

# **Setting Parameter Values for Uneconomic Adjustments in the MRTU Market Optimizations**

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**Department of Market and Product Development**

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# Setting Parameter Values for Uneconomic Adjustments in the MRTU Market Optimizations

## 1. Introduction

This paper provides an initial list of parameter values for uneconomic adjustments that the California ISO (CAISO) is using for discussion purposes. This list is being provided to stakeholders and the Market Surveillance Committee (MSC) at this time to set the stage for stakeholder discussions. The CAISO will be collecting issues and concerns associated with the levels of the various parameter values from stakeholders and the MSC at a July 30<sup>th</sup> joint stakeholder/MSC meeting. The goal is to have the ultimate parameter values result in software solutions that are consistent with the provisions of the MRTU tariff. Test results will be used to validate or change these parameter values. The CAISO will continue to work with stakeholders and test the proposed parameter values to ensure that the final values used at MRTU start-up are reflective of the all of the MRTU tariff provisions.

The CAISO has also included a description of how Ancillary Service prices will be set under MRTU prior to the implementation of scarcity pricing. This issue and the initial parameter values will be discussed at the joint MSC/Stakeholder meeting on July 30<sup>th</sup>.

## 2. Proposed Process and Timetable

As the first step in the process, the CAISO will gather issues related to the parameter values from stakeholders and the MSC. Once the set of issues have been identified, the CAISO will work with stakeholders to resolve the issues and post a proposal of parameter values that address the issues to the extent possible. Stakeholders will be afforded the opportunity to again provide comments prior to the finalization of the parameter values that will be used at MRTU go live. In a subsequent paper on Parameter Values, the CAISO will provide additional process milestones and dates leading up to the posting 30 days prior to MRTU market launch of the parameter values to be used during the final 30 days of pre-production testing and in the MRTU markets when they begin production operation.

## 3. Ancillary Service Pricing Under Deficiency Conditions

Ancillary Service (A/S) modeling under MRTU follows the principle that there is no scarcity pricing until the Federal Energy Regulatory Commission (FERC) mandated Scarcity Pricing design is implemented.

In the July 2005 Order and September 2005 Order, FERC accepted in concept the CAISO's initial limited scarcity proposal as part of its proposed market power mitigation package. That is, under MRTU, the CAISO has included a limited "scarcity pricing" mechanism that raises energy bids to the bid cap when there are insufficient energy bids in Real-Time Market and when no contingency events have occurred (Tariff Section 34.8). In its September 21, 2006 Order, FERC directed the CAISO to develop a more extensive reserve shortage scarcity pricing approach, file and implement it within 12 months of the start-up of MRTU.

Following the FERC Orders, the CAISO developed the A/S pricing mechanism under MRTU by assuming there is no actual scarcity. If there is insufficient A/S supply in Scheduling Run, the CAISO will adjust the minimum requirements for the A/S in Pricing Run to eliminate supply deficiency. Eventually an economic bid will set the A/S market clearing price (ASMP) together with opportunity cost from providing energy (if there is any).

For example, if the minimum requirement for Regulation Up in the CAISO Region is 350 MW while the total available bid-in supply is only 345 MW, there will be a 5 MW deficiency in the Scheduling Run. In the Pricing Run, the requirement for Regulation Up will be reduced to 345 MW so that the requirement can be met by the economic bids. An economic bid will always be set by the Regulation Up ASMP of the marginal unit, which is the sum of its Regulation Up bid plus the opportunity cost from providing energy.

Also, based on reliability requirements, A/S modeling under MRTU follows two guidelines in the event of insufficient A/S supply:

1. If there is a supply deficiency of an A/S product, the CAISO will not procure more A/S of lower quality to meet the requirement for the A/S product which is deficient; and
2. If there is supply deficiency of an A/S reserve in a Sub-Region, the CAISO will try to procure more of such or higher quality A/S in the outer Region in order to meet the WECC MORC requirements in the CAISO system.

## 4. Parameter Tuning Analysis – Further Results

The CAISO's June 9 White Paper contained the parameter values for the Integrated Forward Market (IFM) runs that had been developed as of that date, based on tariff requirements and testing of the MRTU market software. During the stakeholder meeting on May 13, the presentation given by Jim Price explained the process that the CAISO uses to develop the parameter values, and illustrated their results.<sup>1</sup> The explanation from the May 1 stakeholder meeting has been incorporated into this document. Additional testing since that time has identified only a few changes to the recommended values in the last White Paper, which are stated in section 4.2 below.<sup>2</sup>

Further testing has allowed the CAISO to develop parameter values for the Residual Unit Commitment (RUC) process, described in section 4.3 and the Real-Time Market in section 4.4.

### 4.1. Day Ahead Market Discussion

The parameter values recommended for the IFM based on the parameter tuning efforts to date are set to implement a priority order that is consistent with the MRTU tariff, particularly sections 31.3.1.3 (Reduction of Load Aggregation Point (LAP) Demand) and 31.4 (Uneconomic Adjustments in the IFM). Section 31.4 lists the scheduling priorities in IFM as follows:

1. Reliability Must Run (RMR) Generation pre-dispatch reduction;

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<sup>1</sup> The May 13<sup>th</sup> presentation is available at <http://www.caiso.com/1fc5/1fc5e2b72f540.pdf>.

<sup>2</sup> The previously-stated values for "Market energy balance" and "Transmission constraints: Intertie scheduling" were the original values that were used by default by the CAISO's vendor. Subsequent analysis by the CAISO shows that the original values can be reduced while maintaining the relative priorities of these constraints, and the table in section 6.2 has revised values for these parameters.

