Comments of Pintail Power LLC

on the CAISO

Hybrid Resources Issue Paper

Submitted by	Organization	Date Submitted
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Pintail Power LLC provides these written comments to CAISO in the interest of assuring that hybrid resources have fair market access in order to reliably and safely deliver energy at the lowest cost while reducing the impact of carbon emissions associated with the power sector in California.

We believe that CAISO would benefit from a broadened perspective on hybrid resources, which have unique performance capabilities, operational characteristics, and economic and environmental attributes that go beyond solar+storage. Hybrid resources include a broad range of generation plus storage combinations that provide large-scale and long-duration, flexible ramping, low-carbon dispatchable power and fuel efficiency, and do so at lower cost with longer life, and without the risks to workers, first responders, and the public of fluoride-bearing electrochemical batteries.

We are concerned that modeling and market optimization may not fully incorporate the economic and technical characteristics of hybrid resources, potentially introducing inequities and economic inefficiency into the CAISO market. Many hybrid resources are especially well-suited for long-duration storage (24 hours or more), and their use cannot be optimized with solvers that consider only the day-ahead. We believe that market optimization should consider long duration storage, currently available from hybrid systems.

- As an example, consider storage of 25 hours of discharge energy over a weekend. How would CAISO optimize such a system to be discharged 5 hours per day during the week?
- A fast-charge hybrid system accumulates 12 hours of storage during the 8-hour solar day, ramping down its charge rate as PV generation declines and then dispatching overnight to reduce fuel use and GHG emissions overnight.

We are also concerned about inappropriate classification of resources as hybrids. If a storage component is used only to improve the economic or operational characteristics of a generating resource, and is not providing storage capability to the grid, we believe it is NOT a hybrid resource.

- Solar plus storage that is charged exclusively from solar in order to qualify for favorable tax treatment, is NOT a hybrid resource but is instead a renewable resource with different dispatch characteristic.
- Likewise, adding a short-duration battery to peaking plant, changes the dispatch characters of a traditional resource (spin and ramping), but is not a Hybrid resource.

We believe that Cost of New Entry is a vital element of capacity planning, but that financial, tax, risk, and rate of return issues are outside the scope of CAISO's energy market. Market mechanisms should neither impede nor favor particular financing strategies like ITC, tax equity, etc.

