Attachment A – Examples of Convergence Bidding and Local Market Power Mitigation

This attachment provides a series of examples illustrating the potential impacts of various convergence biding strategies under the Local Market Power Mitigation (LMPM) provisions incorporated in the CAISO's MRTU market design.[1]

Base Case (Without Virtual Bids)

The following examples are based on a hypothetical supplier controlling a generation portfolio within a load pocket, in which the supplier has significant locational market power. The table below shows the Integrated Forward Market (IFM) bids and Default Energy Bids (DEB) of the seven units owned by the supplier within the load pocket. In each of the following examples, it is assumed that the DEBs equal the generator's actual marginal costs. [2]

Table A0. Hypothetical Generation Portfolio within Load Pocket

Unit	MW	DEB	Bid
1	200	$15	$35
2	200	$25	$45
3	200	$35	$55
4	200	$45	$65
5	200	$55	$75
6	200	$65	$145
7	200	$75	$145

In this base case scenario, there are not virtual bids, so that the pre-IFM LMPM process and the IFM area based only on physical supply bids. The examples also assume that all pre-IFM LMPM runs are based on the CAISO's Day Ahead demand forecast, as will occur under the initial MRTU market design. However, it should be noted that FERC has directed the CAISO to consider modifying the LMPM to be based on bid in demand as part of a future MRTU release.

Under the LMPM provisions incorporated in the CAISO's MRTU market design, the first pass of the pre-IFM LMPM process is conducted with only the competitive constraints of the CAISO system enforced (the CC run). The LMPM routine is then run a second time with all constraints enforced (the AC run). Any unit that has additional capacity dispatched in the AC run that was not dispatched in the CC run is then subject to bid mitigation under LMPM.

As shown in Figure A1, this example assumes that about 720 MW of the generator's capacity within the load pocket would be dispatched in the CC run (i.e. bids from Units 1 through 4), while 1,100 MW of the generators capacity would be dispatched the AC run (Unit 1 through 6).

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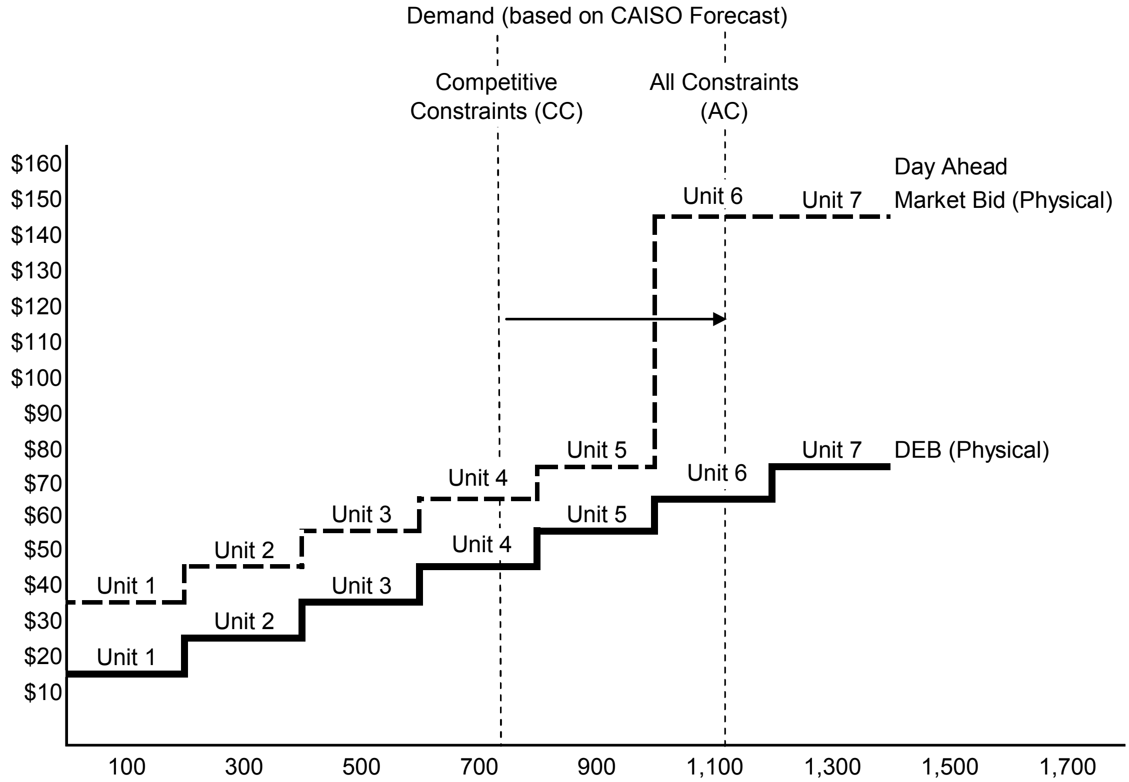
[1] The original presentation of these examples given at the 10 August 2007 CAISO Market Surveillance Committee meeting can be found at the following link: http://www.caiso.com/1c33/1c33cc343d230.pdf