2. Day-Ahead Transmission Ownership Right (TOR) Self-Schedules (balanced demand and supply reduction);
3. Day-Ahead Existing Transmission Contract (ETC) Self-Schedules (balanced demand and supply reduction); different ETC priority levels will be observed based upon global ETC priorities provided to the CAISO by the Responsible Participating Transmission Owners (PTOs);
4. Other Self-Schedules of CAISO Demand reduction subject to Section 31.3.1.3, exports explicitly identified in a Resource Adequacy Plan to be served by Resource Adequacy Capacity explicitly identified and linked in a Supply Plan to the exports, and Self-Schedules of exports at Scheduling Points explicitly sourced by non-Resource Adequacy Capacity;
5. Self-Schedules of exports at Scheduling Points not explicitly sourced by non-Resource Adequacy Capacity, except those exports explicitly identified in a Resource Adequacy Plan to be served by Resource Adequacy Capacity explicitly identified and linked in a Supply Plan to the exports as set forth in Section 31.4(d);
6. Day-Ahead Regulatory Must-Run Generation and Regulatory Must-Take Generation reduction;
7. Other Self-Schedules of Supply reduction; and
8. Economic Bids of Demand and Supply.

Section 31.3.1.3 further specifies the priority process for resolving situations where the IFM cannot resolve a non-competitive transmission constraint utilizing effective Economic Bids, such that load at the LAP level would otherwise be adjusted to relieve the Constraint, of which the first two steps are summarized as follows:<sup>3</sup>

Step 1: Schedule the Energy from Self-Provided Ancillary Service Bids from capacity that is obligated to offer an Energy Bid under a must-offer obligation such as from an RMR Unit or a Resource Adequacy Resource.

Step 2: Relax transmission constraints, subject to provisions including applying a penalty price for pricing transmission constraints at three times the Energy Bid cap, and this penalty price being less than the penalty price for curtailing firm, price-taker load.

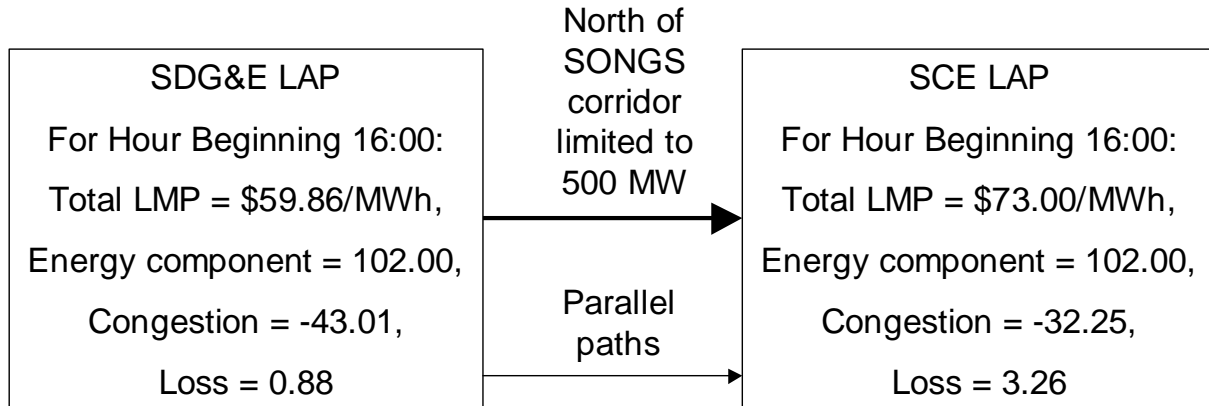
When economic bids are available to manage constraints, the price impact of even severe constraints can be moderate, as shown in an example presented at the May 13 stakeholder meeting. In this example, the capacity of the North of SONGS corridor, which connects SDG&E to SCE, is reduced by 79.5% of its normal value. This constraint and the resulting LMPs for the peak hour of the CAISO's test case are shown in Figure 1. Because there are adequate economic bids in this case to manage this constraint without resorting to adjustments to self-schedules or relaxation of transmission constraints, the scheduling and pricing runs produce consistent prices, and LMP impacts are moderate and understandable, as shown in Figure 2. No reduction of self-schedules is needed to enforce this constraint.

