California Independent
System Operator Corporation

Issue Paper

Post-Release 1 MRTU Functionality for Demand Response

The California Independent System Operator's (CAISO) Market Redesign and Technology Upgrade (MRTU) is a comprehensive program that enhances grid reliability and fixes flaws in the ISO markets. It keeps California compatible with market designs that are working throughout North America and replaces aging technology with modern computer systems that keep pace with the dynamic needs of California's energy industry. MRTU integrates and optimizes market and operational functions using a full network model, and importantly, adds a Day-ahead energy market. When implementing a program with this complexity, not all market design features can be included in the initial release. As such, the CAISO intends to supplement the MRTU functionality through future releases, including greater functionality related to demand resources and their integration into the wholesale electricity markets and grid operations.

Even though it was part of the original conceptual market design, one desirable feature that could not be fully implemented in MRTU Release 1 was the more complete modeling of demand resources, also known as "Participating Loads." In particular, the original market design contemplated options for scheduling Loads at either their physical location or through broad load aggregations. However, it was resolved that most Loads should be scheduled at high-level Load Aggregation Points (LAPs), with few exceptions, even though an LMP based market, like MRTU, uses fairly specific physical locations as the basis for system dispatch. The CAISO attempted to reconcile the scheduling of base load at the high-level LAPs while dispatching Participating Loads at physical locations, but the associated issues that sprang forth could not be timely resolved. Eventually, it was determined that Participating Load should in fact be scheduled at physical locations (including aggregations of Loads within geographic areas) for both the base load and the dispatched demand response, but MRTU's implementation was too far advanced to return to conceptual design stages and development work. Thus, the CAISO is implementing simplified Participating Load functionality in MRTU's initial release.

With MRTU Release 1 development approaching completion, the CAISO is ready to reconsider the original conceptual design features considered and development work completed for demand resources in the next installment of MRTU. Because the more robust Participating Load model was partially developed, it may be possible to complete its implementation in relatively short order notwithstanding corporate priority and resource constraint issues. For example, FERC has directed the CAISO to implement other near term additions to the MRTU design within 12 months of MRTU Release 1 such as convergence bidding and scarcity pricing. Whether the full Participating Load functionality can be implemented expeditiously will depend on whether its design is sufficient for near-term market needs, but even after its initial implementation, the CAISO can continue to consider enhancements to the design.

This Issue Paper has two attachments that describe the Participating Load functionality that the CAISO hopes can be implemented expeditiously. Attachment A is an excerpt from the CAISO's April 29, 2002, Comprehensive Market Design Proposal for the Market Design 2002 Project (MD02), with minor updates to reflect changes in MRTU since the initial MD02 proposal. Attachment B is a comparison of market designs for Participating Load between MRTU Release 1 and the full Participating Load model.

Given this background, this Issue Paper presents a single issue on which the CAISO invites input:

- Should the CAISO proceed to plan the implementation of the full Participating Load functionality as described herein (in the context of the evolved MRTU market design) or do the original design concepts for full participating load need further refinement and reconsideration?

As noted above, enhancements to the Participating Load functionality as outlined in this Issue Paper can be further enhanced and improved upon in the future.

Attachment A

Conceptual Market Design Update:
Demand Side Bidding and Options for Demand Response

The two sections of text in this attachment present an initial update to sections 5.8.2.2 and 5.8.3, with the same titles, which were part of the CAISO's April 29, 2002, Comprehensive Market Design Proposal for the Market Design 2002 Project (MD02). Minor updates to the following description have been made to reflect changes in the overall MRTU design since the MD02 proposal was first submitted to FERC:

- References to FERC's Standard Market Design have been replaced with current references to MRTU's policy context, "MD02" has been replaced with "MRTU", references to sections of original MRTU Comprehensive Design Proposal have been replaced with references to this document, and the surrounding wording has been updated for the current context.
- Discussion of Available Capacity (ACAP) requirements has been deleted, because ACAP has been superseded with Resource Adequacy requirements.
- The Hour-Ahead Market that was originally proposed in MD02 was later eliminated.
- MRTU Release 1 includes scheduling and settlement of Participating Load at its physical location, using custom load aggregation. The initial MD02 filing had offered an optional of scheduling at physical locations or higher aggregations, and this was replaced in subsequent filings with scheduling of base load at high-level aggregations and dispatch of the price-responsive demand of Participating Loads at their physical location. Difficulties in reconciling these geographic levels for scheduling base load versus price responsive demand led to the need to defer the full Participating Load functionality. Attempts to reconcile these geographic levels for base load versus price response had also led to requiring the base load of Participating Load customers to be self-scheduled in the Day-Ahead Market, but having both the Day-Ahead and Real-Time scheduling at the same level now allows the full price response to be allowed that was originally proposed.
- Market power mitigation is being considered through separate processes and thus is not described in this issue paper.

