The number of invalid flexible ramping sufficiency test failures identified by the ISO during the price validation process and related infeasibilities decreased significantly during December. As shown in these figures, the frequency of valid under-supply infeasibilities in the Arizona Public Service area decreased during December from the previous month while the frequency of valid over-supply infeasibilities increased. Almost all of these infeasibilities occurred during hours when the area failed the flexible ramping sufficiency test. In particular, Arizona Public Service failed the downward sufficiency test frequently, which limited exports and contributed to over-supply infeasibilities.

In past DMM reports, price corrected infeasibilities were assumed to be invalid because of the underlying error that caused the infeasibility. However, the ISO has indicated that many of the corrections during November and December were used to address issues with the transition period pricing mechanism when infeasibilities were still valid. Specifically, when transition pricing provisions were triggered by power balance constraint relaxations, shadow prices associated with the flexible ramping product were not always set to \$0/MWh as intended, which allowed the market software to use the last economic bid. Price corrections for these results were entered by the ISO as a result. The ISO implemented a fix for this issue on December 12, 2016.

Figure 1.6 and Figure 1.7 show the average weekly prices in the 15-minute market and 5-minute market *with* and *without* the special transition period pricing provisions applied to mitigate prices in the Arizona Public Service area during December. These figures also include the average bilateral price benchmark for comparison to Arizona Public Service prices, depicted by the dashed blue lines. For this analysis, the estimated price without transition period pricing is calculated as follows:

- When the power balance constraint was relaxed for an energy shortage and the conditions for the load bias limiter were not met, we assume prices would be \$1,000/MWh minus estimated losses, which averaged around 3 percent during these intervals.
- When the power balance constraint was relaxed in the market software for an excess of energy and the conditions for the load bias limiter were not met, it is assumed prices would be -\$155/MWh plus estimated losses, which also averaged around 3 percent during these intervals.
- When the load bias limiter would have triggered, the counterfactual price would be equal to the actual price that resulted with transition period pricing in effect.
- When the power balance constraint was relaxed under conditions that triggered a price correction and the flexible ramping sufficiency test result was valid, then these intervals were treated as *valid* infeasibilities because the corrections were primarily to account for issues with the transition period pricing mechanism rather than an underlying error that produced the infeasibility. As such, penalty parameters were included in the counterfactual price when the conditions for the load bias limiter were not met. Because some of these infeasibilities may have been invalid, this may overestimate the impact of transition period pricing.
- Otherwise, when the power balance constraint was relaxed following an underlying issue including an invalid failure of the sufficiency test, then these intervals were treated as *invalid* infeasibilities and the penalty parameters were not included in the counterfactual price. The ISO has indicated that an invalid failure of the flexible ramping sufficiency test does not necessarily indicate an invalid power balance constraint relaxation. To the extent that some of these infeasibilities should be valid, this may underestimate the impact of transition period pricing.

Figure 1.7 Average prices by week – Arizona Public Service (15-minute market)