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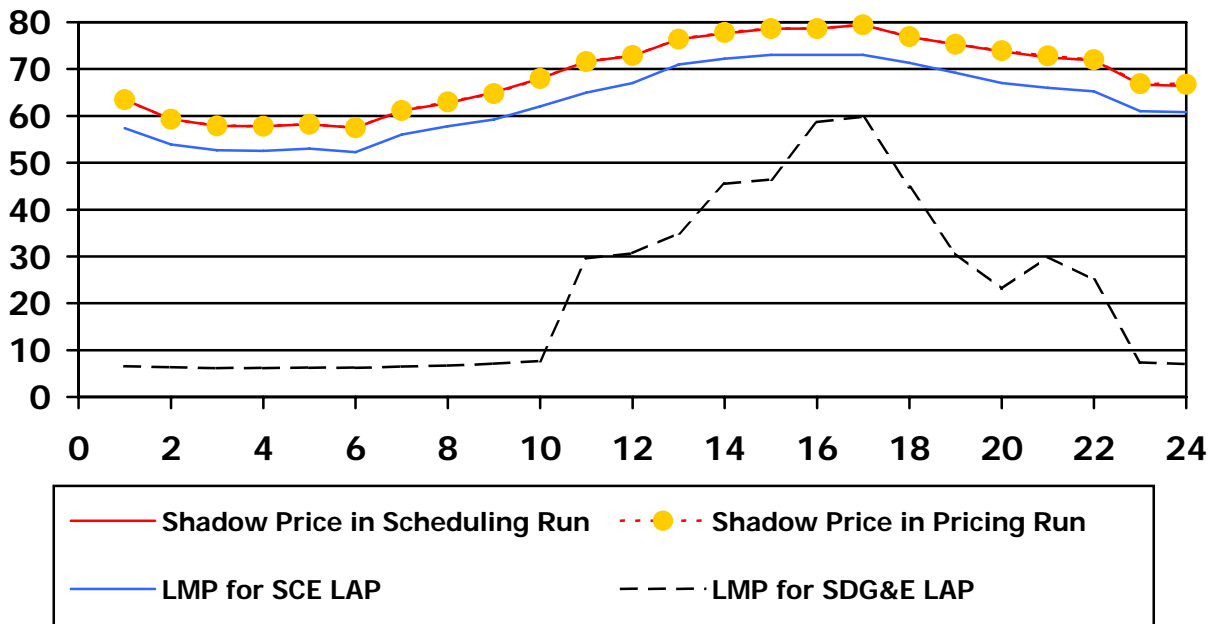
<sup>3</sup> In the tariff there is a Step 3 identified in which load distribution factors would be adjusted. At this point it appears unnecessary and impractical to execute this step. Therefore the parameter tuning is not relying on Step 3 for analysis.

**Figure 1: Example of Transmission Impact on Large Areas**

Example: The North of SONGS corridor connects SDG&E to SCE. For Parameter Tuning testing, its limit is reduced by 79.5%, to 500 MW. Other transmission limitations discussed for other examples also apply.



**Figure 2: Moderate Impact of Severe Constraint When Economic Bid Resolve Constraints,**



However, if effective economic bids are insufficient to manage constraints, self-schedules are respected in the market optimization in accordance with Sections 31.3.1.3 and 31.4 of the MRTU Tariff, as listed above. Priorities are implemented in the scheduling run through uneconomic bid adjustments for self-schedules, and penalty prices for constraint violations. An example of a constraint at the Blythe intertie (a radial constraint) shows how self-schedules are

adjusted, and the impact on LMPs at the constrained locations. The following results (presented at the May 13 stakeholder meeting) present three cases:

- Case 1: All self-schedules are feasible, and economic bids are limited to enforce binding intertie constraint (Imports are shown with positive sign).
- Case 2: ETC self-schedule increases to 150 MW. Other (generic) self-schedules must be reduced, to the point where the constraint is enforced.
- Case 3: Reduced export bids require reduction of the ETC self-schedules, after other self-schedules are reduced to zero MW

The resulting adjustments to self-schedules, and impacts on Locational Marginal Prices (LMPs), are as follows:

	Case 1. Economic bids are limited	Case 2. Generic self-schedules are constrained	Case 3: ETC self-schedules are constrained
Final schedules for economic bids	-59 MW	-80 MW	-12.5 MW
Final generic self-schedules	154 MW	30 MW	0 MW
Final ETC self-schedules	5 MW	150 MW	112.5 MW
Intertie shadow pricing (scheduling run)	\$55.36/MW	\$601.42/MW	\$3254.81/MW
Scheduling run LMP	\$2.87/MWh	-\$550/MWh	-\$3200/MWh
Pricing run LMP	\$2.87/MWh	-\$30/MWh	\$-30/MWh