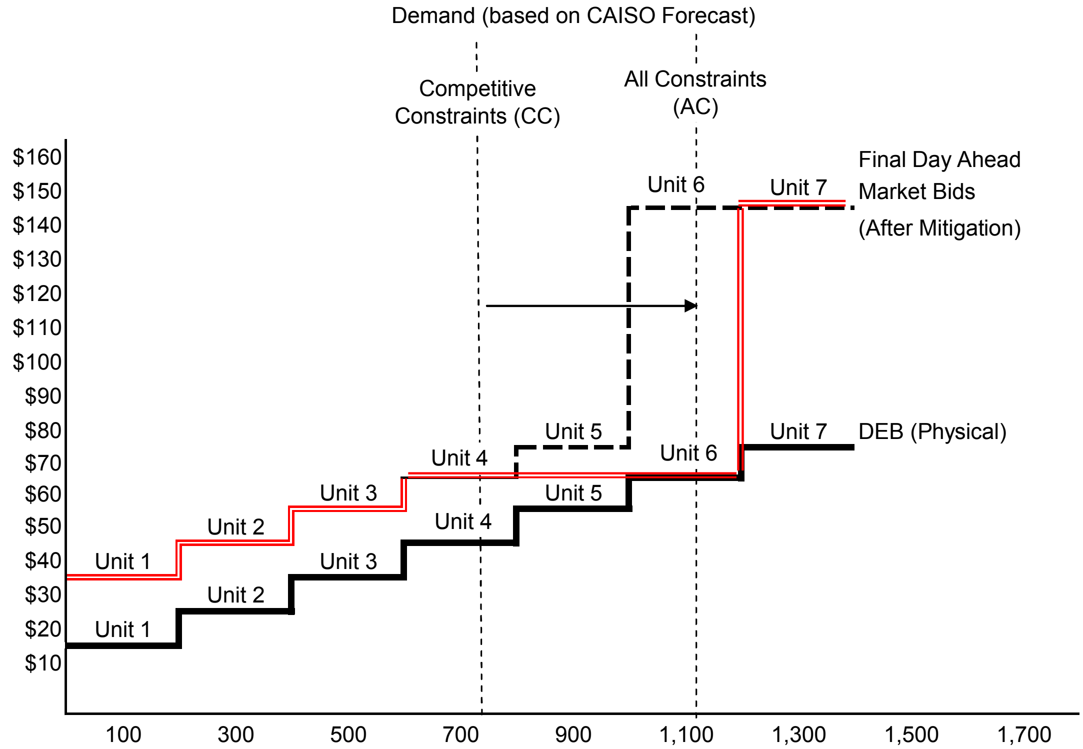
[2] In practice, under MRTU market rules, DEBs will be at least 10% above marginal costs (under the cost-based DEB option). DEBS may be significantly higher for units under the LMP-based option units eligible for the $24 adder for Frequently Mitigated Unit (FMU).

Figure A1: Base Case - Pre-IFM LMPM Model Runs



Thus, under this base case scenario, Units 4 through 6 would be subject to bid price mitigation, as shown by the red double line in Figure A2. Since some of Unit 4's capacity cleared in the AC run, the highest bid from Unit 4 dispatched in the AC run becomes the floor below which Unit 4's bid curve are not mitigated. However, all bids from Unit 5 and 6 get mitigated to their DEB. Since no capacity from Unit 7 would be needed to meet demand based on the AC run, no mitigation applied to bids from Unit 7.

Figure A2: Base Case - Mitigated Supply Curve



In the IFM market, the mitigated supply bid curve depicted in Figure A2 would be combined with demand bids (rather than the forecast) to determine the final market clearing quantity (MCQ) and market clearing price (MCP) in the Day Ahead market. As shown in Figure A3, this example assumes that demand bids in the IFM are somewhat elastic, but that the amount of demand clearing against demand within the load pocket given the final mitigated bid curve equals the actual demand forecast (1,100 MW), with a MCP of $65/MW.[3]

Table A2 shows the generator's net operating profits under this based case scenario ($30,000). The following section of this attachment provide a series of examples that build on the base case scenario, and examine how the generators profits and other market outcomes change under scenarios representing different virtual bidding patterns that may be employed by the generator and other market participants.

[3] In this example, demand within the load pocket essentially represents net residual demand after considering the amount of supply that can be imported into the load pocket.

