

CAISO Ramping Logic Requirements

Market Dispatch Operating Point Ramping Requirements

1. Online resources shall ramp continuously from one DOT to the next, i.e., from the middle of a dispatch interval to the middle of the next dispatch interval.
2. Starting-up resources shall jump from zero up to Pmin at the start of the dispatch interval and then ramp continuously to the DOT, i.e., from the start of the dispatch interval to the middle of that dispatch interval.
3. Shutting-down resources shall ramp continuously from the DOT to Pmin at the end of the dispatch interval, i.e., from the middle of the dispatch interval to the end of that dispatch interval, and then jump from Pmin down to zero.
4. The DOP shall jump vertically from the previous DOT to the “projected output” used for dispatch initialization, if different from the previous DOT. The projected output is extrapolated from the actual output (SE solution or telemetry) toward the previous DOT at the applicable ramp rate.
5. Resources shall have a feasible DOP ramp with respect to their applicable ramp rate, i.e., the DOP shall not ramp faster than the applicable ramp rate. The applicable ramp rate shall be the operational ramp rate unless: a) the resource is on Regulation (in any of the two consecutive dispatch intervals) in which case the regulating ramp rate is used; b) there is a ramp rate derate in effect for the first dispatch interval of the Time Horizon in which case the derated ramp rate is used; or c) the resource is crossing a forbidden operating range in which case the applicable ramp rate is derived by dividing the width of the forbidden operating range with the relevant crossing time.
6. The DOP ramp shall be “as smooth as possible,” i.e., as close as possible to the linear trajectory between the “projected output” and the DOT, unless the resource is crossing a forbidden operating range in which case the DOP ramp shall be equal to the applicable ramp rate. A smooth DOP ramp can be calculated by a process described in the next section.

Dispatch Operating Point Logic Detail

Requirements 1 through 4 are straightforward. For Requirement 5, the regulating ramp rate becomes the applicable ramp rate in a dispatch interval when the regulation status is set in that interval and the DOP is within the relevant regulating range and not inside a forbidden operating range.

For Requirement 6, if the applicable ramp rate is the operational ramp rate, the DOP is linear from the “projected output” to the DOT if all operational ramp rates within that range are greater than or equal to that smooth linear ramp. Otherwise, the DOP is piece-wise linear with breakpoints at the output level when the operational ramp rate changes.

In the case of two operational ramp rates within the DOP range, a faster and a slower one, compared to the smooth linear ramp, the DOP must ramp at the slower ramp rate within the slower ramp range and then linearly to the start or end of the DOP range depending on whether the faster

operational ramp rate is encountered before the slower one or vice versa. In the general case where there are more than two operational ramp rates within the DOP range, there may be multiple DOPs that meet the requirements. It is assumed that a process similar to the cross-hourly ramping between Day-Ahead Schedules (in absence of Bids or OOS Instructions) is used to determine the DOP. The steps in this process are as follows:

1. Calculate the smooth linear ramp from the “projected output” to the DOT. Start by an initial DOP that uses the applicable operational ramp rate as it changes through the DOP range. This DOP reaches the DOT level at or before the DOT time because the DOT is feasible.
2. If the DOP reaches the DOT level at the DOT time, exit.
3. Loop chronologically (earlier first) through each DOP segment that corresponds to each operational ramp rate in the DOP range. 4. If the operational ramp rate of the DOP segment is less than the smooth linear ramp, skip this segment.
4. Reduce the DOP segment ramp until the DOP segment ramp becomes equal to the smooth linear ramp or the DOP reaches the DOT level at the DOT time.
5. If the DOP reaches the DOT level at the DOT time, exit, otherwise proceed with the next DOP segment.

Summary:

A resource is expected to follow the DOP between DOTs (DOP becomes DOT after the end of binding interval). The DOP should be a controlled trajectory from the current or projected operating point to the next DOT, limited by the applicable ramp rate. DOP is the intermediate calculated point based on the bid in ramp rate in MW/Min. The trajectory should be linear where possible, but may become piecewise linear when operational ramp rates change across the output range or when physical limitations apply.

CAISO Regulation Ramping Requirements

If on Regulation, which has a different ramp logic, and while on Automatic Generation Control (AGC), the resource would be ramping at a much quicker rate for every 4-second interval based on regulation needs.

Resources are expected to follow a linear ramp profile when transitioning from following a regulation set-point to following a Dispatch Operating Target (DOT) / Dispatch Operating Point (DOP). As soon as a resource is no longer providing Regulation, it is critical that they do not instantaneously jump to their DOT. Doing so can have significant impacts to the grid and can cause Area Control Error (ACE) Excursions if multiple resources have similar behavior in the same direction. Plant owners and scheduling coordinators are expected to ramp smoothly, in a linear fashion, to meet their ADS DOT time. A symmetric ramp between mid-point to mid-point between two five-minute dispatches need to be honored. Resources need to ramp based on the 5-minute duration instead of instantaneously ramping.

