



# An Optimization Model for Resource Sufficiency Evaluation in EDAM

CAISO EDAM Team

EDAM Working Group 1:  
Supply Commitment and Resource Sufficiency Evaluation  
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# Objective

- Use the submitted resource energy bid range (no bid prices)
  - ◆ Calculate for each EDAM BAA a feasible hourly resource schedule profile over the Trading Day that meets demand forecast and uncertainty requirements, as adjusted by bucket-1 transfers
  - ◆ To minimize hourly failures
  - ◆ Subject to
    - Energy bid limits
    - Ramp rate capability limits
    - VER forecast, for VER
    - Daily energy limits, for hydro resources
    - State of charge limits, for storage resources

# Simplification to allow on-demand execution

- No transmission constraints or scheduling limits of any kind
- No startup time, minimum up/down time, or daily starts
  - ◆ If bids are submitted, the resource is online, otherwise it is offline
  - ◆ Startup time from initial condition considered
- No MSG states or transition times
  - ◆ Model MSG as a single state with continuous energy bid range
- Ignore ancillary services and imbalance reserves
  - ◆ Separate test for AS/IR bid sufficiency to meet AS/IR requirements
- Use a weighted-average flat ramp rates

# Notation

$i$	Resource index	$e$	State of charge
$t$	Time period index (0 for initial condition)	$\eta$	Charging efficiency
$x$	High potential schedule	—	Denotes lower limit
$y$	Low potential schedule	—	Denotes upper limit
$D$	Demand forecast, adjusted for bucket-1 energy transfers	(-)	Denotes charging schedule
$IRUR$	Imbalance reserve up requirement, adjusted for bucket-1 IRU transfers	(+)	Denotes discharging schedule
$IRDR$	Imbalance reserve down requirement, adjusted for bucket-1 IRD transfers	$v$	Upward capability shortfall
$LEL$	Lower economic limit	$w$	Downward capability shortfall
$UEL$	Upper economic limit	$u$	Discharge binary variable
$RR$	Ramp rate	$\gamma$	Upward capability binary variable
$E$	Daily energy limit	$\delta$	Downward capability binary variable

# Requirement constraints

- Upward capability requirement

$$\sum_t x_{i,t} + v_t \geq D_t + IRUR_t$$

- Downward capability requirement

$$\sum_t y_{i,t} - w_t \leq D_t - IRDR_t$$

- Common initial condition

$$x_{i,0} = y_{i,0}, \forall i$$

# Capacity and ramp capability constraints

- Capacity constraints

$$LEL_{i,t} \leq x_{i,t} \leq UEL_{i,t}, \forall i, t$$

$$LEL_{i,t} \leq y_{i,t} \leq UEL_{i,t}, \forall i, t$$

- Ramp capability constraints

$$-60 RR_i \leq x_{i,t} - x_{i,t-1} \leq 60 RR_i, \forall i, t$$

$$-60 RR_i \leq y_{i,t} - y_{i,t-1} \leq 60 RR_i, \forall i, t$$

- Energy constraints

$$\underline{E}_i \leq \sum_t y_{i,t}, \quad \sum_t x_{i,t} \leq \bar{E}_i, \forall i$$

$$\underline{e}_i \leq e_{x,i,t} \leq \bar{e}_i, \quad \underline{e}_i \leq e_{y,i,t} \leq \bar{e}_i, \forall i, t$$

- Storage model

$$e_{x,i,t} = e_{x,i,t-1} - \left( x_{i,t}^{(+)} + \eta_i x_{i,t}^{(-)} \right)$$

$$x_{i,t} = x_{i,t}^{(+)} + x_{i,t}^{(-)}$$

$$0 \leq x_{i,t}^{(+)} \leq u_{x,i,t} UEL_{i,t}$$

$$(1 - u_{x,i,t}) LEL_{i,t} \leq x_{i,t}^{(-)} \leq 0$$

$$e_{y,i,t} = e_{y,i,t-1} - \left( y_{i,t}^{(+)} + \eta_i y_{i,t}^{(-)} \right)$$

$$0 \leq y_{i,t}^{(+)} \leq u_{y,i,t} UEL_{i,t}$$

$$(1 - u_{y,i,t}) LEL_{i,t} \leq y_{i,t}^{(-)} \leq 0$$

$$y_{i,t} = y_{i,t}^{(+)} + y_{i,t}^{(-)}$$

# Objective function alternatives

- Minimize upward and downward capability shortfall

$$\min \sum_t (v_t + w_t)$$

- Minimize the number of hourly failures

$$\gamma_t = \begin{cases} 1 & \because v_t > 0 \\ 0 & \because v_t = 0 \end{cases} \Rightarrow \begin{cases} v_t \leq \gamma_t M \\ v_t \geq (1 - \gamma_t) M \\ \gamma_t = \{0,1\} \end{cases}, \forall t$$

$$\delta_t = \begin{cases} 1 & \because w_t > 0 \\ 0 & \because w_t = 0 \end{cases} \Rightarrow \begin{cases} w_t \leq \delta_t M \\ w_t \geq (1 - \delta_t) M \\ \delta_t = \{0,1\} \end{cases}, \forall t$$

$$\min \sum_t (\gamma_t + \delta_t)$$

# Properties

- Executed for each BAA separately
  - ◆ In parallel for all BAAs
- Upward and downward capability are co-optimized
  - ◆ Simultaneous upward and downward test
- Single test for both capacity and flexibility
  - ◆ Ramp capability constraints are enforced
- Hourly failures and hourly shortfalls are identified
- Weighting factors can place increased importance on certain hours, e.g., peak hours, or direction, i.e., upward or downward