Revised Straw Proposal

Modeling of Multi-Stage Generating Units

April 13, 2009

Modeling of Multi-Stage Generating Units

Prepared for Discussion on a Stakeholder Call – April 17, 2009

1 Summary

Due to their technology, multi-stage generating units have Forbidden Operating Regions in which they cannot operate. That is, between their minimum and maximum operating levels, there are output levels at which the units cannot be dispatched, but rather must be transitioned through. The reason for this is that multi-stage generating units are actually comprised of multiple generators, often termed "embedded generating units."

The Market Redesign and Technology Upgrade (MRTU) design has Forbidden Operating Regions captured in the Master File data set by which the ISO records critical operating and business information for each generating unit. The ISO Integrated Forward Market and Real Time Market software was designed to account for the Forbidden Operating Region constraints so that multi-stage generating units are not infeasibly scheduled or dispatched. It is important to note, however, that while the enforcement of the Forbidden Operating Region constraints keeps units from being dispatched at infeasible output levels, it does not economically optimize the dispatch of multi-stage generating units. That is to say, simply forbidding the software from certain dispatch ranges for specific units does not optimize that dispatch with respect to costs, the various operating configurations of multi-stage generating units, and other resources in the market.

It is for this reason that the Federal Energy Regulatory Commission mandated[1] that the ISO modify the software used to reach an economic dispatch solution to explicitly account for the operating constraints of multi-stage generating units. At this time, the proposal for changes to modeling multi-stage units will be applied only to those units that have specified Forbidden Operating Regions in the Master File. The ISO can evaluate the impact of extending the change to other units with operational dependencies if and when the need arises.

The market simulation efforts involving the ISO and market participants revealed stability and performance issues regarding the enforcement of the Forbidden Operating Region constraints within the Real Time Market software. These issues were reviewed during the October 28th meeting of the ISO Board of Governors, and the Board approved a recommendation to defer the functionality for enforcing Forbidden Operating Regions from the Real Time Market optimization. The Commission has since approved the proposed tariff amendment deferring the implementation of the functionality enforcing Forbidden Operating Regions in the Real-Time. [2]

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1 Paragraph 573 of FERC's September 21, 2006 Order on MRTU "direct(s) the ISO to continue working with software vendors to develop an application that will accurately detail the constraints of combined cycle units, and to file tariff language" for implementation of such improvements no later than three years after MRTU start up.

2 The explanatory memorandum and presentation to the ISO Board of Governors and the approved Board motion to defer this functionality is located at: http://www.caiso.com/2067/2067aeac40f40.html. *See California Indep. Sys. Operator Corp.,* 125 FERC ¶ 61,081 (2009) http://www.caiso.com/2347/2347502a5c5d0.pdf.

Thus, the ISO software in place for MRTU *go live* will not automatically dispatch multi-stage generating units through their Forbidden Operating Regions. As a result, the ISO now proposes to expedite the design and implementation for the explicit modeling of multi-stage generating units into the market software. Specifically, the ISO is targeting resolution of policy issues associated with the explicit modeling of multi-stage generating units to go before the ISO Board of Governors for approval in May of 2009, so that these modeling features could be implemented within six to nine months of MRTU *go live*.

The Forbidden Operating Region functionality will be reinstated once modeling of multi-stage units is thoroughly tested. As long as the FOR functionality is not being used to substitute for accurate modeling of multi-stage units, its reinstatement will not contribute to unstable results like those seen in market simulation.

With this *Revised Straw Proposal*, the ISO offers a conceptual approach for the modeling of multi-stage generation units in the MRTU software that is based on the pseudo-plant model. Scheduling Coordinators will submit operating parameters and costs associated with *ten* configurations of their multi-stage unit. Scheduling Coordinators will be able to submit monotonically non-decreasing bid curves for each of the configurations into the Integrated Forward Market. The ISO model will use these configuration-based or "sub-resource" bids to determine the optimal dispatch for a given hour. Scheduling Coordinators can submit up to *three* configurations of their multi-stage unit into the real time market, subject to some restrictions which are described in section 5 of this *Revised Straw Proposal*.

2 Process and Timetable

The ISO intends to identify appropriate changes to its MRTU market software to address the multi-stage generating unit modeling issue described here, to submit the proposed policy changes to the ISO Board of Governors and to file any necessary CAISO tariff amendments for approval at FERC. The ISO will strive to implement the changes to the MRTU model within the first six to nine months of MRTU *go live*.