Figure A3: Base Case – IFM Results from Bid-In Demand and Mitigated Supply Curve

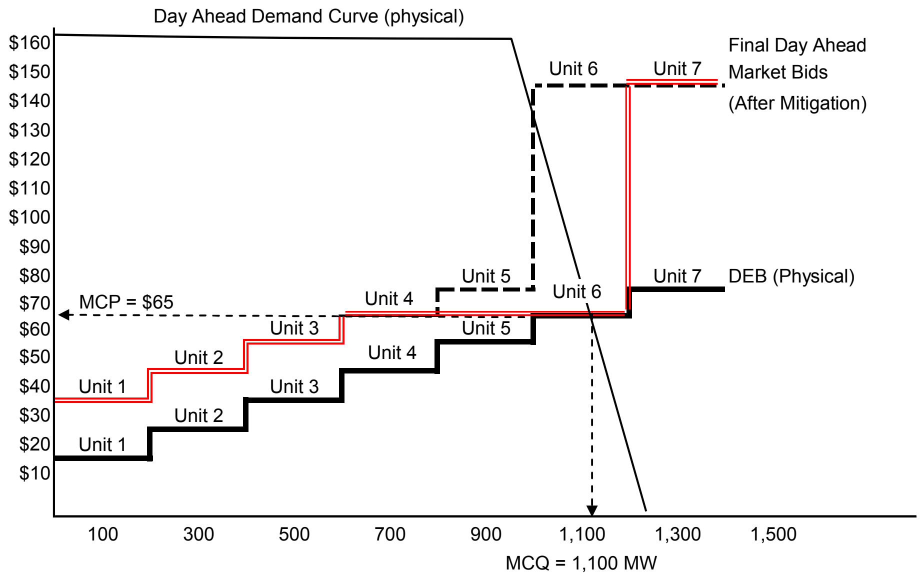


Table A2: Base Case – Generator's Net Operating Profits

Day Ahead Market

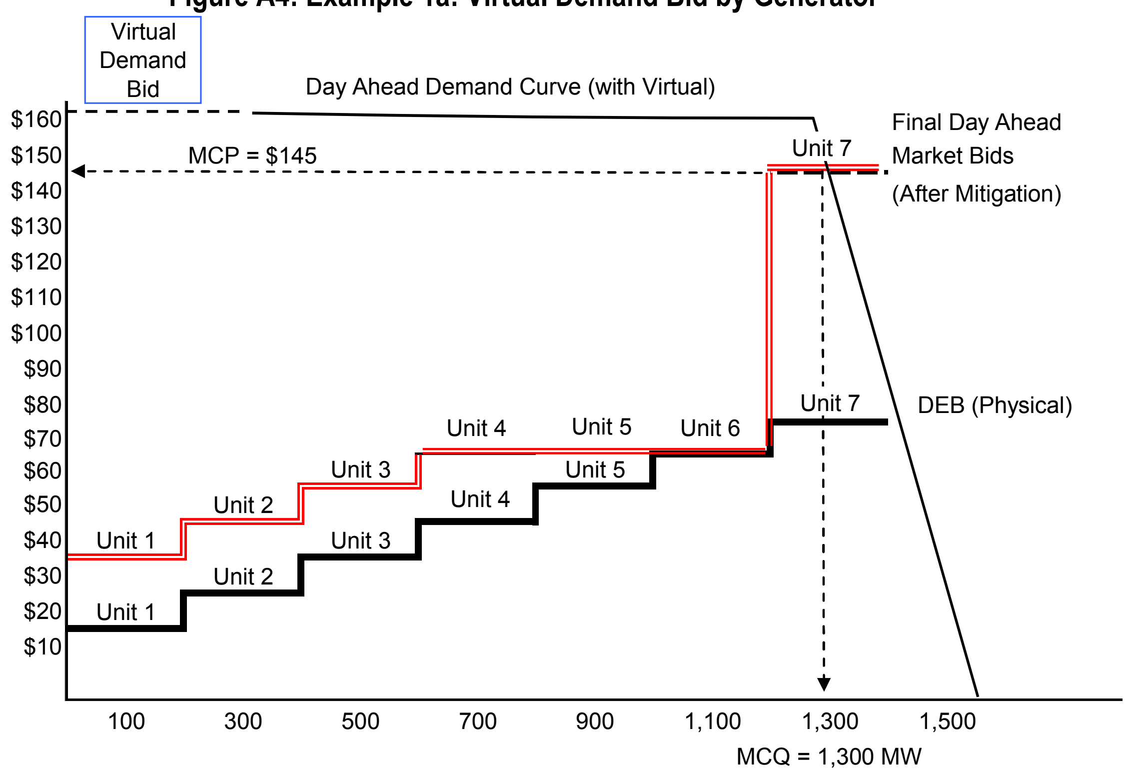
Unit	MW	DEB	MCP	Net
1	200	$15	$65	$10,000
2	200	$25	$65	$8,000
3	200	$35	$65	$6,000
4	200	$45	$65	$4,000
5	200	$55	$65	$2,000
6	100	$65	$65	$0
7	0	$75	$65	$0
	1,100			$30,000

Example 1: Virtual Demand Bidding by Generator

Figure A4 builds upon the base case scenario descried in the previous section, assumes that an additional 300 MW virtual demand bid is placed by the generator (or another participant) in the IFM at on or more nodes within the load pocket. In this example, it is assumed that the virtual demand is submitted at a relatively high price of $160/MW, which would essentially reflect a “price taking” demand bid under conditions in this scenario. As shown in Figure A4, this virtual demand bid shifts the demand curve out to the right, so that the IFM clears at an unmitigated portion of the supply curve (Unit 7). As previously noted, under current LMPM provisions Unit 7 would not be mitigated in the pre-IFM LMPM process since this unit would not be needed to meet the CAISO forecast of “physical” demand.

Under this scenario, the IFM price is set at Unit 7’s unmitigated bid of $145, with a MCQ of 1,300 MW within the load pocket. However, in the real time market, the actual load requirement (net of imports) would equal 1,100 MW, while 1,300 MW of supply would have been scheduled through the IFM. As a result, up to 200 MW of supply would be decremented in real time. As shown in Figure 4, assuming Units 6 and 7 submitted real time energy bids at their marginal costs, these units would be decremented below their IFM schedules, with Unit 6 setting the real time MCP at $65/MW.

Figure A4: Example 1a: Virtual Demand Bid by Generator



As shown in Table A3, under this scenario, the generator's net profit increases to $110,000, compared to the base case of $30,000. Although the generator would loose $25,000 on the 300 MW virtual demand bid, the generator's overall profits increase due to the impact of its virtual demand bid on the IFM MCP. This illustrates how virtual demand bidding may increase generator's profits due to the effect of virtual bids on the generator's overall portfolio of resources.