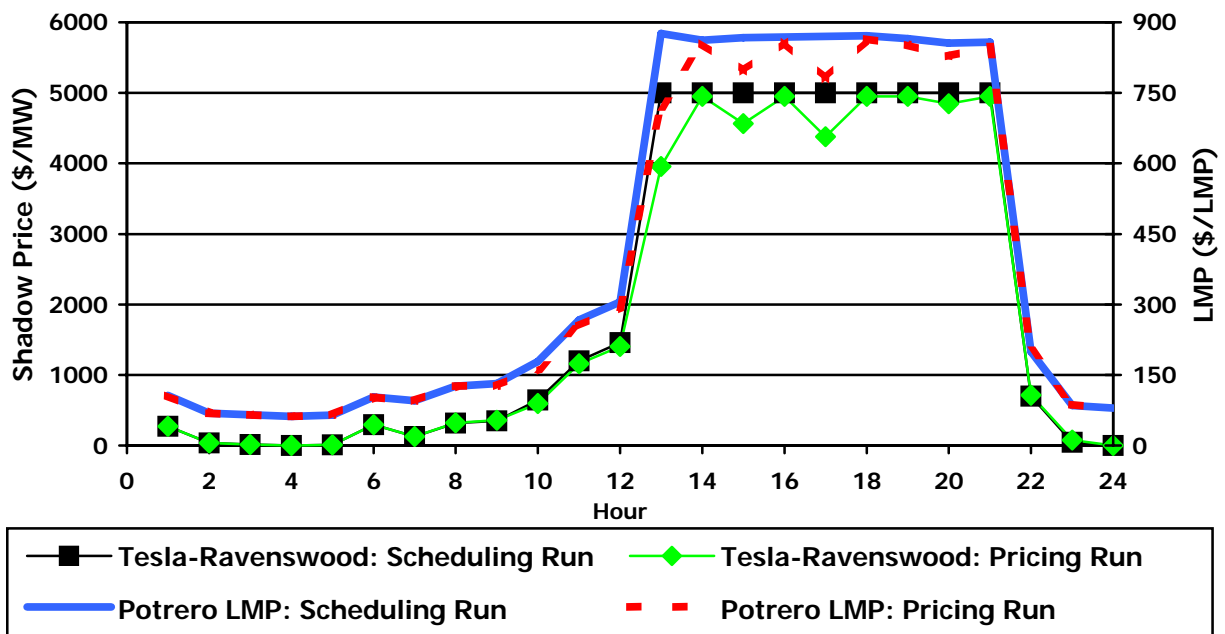
In this example of the radial Blythe intertie, the transmission constraint is enforced in Case 1 using economic bids and the LMPs in the scheduling and pricing runs are consistent. The increase in ETC self-schedules in Case 2 (to more than the intertie capacity) requires generic self-schedules to be adjusted to the amount that is supported by the intertie capacity plus the amount of export bids, in order to enforce the transmission constraint and manage congestion. In Case 3, after the reduction in the export bid capacity, the generic self-schedules can no longer be scheduled, and enforcing the transmission constraint requires adjusting the ETC self-schedules. Achieving this result in the optimization process requires the penalty price for adjusting ETC self-schedules to be lower than the penalty price for transmission capacity, but this does not mean that the ETC schedules are being adjusted based on economics. Economic bids, as well as adjustments to generic self-schedules, are exhausted in this case, before ETC self-schedules are adjusted. In this case, the lower end of the range of penalty prices for ETC self-schedule adjustments (equal to two times the penalty price for generic self-schedules) is illustrated, but the CAISO's proposed penalty price values for the start of MRTU include values nearly as high as the penalty price for transmission constraints, if TRTC instructions support the assignment of such priorities. For transmission constraints, the CAISO is developing examples within looped (not radial) portions of the CAISO network, to illustrate the conditions under which the CAISO's proposed penalty prices for ETC self-schedules still preserve the ETCs' scheduling priority, for discussion at the July 30 MSC and stakeholder meeting.

As described in section 4.2 of this document, the penalty price value for transmission constraints in the scheduling run is \$5000/MW, so that economic bids at the bid cap will be selected in the optimization process even if they are only 10% effective in relieving transmission

constraints. This is simply a principle for developing the value of the penalty price, and does not limit the use of bids with lower effectiveness and lower bid prices: a bid with effectiveness above 5% and a \$250 bid price would be selected by the optimization, and the CAISO's operators will be able to see higher priced economic bids with low effectiveness, so they can consider them as they review the results of optimization. In the pricing run, the CAISO's will first attempt to enforce constraints using a lower penalty price equal to three times the bid cap (\$1500), as described in MRTU Tariff section 31.3.1.3. If this is not effective in managing congestion in the pricing run, the same value as used in the scheduling run (\$5000) will be used in a very narrow range around the constraint relaxation that was necessary in the scheduling run (plus and minus "epsilon"), to place a limit on the cost of any further constraint relaxation. Pursuant to section 31.3.1.3, a value of more than three times the bid cap is used as the scheduling run penalty price for adjustments to generic self-schedules of Demand, which is assigned as \$1600/MW. Then in the pricing run, all bids are limited to the bid cap and floor.

The pricing run result of using these penalty price values has been more moderate in the CAISO's testing than one might think from heading values like \$5000, because power transfer distribution factors (PTDFs, or "shift factors") limit the impact of transmission shadow prices on LMPs. The test results presented in Figure 3 show the impact of these values on San Francisco LMPs due to extreme Bay Area congestion that the CAISO created for test purposes, as discussed at the May 13 stakeholder meeting, by reducing the capacity of the Tesla – Ravenswood 230 kV line to less than 33% of its normal capacity (thus causing constraint relaxation in several hours of the test case) in addition to similar reductions of other Bay Area constraints. In this case, the most effective resource for managing constraint is Potrero in San Francisco. LMPs at Potrero (with 16% effectiveness) during the affected hours are \$721 to \$865.

**Figure 3: LMP Impact from Relaxation of Transmission Constraint**



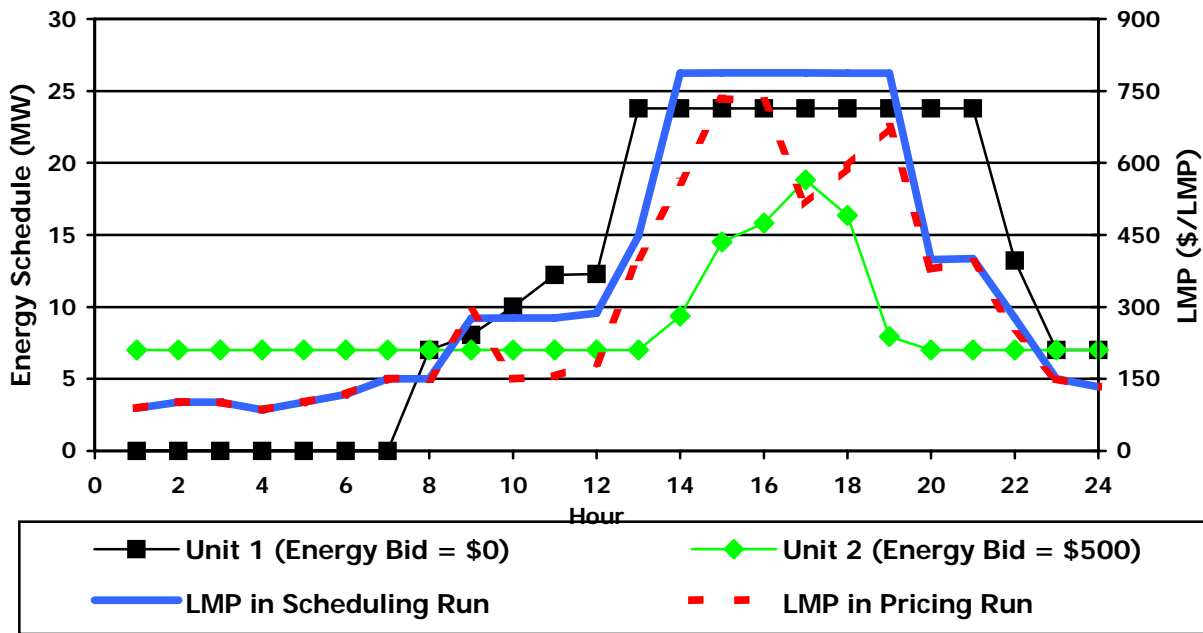
With transmission constraint penalty prices and uneconomic bid prices for generic self-schedules determined (and resulting LMPs known), the penalty prices for Step 1 of section



