Ancillary Services Products and Practices in CAISO

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Market Structure

- Market for Congestion Revenue Rights
- Day-ahead market
- Real-time pre-dispatch market
- Real-time dispatch market
<table>
<thead>
<tr>
<th>Market Products</th>
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<tbody>
<tr>
<td><strong>CRRs (obligations)</strong></td>
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<tr>
<td>- seasonal or monthly,</td>
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<td>- peak and off-peak</td>
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<td><strong>Energy</strong></td>
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<tr>
<td>- 60, 15, 5 minutes</td>
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<td><strong>Virtual energy</strong></td>
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<tr>
<td><strong>Operating reserves (spinning and non-spinning)</strong></td>
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<tr>
<td>- Upward and Downward</td>
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<tr>
<td>- Capacity and Mileage</td>
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<tr>
<td><strong>RUC Capacity</strong></td>
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<td>...flexible ramp, corrective capacity</td>
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CAISO operates both day-ahead and real-time markets

Market Timeline:

DayAheadMarket(DAM)

T - 7 days 10:00 13:00

- Bids Submitted SIBR
- DAM Process Begins
- Clear the Market
- Publish Results CMRI

Applications:
- SIBR - Scheduling and Infrastructure Business Rules
- CMRI – California ISO Market Results Interface
- ADS – Automated Dispatch System
- SLIC – Scheduling and Logging for ISO of California – Outages
- MRI-S – Market Results Interface - Settlements

Real Time Market (RTM)

T-1 after 13:00 T-75min

- Bids Submitted SIBR
- RTM Process Begins
- Clear the Market
- Receive Dispatches ADS
- Settlements MRI-S

Beginning at midpoint of each 5min period
Requirement and procurement of AS

- Operating reserves requirements are set based on largest contingency and 6% of forecast load and current operating conditions
- Regulation is set based on seasonal and hourly needs
- Procurement of AS is based on economics and resources attributes
- AS are expected to be procured from day-ahead market
- Real-time market can procure incremental needs for AS
- CAISO is currently evaluating Pilots for procuring AS from renewable resources
Regulation is a market product

Regulation is procured through both the day-ahead and real-time markets.

Regulation (and Operating reserves) awards do not consider congestion management since it is capacity.

Operators can block certain resources from being awarded ancillary services if concerns of congestion management exists.

AGC dispatches are paid at real-time prices.
Standard five-minute interval dispatch starts to run automatically at minutes 2.5, 7.5, 12.5 and so on.

- **BI**: Binding Interval
- **AI**: Advisory interval
- **DOT**: Dispatch Operating target

![Diagram](image)
Contingency runs are manually triggered by operators

**Standard Run**

- Time intervals: $t_s$ to $t_e$
- Duration: 7.5 min
- BI: Beginning Interval
- $A_I_1$ to $A_I_4$:
  - $A_I_1$: 2.5 min
  - $A_I_2$: 5 min
  - $A_I_3$: 5 min
  - $A_I_4$: ...
  - $A_I_{12}$: ...
- DOT: Duration of Trigger

**Contingency Run**

- Time intervals: $t_s$ to $t_e/t_1$ to $t_2$
- Duration: 10 min

- Contingency occurs

- Contingency run covers one single 10 minute interval
- Contingency run can be initiated at any time
- Operating reserves get available into the supply stack
- Fast start units may be started up
- Operators may choose to run with Power flow
- Multiple contingency run can be executed
- Additional demand can be requested to clear
Timeline after RTED dispatches

- Automatic dispatch. RTD dispatches for load following and ramp on five-minute basis.

- Automatic dispatch. Resources on AGC (frequency regulation) are used to balance the system on 4-second basis under normal system conditions.
  
  - Resources moving into and out of AGC response only if the system is outside the permissive ACE dead band.

- Frequency response. Automatic based on resources with droop control.

- Only RTD dispatches accounts for congestion management
Timeline after RTED dispatches under contingencies

• Typically for loss of generation > 500MW
• 15 minutes to recover (pre-contingency ACE)
• 10-minute contingency runs. Deploy energy, reserves and startup peakers.

• Automatic dispatch. Resources on AGC (frequency regulation) are used to balance the system on 4-second basis under normal system conditions.
  – Resources moving into and out of AGC response only if the system is outside the permissive ACE dead band.

• Frequency response. Automatic based on resources with droop control.

• Contingency runs accounts for congestion management
GCARM more efficiently dispatches resources around known constraints

- Enhances the SCED to be immediately secure if generator contingency or remedial action scheme activated
  - Currently, market just considers transmission loss

- Transmission system relies on an already large and increasing amount of arm-able remedial action scheme generation
  - Over 20,000 MW of remedial action scheme arm-able generation
  - Operations team must manually manage related constraints

- Generators associated with remedial action schemes cannot be optimally dispatched in market until now
  - Operators currently disable contingencies, manually monitor flows, and engage in out of market action to manage around these constraints
GCARM proposal
Generator Contingency

Model the “pick-up” effect of the system for a generator loss

- Consistent with reliability studies for generator loss
- Consistent with operator’s real-time contingency analysis tool
- Incorporate the potential change in electrical flows into locational marginal prices

Loss of generation spread to other online resources to model transmission line flows.

Most **GEN 1 output** picked up by **GEN SYSTEM**.

**GEN 1** locational marginal price considers flows on **LINE 1** due to pick-up by **GEN SYSTEM**.
Flexible ramping product conceptual design

FRU(t) procurement target

FNL(t+1) + UU(t+1) - FNL(t)

FNL(t+1) - DU(t+1) - FNL(t)

FRD(t) procurement target

Net system demand

FNL+ upward uncertainty (UU)

FNL(adv)

Forecasted net load (FNL)

FNL - downward uncertainty (DU)

FRU and FRD cover the net load movements from binding interval t to the advisory interval t+1