Table A3: Example 1a: Generator's Net Revenues with Virtual Demand Bid by Generator

Day Ahead Market

Unit	MW	DEB	MCP	Net
1	200	$15	$145	$26,000
2	200	$25	$145	$24,000
3	200	$35	$145	$22,000
4	200	$45	$145	$20,000
5	200	$55	$145	$18,000
6	200	$65	$145	$16,000
7	100	$75	$145	$7,000
	1,300			$133,000

	MW	DA MCP	RT MCP	Net
Virtual Demand	300	$145	$65	-$24,000

Real Time Market

Unit	MW	DEB	MCP	Net
6	-100	$65	$65	$0
7	-100	$75	$65	$1,000
Total				$110,000

Under the scenario described above, the Day Ahead market would clear at $145/MW, while the real time market would clear at $65/MW. If this price differential continued to occur in a consistent or predictable manner, traders or other market participants would be expected to react by placing virtual supply bids at prices between this price range. For example, under the assumption of an extremely efficient virtual trading market, a trader might respond to the scenario in Example 1a by placing a virtual supply bid for 300 MW at $66/MW. As shown in Figure 5, this 300 MW virtual supply bid would shift the supply curve and prevent the unmitigated $160/MW bid from Unit 7 from being accepted, so that the IFM would clear at $66/MW.

As shown in Table A4, the generator's total net revenues under this scenario would be $30,900, compared the based case (without any virtual bidding) of $30,000. The relatively small increase in the generator's revenues in this example compared to the base case result from the increase in the IFM price from $65/MW to $66/MW which results from the virtual supply and demand bids.

Figure A5: Example 1b: With Virtual Supply by Trader

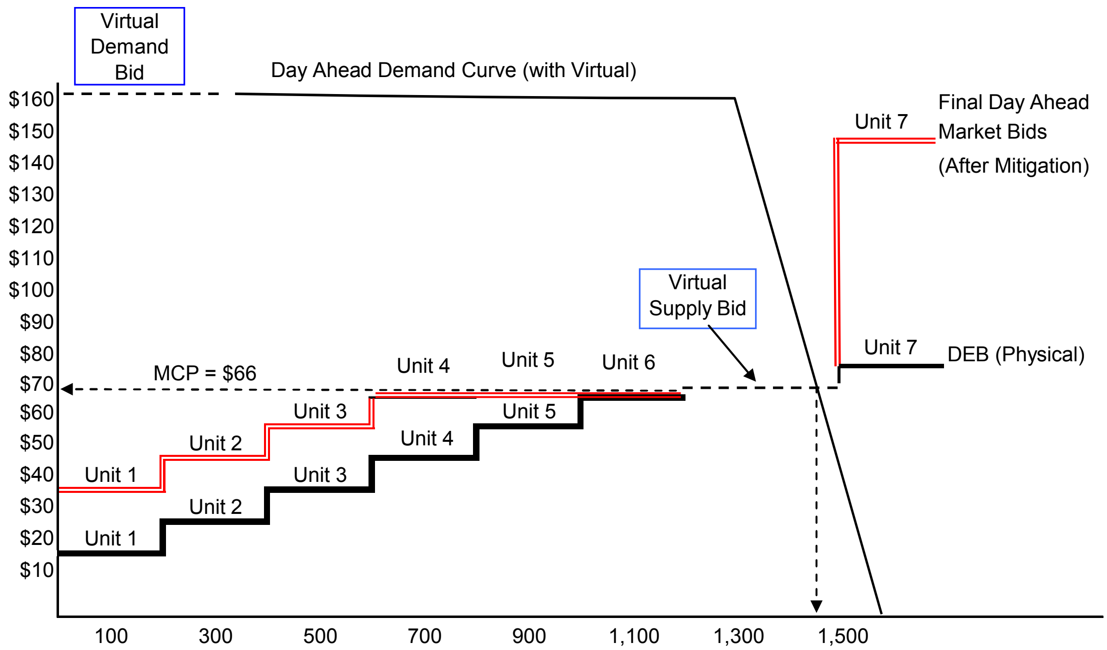


Table A4: Example 1b: Generator's Net Revenues with Virtual Supply Bid by Trader

Day Ahead Market

Unit	MW	DEB	MCP	Net
1	200	$15	$66	$10,200
2	200	$25	$66	$8,200
3	200	$35	$66	$6,200
4	200	$45	$66	$4,200
5	200	$55	$66	$2,200
6	200	$65	$66	$200
7	0	$75	$66	$0
	1,200			$31,200

	MW	DA MCP	RT MCP	Net
Virtual Demand	300	$66	$65	-$300
Total				$30,900

This illustrates how virtual supply bids by traders (i.e. other than generators) may establish a "price collar" that helps to prevent or lessen price spikes in the IFM due to virtual demand bids or any form of economic withholding by generators in the Day Ahead market.

In addition, it should be noted that another way in which the impact of the generator's demand bid in the scenario described above may be mitigated would be to include the virtual bid in the demand used in the LMPM process and/or base LMPM based on total bid-in demand (i.e. physical as well as virtual demand). Given the demand bid curve shown in Figure A4, mitigating IFM bids based on total bid-in demand would result in Unit 7 being subject to bid mitigation, so that its $140/MW market bid would be mitigated to its DEB of $75/MW. Although the IFM price would still increase from $65/MW to $75/MW as a result of the generator's virtual demand bid, this would greatly reduce the impact and profitability of demand bidding by the generator. As shown in Table A5, this would reduce the generators profits from IFM, virtual and real time transactions to $41,000.