The table below summarizes the key steps in the stakeholder process on multi-stage generating unit modeling, starting with the release of an *Issue Paper* and ending with submission of the ISO management proposal to the Board. Please note the changes in the schedule below.

November 7, 2008	Post Issues paper
November 14	Stakeholder conference call
November 21	Stakeholder comments due *
February 17, 2009	Post Straw Proposal
February 25	Stakeholder conference call
March 4	Stakeholder comments due *
April 13	Post Revised Straw Proposal

April 17	Stakeholder conference call
April 24	Stakeholder comments due *
April 28	Post Draft Final Proposal
May 18-19	Presentation to ISO Board of Governors

* Please e-mail comments to Gillian Biedler at gbiedler@caiso.com

3 Key Criteria for Evaluating Potential Solutions

This section provides some key evaluation criteria the ISO believes are important. Stakeholders are invited to identify and suggest other criteria that should be considered in assessing potential solutions.

- Any policy that is developed should achieve the objective of more accurately incorporating the operating parameters of multi-stage generating units so that the units will be economically and feasibly dispatched, and so that the market can benefit from their full participation.

- Any policy that is developed should address the need for Bid Cost Recovery for the embedded generators, i.e. operating configurations, of multi-stage generating units.

- Policy and design options should be evaluated for implementation feasibility and costs for both the ISO Stakeholder and for the ISO. This evaluation should be done keeping in mind (1) the magnitude of the potential issue, and (2) work that has already been done on multi-stage modeling for other markets.

4 Candidate Design Options

There are two primary categories of models for multi-stage generating units. These are pseudo-plant (or configuration-based) models, and pseudo-unit models. Discussion of these approaches is included below:

Pseudo-plant models treat various configurations of a multi-stage unit as units themselves, allowing the resource owner to bid these configurations or pseudo-plants into the market independently. The market optimization chooses which configuration, if any, is part of the optimal solution. In this type of model, the configurations are mutually exclusive, which means that only one configuration can be chosen by the optimization. This pseudo-plant model is employed by the market being developed by ERCOT.

The pseudo-plant approach is problematic from an implementation standpoint. A 3 x 1 combined cycle unit that would have more than ten possible configurations would require ten pseudo-plants. A 4 x 2 combined cycle unit could have over forty possible configurations or pseudo-plants. Modeling each of the potential configurations of a

resource would give more granularity to the dispatch results. However, investigation into recent attempts to model multi-stage units based on the pseudo-plant approach has shown this to be infeasible due to the large number of variables and permutations with which the optimization engine must cope. In particular, these trials take more time to run than is acceptable for real time dispatch due to their complexity.

Pseudo-unit models divide resources into mutually exclusive aggregations that may include portions of an embedded unit. For example, a 3 x 1 combined cycle generating unit would be modeled as three separate pseudo-units. Each of the three pseudo-units would be one gas turbine plus one third of a steam turbine. This is similar to the way the NYISO and PJM approximate the modeling of different configurations of multi-stage generators. This is less than ideal because such a model requires market participants to assign costs and operating parameters to pseudo-units, which is not necessarily intuitive or accurate. In addition to assigning costs to such a pseudo-unit, resource owners would need to provide operating constraints for them. Again, this is not intuitive.

Although the pseudo-unit model is much simpler from an implementation standpoint, it does not appreciably improve the ability of market participants to offer the inherent flexibility of multi-stage units into the market.

5 Proposed Resolution

Based on Stakeholder feedback and evaluation of what is done in other markets, the ISO proposed in its *Straw Proposal* that a modified pseudo-plant approach be taken in developing multi-stage unit modeling in our market. The proposed design recommended configuration-based modeling of multi-stage units in the day-ahead market, and then fixing the configuration outcome of that market going into real time. If no configuration was chosen in the day ahead, the participant bidding the multi-stage unit could choose one configuration to bid into the real time market. This approach was determined to be unsatisfactory to meet the needs of market participants striving to accurately bid in the flexibility and operating considerations of multi-stage units.

The ISO's *Revised Straw Proposal*, summarized below, seeks anew to respect the implementation constraints we will face while providing the framework necessary to accurately bid and model and dispatch multi-stage units. The major revision to the ISO's proposed design enhancement is that participants will be able to bid up to *three* configurations into the real-time market. The main limitations, in addition to the number of configurations that the participant may bid into real time for an MSG unit, are the requirements as follow:

1. At least one configuration's bid must be sufficient to cover any day-ahead energy schedule and Residual Unit Commitment schedule or award;
2. All configurations bid into real time must reserve capacity to fulfill day-ahead ancillary services awards;
3. Configurations bid into the real time market for a particular hour can be feasibly transitioned between one another by the 15-minute unit commitment that occurs in real time; and
4. At least one configuration bid into the real-time market must be feasible given the configurations bid into the previous hour.

