Bulk Storage

Author:
Sami Mardini, Director of Product Marketing, EnerVault Corporation, +1 626 318 2646,
smardini@enervault.com

1. Overview Section

2. Use Case Description

This Use Case describes a hypothetical 100 MW energy storage system (ESS) functioning effectively as a bulk storage plant, referred to here as a "bulk storage," that connects to and charges from or off the transmission grid to deliver capacity, ancillary services, and energy to wholesale markets.

It is assumed that the resource has successfully connected to the transmission grid under California ISO interconnection rules and processes and includes CAISO-approved telemetry that allows for remote monitoring of the resource and related factors (i.e., generation output, availability, meteorological data, and circuit-breaker status).

2.1 Objectives

A "bulk storage" plant participates in wholesale markets and offers base load dispatchable capacity and energy and ancillary services for balancing and reliability.

In comparison to conventional fossil fuel plants, a bulk storage plant may offer several advantages, including: energy arbitrage, better operational flexibility, renewable integration (including over generation), procurement flexibility, and risk mitigation. When charged with excess renewable energy, a bulk storage plant will offer emission free energy. When charged with fossil fuel generation, bulk storage can reduce fuel usage and reduce emissions by improving traditional generators capacity utilization and optimizing efficiency, i.e. decrease generation fleet's heat rate.

Additionally, use of bulk storage may avoid curtailment because of oversupply situations.

2.2 Actors

In this Use Case, the storage facility may be owned by 1) the utility, 2) a merchant supplier similar to an IPP, or 3) a third party that operates the facility under a under a long-term power purchase agreement with the utility (similar to a "tolling" agreement).

2.3 Proceedings and Rules that Govern Procurement and Markets for This Use

	Description	*Applies to*
CPUC	Long-term Procurement Proceeding	Utility

CPUC	Resource Adequacy	Utility
CAISO	GIP	Project developer/owner

2.4 Location

The bulk storage plant is connected to the transmission grid and is an independent facility that is separate from other generators. However it can be co-located with a generation plant. It may charge from or off the grid and discharges into the grid.

2.5 Operational Requirements

The "capacity" of a bulk storage plant typically exceeds 100 MW and 6-8 hours.

A key feature of bulk storage plants is operational flexibility. A variety of requirements could be considered for operational flexibility that may need to be satisfied, including ramp rate, start/stop times, re-starts, minimum run times, dynamic range, emissions limits, hours of availability, etc.

The ISO may dispatch energy from its 5-minute market (aka, Balancing Energy Ex-Post Pricing, or BEEP-stack) which represents a real-time market for ancillary services.

Bulk storage plants can participate in this real-time market and supply incremental energy in the same manner as traditional generators.

2.6 Applicable Storage Technologies

The bulk storage plant peaker is most likely to be based on pumped storage, large scale compressed air storage (CAES) or large scale Redox Flow Batteries (RFB).

Storage Type	*Storage capacity*	*Discharge Characteristics*
Redox Flow Batteries (RFB)	**100 to 500 MW / 6 to 8 Hrs**	**Long 100% DOD cycle life**
Pumped Hydro		
CAES or RAES	**10MW to 500MW/6 to 12 hours**	**Long 100% DOD cycle life**

Redox Flow Batteries (RFB) are especially suited for large capacity energy storage.

The decoupled power and energy of RFB provides the maximum flexibility in sizing system power and energy appropriately for the target application from common building blocks. System power is tailored via integrating groups of electrochemical stacks with power electronics. Optimizing system energy is achieved by adjusting the volume of liquid electrolytes and tank sizes. As result, RFB cost per kWh decreases with increased duration.

An additional major benefit of the decoupled power and energy in RFB technology is a high degree of safety as only the electrolytes contained in the stacks can release energy. This characteristic limits the risk of unintended energy release to a small fraction of the system's total energy as there is no mechanism for electrolytes contained in the separate storage tanks to react. This provides increased location flexibility and accelerates the permitting process.

Most importantly for bulk storage, RFBs are free of the geological and geographic requirements that constrain deployment of pumped hydro and cavern-based large scale CAES and necessitate new transmission lines. . Newer CAES such as isothermal CAES using above ground high pressure tanks and RFB bulk storage plants can be easily co-located with existing generation plants or close to a transmission substation.

