California ISO
Your Link to Power

Straw Proposal

Modeling of Multi-Stage Generating Units

February 17, 2009

Modeling of Multi-Stage Generating Units

Prepared for Discussion on a Stakeholder Call – February 25, 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, for MRTU *go live* the ISO software 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 early 2009, so that these modeling features could be implemented within 6-9 months of MRTU *go live*.

With this initial *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 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. In the Real Time market, the multi-stage unit will be dispatched within the configuration selected by the IFM for that hour. If none of the multi-stage unit's configurations were taken in the IFM, *one* configuration for that unit may be bid into the RT market.

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 year or 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 *
March 10	Post Final Proposal
March 24-25	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 not 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 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 proposes that a modified pseudo-plant approach be taken in developing multi-stage unit modeling in our market. Stakeholder feedback showed that there is a strong preference for the configuration-based modeling of multi-stage units. This approach is significantly more challenging to implement, however. The ISO *Straw Proposal*, summarized below, seeks to respect the implementation constraints we will face while providing the framework necessary to model multi-stage units.

- IFM Bidding: We recommended that the model optimize over the various configurations of multi-stage units as mutually exclusive resources in the IFM. If one of a multi-stage unit's configurations is taken in the IFM, then that configuration is locked in place for that hour in the Real Time market. This will avoid the implementation infeasibility that would arise if the Real Time optimization was required to solve given all the various configurations of multi-stage units. This closely follows what has been developed for the ERCOT.
- Bid Restrictions: 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. It may be necessary to limit the number of configurations per unit for which a Market Participant can submit bids into the IFM. For example, a multi-stage unit with forty possible configurations may in practice need only six or ten configurations available to be bid into the market. Depending on implementation difficulties with optimizing over all possible configurations, we recommend that the option to limit the number of configurations that a participant can bid into the IFM be preserved.
- Ancillary Services: We propose that multi-stage generating units that are certified to provide Ancillary Services have two options for bidding in that capacity. First, they can submit AS bids only with the energy bid for the configuration that includes the maximum output of the resource. Second, they obtain certification to provide AS at the configuration level, and can then bid in AS for those configurations for which they are certified.
- 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 *one* configuration 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.
- Information Submittal: Market participants with multi-stage generating units will need to submit detailed information on those units in similar fashion to what is required by ERCOT. A sample of the form used by ERCOT for the capture of this information is included in Appendix B.

- Market Power Mitigation: We recommend that Market Power Mitigation be performed on a configuration-by-configuration basis. Since Market Power Mitigation 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 pass of the Mitigation 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.
- Bid Cost Recovery: We recommend that Bid Cost Recovery be available at the resource level. 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.

Below, the issues that were identified in the Issue Paper are reiterated and followed by a description of how the proposed design of multi-stage generating unit modeling addresses these issues.

5.1 Inaccurate reflection of operating characteristics

Much of the inherent flexibility of multi-stage generating units goes unused by the optimization which can lead to suboptimal dispatch and thus higher costs. In addition to the multi-stage generating units' flexibility that is foregone due to software limitations, multi-stage generating unit owners and operators limit the flexibility they offer into the market in order to protect against uneconomic or infeasible dispatches.

Specifically, operators of multi-stage generating units will face difficulties in protecting infeasible operating ranges particularly given limitations on ramp rates and the suspended functionality of Forbidden Operating Regions upon MRTU *go live*. As a result, operators of multi-stage generating units, to avoid dispatches that are infeasible, will have the incentive to deviate from such dispatches or to bid so as to operate at their preferred configurations. Once in the preferred and stable operating configuration, the owner of a multi-stage generating unit will need to manually adjust the unit's dispatch range (via unit de-rates, for example) in order to eliminate the possibility that the ISO would dispatch the unit between configurations. This poses an operational burden in that more operator management of the resource is required.

5.1.1 How the Straw Proposal addresses this issue

Detailed information at the pseudo-plant level will be used by the IFM optimization in choosing a configuration at which to award a schedule for the multi-stage unit in the IFM. Additionally, the information submitted by the owners or operators of these units will include constraints for transitions between configurations so that if the IFM chooses one configuration in hour 5, for example, and a different configuration in hour 6, the necessary considerations for that transition are respected.

Additionally, the proposal seeks to keep the units in the market by allowing them to be bid in under one configuration in the Real Time Market if the unit did not receive a schedule in the IFM.

5.2 Bid structure inadequate to capture unit flexibility

It is difficult and potentially misleading to create a continuous, monotonically non-decreasing bid curve that represents the full range of embedded operating configurations of a multi-stage generating unit. Further, submitting a curve that cannot accurately reflect operating constraints might expose operators of multi-stage generating units to infeasible or costly dispatches. As mentioned above, this will leave those operators to bid and/or re-rate their units in order to force the dispatch of their units to be within specific operating ranges or configurations. Again, this impedes the inherent flexibility of the multi-stage generating units from being realized by the market.