Table A5: Example 1c: Generators Net Revenues with LMPM Based on Total Bid-in Demand

Day Ahead Market

Unit	MW	DEB	MCP	Net
1	200	$15	$75	$12,000
2	200	$25	$75	$10,000
3	200	$35	$75	$8,000
4	200	$45	$75	$6,000
5	200	$55	$75	$4,000
6	200	$65	$75	$2,000
7	100	$75	$75	$0
	1,300			$42,000

	MW	DA MCP	RT MCP	Net
Virtual Demand	300	$75	$65	-$3,000

Real Time Market

Unit	MW	DEB	MCP	Net
6	-100	$65	$65	$0
7	-100	$75	$65	$1,000

Total	$40,000

Example 2: Virtual Supply Bidding by Generator

Under MRTU, bids from physical supply resources are subject to mitigation based on their marginal operating costs or other DEB options designed to be reflective of a resources marginal costs (such as the LMP-based option). However, since virtual bids would presumably be based on each participant's *expectations* of Day Ahead and real time prices, none of these approaches for mitigating physical bids may be readily applied to for mitigating virtual bids. This is reflected in the fact that no other ISO's with convergence bidding apply any mitigation to virtual bids.

Given that virtual supply bids would not be subject to bid mitigation, another concern with virtual supply bids could have the effect of circumventing or undermining the bid mitigation provisions incorporated in the LMPM process, as described in the following example. As shown in Figure A6, by submitting a virtual supply bid at $140/MWh – just under the $150 bids submitted for Units 6 and 7– a generator could have that virtual supply bid dispatched in the second run of the LMPM process (or AC run). As illustrated in Figure A7, this virtual supply bid would shift the supply curve so that Unit 6 was not longer subject to bid mitigation in the pre-IFM LMPM process. Instead, the MCP would be set by the virtual supply bid of $135/MW, as depicted in Figure A8.

Under this scenario, the real time price would still be expected to clear at $65/MW, as Unit 6 would be dispatched to provide 100 MW in real time (at its mitigated price) in order to meet the difference between the amount of physical generation scheduled in the IFM (1,000 MW) and the actual supply needed from within this load pocket in real time (1,100 MW). As shown in Table A6, due to the increase in the IFM MCP under this scenario, the generator's net revenues would be $101,750, compared to the base case of $30,000.