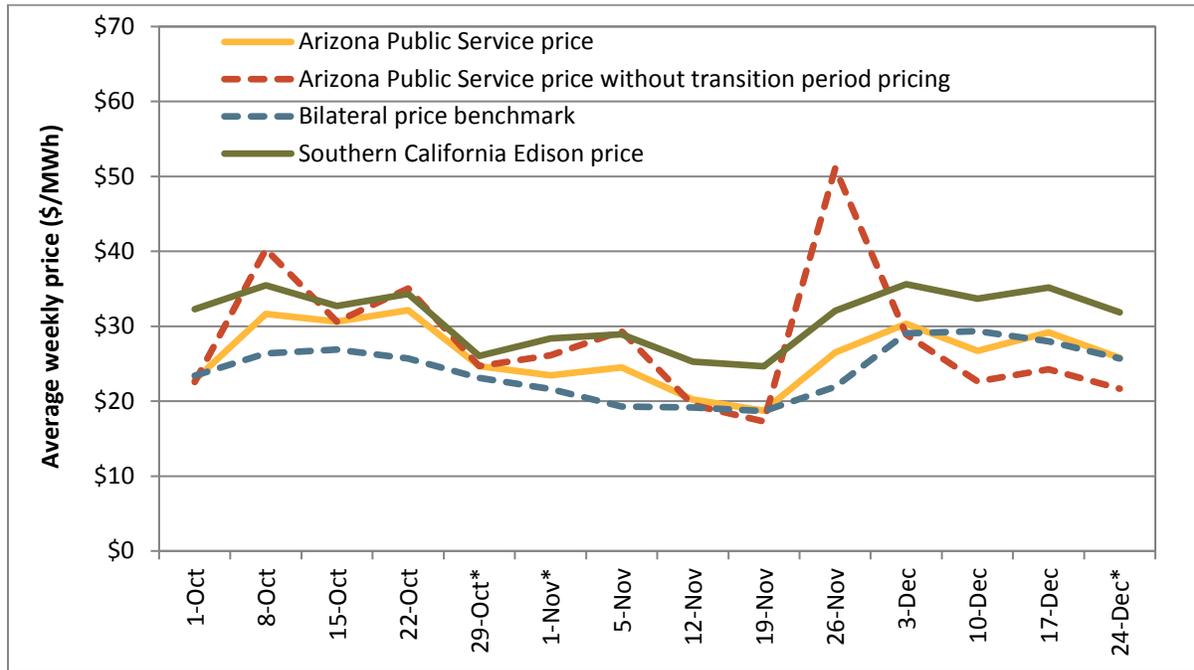
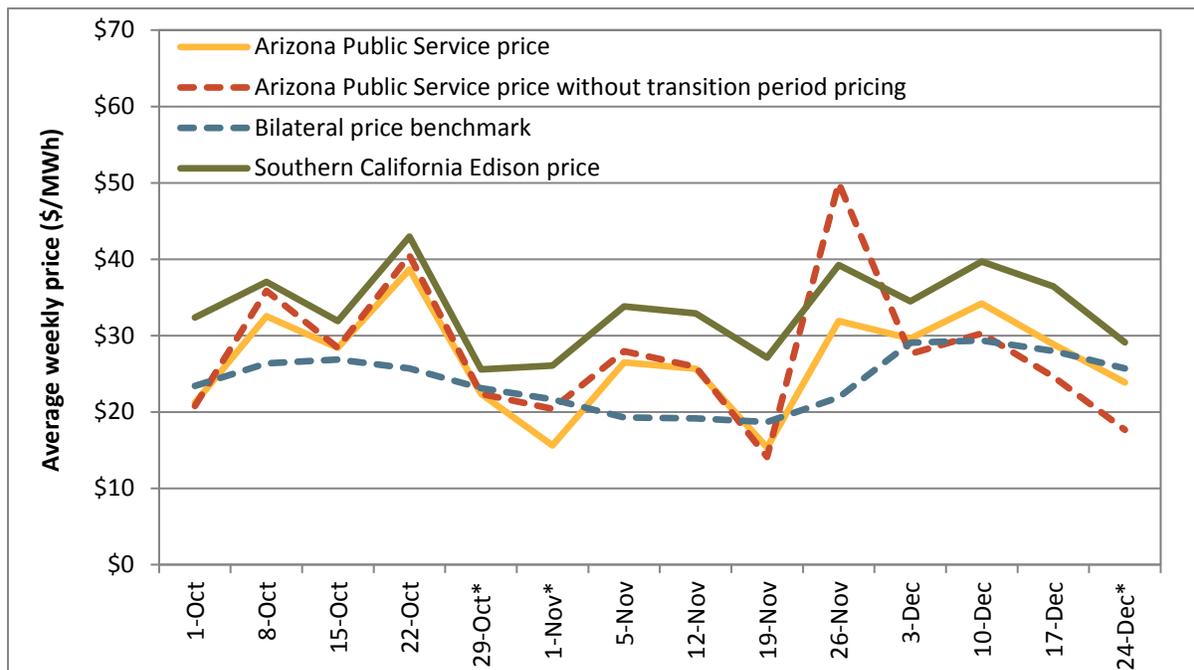


Figure 1.8 Average prices by week – Arizona Public Service (5-minute market)



Prices with and without transition period prices diverged somewhat during December because of over-supply infeasibilities in the 15-minute and 5-minute markets. This caused average prices without price discovery to be about \$3/MWh lower than prices with price discovery in the 15-minute and 5-minute markets. As a result, prices without transition period pricing tracked about \$9/MWh below Southern California Edison prices during the month.