5.2.1 How the Straw Proposal addresses this issue

Being able to submit bids for a particular configuration of a multi-stage generating units will enable the Market Participant to accurately reflect the trade-offs – both economic and engineering – that are faced when the unit is operating in that configuration. The addition of software functionality to richly model the characteristics of multi-stage generating units will enable the market to benefit from their flexibility. While the Forbidden Operating Region functionality simply moves units through their Forbidden Operating Regions, modeling of multi-stage units will capture the operating parameters that vary with output levels. These parameters would include operating and start-up costs, hold times, nuances in ramping capabilities, varying heat rates and energy costs, and dual regulating ranges. Multi-stage unit modeling can optimize with respect to these output-varying parameters because it relieves the constraint that these resources must submit a single monotonically increasing bid curve.

5.3 Multi-Stage Modeling and Forbidden Operating Region Functionality

The need for both the Forbidden Operating Region functionality and the multi-stage unit modeling is not clear at this time. In theory, the multi-stage modeling would supplant the need for Forbidden Operating Region as the modeling would be a more sophisticated implementation of these constraints. Once there are software options to evaluate for the multi-stage modeling, more robust analysis of the need for maintaining the Forbidden Operating Region functionality will be possible.

5.3.1 How the Straw Proposal addresses this issue

It is possible that the Forbidden Operation Region functionality will be necessary to accurately dispatch multi-stage units after the implementation of multi-stage modeling. In this case, Forbidden Operating Regions will be used simply to prevent dispatch in a range through which a unit can only transition. The Forbidden Operating Region functionality will not be used to approximate the operating constraints of multi-stage units.

5.4 Bid Cost Recovery

The current structure of Bid Cost Recovery (BCR) is based on the cost components of a resource's bid. The ISO uses resource-specific Start-Up and Minimum Load costs for this calculation, and the resources bid for the Energy bid cost component. Under MRTU as currently designed, one value for each of these costs is recorded for each resource. The stakeholder process will evaluate the concept that multi-stage generating resources, which are comprised of multiple embedded

generators, might be better served by a more tailored calculation of BCR. In particular, a BCR calculation that uses the output-varying values for costs such as Start-Up and Minimum Load for each of the embedded generators rather than for the composite unit as a whole may be preferable to the calculation currently in place. The potential benefits of such a change, as well as the feasibility of it from an implementation standpoint, are to be evaluated.

5.4.1 How the Straw Proposal addresses this issue

The net revenue calculation for each unit for each hour will still be calculated at the resource level, but will be reflecting of the configuration-level costs for whatever configuration at which the unit was dispatched in the hour. If the unit is eligible for Bid Cost Recovery, the value of that payment will be calculated using the configuration-specific information submitted to the ISO.

6 Conclusion

The ISO is initially targeting the 6-9 month period after MRTU start-up for incorporating such modeling within the ISO market systems. The ISO is assessing implementation requirements for this Straw Proposal amidst the continuing focus and priority for the MRTU *go live*. The ISO will seek to keep stakeholders apprised should changes become necessary in the planned implementation of these important features for multi-stage generating units.

The ISO suggests greater benefit will be reached by evaluating the overall impact of enhanced modeling of multi-stage generators, rather than just examining software impacts related to dispatch through Forbidden Operating Regions which do not assess all costs or options for optimal dispatch. Thus this stakeholder process will consider a broad range of issues related to modeling various operating configurations of resources – within a future operating state where such enhanced modeling is in place. This stakeholder discussion generally will *not* review issues related to the market operations process for handling Forbidden Operating Regions after MRTU *go live*, but prior to the incorporation of this modeling feature.

The ISO invites stakeholder comments and discussion on this Straw Proposal. The ISO will conduct an initial conference call to review this *Straw Proposal* on February 25, 2009. Written comments should be sent to gbiedler@caiso.com by close of business on March 4th.

7 Appendix A

Below please find summary statistics on the composition of the group of Multi-Stage Generating Units. Each of these 60 units has at least one Forbidden Operating Region, and some have as many as three.

Generation Technology		
Combined Cycle	CCYC	15
Gas	GTUR	15
Hydro	HYDR	11
Other	OTHR	1
Pump	PTUR	2
Steam	STUR	16
Total		60

Forbidden Region Summary Statistics		
Bottom of Forbidden Region	Minimum	0.10
	Average	94.40
	Maximum	551.00
Crossing Time	Minimum	1.00
	Average	17.10
	Maximum	90.00
Top of Forbidden Region	Minimum	2.00
	Average	125.45
	Maximum	579.00

8 Appendix B

Accompanying this *Issue Paper* as separate files, please find a blank copy of the Resource Asset Registration Form (RARF) used by ERCOT, and a glossary that accompanies this form. The ISO proposes that we have a similar information submittal vehicle for multi-stage generating units in order to capture the detailed operational and economic information associated with the units' possible operating configurations.