5.1 IFM Bidding

We recommended that the model optimize over up to *ten* configurations of each multi-stage units as mutually exclusive resources in the IFM. Under this proposal, market participants will be able to submit bid curves for the individual configurations of their multi-stage units into the IFM. Those bids must follow all the bid-submission rules for standard resources including being non-decreasing. These ten (or fewer) configurations will be stored in the Master File. Any changes to the configurations can be made through the ten-day process by which changes are made to Master File data.

5.2 Real Time Bidding

We recommend that, in the event that none of the configurations of a multi-stage unit are taken in the IFM, the Market Participant can bid in *three* configurations of that unit into the Real Time Market. This limitation is recommended in order to limit the number of configurations over which the Real Time Market must optimize, but at the same time enable the multi-stage units to fully participate in the market. If one of a multi-stage unit's configurations is taken in the IFM, then that configuration or one that can support the day-ahead energy schedule and RUC schedules or awards must be bid into the real time market for that same hour. Two other configurations may also be bid into the real time market provided that transitions within those three configurations are feasible and that the transition from the previous hour is feasible. All configurations bid into the real time market must reflect a reservation of capacity in the amount of any day-ahead award of ancillary services. The SIBR software will validate real-time configuration-level bids to ensure that these stipulations are met, and that transitions between bid-in configurations are feasible according to the information in the ISO Master File data.

We recommend that Bid Cost Recovery be available at the resource level, and that the ISO only pay commitment costs (including transition costs) associated with the real time market. If, however, a resource self-schedules energy and/or self-provides ancillary services in the real time, then IFM commitment costs (including transition costs) would be eligible for BCR. The net revenue calculation for any given hour will be performed at the resource level although the cost component of that calculation will be informed by the configuration-level costs. The sequential netting that is performed to arrive at the BCR values is complex. For the purpose of gaining intuition for how the calculation would be done in the case of MGS units, but without going through the rigorous accounting, please consider the following example in which an MSG resource was dispatched in only three hours of a day:

Table 1: Simple Example of Bid Cost Recovery for MSG Units

Hour Ending	Configuration Dispatched	Bid Costs	MW * LMP	Net Revenue
13	1	$10,000 (SU and ML)	120 MW*$25	-$7,000
14	2	$2000 (transition)	200 MW*$30	$4,000
15	2	-	190 MW*$15	$2,850
Total				**-$150**

In this highly simplified case, the resource came up short for this day, and is eligible for Bid Cost Recovery in the amount of $150.

5.3 Resource Adequacy Offer Obligations

In order to meet resource adequacy offer obligations, multi-stage units with such contractual arrangements should offer in at least one configuration into each the day-ahead and real-time markets. If a multi-stage resource with an offer obligation does not offer in a configuration that can fulfill the offer obligation, the SIBR system will insert a default energy bid and $0 ancillary services bid for the configuration designated by the Scheduling Coordinator as the default configuration for meeting the unit's resource adequacy obligation. The SIBR system will *not* extend the bid curve for a configuration that was not bid in to the full megawatt value of the RA obligation.

In the real-time market, in which the number of configurations that can be bid in for a multi-stage unit is limited to three, the automatic insertion of the default price-taking resource adequacy would be a fourth configuration. Rather than overwrite a submitted configuration-level bid, the system will insert a fourth configuration bid for the resource.

5.4 Residual Unit Commitment

A multi-stage unit can be committed in the Residual Unit Commitment run at any configuration with capacity equal to or greater than the configuration committed in the day-ahead market[3]. If a configuration is given a RUC schedule or award, the scheduling coordinator is obligated to offer the configuration for the megawatt value scheduled/awarded into the real-time market. If the configuration scheduled or awarded by RUC can additionally accommodate the day-ahead energy schedule and ancillary service award and any Resource Adequacy offer obligation, then bidding in this configuration to that megawatt value will satisfy the all the real-time bidding requirements. In that case, the Scheduling Coordinator has two remaining configuration-level bids that are restricted only in that they can be feasibly transitioned within and between hours, and that capacity is reserved for any day-ahead AS award.