2 Load bias limiter

When the load bias limiter is triggered it has the same effect as the transition period pricing feature and causes prices to be set by the last economic bid dispatched rather than the \$1,000/MWh penalty price for under-supply power balance relaxations and -\$155/MWh penalty price for over-supply power balance relaxations. A more detailed description of the load bias limiter is included in DMM’s April 2015 report.⁵ The ISO also included a discussion of the load bias limiter in its answer to comments regarding available balancing capacity on November 24, 2015.⁶

Table 2.1 shows the average 15-minute and 5-minute market price with transition period pricing as well as counterfactual estimates for prices without transition period pricing and without either transition period pricing or the load bias limiter. The estimates for the counterfactual prices use the same methodology discussed in the previous section.

The frequency of intervals in which both the power balance constraint was relaxed and the load bias limiter would have triggered increased from the previous month for Arizona Public Service in the 5-minute market. The majority of intervals in which these conditions were met occurred because of over-supply conditions. As a result, hypothetical 5-minute market prices with only the load bias limiter would have been about \$0.67/MWh higher than prices without the load bias limiter and transition period pricing. In the 15-minute market, the load bias limiter would have been triggered during four intervals when the power balance constraint was relaxed for over-supply conditions such that the load bias limiter would have increased 15-minute prices by about 1 percent had the load bias limiter been in place and not transition period pricing.

Table 2.1 Impact of load bias limiter on Arizona Public Service prices (December 2016)

	Average proxy price	Price with transition period pricing	Estimated price without transition period pricing	Estimated price without transition period pricing or load bias limiter	Potential impact of load bias limiter	
					Dollars	Percent
<i>Arizona Public Service</i>						
15-minute market (FMM)	\$27.89	\$27.80	\$24.25	\$24.06	\$0.19	0.8%
5-minute market (RTD)	\$27.89	\$29.24	\$26.12	\$25.45	\$0.67	2.6%

⁵ Report on Energy Imbalance Market Issues and Performance, Department of Market Monitoring, April 2, 2015, pp.34-35. http://www.caiso.com/Documents/Apr2_2015_DMM_AssessmentPerformance_EIM-Feb13-Mar16_2015_ER15-402.pdf.

⁶ Answer of the California Independent systems Operator Corporation to Comments, November 24, 2015, pp. 13-21. http://www.caiso.com/Documents/Nov24_2015_Answer_Comments_AvailableBalancingCapacity_ER15-861-006.pdf.

3 Flexible ramping sufficiency test

The flexible ramping sufficiency test ensures that each balancing area has enough ramping resources over an hour to meet expected upward and downward ramping needs. The test is designed to ensure that each energy imbalance market area has sufficient ramping capacity to meet real-time market requirements without relying on transfers from other balancing areas. This test is performed prior to each operating hour.

When the energy imbalance market was initially implemented there was an upward flexible ramping sufficiency test. In November 2016, the ISO implemented an additional downward ramping sufficiency test in the market with the introduction of the flexible ramping product, which replaced the flexible ramping constraint. These tests are designed to ensure that there is sufficient resource capacity available to meet forecasts and net exports for any given hour. Therefore, the test is implemented so that if an area fails the upward sufficiency test, energy imbalance market transfers are frozen and cannot be increased above base schedules.⁷ Similarly, if an area fails the downward sufficiency test exports cannot be increased. In addition to the sufficiency test, each area is also subject to a capacity test. If an area fails the capacity test, then the flexible ramping sufficiency test fails as a result.

Unlike the flexible ramping constraint, the demand for flexible ramping product is set by a demand curve, rather than a single target. With the implementation of the flexible ramping product the ISO began using the maximum requirement from the demand curve for the sufficiency test, instead of the old targets.⁸ DMM asked the ISO to reconsider how it uses the requirement from the demand curve and how the flexible ramping credit is calculated.

Limiting transfers can impact the frequency of power balance constraint relaxations and thus price separation across balancing areas. Almost all of the power balance constraint relaxations in the Arizona Public Service area occurred during hours when the area failed the flexible ramping sufficiency test in December. Constraining transfer capability may also impact the efficiency of the energy imbalance market by limiting transfers into and out of a balancing area that could potentially provide benefits to other balancing areas.