Figure A6: Example 2a: Virtual Demand Bid by Generator

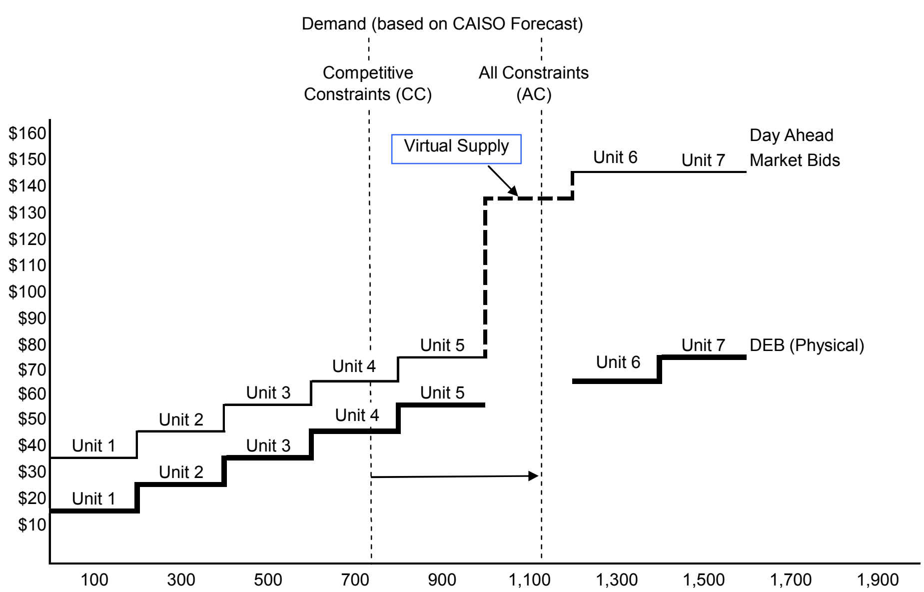


Figure A7: Example 2a: Mitigated Supply Curve

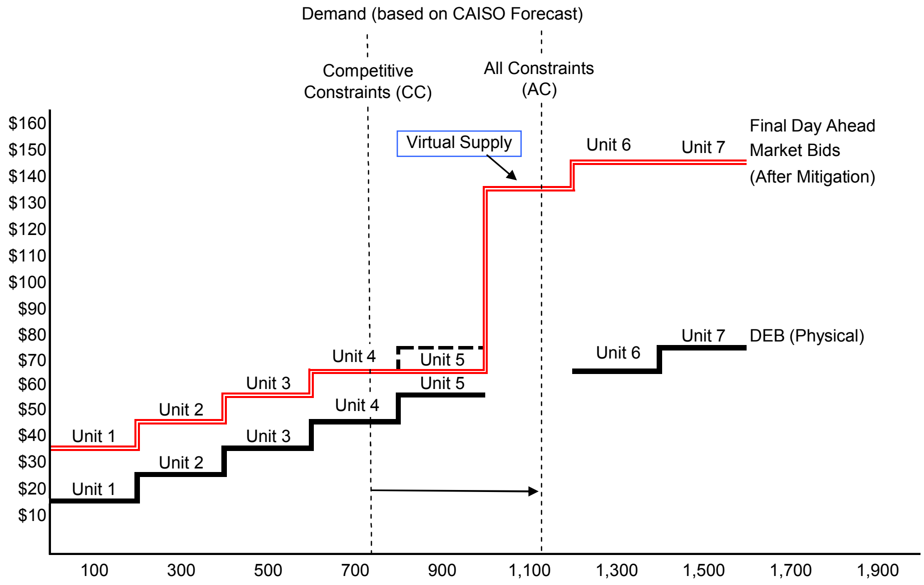


Figure A8: Example 2a: Market Clearing with Mitigated Supply Curve

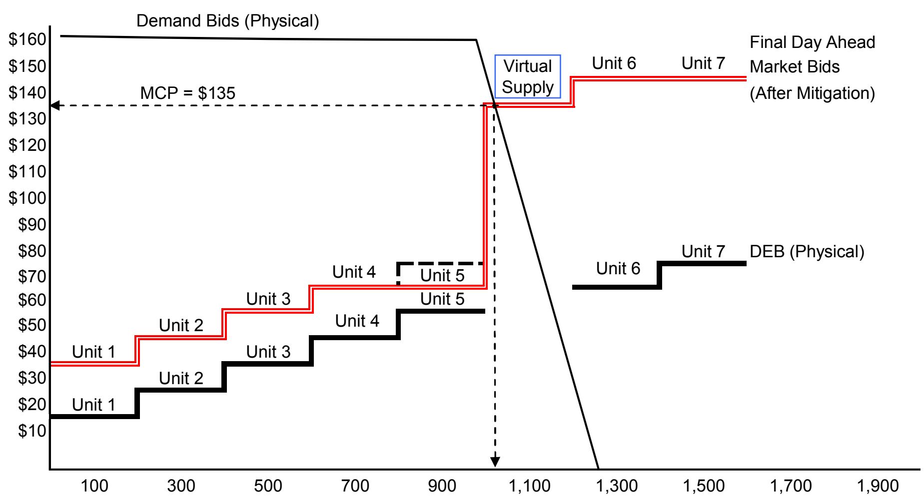


Table A6: Example 2a. Generator's Net Revenues with Virtual Supply Bid by Generator

Day Ahead Market

Unit	MW	DEB	MCP	Net
1	200	$15	$135	$24,000
2	200	$25	$135	$22,000
3	200	$35	$135	$20,000
4	200	$45	$135	$18,000
5	200	$55	$135	$16,000
6	0	$65	$135	$0
7	0	$75	$135	$0
	1,000			$100,000

	MW	DA MCP	RT MCP	Net
Virtual Supply	25	$135	$65	$1,750
Total				$101,750

Again, however, if the price differential in this example continued to occur in a consistent or predictable manner, traders or other market participants would be expected to react by placing lower priced virtual supply bids (i.e. between the generator's $135/MW bid in Example 2a and the equilibrium competitive price of $65/MW resulting under the base case). For example, under the assumption of an extremely efficient virtual trading market, a trader might respond to the scenario in Example 2a by placing a virtual supply bid $66/MW. As shown in Figure A9, this $66/MW virtual supply bid would shift the supply curve and prevent the $135/MW virtual supply bid from being accepted, so that the IFM would clear at $66/MW.

Under this scenario, the generator's net revenues would be $31,000, compared to net revenues of $30,000 under the based case. Meanwhile, the trader would earn the $1 price difference between the IFM and real time for the 25 MW of its virtual supply which was accepted, for a total of $25. Thus, while the impacts of the generator's virtual bidding on overall costs was greatly reduced by the trader's virtual supply bids, overall costs increased slightly due to the increase in the IFM price from $65/MW to $66/MW in this example.

Figure A9: Example 2b: With Virtual Supply by Trader

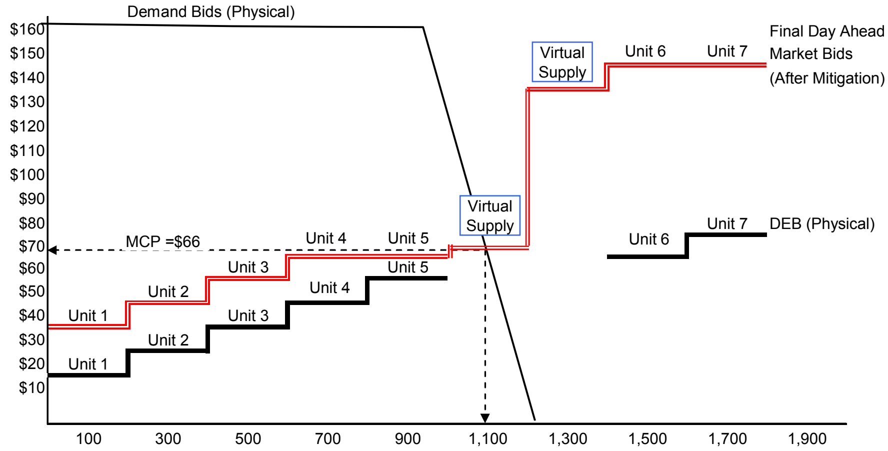


Table A7: Example 2b. Generator's Net Revenues with Lower Priced Virtual Supply Bid by Trader

Day Ahead Market

Unit	MW	DEB	MCP	Net
1	200	$15	$66	$10,200
2	200	$25	$66	$8,200
3	200	$35	$66	$6,200
4	200	$45	$66	$4,200
5	200	$55	$66	$2,200
6	0	$65	$66	$0
7	0	$75	$66	$0
	1,000			$31,000

Example 3: Real Time Uninstructed Deviations

This section illustrates the potential interactions between virtual bidding and uninstructed deviations by generators. For sake of illustration, the first example builds upon the scenario similar to the scenario in Example 1a, in which a generator submits a 300 MW virtual demand bid, while a trader submits virtual supply bids at $66/MW which serve to offset much of the impact of the generator's virtual demand bid on the IFM price. However, in this example, it is assumed that one or more traders submit 500 MW of virtual supply at $66/MW. As depicted in Figure A10, under this scenario, the generator has 1,000 MW of physical generation scheduled to operate through the IFM market (Unit 1 through Unit 5), combined with a 300 MW virtual demand bids, representing a net position of 700 MW in the IFM and 300 MW in the real time market.