31.3.1.3 (Reduction of LAP Demand) have been determined through empirical testing. Scheduling Energy from capacity that was submitted as self-provided AS depends on:

- Penalty price for releasing self-provided AS capacity,
- Energy bid price, and
- Ancillary service regional price.

Based on empirical results, the CAISO proposes the values of \$275, \$280, and \$285/MW for conversion of self-provided AS to Energy, which is discussed further in section 4.3 of this document. To demonstrate the empirical effectiveness of these values, the CAISO constrained certain Bay Area locations by reducing the capacity of the Tesla – Ravenswood 230 kV line, Crockett – Sobrante 230 kV line, and Claremont – Oakland 115 kV line, producing similar LMPs as shown in the previous example, for two peakers in Alameda that the CAISO entered in its test data as providing Non-Spinning Reserve. As shown in Figure 4 (and discussed at the May 13 stakeholder meeting), the scheduling of Energy from self-provided AS depends on illustrative energy bid price: full scheduling as Energy occurs when the Energy bid is \$0/MWh, and partial scheduling when the Energy bid is \$500/MWh.



Additional penalty prices in the Day-Ahead Market include (as examples, among those discussed at the May 13 stakeholder meeting) AS requirements and Reliability Must-Run (RMR) pre-dispatch. The Day-Ahead Market attempts to procure 100% of the forecasted AS requirement, so the penalty price must be higher than that of generic self-scheduled Demand and is set at \$2000. Note, however, that this is lower than the penalty price for ETC self-schedules, so the CAISO would forego AS procurements in order to honor ETC self-schedules. RMR pre-dispatch occurs to maintain system reliability and results from engineering analyses of daily conditions, so it takes priority (at \$6000) over transmission capacity constraints and all self-schedules, having lower priority than only Intertie scheduling capacity (for which schedules exceeding the scheduling capacity would be unlikely to be accepted by neighboring Balancing Authority Areas), and Market energy balance, which ensures that the Day-Ahead Market results in scheduling matching supply and demand schedules.

The recommended scheduling run and pricing run penalty price values for the Day Ahead Market based on the CAISO's parameter tuning analysis to date are summarized in the following tables, with comments explaining the rationale for these values.

## 4.2. Integrated Forward Market (IFM) Parameter Values

The following parameter values, which have been confirmed through ongoing testing, represent the CAISO's current recommended values for the Integrated Forward Market.

Penalty Price Description	Scheduling Run Value <sup>4</sup>	Pricing Run Value	Comment
Market energy balance	6500	1500	In the scheduling run, it is essential to produce supply matching demand plus losses. In the pricing run, the penalty price is the same as for transmission constraints to ensure that LMPs remain within a reasonable range. This is relevant to the MPM and RUC passes in which the objective is to meet CAISO Forecast Demand.
Transmission constraints: Intertie scheduling	7000	7000	Intertie scheduling constraints are explicitly excluded from the LAP clearing mechanism described in section 31.3.1.3. The CAISO is currently considering reducing the pricing run parameter to 1500 for consistency with other transmission constraints. Further testing will be conducted to determine which value results in more appropriate pricing outcome.
Reliability Must-Run (RMR) pre-dispatch curtailment (supply)	-6000	-30	The CAISO considers transmission constraints when determining RMR scheduling requirements. However, for this and other parameters listed below, bid prices are limited to between -\$30 and \$500 in the pricing run, as described earlier in this paper.
Pseudo-tie layoff energy	-6000	-30	Pseudo-tie layoff energy is scheduled under contractual arrangements with the Balancing Authority in whose area a pseudo-tie is located.
Transmission constraints: branch, corridor, nomogram (base case and contingency analysis)	5000	1500, 5000	In the scheduling run, the guideline applied to transmission constraints is that an Economic Bid should be accepted if it is priced at the bid cap and is at least 10% effective in relieving a transmission constraint. In the pricing run, two penalty price segments are available: one is

<sup>4</sup> Penalty values are negatively valued for supply reduction and positively valued for demand reduction.

