Hybrid Energy Storage + Gas Turbines: A Practical Pathway to Net Zero

The combination of renewable energy storage with thermal generation offers a practical solution to the challenges of net zero emissions. Hybrid energy storage combines commercially proven thermal energy storage with thermal generation in a system that can be deployed immediately to cut emissions and avoid renewable curtailment. The hybrid approach reduces the cost of large-scale storage, improves energy security, grid reliability and resilience, and enhances the viability of both thermal generation and renewables for vendors, developers and asset owners. Leveraging existing gas turbine assets reduces the cost of energy, hedges fuel and renewable resource cost and availability, reducing risk during extreme events. Hybrid fuel economy provides a practical glidpath for methane fuel to be replaced by hydrogen to achieve net zero targets.

Renewable curtailment will increase without large scale, long duration, cost-effective storage in place to capture excess

Hybrid Energy Storage improves the ability to rapidly meet the utility-scale challenge from 5 to 500MW

Hybrid Synergy
- Lower marginal cost of energy
  - Less fuel
  - Less primary energy input
- Lower capital cost of storage
  - Smaller charging process
  - Smaller storage reservoir
  - More storage on small footprint
- Greater return on investment
  - Higher capacity factor
  - Transform existing assets

Generally, energy storage involves a primary energy input in the form of electricity and a charging process to transform electricity for storage within a reservoir. The reservoir could be electrochemical (battery), water (pumped storage), pressurised air (CAES), or liquid salt (thermal energy storage). Ultimately, the stored energy is discharged through a transformation process to deliver primary energy (electricity) as an output. To reduce the cost of large-scale storage it is vital to maximise energy delivered per unit of storage medium.

The Liquid Salt Combined Cycle (LSCC) hybrid starts with a proven combined cycle that includes a gas turbine, steam turbine and heat recovery unit. Pintail Power adds a two-tank molten salt energy storage system derived from concentrated solar power, but instead of heating salt with sunlight, renewable electricity from the grid powers efficient and flexible electric heaters which provide flexibility during charging including fast frequency response. LCSG uses stored energy for evaporation so the heat recovery unit only provides sensible heating, while the innovation results in 2-3 times more steam flow than in a conventional combined cycle, which boosts the power output of the steam turbine and creates synergies. More energy is delivered per ton of salt to reduce the cost of storage media to <$25/kWh (a fraction of battery packs). Fuel heat rate is reduced to about half what a gas turbine peaker would require. The steam cycle can be started without burning fuel, so LSCC retains peaker-like flexibility for fast start-up and ramping during discharge. The low-fuming quartz salt is non-toxic, non-flammable and can be operated without rate of charge or state of charge constraints.

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Broadly Deployable Across US: Equipment vendor neutral, can be added to existing or new plants, multiple EPCs ready to engage

At left is an example of an add-on to an asset that already exists: a twin LM6000 peaker plant, 100 megawatts of capacity. A single unit converted to LSCC, a could discharge 91.9 MW, and customary 120-foot diameter conventional carbon steel tanks hold 1746 MWh – 19-hour duration. The 4880 l/kWh fuel heat rate beats every combined cycle in the world. The primary energy rate is less than one which corresponds to an (electrical only) round trip efficiency greater than 100%. There are two energy inputs, accounted for in MCOE, with low-cost renewables replacing high-cost fuel. Most importantly is the estimated installed cost of this system: $150 per kWh, about 1/3 the cost of a battery system.

Contact us for paper ASME-GT2022-82343, summarizing work performed by Pintail Power, the Electric Power Research Institute and Southern Company. Supported by the US Department of Energy under contract DE-PS002016.

LSGCC hybrids leverage existing assets, infrastructure, workforce to advance the clean energy transition with long-duration energy storage. Supply chain and new tax incentives further improve the strong economic advantages of this approach.

U.S. Gas Plants by Capacity

Source: www.eia.gov

EnergyGPS

Hybrid Energy Storage

Renewable

Electric Power

Heat storage

Electricity

Gas Turbine

Steam Turbine

Liquid Salt Combined Cycle™ (LSCC)

Hot Salt Pump

Cold Salt Pump

Carbon Steel Field erected salt tanks

Steam Drum

Startup Superheater

Condenser

Desserator

Evaporator Electric heater

Electricity

Fuel

Reducer

Saturated Steam

Feedwater

Saturated Steam

LDSS

Discharge Power

Facility Scale (10MW) Layout

ASME PTC-53 defines the performance figures of merit: how much energy input per unit of electric energy output. In a classical storage system this is the Primary Energy Rate (PER), which is inverse Round-Trip Efficiency. With a hybrid, fuel energy is added to aid the discharge or make the discharge more efficient or more cost effective by getting more energy out of the storage reservoir. To account for fuel, the customary metric for thermal power plants, the Fuel Heat Rate (FHR) is used. These performance metrics determine the marginal cost of energy discharged from the system.

Performance Metrics (ASME PTC-53)

\[ \text{PER} = \frac{\text{Electric Energy Output}}{\text{Fuel Energy Input}} \]

\[ \text{FHR} = \frac{\text{Fuel Energy Input}}{\text{Primary Energy Output}} \]

Marginal Cost of Energy

\[ \text{MCOE} = \left( \frac{\text{FHR}}{\text{PER}} + \text{PER} \right) \times \text{Cost of Fuel} + \text{Cost of Electricity} \]

Patents assigned to Pintail Power Ltd.
US: 9,582,578; 10,032,016; 10,116,523; 10,156,523; 10,256,523; 10,295,523; 10,359,523; 10,403,523

Source: https://physics.weber.edu/schroeder/energy/PowerPlantsMap.html

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