Since virtual supply and demand bids are "liquidated" prior to the real time market, the LMPM process performed prior to real time is based solely on forecasted demand combined with schedules and bids for physical generating units. Given the IFM results depicted in Figure A10, this process would result in mitigation of bids for Unit 6 in the real time market. However, as shown in Figure A11, bid from Unit 7 would not be mitigated in the real time market since the CAISO software would not expect the need to dispatch Unit 7 to meet real time demand.

Under this scenario, the CAISO would issue a dispatch instruction to Unit 6 for 100 MW in order to meet real time demand. If responses to the dispatch instruction, the real time MCP would be set by the $65/MW mitigated bid of Unit 6, so that the generator would earn a net loss of $300 on its 300 MW virtual demand bid. However, by not responding to the full 100 MW dispatch instruction to Unit 6 the generator could force the CAISO to dispatch an unmitigated $135/MW bid from Unit 7, as depicted in Figure A12. As shown in Table 9, this would increase the generator's net revenues to over $65,000, compared to the base case of $30,000.

In addition, it should be noted that in this example and virtually any scenario in which a generator has a significant position in the real time market through virtual bids, a similar result could be achieved by having one or more the generators units scheduled in the IFM operate below their IFM schedule, or through a unit outage. If such deviations or outages occurred in a routine and predictable manner, such patterns might be mitigated by virtual bidding of other participants and/or subject to referral to FERC under the Commission's anti-manipulation rules. However, any generator pursuing such a strategy could be expected to ensure that deviations and outages in a manner that was not predictable for other participants, and which could be very difficult to detect and prove given the standard of proof required under FERC's anti-manipulation rules.

Figure A10: Example 3a. 300 MW Virtual Demand Bid by Generator with 500 MW of Virtual Supply by Traders

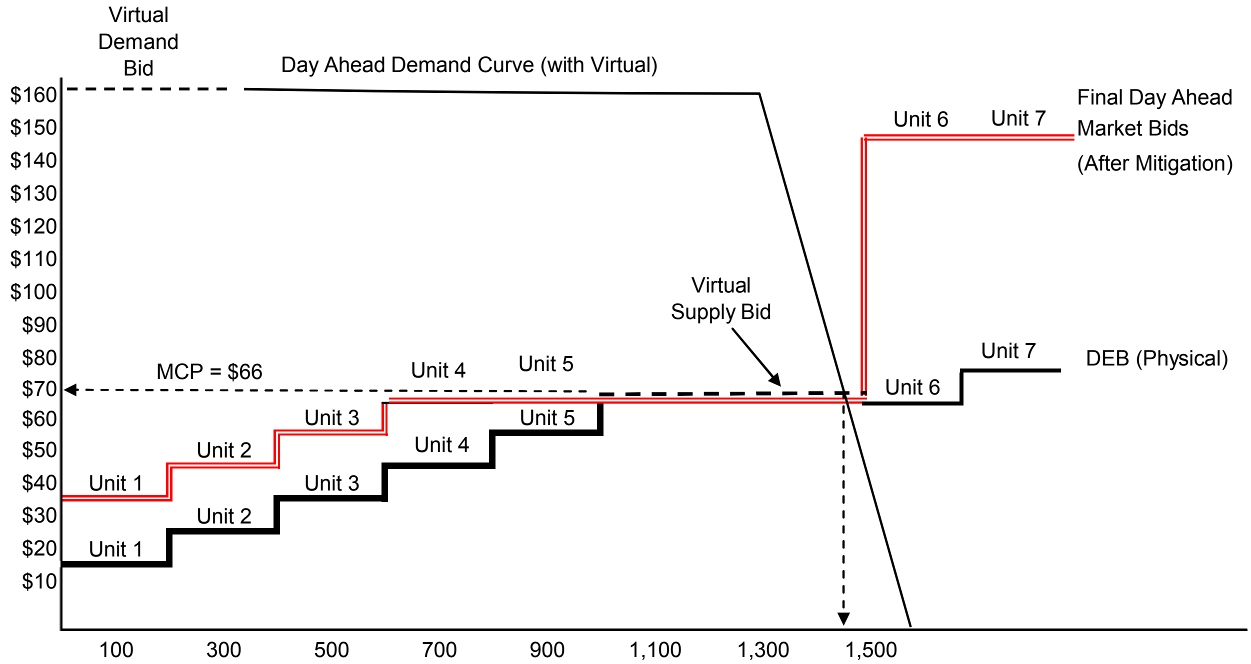


Figure A10: Example 3a. Real Time Market Bid Mitigation

Real Time Demand (based on CAISO Forecast)