5.5 Reliability Must Run Units

Reliability Must Run units will be dispatched and settled per their contracts. RMR contracts negotiated in the future can include different costs for different configurations.

5.6 Ancillary Services

We propose that multi-stage generating units that are certified to provide Ancillary Services obtain certification to provide AS at the configuration level, and can then bid in AS for those configurations for which they are certified.

Any ancillary services award from the day-ahead market will carry through to the real-time market. Thus, bids for any configuration in the real-time must respect the reservation of awarded AS capacity. SIBR will reject real-time bids for which energy bid plus the day-ahead awarded AS capacity exceed the upper operating limit of the configuration. SIBR will also reject bids for configurations that are not certified to provide ancillary services if the resource received an AS award in the day-ahead market.

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[3] Note that this requires that Market Participants bidding in a multi-stage unit rank the configurations. The ranking of the configurations will be a part of the Master File data.

5.7 Information Submittal

Market participants with multi-stage generating units will need to submit detailed information on those units[4]. In particular, information will be required for each configuration and will include the same specificity as is required for generators in general. Parameters such as operating minimum and maximum values, minimum run times, minimum down times, ramp rates, AS certifications, heat rates, etcetera will be stored at the configuration level. Additionally, the ISO will require data related to the transitions between the configurations of each multi-stage unit. For each transition between configurations that is feasible, the ISO will require transition time and cost information. This is akin to the start-up and shut-down related data provided for single-stage generators since each transition between the configurations of multi-stage units is like a shut down of one configuration and a start up of another. There will be the need to have a default configuration flag for the purpose of meeting resource adequacy offer obligations as noted above. Finally, the configurations for a multi-stage unit will need to be ranked for the purpose of Residual Unit Commitment. The need for additional data items may become apparent in the implementation stage of this effort.

5.8 Local Market Power Mitigation

We recommend that Local Market Power Mitigation be performed on a configuration-by-configuration basis. Since LMPM is performed on all clean bids submitted for use in the IFM, individual configurations' bids may be flagged for mitigation. Configurations (or pseudo-plants) that are incremented up in the All Constraints Run would have their bid mitigated based on the relevant operating parameters which would be included in the configuration-level information. In addition, if a unit has a configuration committed in the Competitive Constraints Run, and another committed in the All Constraints Run, both configurations' bids would be flagged for mitigation. An example of how the market power mitigation will be implemented is included in Appendix A to this proposal.

Default Energy Bids, whether cost-based or negotiated, will be developed by configuration.

5.9 Self-Schedules

Self-Schedules must be such that transitions between configurations are feasible. In addition, market bids must be feasible given self-schedules. For each hour, only one configuration is permissible in a self-schedule.

5.10 Outage & De-Rate Reporting

The ISO recommends that the SLIC tool for outage and de-rate reporting be adapted so that within a resource's SLIC screen, a Scheduling Coordinator can select specific units within the resource that are out or de-rated. The SLIC tool will then be able to extrapolate these outages or de-rates to the configurations of which the unit is a component. If the MSG resource experiences a ramp de-rate, then the new four-segment ramp curve will be applied to all configurations. If the ramp de-rate is known in time, the scheduling coordinator can use the configuration-level bids to tailor the revised ramp curve to the individual configurations.

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[4] A sample of the form used by ERCOT for the capture of this information was included as Appendix B to the Straw Proposal posted on February 17, 2009. This document and the glossary that accompanies it are available at the following link: http://www.caiso.com/2078/2078908392d0.html

5.11 Uninstructed Deviations

Under the current MRTU market design, penalties for uninstructed deviations from dispatches are tabulated but not assessed. In part, this is because multi-stage units are not currently being modeled and thus dispatched accurately, and so penalizing participants for deviated from sub-optimal dispatches would be unfair. The extent of uninstructed deviations will continue to be carefully monitored after the implementation of MSG unit modeling to determine if there is a need to seek authority to impose uninstructed deviation penalties.

Telemetry data will indicate to the ISO the operating range of the configuration in which the resource was dispatched. The ISO will incorporate into the market systems the individual telemetry data from each unit that is part of a multi-stage resource. If the resource is operating within the range of the dispatched configuration and deviates from instructions, the usual non-response to dispatch rules will apply. If the resource is outside the configuration's range based on telemetry data, then it will be dispatched to the boundary of the actual configuration based on the requirements of the dispatcher.