2.7 Non-Storage Options for Addressing this Objective

Alternatives available to address functions associated with a bulk storage plant are:

- Thermal generators
- Hydroelectricity
- Combined Cycle Combustion Turbine (CCGT) coupled with TES

3. Cost-Effectiveness Analysis

3.1 End Uses / Benefits

End Use	*Primary/ Secondary*	*Benefits/Comments*
1. Frequency regulation	P	Faster response
2. Spin	P	Smaller incremental capacity with faster response and will increase efficiency and reduce maintenance of existing peakers
3. Ramp	P	Same as above
4. Black start	S	
5. Real-time energy		

balancing		
6. Energy arbitrage	P	Storage-specific benefit not possible with traditional generators
7. Resource Adequacy	P	Optimized sizing with smaller incremental capacity and high locational flexibility
8. VER[1] / wind ramp/volt support,	P	
9. VER/ PV shifting, Voltage sag, rapid demand support	P	
10. Supply firming	P	
11. Peak shaving: load shift		
12. Transmission peak capacity support (deferral)		
13. Transmission operation (short duration performance, inertia, system reliability)		
14. Transmission congestion relief		
15. Distribution peak capacity support (deferral)		
16. Distribution operation (volt/VAR support)		
17. Outage mitigation: microgrid		
18. TOU energy mgt		
19. Power quality		
20. Back-up power		

[1] VER = Variable Energy Resource

3.2 Other Beneficial Attributes

Attribute	*Benefits/Comments*
Modularity/Incremental build	Highly dependent on choice of technology
Faster build time	Choice of technology and chemistry influences permitting time
Locational flexibility	Highly dependent on storage technology
Safety and Environmental Impact	Highly dependent on storage technology
Procurement flexibility	
Other?	

3.3 Costs

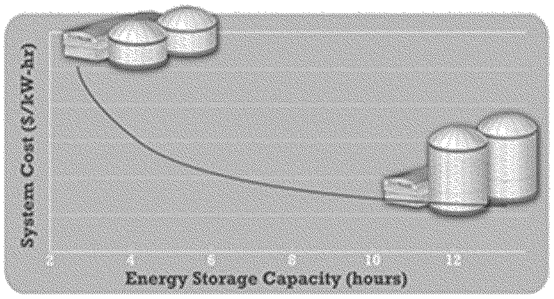
Cost Type	*Description*
Installation	
O&M	

3.4 Cost-effectiveness Considerations

Above ground CAES and Redox Flow Batteries (RFB) are especially suited for large capacity energy storage.

The decoupled power and energy of RFB provides the maximum flexibility and cost-effectiveness in sizing system power and energy appropriately for the target application from a common building block.

System power is tailored via integrating groups of electrochemical stacks with power electronics. Optimizing system energy is achieved by adjusting the volume of liquid electrolytes and tank sizes. As result, RFB cost per kWh decreases with increased duration.



An additional major benefit of the decoupled power and energy in RFB technology is a high degree of safety as only the electrolytes contained in the stacks can release energy. This characteristic limits the risk of unintended energy release to a small fraction of the system's total energy as there is no mechanism for electrolytes contained in the separate storage tanks to react. This provides increased location flexibility and accelerates the permitting process.

Most importantly for bulk storage, RFB and isothermal above ground CAES are free of the geological and geographic requirements that constrain deployment of pumped hydro and large scale CAES and necessitate new transmission lines. In fact RFB bulk storage plants can be easily co-located with existing generation plants or close to a transmission substation.

4. Barriers Analysis & Policy Options

4.1 Barrier Resolution

Barriers Identified	*Y/N*	Policy Options / Comments
System Need		
Cohesive Regulatory Framework		
Evolving Markets		
Resource Adequacy Value		
Cost Effectiveness Analysis		
Cost Recovery Policies		

Cost Transparency & Price Signals		
Commercial Operating Experience		
Interconnection Processes		
Issues with RFO design and offer evaluation process		
Operational flexibility requirements unclear		
Value of operational flexibility unclear		
Value of portfolio/procurement flexibility undefined		

4.2 Other Considerations

5. Real World Example

http://www.industcards.com/ps-usa.htm

	Source

6. Conclusion and Recommendations

Is ES commercially ready to meet this use?

Pumped hydro and large-scale CAES are commercially available. RFB and above ground Isothermal CAES alternatives are being developed.

Is ES operationally viable for this use?

Yes as proven by major pumped storage projects. See section 5

What are the non-conventional benefits of storage in this use?

Refer to section 3.2

Can these benefits be monetized through existing mechanisms? If not, how should they be valued?

No. A project-specific scoring system for non-monetized benefits should be considered and included in evaluating ES solutions.

Is ES cost-effective for this use?

What are the most important barriers preventing or slowing deployment of ES in this use?

What policy options should be pursued to address the identified barriers?

See section 4

Should procurement target or other policies to encourage ES deployment be considered for this use?

Yes. Targets with incentives are needed to accelerate adoption leading to higher volumes that will greatly improve cost-effectiveness