Figure 3.1 shows the frequency that Arizona Public Service failed the sufficiency test in the upward or downward direction. In addition, the chart shows the number of hours where an underlying issue caused the sufficiency test to fail. For Arizona Public Service in December, the frequency of valid upward sufficiency test failures decreased slightly while the frequency of valid downward sufficiency test failures increased from the previous month. This includes 53 hours that the sufficiency test failed in the upward direction and 161 hours in which the sufficiency test failed in the downward direction, or

⁷ Business Practice Manual for the Energy Imbalance Market, August 30, 2016, p. 45-52:

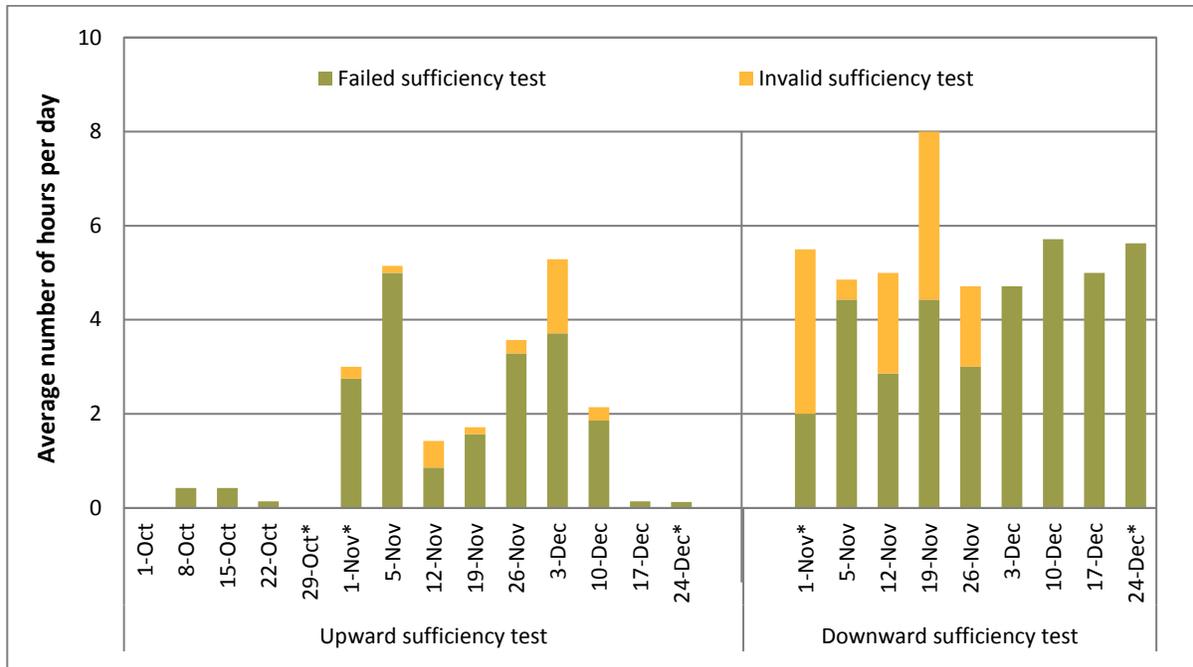
https://bpmcm.aiso.com/BPM%20Document%20Library/Energy%20Imbalance%20Market/BPM_for_Energy%20Imbalance%20Market_V6_clean.docx.

⁸ For further detail, see DMM's presentation on January 18, 2017 by Keith Collins to the Market Performance and Planning forum on the calculation of the flexible ramping sufficiency requirement: http://www.aiso.com/Documents/Agenda-Presentation-MarketPerformance-PlanningForum_Jan18_2017.pdf.

failures in about 29 percent of all hours. The ISO listed multiple reasons for the high frequency of failed flexible ramping sufficiency tests in its December report.⁹

In addition, the number of sufficiency tests in the downward direction that failed because of an underlying issue decreased significantly during December. This was related to several enhancements and fixes that were created in the market software during November and December to ensure that the inputs for the test were being calculated correctly.

Figure 3.1 Arizona Public Service flexible ramping sufficiency test results



⁹ These are listed in the ISO’s December 2016 Report: http://www.caiso.com/Documents/Apr4_2017_EIMInformationalReport-TransitionPeriod_ArizonaPublicService_Dec2016_ER15-2565.pdf.

CERTIFICATE OF SERVICE

I certify that I have served the foregoing document upon the parties listed on the official service list in the captioned proceedings, in accordance with the requirements of Rule 2010 of the Commission's Rules of Practice and Procedure (18 C.F.R. § 385.2010).

Dated at Folsom, California this 1st day of May, 2017.

/s/ Grace Clark
Grace Clark