Example:

If a resource is no longer providing regulation after the top of the hour, then the resource should follow the regulation set-point from AGC until the top of the hour and then ramp linearly toward the next interval DOT based on Target time (13:02:30). Regulation set-point from AGC needs to be followed based on Real-Time Pre-Dispatch (RTPD) binding interval (Example: 12:45 to 13:00) while RTD DOT binding interval is 12:57:30 to 13:02:30. Resources should not start ramping prematurely and are expected to follow the associated ramp logic outlined in the graph below.

- **Prior interval AGC = No; next interval AGC = No:** Ramp linearly from the prior DOT/DOP to the next DOT/DOP.
- **Prior interval AGC = No; next interval AGC = Yes:** Ramp linearly toward the next DOT/DOP until AGC begins, then follow AGC.
- **Prior interval AGC = Yes; next interval AGC = Yes:** Remain on AGC.
- **Prior interval AGC = Yes; next interval AGC = No:** Remain on AGC through the end of the applicable 15-minute FMM interval, then ramp linearly to the next RTD DOP.

ADS AGC Flag and Redundancy Expectations

The ADS AGC flag is provided as an indication of whether a resource is expected to be operating on Automatic Generation Control (AGC), however Resources should not consider this flag as the sole source for determining Regulation obligations or AGC status.

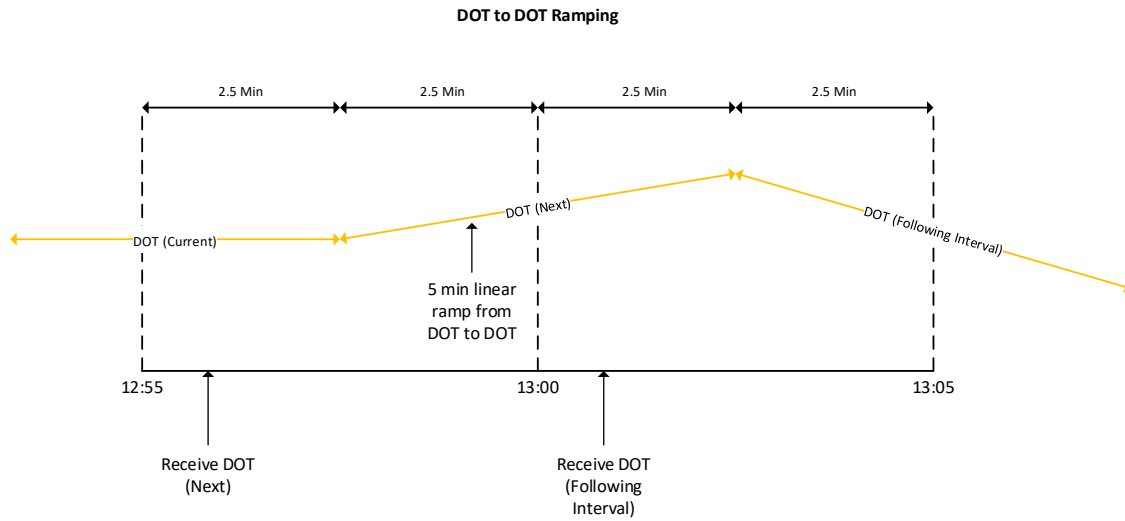
Since applications (such as ADS) can experience unavailability, ie: during certain maintenance periods, market disruptions, communications failures, or other abnormal conditions, resources shall be capable of determining AGC status without reliance on the ADS AGC flag.

Resources shall maintain redundant methods for determining AGC status and Regulation requirements. Resource operators and Scheduling Coordinators should use Regulation awards and schedules, including information available through CMRI and other CAISO market communications, to validate AGC obligations.

Control systems should be designed to utilize both award data and ADS indicators and include fallback processes to ensure resources remain on AGC for the full duration of applicable Regulation awards.