Hybrid Resources: our high-level view

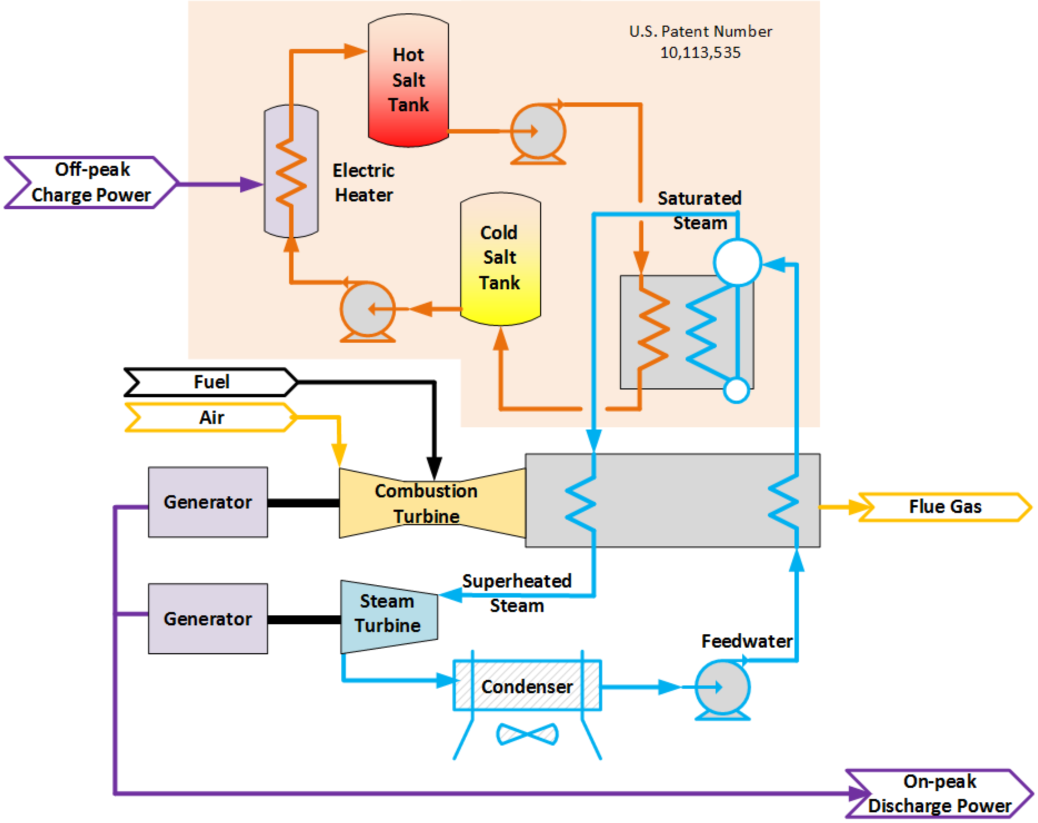
1. Hybrid resources combine an energy storage resource with a generating resource at the same location sharing a common connection to the grid.
    a. Charging of storage may be from the CAISO grid or from both the co-located generating and the grid.
    b. Recharging a storage resource from the co-located generating resource is especially advantageous for micro-grids.
2. Physically, the co-located storage and generation resources may be:
    a. uncoupled (e.g. a battery charging and discharging from/to the grid plus PV),
    b. closely coupled (e.g. a CAES system that relies on exhaust heat to efficiently extract stored energy).
    c. There are many types and degrees of coupling, which generally aim to optimize the levelized cost of storage. Hybrid systems can deliver transmission level storage at a fraction of the cost of Lithium batteries.
3. The generation can be conventional (e.g. combustion turbine or RICE) or renewable (e.g. solar, wind, geothermal).
4. Energy storage systems transform electrical energy into potential energy, and later transform the potential energy to electrical energy for delivery to the grid. The transformation may use many forms of potential energy such as:
    a. electrochemical (e.g., battery),
    b. gravitational (e.g. pumped storage),
    c. mechanical (e.g. a flywheel, or compressed air),
    d. thermal (e.g. sensible heat like molten salt, of latent heat like liquid air),.
5. Each storage medium has unique cost and density characteristics that influence capital cost, may have usage and lifetime limitations, and may have unique geotechnical, topological, hydrological, or environment characteristics.
6. There are losses associated with charging and discharging transformation processes as well as standby losses while the Energy Storage System is in a quiescent state.
    a. The ASME PTC-53 Performance Test Code for Energy Systems provides methods for determining these losses.

7. Hybrid systems may have multiple energy inputs (e.g., electrical energy goes into storage and fuel enhances extraction of electrical energy from the stored potential energy). Accordingly, PTC-53 recommends the use of figures of merit for each of the energy streams:
    a. Heat Rate (Btu per kWh) is the fuel energy consumed per unit of electrical energy discharged.
    b. Primary Energy Rate (kWh per kWh), or Electrical Rate in the case of electrically charged systems, is the electrical energy consumed per unit of electrical energy discharge.
    c. These figures of merit directly factor into economic dispatch analogous to thermal generators. Economic dispatch then relies on a "park spread" than would include cost of fuel and the cost of energy in storage.
    d. The energy in storage is fungible, so the inventory is appropriately valued at average cost.
    e. The term "round trip efficiency" is accordingly potential confusing and misleading, especially as some hybrid systems can deliver more electrical energy than was input.
8. Hybrid systems can decouple the discharge power from the stored energy by using bulk storage media instead of cellular media (batteries). This makes low-cost, long-duration storage economically feasible.
    a. Bulk storage has economy of scale: the volume of a cylinder is proportional to diameter squared, while cost of the cylinder is proportional to diameter (for atmospheric pressure storage).
    b. Inexpensive bulk storage media are readily available, such as molten salt or compressed or liquefied air
    c. Loss rates and standby power requirements from bulk storage are generally *de minimus* (< 1% per day for hot thermal storage, and 0.1% per day for cryogenic liquid storage). Bulk systems may not require active thermal management, unlike many batteries.
    d. We note that non-hybrid energy storage system (e.g. Pumped storage, adiabatic CAES, and flow batteries) also use bulk storage to de-couple energy from storage.
9. By decoupling the charging and discharging transformation processes, hybrid systems can provide fast charging to address over-generation. In contrast most pure storage (pumped hydro, batteries, share common charging and discharging infrastructure.
    a. Fast charging capability is limited by the interconnect capacity from a load perspective and by the capital cost of the charging transformation process.
    b. Load can be provided by electric heaters for thermal energy storage or motor driven compressors for CAES, LAES, and Heat pump-based storage systems
    c. Up to a few hundred MW, medium voltage electrical heat is more flexible and lower capital cost than compressor trains.
10. Hybrid resources can often be cost-effectively integrated with existing thermal generating facilities to reduce capital cost, improve fuel efficiency, add capacity, and retain the capacity of marginal thermal generating units.