			priced at three times the Energy Bid cap pursuant to section 31.3.1.3, extending from the original limit to any constraint relaxation resulting from the scheduling run, minus a small amount called "epsilon", then the second of "epsilon" around the relaxed limit must equal the penalty price of the scheduling run in order to ensure reasonable LMPs. The CAISO is considering a single penalty price segment priced at three times the bid cap for pricing run. Further testing will be conducted to determine which scheme results in more appropriate pricing outcome.
TOR self schedule	4500, -4500	500, -30	A TOR Self-Schedule would only be adjusted if it has very high effectiveness in relieving a constraint that cannot otherwise be enforced.
ETC self schedule	3200, -3200	500, -30	An ETC Self-Schedule would only be adjusted if it has high effectiveness in relieving a constraint that cannot otherwise be enforced. The typical value is set at 200% of the generic self-scheduled demand, but different values from \$3400 to \$4500 are possible if differential priorities are established among ETC rights.
Converted Right (CVR) self schedule	3200, -3200	500, -30	A CVR Self-Schedule is assigned the same priority as the typical value for ETC Self-Schedules.
Ancillary Service Region Regulation-up and Regulation-down Minimum Requirements	2500	0	In the event of bid insufficiency, AS minimum requirements would be honored in priority to serving generic Self-Scheduled demand, but not at the cost of overloading transmission into AS regions. In the pricing run, the penalty price of \$0 applies to a very small amount (on the order of "epsilon") of capacity, which then allows the highest-priced accepted bid to set the market clearing price.
Ancillary Service Region Spin Minimum Requirements	2250	0	Spin reserve minimum requirement is enforced with priority lower than regulation up minimum requirement in scheduling run.
Ancillary Service Region Non-Spin Minimum Requirements	2000	0	Non-spin reserve minimum requirement is enforced with priority lower than spin minimum requirement in scheduling run.
Ancillary Service Region Maximum Limit on Upward Services	1500	0	In the event of multiple AS regional requirements having bid insufficiency, it is undesirable to have the multiple constraints produce AS prices significantly

			exceeding the AS bid cap. An alternative for enforcing sub-regional AS requirements is to enforce a maximum AS requirement on other AS regions, thereby reducing the AS prices in the other regions without excessive AS prices in the sub-region with bid insufficiency.
Perfect hedge without scheduling priority (lowest ETC priority level)	1600, -1600	500, -30	Some merchant transmission may receive "perfect hedge" settlement treatment but not high scheduling priority, and a resource associated with such would thus be priced the same as generic self-schedules for demand.
Self-scheduled CAISO demand and self-scheduled exports using identified non-RA supply resource	1600	500	Pursuant to section 31.3.1.3, the uneconomic bid price for self-scheduled demand exceeds the penalty price for relaxed transmission constraints in the pricing run.
Self-scheduled exports not using identified non-RA supply resource	800	500	Self-scheduled exports using RA capacity would be priced at 50% of generic self-schedules for demand.
Regulatory Must-Run and Must Take supply curtailment	-750	-30	Regulatory must-run and must-take supply received priority over generic self-schedules for supply resources.
Price-taker supply bids	-550	-30	Generic self-schedules for supply receive higher priority than Economic Bids at the bid cap, and would be priced 10% higher in the scheduling run.
Conditionally qualified Regulation Up or Down self-provision	-285	-285	Conversion of AS self-schedules to Energy pursuant to section 31.3.1.3 will give higher priority to maintaining the availability of regulation, over spinning and non-spinning reserve. The CAISO is also considering using the AS bid floor as pricing run pricing parameters for all types of AS self provision for consistency with energy self-scheduling parameter in pricing run which is the bid floor of energy for generation. Further testing will be conducted to determine the appropriate value.
Conditionally qualified Spin self-provision	-280	-280	Conversion of AS self-schedules to Energy pursuant to section 31.3.1.3 will give higher priority to maintaining the availability of spinning reserve, over non-spinning reserve.
Conditionally qualified Non-Spin self-provision	-275	-275	The CAISO has determined this penalty price for conversion of self-provided non-spinning reserves through empirical testing, as a value that balances the maintenance of AS self-schedules with

			ensuring that the conversion to energy occurs before transmission constraints are relaxed.
Conditionally unqualified Reg Up or Down self-provision	-75	-75	In instances where AS self-provision is not qualified pursuant to the MRTU tariff, the capacity can still be considered as an AS bid, along with regular AS bids. The price used for considering unqualified AS self-provision is lower than the AS bid cap, to allow it to be considered as an Economic Bid.
Conditionally unqualified Spin self-provision	-50	-50	Same as above.
Conditionally unqualified Non-Spin self-provision	-35	-35	Same as above.

### 4.3. Residual Unit Commitment (RUC) Parameter Values

In addition to the parameters that generally affect the Day Ahead Market, as listed above, the RUC process is affected by constraint penalty prices for minimum on-line capacity, quick-start resource capacity, and minimum load energy. In addition, the RUC process uses uneconomic bid prices for estimated Hour-Ahead self schedules for energy, and the Day-Ahead energy schedules resulting from the IFM run. In setting values for these parameters, it is important to note some key differences between IFM and RUC: IFM uses bids for Demand as well as Supply while RUC uses the full Demand forecast regardless of the available Supply, and RUC is a capacity reservation for additional capacity that would be dispatched in the Real-Time Market, when conditions may vary from the Day-Ahead Market. Thus, the CAISO has placed importance on choosing penalty price values for RUC that will reduce the likelihood of RUC prices that significantly exceed the RUC bid cap, as well as minimizing the likelihood of negative RUC prices.<sup>5</sup> The Market energy balance constraint becomes less critical in RUC than the Intertie capacity constraint, because the CAISO can accept falling short of meeting the Demand forecast if it has committed all available generation and accepted intertie bids up to the intertie capacity, but cannot procure intertie capacity beyond its scheduling limit. At this time, the CAISO is setting the Market energy balance constraint's scheduling run penalty price in RUC to equal the penalty price for adjusting generic self-schedules in IFM, but sets the pricing run penalty price to \$0 so that the last accepted bid will set the RUC market clearing price. The Intertie constraint's penalty price is higher, as discussed above. Scheduling run penalty prices for other transmission are lower than in IFM, because conditions in the Real-Time Market may differ from those in IFM, and thus it is not necessary to create significant LMP differentials until the Real-Time conditions are actually known. Limits on minimum load energy, quick start capacity, and minimum generation affect the RUC capacity reservations, but not at a cost

