

Hydro resources in the CAISO today – a PG&E perspective

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PG&E's hydroelectric generation portfolio

- 66 powerhouses
- 17 watersheds (4 irrigation districts)
- 11,671 GWh annual production

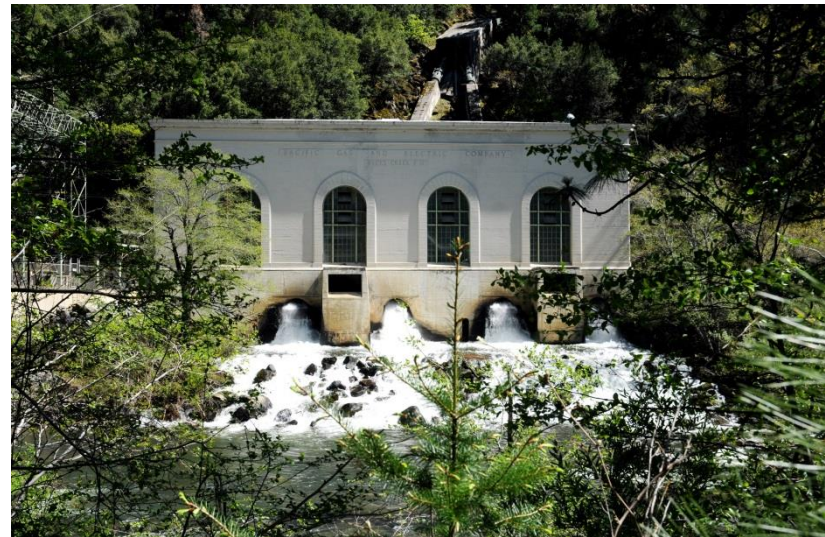


- 3,896 MW maximum rated capacity
- 1 pumped storage powerhouse (1200 MW)



Characteristics of PG&E hydro

- Most forebays are small (less than 1 week storage) – limited exceptions require water planning through end of next water year
- Complex interactions with other market participants and non-electric water uses, some defined in FERC licenses
- Pumped storage large, not closed cycle





Mechanics of day ahead hydro bidding

- Available bid parameters:
 - Self-schedules by hour
 - Energy and Ancillary Service Bids by hour
 - Daily energy limits (MWh)
- Default energy bid prices are determined by monthly use plans, and market power mitigation may mitigate to default bid prices
- Even when bids are synchronized, market results on cascaded systems may not be synchronized, due to
 - Small differences in resource data
 - Differences in grid takeout points (and thus locational pricing)



Mechanics of real time hydro bidding

- Ancillary service bid insertion
- Energy limits are known to real time models, but may be violated due to system constraints
- Effects of market solution horizon on energy limits are not transparent
- Real time bids may be updated up to 75 minutes before flow hour
- Outage management system affects market inputs immediately (for next real time market run)



CAISO market risks

- **Constraints on bidding imposed by use of hydro for Resource Adequacy**
- **Renewables impose high costs on self-scheduling during must-run season**
- **Evaluation of opportunity costs of ancillary service awards**
- **Storms impose high real time imbalance cost risks**