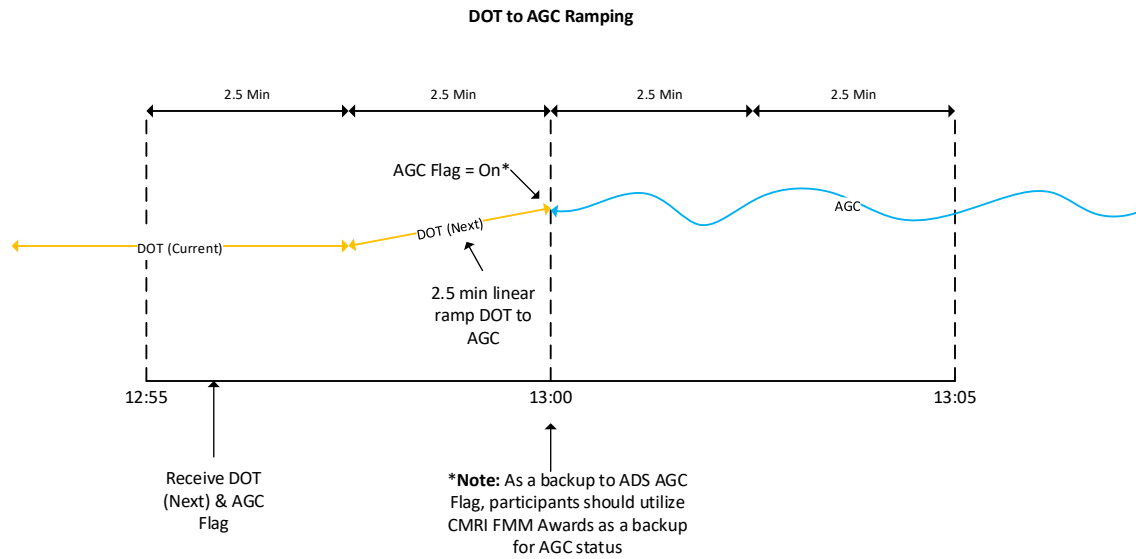
Resources are also expected to maintain the ability to manually or programmatically manage AGC transitions, including the use of configurable delays, interval-based logic, or operator intervention, as necessary to comply with CAISO dispatch and Regulation requirements.

CAISO Resource Ramping: Visual Overview



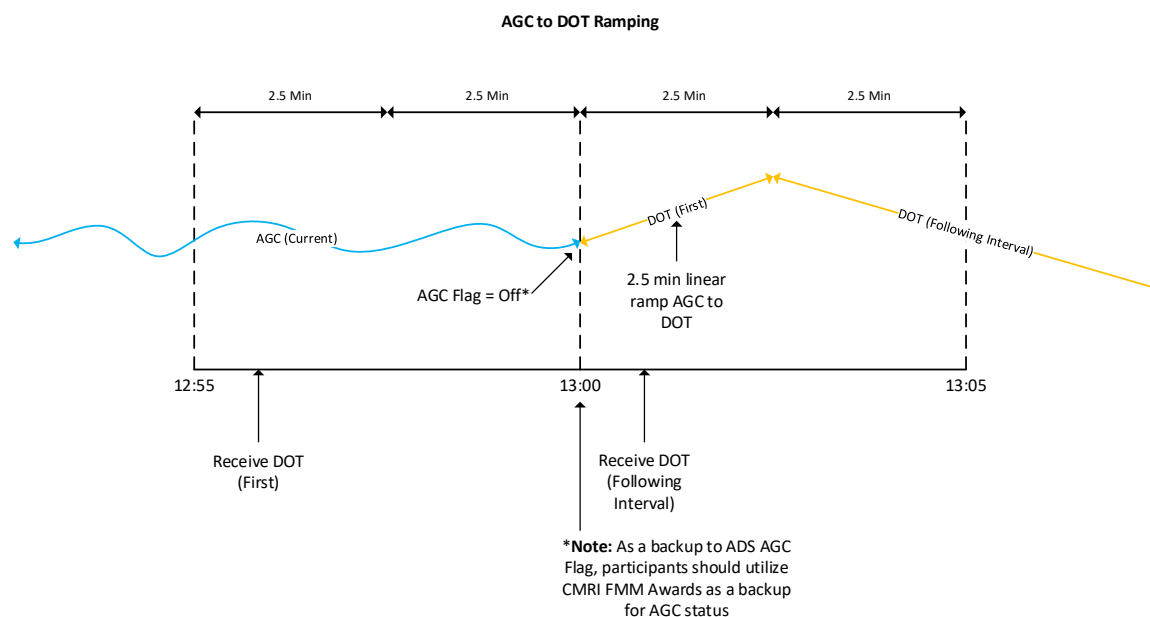
Note:

- DOT = Dispatch Operating Target
- Resources are expected to ramp linearly from DOT-to-DOT based on their bid in ramp rate.



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- AGC = Automatic Generation Control. When resources are operating on AGC, they receive updated setpoints every 4 seconds and are expected to closely follow those dispatch signals.

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Compliance note: This document is intended solely as a summary of operational ramping expectations and is provided for informational purposes. It is a supplemental reference only and does not supersede, replace, modify, or override any requirements contained in the CAISO Tariff, Business Practice Manuals (BPMs), Operating Procedures, or any other applicable CAISO governing documents.