Hybrid Thermal Energy Storage Combined Cycle Example

Energy Storage Combined Cycle integrates electrically heated molten salt thermal storage with combustion turbine exhaust heat as shown schematically in the figure.

- Power output (MW capacity) is approximately doubled compared to the simple cycle.
- Fuel Heat Rate is approximately halved compared to the simple cycle
- Electric Rate is typically less than one (analogous to a "round trip efficiency" more than 100%) because electric energy is derived from both fuel and stored heat.
- Charging load can be sized independently of the discharge generation to enable fast charging subject to interconnect limits.
- Charging load can be flexibly and responsively varied by conventional heater and flow rate control to provide fast ramping up and down, including frequency response.
- Rapid startup is facilitated by using stored energy:
  - Steam cycle can be maintained at hot start conditions using time-shifted low-cost and zero carbon stored energy, without consuming fuel.
  - Steam drum is removed from exhaust gas path to remove thermal stress limitation to quickly reach full power and achieve emissions compliance.
- When suitably charged using low-cost electricity, the system dispatches early in the merit order to increase capacity factor and improve operating economy.
- Molten salt has no state of charge or rate of charge constraints.
- At typical conditions, approximately 2,500 MWh of energy can be stored in a 120-foot diameter tank (similar in design and operating conditions to those at the Solana CSP project). Two tanks (i.e., one hot and one cold) are needed, so only about one acre is required for storage – far more compact than alternatives.



Comments on specific issues

1. Interconnection

We believe ‘charging at CAISO’s direction’ may be sub-optimal for the CAISO market and the owner of a long-duration hybrid resource because of mismatch between the long-duration storage and the relatively short window for market optimization. For example, how would CAISO direct charging of a long-duration asset on Saturday, when the Sunday market would not discharge?

We are also concerned about stranding energy within the storage system, if CAISO directed storage at a relatively high LMP. This would increase the average cost of energy (per discharge MWh) and potentially impair the “park spread” reducing the opportunity to dispatch. (See comments on Markets and Systems)

We would like to see real time and imbalance market considerations.

Long duration hybrid storage could also be split into an allocation subject to CAISO direction, and an allocation that could be arbitraged via Real Time or EIM. For example, CAISO might forecast a need for 4 hours of discharge the next day and schedule charging to meet that need. Opportunistic charging might then be used for arbitrage.

2. Forecasting and Operations

We think that long-duration storage capability can mitigate the reliability risks, if CAISO extends the forecast window.

Generally, we believe that hybrid resources, as we view them, could operate as with a single resource ID. Two IDs might be better split between the charging (load) and discharging (generation) aspects, which would be then linked by a state of charge.

3. Markets and Systems

We believe the systems should be generalized to account for

- Electric Rates (i.e., MWh in divided MWh out) that are more or less than unity
- Charge Rates that differ from discharge rates
- Loss rates
- Stored energy inventory value

For a system with discharge power rating P (MW) the hybrid resource goes from

1. Standby at SOC=X (X representing hours). Stored energy is PX MWh. Assume the starting cost is S dollars, the inventory average cost of energy in storage is A=S/PX ($/MWh).

2. Discharging for d hours, ending at SOC=X -d. Note that inventory cost per MWh is unchanged during discharge although the total inventory and value has decreased. The marginal cost of discharge energy was Fuel Heat Rate (MMBtu/MWh) * Fuel Cost ($/MMBtu) + Electric Rate (MWh/MWh) * Average Cost ($/MWh).
3. Standby for s hours, with a loss rate L (hours per hour), ending at SOC=X-d -sL. Average cost of inventory is unchanged, although both inventory and value have decreased.
4. Charging for c hours at rate R (hours of discharge per hour of charge) at new cost N ($/MWh), ending at SOC= X-d -sL+cR. The value added to inventory is cRPN, and a new average cost of inventory is established.

4. Ancillary Services

No comments at this time

5. Deliverability

No comments at this time.

6. Resource Adequacy

No comments at this time

7. Metering, Telemetry and Settlements

No comments at this time.

8. Additional comments

No additional comments at this time.