6 Conclusion

The ISO is initially targeting the 6-9 month period after MRTU start-up for incorporating modeling of multi-stage generating units within the ISO market systems. Particularly in light of the significant enhancements that this *Revised Straw Proposal* offers over its predecessor, significant software performance issues may need to be overcome. Given the importance and value of competing enhancements to the MRTU market design in this first year of its operation, it may be necessary to prioritize and compromise to accomplish important market enhancements. The ISO will seek to keep stakeholders apprised should changes become necessary in the planned implementation of multi-stage generating unit modeling.

The ISO welcomes stakeholder comments and discussion on this *Revised Straw Proposal.* The ISO will conduct a conference call to review this document on April 17, 2009. If questions, comments or concerns arise before that date, please address them to gbiedler@caiso.com or call Gillian Biedler at 916-608-7203. Formal written comments on this *Proposal* should be sent to gbiedler@caiso.com by close of business on April 24, 2009.

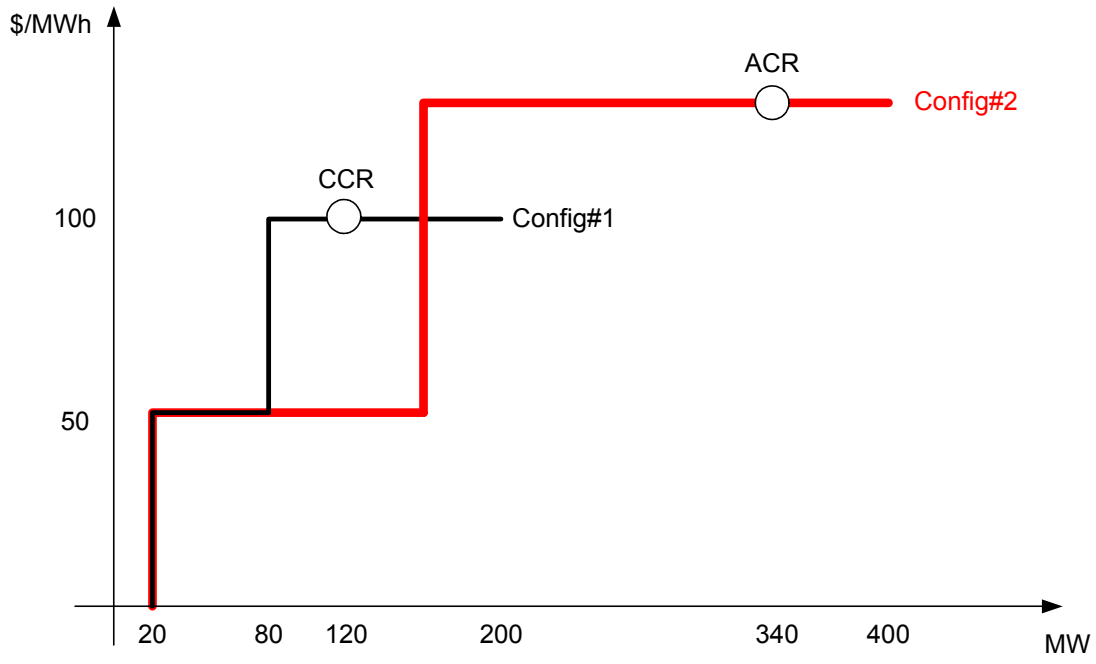
7 Appendix A: Multi-Stage Generating (MSG) Unit Local Market Power Mitigation (LMPM) Example

Assumptions

1. The MSG resource has 2 identical Gas Turbines (GT1 and GT2) and 1 Steam Turbine (ST). The feasible configurations are:
   a. Configuration 1: (GT1 and ST) or (GT2 and ST)
   b. Configuration 2: GT1 and GT2 and ST