<sup>5</sup> In cases where the CAISO has been able to date to examine occurrences of negative RUC prices, they have generally resulted from ramping constraints and minimum run times, which have forced generators to run during hours when it is not economic for them to operate, but are needed during other hours. Nevertheless, the net RUC revenue for these generators over the course of a day has been positive. To minimize the chance of negative RUC prices, the CAISO will examine the desirability of waiving ramping constraints and minimum run time constraints, since the final dispatch decisions will not occur until the Real-Time Market.

exceeding the RUC bid cap in the scheduling run, and are \$0 in the pricing run so that the last accepted bid will set the market price. Day-Ahead energy schedules resulting from the IFM run, and estimated Hour-Ahead self schedules for energy, are assigned the RUC bid cap in both the scheduling run and pricing run, in order to preserve these schedules without excessively impacting RUC LMPs.

Penalty Price Description	Scheduling Run Value	Pricing Run Value	Comment
Transmission constraints: Intertie scheduling	2000	250	The Intertie scheduling constraint must retain higher relative priority than other RUC constraints.
Market energy balance	1600	0	The RUC procurement may be less than the Demand forecast if the CAISO has committed all available generation and accepted intertie bids up to the intertie capacity.
Transmission constraints: branch, corridor, nomogram (base case and contingency analysis)	1250	250	These constraints affect the final dispatch in the Real-Time Market, when conditions may differ from Day-Ahead.
Limits on Minimum load energy, Quick start capacity, and Minimum generation	250	0	These constraints affect the RUC capacity reservations, but not at a cost exceeding the RUC bid cap in the scheduling run, and are \$0 in the pricing run so that the last accepted bid will set the market price.
Day-Ahead energy schedules resulting from the IFM run, and estimated Hour-Ahead self schedules for energy	250	250	These schedules are assigned the RUC bid cap in both the scheduling run and pricing run, in order to preserve these schedules without excessively impacting RUC LMPs.

#### 4.4. Real Time Market Discussion

In most cases the Day Ahead and Real Time market processes (RTUC and RTD) will utilize the same penalty price values for the corresponding Self Schedule types and constraints. There are some design differences between Day Ahead and Real Time, however, which are implemented through different values for the parameter settings.

One key difference between the IFM and the Real Time Market processes is that Demand can be bid in with Economic Bids and Self Schedules in the IFM, whereas internal Demand is essentially fixed at the CAISO Forecast of CAISO Demand in the RTUC process, and is determined to maintain Real Time balance in the RTD. In particular, there is no Self Scheduling of internal Demand in the RTM, though there is Self Scheduling of export Demand in the HASP run of the RTUC. Thus penalty price associated with Self Scheduled internal Demand in the IFM corresponds to the CAISO Forecast of CAISO Demand in the RTUC.

Another key difference is that in the IFM a higher priority is assigned to meeting AS minimum requirements than to scheduling energy to supply load if there is shortage in generating

capacity, whereas in the RTM the market will utilize AS capacity to provide energy if needed to serve load, even if this means falling below required AS quantities. Under this AS priority in the IFM both economic and Uneconomic Adjustments of demand would be utilized to obtain a solution prior to any violations of AS minimum requirements. In contrast, in the RTM market applications, system load has the highest priority, so that minimum AS requirements could be violated in order to dispatch energy from unloaded capacity to meet system load.

Finally, among the RTM market applications, the RTPD (RTUC) co-optimizes energy and AS, whereas the RTD optimizes energy only. Therefore, scheduling run penalty prices and pricing run pricing parameters associated with AS requirements are not relevant in the RTD.

At this point in the parameter tuning analysis, the CAISO has not completed sufficient test cases to provide a basis for definitive recommendations for the Real Time market processes. The values listed in the following tables are therefore mostly the same as their corresponding values in the IFM, with only certain differences based on the considerations noted above. Real Time Market Parameter Values

The Real Time Market (RTM) includes the quarter-hourly Real Time Pre-Dispatch (RTPD, also known as the Real Time Unit Commitment or RTUC, a special hourly running of which is the Hour Ahead Scheduling Process or HASP) and the five-minute Real Time Dispatch (RTD). The basis of the Real-Time priority structure is established in the MRTU Tariff in Sections 34.10.1 and 34.10.2. The table below presents and explains the parameter values to be used in the RTM processes. Except for the penalties protecting AS DA Awards and Self-Provision in RTPD which are relevant for RTD, the RTD parameter values are the same as those of RTUC.