Because the described functionality was partially implemented during the initial Release 1 of the CAISO's Market Redesign and Technology Upgrade (MRTU) program, the CAISO anticipates that it would be able to complete the originally anticipated functionality for supporting demand resources, after MRTU's initial implementation is complete. Based on initial stakeholder input, the CAISO will determine the timing of implementation for these features. (The closer the features are to the CAISO's original design, the sooner their implementation can occur.)

Accommodation of Demand Side Bidding

The CAISO's ongoing market design initiatives recognize that the development of demand resources is a significant part of a comprehensive market design. In general, the MRTU program has identified a number of features that will facilitate demand responsiveness once their implementation becomes feasible. A major piece of the Post-Release 1 MRTU market changes will be to provide for voluntary three-part bids (equivalent to start-up and minimum-load costs, and energy bids) to be submitted to the Residual Unit Commitment (RUC) process as well as the Integrated Forward Market (IFM). This will ensure the most comparable treatment that can feasibly be provided between load and generation resources.[1]

The scheduling and settlement of load offers additional opportunities for response to day-ahead and hour-ahead energy prices. Because Participating Loads submit bids for dispatched "Participating Load" using custom load aggregations, loads can be price-responsive to locational prices through aggregated scheduling. If a LSE serves load that it believes will adjust its load based on forward energy prices, it can include an energy bid curve in its load schedule. Deviations from the resulting energy schedule would then be settled at the real-time energy price.

---

[1] Examples can illustrate how equivalents of start-up and minimum-load costs promote comparable treatment of load and generation resources. If a load has a recovery time after a curtailment before it can be back in operation, which is independent of how long the curtailment lasts, it could bid a start-up cost equal to its energy bid price times that recovery time. A load that needs two hours to restart its industrial process after a curtailment ends, regardless of the length of curtailment, could thus be compensated for a minimum of its recovery cost given 0.5 hour of dispatched operation for a 30-minute curtailment, and for a minimum of its recovery cost given 4 hours of dispatched operation for a 4-hour curtailment.

As with a generator, its cost recovery would be for market revenues plus any net-of-market start-up and minimum-load cost. If the load is un-dispatched after one hour but its bid has a minimum 4 hours "run" time plus a "start-up" cost equal to 2 hours recovery time times its energy bid, it would also have a minimum cost recovery equivalent to 6 hours times its bid price. In this example, if its bid price is $50/MWh plus its start-up cost and the market clearing price (MCP) from 1 to 2 PM is $200 and $40 from 2 PM to 5 PM, it would be assured of least $300/MW of cost recovery (6 hours times $50) but would have received $320/MW in market revenue (1 hour at $200, plus 3 hours at $40), so it would receive no additional revenue to cover its "startup" cost. At a lower MCP, there may be assured cost recovery that would be charged to the market as an uplift. This is the same cost recovery as a CT that bid $50/MWh, and has a 4 hour minimum run time and a $100/MW startup cost.

The intent is to provide flexibility to loads in being dispatched in competition with other resources. In the above example, the load could bid a $300/MW start-up cost, $0 minimum load cost, and a $0 energy bid that covers a 6-hour block time period, with the same result. The load could also use a minimum run time (i.e., minimum time off-line), instead of a fixed start-up cost, if it can perform its recovery during the curtailment and thus have a shorter recovery time after a longer dispatch. Alternatively, the load could bid a minimum-load cost per hour to curtail at all, and bid a different energy price for additional load shedding. Providing this flexibility to the LSE will be essential, and verification increasingly difficult for the ISO, in cases where the LSE uses an aggregation of load resources (e.g., air conditioning cycling on small end-use customers, combined with management of an industrial process) to support its bid.