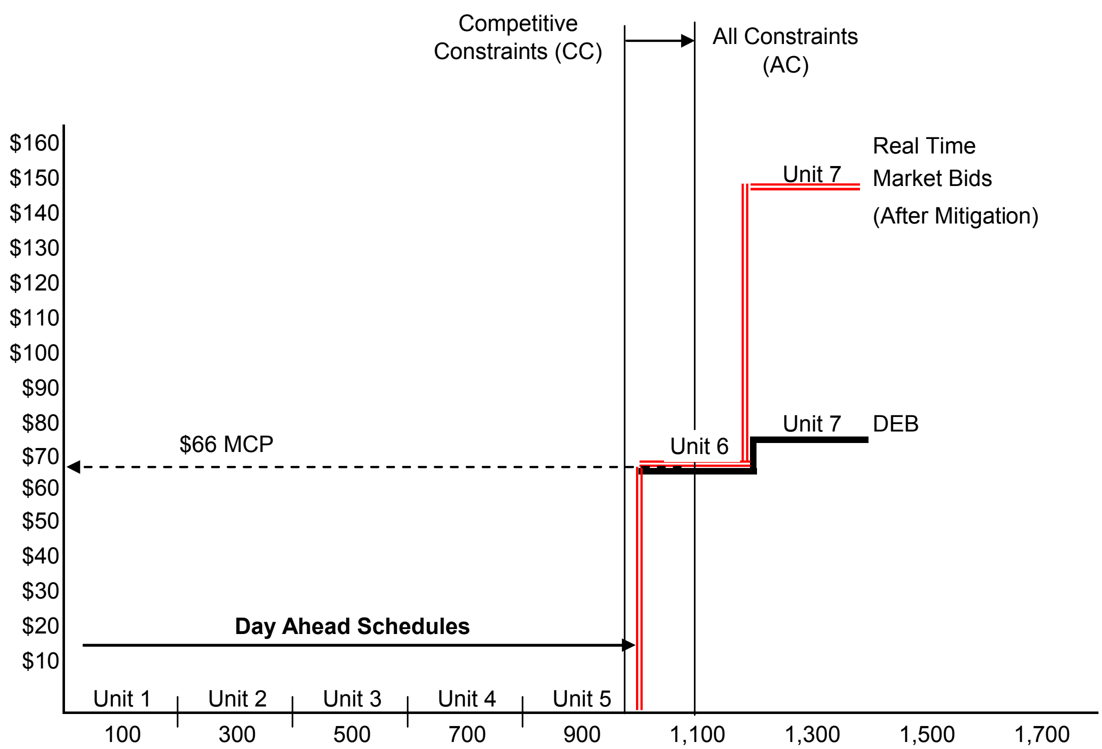


Figure A11: Example 3a. Impact of Uninstructed Deviation by Unit 6

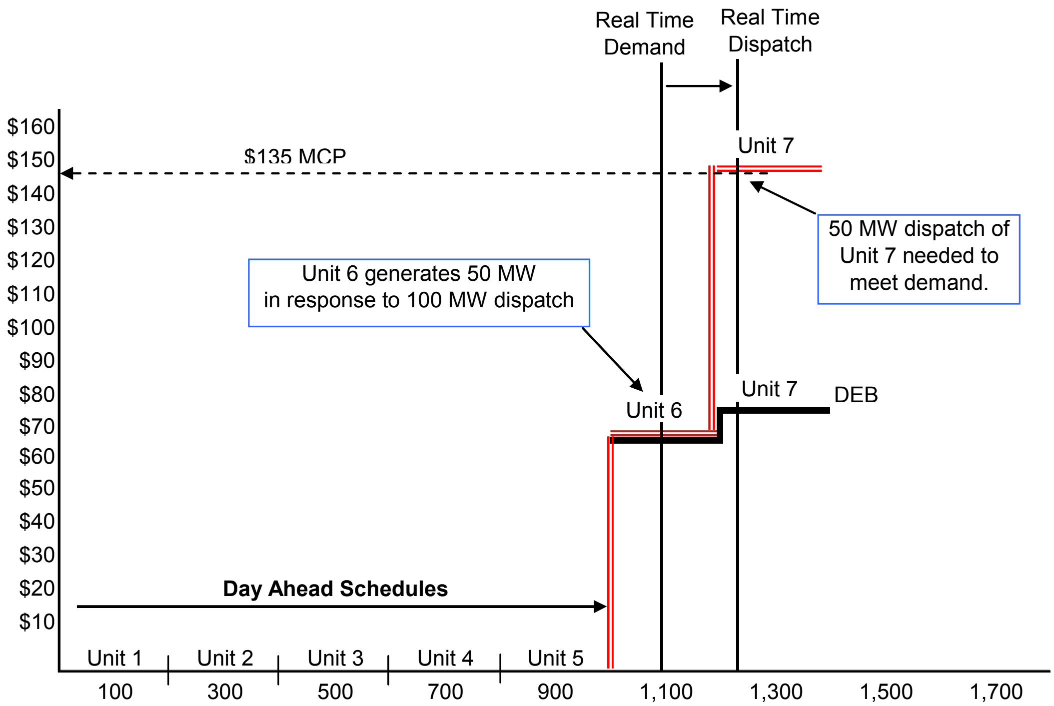


Table A8: Example 3a. Generator's Net Revenues with Uninstructed Deviation

Day Ahead Market

Unit	MW	DEB	MCP	Net
1	200	$15	$66	$10,200
2	200	$25	$66	$8,200
3	200	$35	$66	$6,200
4	200	$45	$66	$4,200
5	200	$55	$66	$2,200
6	0	$65	$66	$0
7	0	$75	$66	$0
	1,000			$31,000

	MW	DA MCP	RT MCP	Net
Virtual Demand	300	$66	$135	$20,700

Real Time Market

Unit	MW	DEB	MCP	Net
6	50	$65	$135	$6,750
7	50	$75	$135	$6,750
	100			$13,500

Grand Total	$65,200