Penalty Price Description	Scheduling Run Value	Pricing Run Value	Comment
Energy balance/Load curtailment and Self-Scheduled exports utilizing non-RA capacity	6500	1500	In the scheduling run, it is essential to produce supply matching demand plus losses. In the pricing run, the penalty price is the same as for transmission constraints to ensure that LMPs remain within a reasonable range. This includes CAISO Forecast of CAISO Demand. Since Self-Scheduled Exports being supported by Non-RA capacity is to receive the same priority as CAISO Forecast of CAISO Demand this same priority is used for such Exports. (Tariff Section 34.10.1). Current software can only support one pricing run parameter value for this constraint.
Transmission constraints: Intertie scheduling	7000	6500	The CAISO is considering reducing the pricing run parameter to 1500 for consistency with other transmission constraints. Further testing will be conducted to determine which value results in more appropriate pricing outcome.
Reliability Must-Run (RMR) pre-dispatch curtailment (supply), and Exceptional	-6000	-30	In the scheduling run, the CAISO considers transmission constraints with lower priority for protecting from relaxation

Dispatch Supply			when determining RMR scheduling requirements. In the pricing run, the bid floor is used as the pricing parameter for any type of self-schedule.
Pseudo-tie layoff energy	-6000	-30	Pseudo-tie layoff energy is scheduled under contractual arrangements with the Balancing Authority in whose area a pseudo-tie is located.
Transmission constraints: branch, corridor, nomogram (base case and contingency analysis)	5000	1500, 5000	In the scheduling run, the guideline applied to transmission constraints is that an Economic Bid should be accepted if it is priced at the bid cap and is at least 10% effective in relieving a transmission constraint. In the pricing run, single penalty price segment is modeled priced at three times the Energy Bid cap pursuant to tariff section 31.3.1.3, extending from the original limit to any constraint relaxation resulting from the scheduling run plus a small amount called "epsilon". The CAISO also considers single penalty price segment priced at three times the bid cap for pricing run. Further testing will be conducted to determine which scheme results in more appropriate pricing outcome.
Real Time TOR Self Schedule	4500, -4500	500, -30	A TOR self-schedule would only be adjusted in scheduling run if it has very high effectiveness in relieving a constraint that cannot otherwise be enforced. Bid cap and bid floor of energy for sink and source pricing parameters in pricing run.
Real Time ETC Self Schedule	3200, -3200	500, -30	An ETC self-schedule would only be adjusted in scheduling run if it has high effectiveness in relieving a constraint that cannot otherwise be enforced. The typical value is set at 200% of the generic self-scheduled exports, but different values from \$3400 to \$4500 are possible if differential priorities are established among ETC rights.
Ancillary Service Region Reg-Up and Reg-Down Minimum Requirements	2500	0	In the event of bid insufficiency, AS minimum requirements would be relaxed rather than causing overloading transmission into local area within AS regions. Zero value for pricing run pricing parameter means that the bid with largest bid price and opportunity cost in total sets the AS price.
Ancillary Service Region Spin Minimum Requirements	2250	0	Penalty price for scheduling run is less than the one for regulation-up requirement for lower in priority



Ancillary Service Region Non-Spin Minimum Requirements	2000	0	Penalty price for scheduling run is less than the one for spin requirement for lower in priority
Ancillary Service Region Maximum Limit on Upward Services	1500	0	Penalty price of scheduling run for maximum limit upward services less than the one for minimum requirement is intended for avoiding an otherwise system shortage through procuring AS from sub-region that exceeds its maximum limit.
Perfect hedge without scheduling priority (lowest ETC priority level)	1600, -1600	500, -30	Some merchant transmission may receive "perfect hedge" settlement treatment but not high scheduling priority, and a resource associated with such would thus be priced the same as generic self-schedules.
Self-scheduled exports not using identified non-RA supply resource	800	500	Self-scheduled exports using RA capacity would be priced at 50% of generic self-schedules for demand.
Regulatory Must-Run and Must Take supply curtailment	-750	-30	Regulatory must-run and must-take supply received priority over generic self-schedules for supply resources.
Final IFM Supply Schedule	-650	-30	
Price-taker supply bids	-550	-30	Generic supply self-schedules receive higher priority than Economic Bids at the bid cap, and would be priced 10% higher in the scheduling run.
Conditionally qualified Reg Up or Down Real Time self-provision (RTPD only)	-285	-285	Conversion of AS self-schedules to Energy pursuant to section 31.3.1.3 will give higher priority to maintaining the availability of regulation, over spinning and non-spinning reserve. The CAISO is also considering using the AS bid floor as pricing run pricing parameters for all types of AS self provision for consistency with energy self-scheduling parameter in pricing run which is the bid floor of energy for generation. Further testing will be conducted to determine the appropriate value.
Conditionally qualified Real Time Spin self-provision (RTPD only)	-280	-280 0	Conversion of AS self-schedules to Energy pursuant to section 31.3.1.3 will give higher priority to maintaining the availability of spinning reserve, over non-spinning reserve.
Conditionally qualified Real Time Non-Spin self-provision (RTPD only)	-275	-275 0	The CAISO has determined this penalty price for conversion of self-provided non-spinning reserves through empirical testing, as a value that balances the maintenance of AS self-schedules with ensuring that the conversion to energy

			occurs before transmission constraints are relaxed.
Conditionally unqualified Reg Up or Down Real Time self-provision (RTPD only)	-75	-75	In instances where AS self-provision is not qualified pursuant to the MRTU tariff, the capacity can still be considered as an AS bid, along with regular AS bids. The price used for considering unqualified AS self-provision is lower than the AS bid cap, to allow it to be considered as an Economic Bid.
Conditionally unqualified Spin Real Time self-provision (RTPD only)	-50	-50	Same as above.
Conditionally unqualified Non-Spin Real Time self-provision (RTPD only)	-35	-35	Same as above.