In all the cases, the dispatch would have considered what is the most economical way of serving the overall energy need, and would dispatch the load resource if it were cheaper in total than other resources, including its startup and minimum-load cost. This will place a practical limit on loads bidding excessive start-up and minimum-load costs, since excessive bids could mean that the load resource would never be dispatched.

MRTU Options for Demand Response

Although the CAISO's MRTU program has evolved considerably since its original roots in FERC's Standard Market Design effort, a principle stated in FERC's March 2002 "Working Paper on Standardized Transmission Service and Wholesale Electric Market Design" (at p. 6) has not lost its significance: "Demand response is essential in competitive markets to assure the efficient interaction of supply and demand, as a check on supplier and locational market power, and as an opportunity for choice by wholesale and end-use customers." The ISO fully supports this role for demand resource programs.

The CAISO's Market Redesign and Technology Upgrade (MRTU) proposals as stated herein further demonstrate the ISO's commitment to demand programs as a vital ingredient for Load Serving Entities (LSEs) to meet their capacity obligation and meet their customers' needs. The implementation of retail demand programs is ultimately the responsibility of LSEs and state agencies, but the ISO is supporting these programs by establishing needed market infrastructure and incentives.[2] When viewed in the context of a capacity obligation, the new ISO design including a capacity obligation will place additional financial incentives on LSEs to develop these programs to reduce their costs. The ISO's proposals also provide improved opportunities for load to respond to prices in the ISO's markets, and to participate as resources that augment supply resources. These opportunities include:

- Ability to recover "start-up" and "minimum-load" costs through Residual Unit Commitment.
- Day-Ahead energy market, allowing a commitment to load reduction at a price established with enough time to schedule daily production at an industrial facility (or similar planning for other loads). Viewed another way, a load can say through its bid that it will reduce its normal energy use if it would need to pay a higher-than-normal price – or that it will use additional energy if it is available at a lower-than-normal price. Currently, loads can deviate from their schedules and be paid as uninstructed deviations at real-time prices, but the real-time prices can be unpredictable from the customer's perspective. Thus, the new Day-Ahead market offers new opportunities for response at a known price.
- Participation in the Real-Time market, receiving the RT price with ability to be dispatched in competition with other resources like inter-ties and CTs, assurance of recovering cost-based start-up costs and a minimum of its bid price for energy, and operation for a minimum run time.
- Ability to receive the Real-Time price during the highest-cost intervals by a cycling response by 5-minute interval, for resources that can offer such response.
- Ability to offer response to locational price variations through DA and RT energy markets.
- Continued ability to participate in Ancillary Service markets, thus receiving a capacity price for providing non-spinning reserve.

---

[2] For example, the end-use load can only get a benefit from the wholesale price if it is allowed by the CPUC (or the local regulatory authority). An end-use load under a bundled retail rate can then benefit from curtailing when the prices go up, or from using more energy when the prices go down, if the retail tariffs established by the CPUC provide an option for real-time pricing, which allows the IOU to pass through some type of charge or credit in addition to the bundled customer's retail rate.

- Continuation of relaxed telemetry requirements for non-spinning reserve (one-minute updates from the participating load to the SC's server, as opposed to four-second updates from generators) and waiver of telemetry requirements for supplemental energy. That is, only interval metering and ability to receive dispatch instructions is necessary to supply supplemental energy, for individual and aggregated loads under 10 MW. For participation in the DA energy market, only the separate reporting of energy metering is needed, at the level at which the price response is offered, using metering requirements established by the Local Regulatory Authority.
- Loads or aggregated load entities must execute a Participating Load Agreement. This establishes sound mechanisms for settlement flows from the ISO to Scheduling Coordinators, which then allows settlement with LSEs and ultimately with end use loads.

Attachment B

Dispatchable Demand Resource Functionality in MRTU

The following content was provided for a MRTU Workshop on Demand Response on November 2, 2006. Minor clarifications are included below.

Introduction

The CAISO's intent is to fully support Dispatchable Demand Resources ("DDRs") in its MRTU software design. In many cases, the needs of price-responsive Demand can be met simply by participation in the CAISO's Energy market, which allows price-responsive Demand bids at Load Aggregation Points in the Day-Ahead Market and settles Real-Time deviations from Day-Ahead schedules at the Real-Time Imbalance Energy price for the Load Aggregation Points, with no Uninstructed Deviation Penalties for Load.