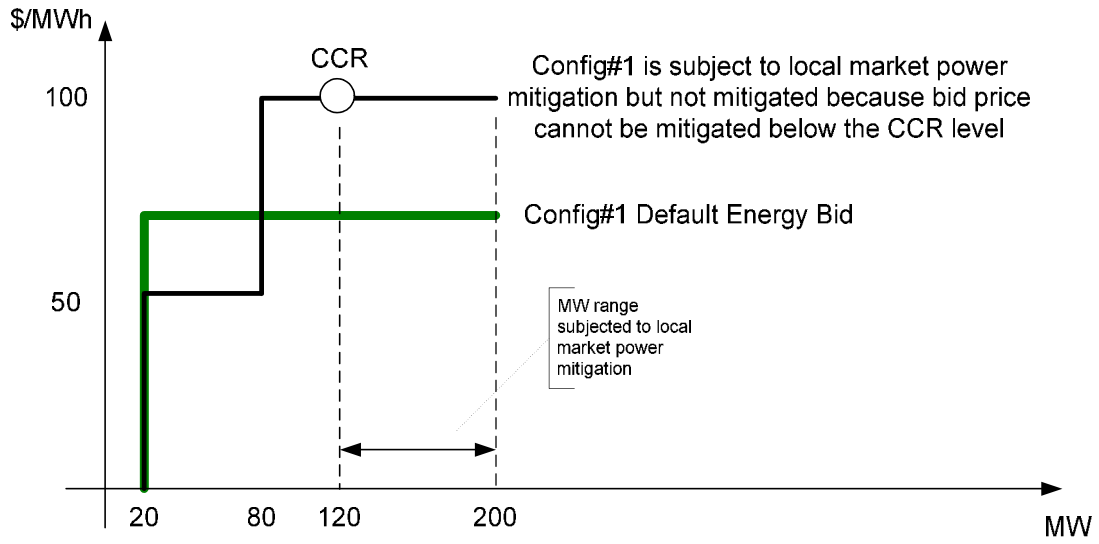
2. The bid curves are as follow:
   a. Configuration 1 (MW, $/MW): (20, 50), (80, 100), (200, 100)
   b. Configuration 2 (MW, $/MW): (20, 50), (160, 130), (400, 130)

3. Configuration 1 (Config#1) is committed in the Competitive Constraints Run (CCR) at 120 MW; configuration 2 (Config#2) is committed in the All Constraints Run (ACR) at 340 MW, as is shown below:



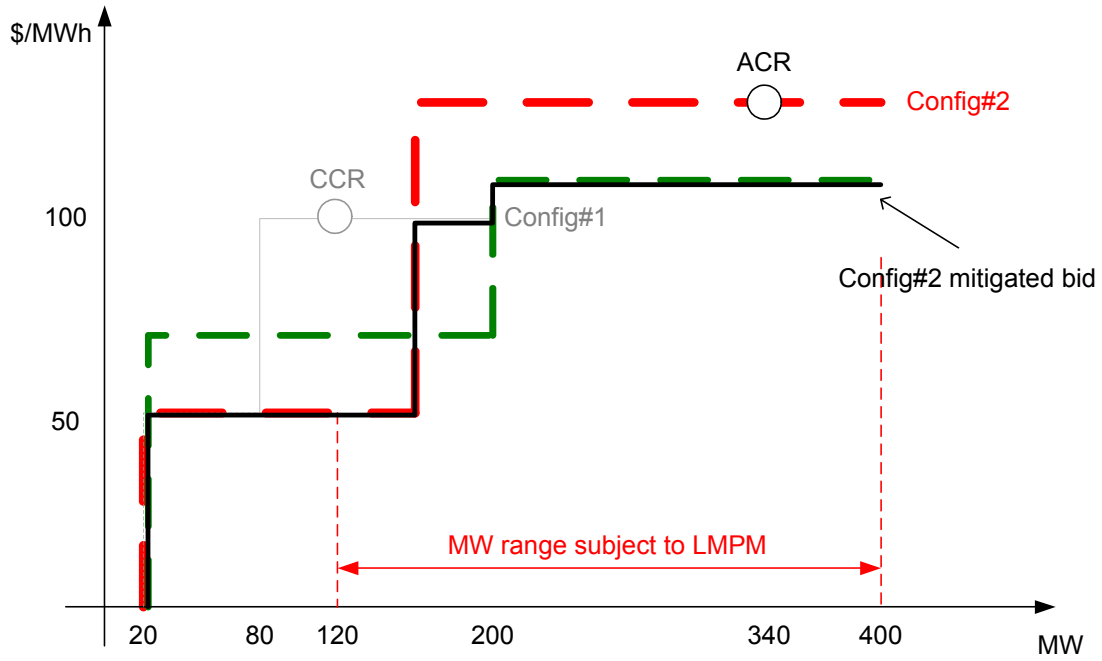
Configuration 1 Mitigation

Config#1 is subject to local market power mitigation but not mitigated because bid price cannot be mitigated below the CCR level.



Configuration 2 Mitigation

Config#2 is mitigated to the lower of the submitted bid price and the default energy bid price but not lower than the CCR bid price of the CCR corresponding configuration.


$/MWh
ACR
Config#2
CCR
100
Config#1
Config#2 mitigated bid
50
MW range subject to LMPM
20
80
120
200
340
400
MW