Technical Bulletin

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Simplified Ramping

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Background

Prior to start of the new market (MRTU), the CAISO was deferred its implementation of a more flexible approach of accounting for a resource ramp rate constraints. The CAISO is now planning again for implementation of the revised ramp rate accounting approach. Following is technical information explaining the new ramp rate accounting approach.

Inter-interval Ramping Constraints

The maximum amount of supply available to the ISO markets is generally thought of as the sum of the bid-in capacity of all generators and demand response resources. Because the market optimization honors resource performance constraints, however, the available supply in any given market interval is further constrained by available ramping capability. Modeling ramp rate constraints correctly is an important element of the MRTU market design that enables the ISO markets to produce feasible inter-interval schedule changes and dispatch instructions.

The MRTU design treats ramping constraints in a manner that balances the requirements of reliability, market supply and schedule feasibility.[1] The MRTU approach is implemented in the software as a pair of ramp rate constraints that apply to inter-interval energy schedules and ancillary services awards. These constraints apply to each generating unit during the ramping process between two consecutive market clearing intervals, in both the day-ahead and the real-time markets. One constraint, in the upward direction, uses the resource's ramping capability to limit a weighted sum of its inter-interval energy schedule change or dispatch instruction and its regulation up, spinning, and non-spinning reserve awards. The second constraint, in the downward direction, limits a weighted sum of the resource's inter-interval energy schedule or dispatch change and its regulation down award.

[1] See ISO MRTU Tariff sections 31.3 and 34.5 and the ISO Business Practice Manual for Market Operations sections 6.6 and 7.1.

The constraints are expressed as the following equations:

$$(p_{i,t}^{En} - p_{i,t-1}^{En}) + \alpha(p_{i,t-1}^{Ru} + p_{i,t}^{Ru}) + \beta(p_{i,t-1}^{Sr} + p_{i,t}^{Sr}) + \eta(p_{i,t-1}^{Nr} + p_{i,t}^{Nr}) \le RampRate(p_{i,t-1}^{En}) \cdot T$$

and

$$(p_{i,t}^{En} - p_{i,t-1}^{En}) - \alpha(p_{i,t-1}^{Rd} + p_{i,t}^{Rd}) \ge -RampRate(p_{i,t-1}^{En}) \cdot T$$

where,

$p_{i,t}^{En}$, $p_{i,t-1}^{En}$ = energy schedules of unit *i* in intervals *t* and *t-1*

$p_{i,t}^{Ru}$, $p_{i,t-1}^{Ru}$, $p_{i,t}^{Rd}$, $p_{i,t-1}^{Rd}$, $p_{i,t}^{Sr}$, $p_{i,t-1}^{Sr}$, $p_{i,t}^{Nr}$, $p_{i,t-1}^{Nr}$ = Regulation Up, Regulation Down, Spinning, and Non-Spinning Reserve awards to unit *i* in interval *t* and *t-1*

$RampRate(p_{i,t-1}^{En})$ = operational ramp rate of unit *i* at dispatch level $p_{i,t-1}^{En}$ (MW/minute)[2]

T = length of an interval (minute)

α, β, η = ramp-sharing coefficients.

These ramp rate constraints apply to all the MRTU markets, both day-ahead and real-time, but with different ramp-sharing coefficients depending on the length of the optimization interval in each market. The ISO's recommended coefficient values are listed in the following table.

Market	Interval Length (minute)	α	β	η
IFM	60	1.00	0	0
RTUC	15	0.75	0	0
RTED	5	0	0	0

The coefficient α has a positive value. This means that Regulation Up or Down has to compete with energy for the unit's ramping capability. This choice of coefficient value is based on operational reliability considerations. Specifically, it is important that the ISO retain the regulating capability of its supply of Regulation Reserve during the period of the inter-interval ramp, as this is often the time when Regulation Reserve is particularly needed. Setting this coefficient to zero and thereby sharing Regulation Reserve ramping with energy change ramping could significantly reduce the effectiveness of regulation to meet control performance.

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[2] The operational ramp rate is expressed as a constant value in order to simplify this exposition, but the actual software implementation utilizes the operational ramp rate function, which is a function of the unit's operating level.

In the MRTU markets a generating unit can be awarded Regulation Reserve in a MW amount that can be up to 10 minutes of its ramping capability in each interval. Thus in order to preserve 100 percent of the unit's ramping capability to meet its awarded Regulation Reserve at all times in the IFM, it would be necessary to set α = 3.00. Ignoring for the moment any potential awards of spinning or non-spinning reserves, a setting of α = 3.00 means that the unit's ramping capability during the 60-minute period between the midpoint of hour t-1 and the midpoint of hour t will be sufficient to cover both its inter-hour energy schedule change and 100 percent of its Regulation Reserve awards in each hour, at all times during that period. With α = 1.00 in IFM, the inter-interval ramp rate constraints preserve ramping capability for up to 20 minutes within the 60-minute inter-hour period for the awarded Regulation Reserve in intervals t and t-1. This means that there is at least one-third of the average Regulation Reserve award across consecutive hours available at all times during the inter-interval ramp. Of course, if there is no inter-hour energy schedule change then all of the awarded Regulation Reserve is available at all times.

The RTUC has an interval length of 15 minutes, which is 75 percent of the 20 minutes maximum possible ramp capability that could be needed for the Regulation Reserve awards in intervals t and t-1. The setting of α = 0.75 will preserve sufficient ramp capability for awarded Regulation Reserve between two consecutive 15-minute RTUC intervals, without any ramp sharing between the Regulation Reserve award and the inter-interval energy schedule change.

For RTED, based on testing and comparability with current operating practice an α = 0 will be used as intial setting. Setting α = 0 will allow a resource that is awarded regulation but is not operating witin its regulation range to be disaptched back within its regulation range to allow the resource to regulate as fast as the resource's operational ramp rate would allow. In addition, using α = 0 in RTED will allow the resouce to make maximum use of its ramping capability. Since no regulation is being awarded in RTED, setting α = 0 will no have no affected on regulation capacity awarded from the DAM or RTUC.

Setting β and η equal to zero means that operating reserves (Spinning and Non-Spinning) are able to share the unit's ramping capability with energy. That is, the unit can be awarded operating reserves up to its maximum ramping capability in an interval regardless of the size of its inter-interval energy schedule change. Stated another way, the award of operating reserves to the unit does not prevent its full ramping capability from being used to move between operating levels in two consecutive intervals. However, the total A/S award in the upward direction (the sum of Regulation Up, Spinning, and Non-spinning) or downward direction (Regulation Down) to each generating unit cannot exceed its 10-minute ramp capability.

The coefficient values in the table above have been set based on the outcomes of MRTU testing process. In the course of testing it was found that if the values are set too high – for example if all three coefficients are set to equal 3.0 in the IFM constraint equations – there will be no ramp sharing between the energy schedule change and the provision of ancillary services. As a result the market will use the available resources most conservatively and will create unnecessary transitory shortage conditions. In the worst cases observed, the market was extremely short of supply in certain hours and had to curtail demand dramatically in order to reach a solution.[3]

[3] The recent FERC order on the Midwest ISO Ancillary Services Market accepted the similar concept of ramp sharing for the Midwest ISO Ancillary Services market design. ORDER AUTHORIZING MIDWEST ISO ANCILLARY SERVICES MARKET START-UP, Docket No. ER09-24-000 (Dec. 18, 2008)