Alternatively, Participating Loads that participate in the CAISO's imbalance energy and ancillary services markets, and pumped storage facilities, are types of DDRs that are modeled with added functionality in the CAISO's MRTU software. In the initial release (Release 1) of the MRTU software, Participating Loads will be able to participate in the wholesale energy and ancillary service markets with certain limitations based on software functionality. The CAISO is working to address some of these limitations in its Release 1 and intends to develop a more robust and comprehensive integrated solution for participation of DDRs in Release 2 of its MRTU software.

Following is a more detailed description of the design challenge and a comparison of the CAISO's intended approach to incorporate DDRs in Release 1 and Release 2 of its MRTU software.

Description of Limitations

A full DDR model is not contemplated for Release 1 of the MRTU software. In 2005, consultants to the CAISO identified a design flaw related to Participating Load that would have resulted in inequities between prices settled at Load Aggregation Points and those settled at individual nodes. Based on this finding, the CAISO deferred the full implementation of DDR to Release 2, realizing the need to give the entire issue further thought and to get the design, rules and validation "right." However, recognizing that most of the existing Participating Loads are large hydro pumps, the CAISO will support participating pump load (or other Participating Load that can operate like a pump) by implementing a pump/storage model in Release 1 of the MRTU software. While the pump/storage model is able to provide some desired attributes of a DDR model (e.g., multi-part bids and some inter-temporal constraints), it has limitations including an inability to aggregate loads that share common metering. Therefore, as an alternative to the pump/storage model, the CAISO is also prepared to support Participating Loads using the same Energy bid structure as non-participating Loads, and to support the Participating Loads' eligibility to provide Non-Spinning Reserve through a manual work-around, provided that metering and the network topology support this arrangement.

The Pump/Storage Model - Release 1

The pump/storage model models a pump as a negative generator when in the pump mode and as a normal generator when in the generator mode. For a simple pump or demand response resource, the negative generator mode of the pump/storage model would be used.

The full DDR model would allow a pump to curtail a portion of its base load in the Day-Ahead market. The pump/storage model, however, will only allow for a pump to bid to buy/pump in the Day-Ahead Market at its full capability, and only allow curtailment in the Real-Time Market based on its Day-Ahead schedule. If the pump was not scheduled in the Day-Ahead Market, it could offer to buy/pump in the Real-Time Market.

In addition, the full DDR model will support bids at different operating levels and incorporate a variety of inter-temporal operating constraints, while the pump/storage model supports only a single on/off state in pump mode (as a negative generator) with inter-temporal constraints limited to (1) minimum pumping time, (2) the maximum pumping energy per day, and (3) the maximum number of pumping cycles.

Extended Non-Participating Load with Non-Spinning Reserve Eligibility Model - Release 1

For some market participants, the attributes of a full DDR model are critical (e.g., multi-segment bid curves or aggregation of multiple loads). The CAISO will offer an alternative model to these market participants, allowing them to submit Energy bid curves as if they are non-participating Loads, and also to bid in the Non-Spinning Reserve market. The CAISO will work with individual market participants to ensure that the metering arrangements and the CAISO's network model can be configured appropriately. This alternative involves adding a pseudo-generator to the CAISO's network model to support bidding and dispatch as Non-Spinning Reserve. In the case of aggregated Loads, the CAISO must also be able to add a Pseudo Generator to its network model that will allow Energy bids to be modeled using the same functionality as generators from the CAISO.

Full DDR Model - Post-Release 1

Table 1 below draws a comparison between Release 2 (the full DDR model) and Release 1 (the initial proposed pump/storage model).

Table 1: Compare & Contrast - Release 1 vs. Post-Release 1

Attribute	Full Dispatchable Demand Resources Model (Post-Release 1)	Pump/Storage Model (Release 1)	Extended Non-Participating Load Model (Release 1)
Model	• Base Load as Price-Taker • Logical Generator represents generator dispatch capability from Base Load	• Pump model as negative generator mode of pump/generator model where positive generator mode is not used	• Load operates as non-participating Load • Manual work-around by CAISO allows participation as Non-Spinning Reserve
Number of energy bid segments	Up to 10 segments	Single Segment (Pump is on or off)	Up to 10 segments
Aggregate physical resources?	Yes	No	Yes
Bid Components	Three-part bid: • Load Curtailment Cost • Minimum Load Reduction Cost • Load Energy Bid	Two-part bid: • Shut-Down Curtailment Cost • Pump Energy Costs	One-part bid: • Load Energy Bid
Base Load Supported	Yes	No	No
Settlement	• Base Load at nodal LMP • Curtailment from Base Load is settled to ensure recovery of Minimum Load Reduction Cost plus Load Curtailment Cost • Dispatch beyond minimum load reduction is settled at nodal LMP in DAM/RTM	• In DAM pump can only bid to buy energy. If scheduled, pump load is charged DAM LMP. If not scheduled in DAM, no charge. • In real-time any curtailment from DAM schedule will be paid nodal LMP plus shutdown curtailment cost. If pump not scheduled in DAM, pump resource may offer to buy to pump in RTM.	• CDWR pumps will have separate Load Aggregation Points (LAPs) for DAM and RTM LMP calculation. For other potential Participating Loads, CAISO will determine feasible level of LMP disaggregation on a case-by-case basis. • Schedule in DAM is settled at locational DAM price. • Difference between DAM and actual RT Demand is settled at locational RTM price. Participating Load is not subject to Uninstructed Deviation Penalty.
Day-ahead Market Treatment	Dispatchable Demand Resources can be dispatched from Base Load in DAM and be compensated for curtailment/dispatch accordingly in DAM	Model as a negative generator and can only submit offer to buy in DAM	• Energy is scheduled in DAM as non-participating Load. • Participating Load is eligible to bid Non-Spinning Reserve, using pseudo-generators placed at the locations of Loads.

Real-time Market Treatment	May bid to curtail/dispatch load from either DAM level or RTM Base Load level.	In real-time, pump may offer to curtail from DAM schedule (if scheduled in DAM) or offer to buy to pump in RTM if not scheduled to pump in DAM. However, same energy bid used in the Day-Ahead market must be used in all hours. As a result, there is no opportunity for a pump to shape its offer price for different hours.	• Loads determine RT operating point by monitoring RT price. • CAISO dispatches Non-Spinning Reserve as contingency-only reserve, using pseudo-generators placed at the locations of Loads. Actual response will be expected as a reduction in Demand.
Inter-temporal Constraints	Yes • Load Curtailment Time (time to curtail load) • Minimum Load Reduction Time (minimum time after load curtailment) • Minimum Base Load Time (minimum time after load restoration) • Maximum Number of Daily Load Curtailments	Yes • Minimum Up Time (minimum time to stay in pumping mode after switching to that mode) • Maximum status changes (maximum switches into pumping mode) • Daily Energy Limit	No
Load Ramping	Yes • Load Drop Rate • Load Pickup Rate	No	No
Ancillary Service Eligibility	Eligible to provide Non-Spinning Reserve	Eligible to provide Non-Spinning Reserve	Eligible to provide Non-Spinning Reserve

In summary, a full Dispatchable Demand Resources model would likely consist of the following:

- A three-part bid consisting of:
  - Load curtailment cost
  - Minimum load reduction cost
  - Load energy bid
- Load curtailment time (time to begin curtailing load)
- Minimum load reduction time (minimum operating time after load curtailment)
- Minimum base load time (minimum time in normal operation after load restoration)
- Maximum number of daily load curtailments
- Load drop rate
- Load pickup rate
- Maximum non-spinning reserve capacity (load reduction within 10 minutes)

In addition, the DDR model is contemplated to have the following attributes:

- When the DDR is dispatched from the base load, it is eligible for recovering its load curtailment cost and its hourly minimum load reduction cost
- When the DDR is dispatched, it is paid its LMP for the load reduction

Thus, a DDR resource could be compared and contrasted to a generator as follows:

Dispatchable Demand Resource	Generator Resource
Load Schedule	Base Load
Minimum load reduction	Minimum generator output
Minimum load	Maximum generator output
Load curtailment time	Start-up time
Minimum load reduction time	Minimum up time
Minimum base load time	Minimum down time
Maximum number of daily curtailments	Maximum daily start-ups
Load drop rate	Ramp up rate
Load pickup rate	Ramp down rate
Load curtailment cost	Start-up cost
Minimum load reduction cost	Minimum load cost