Evaluating Emerging Long-duration Energy Storage Technologies

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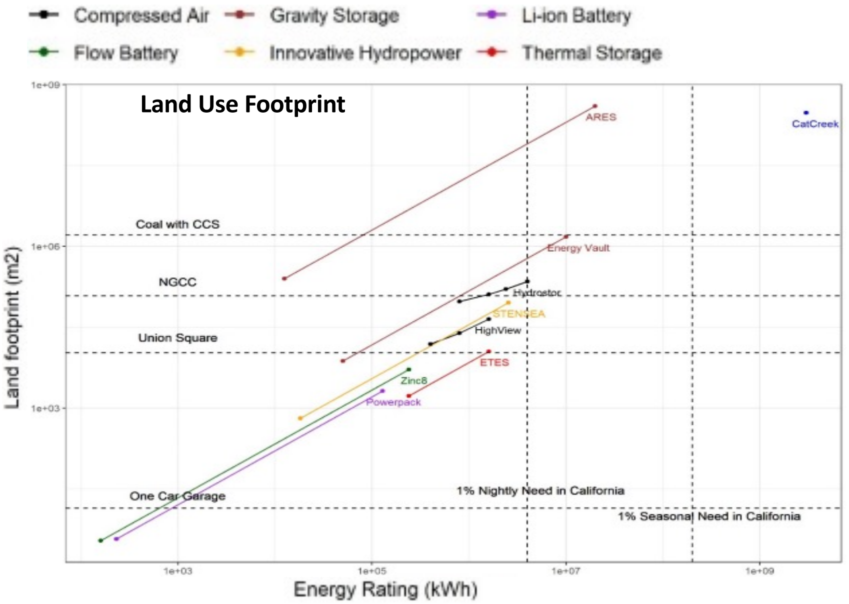
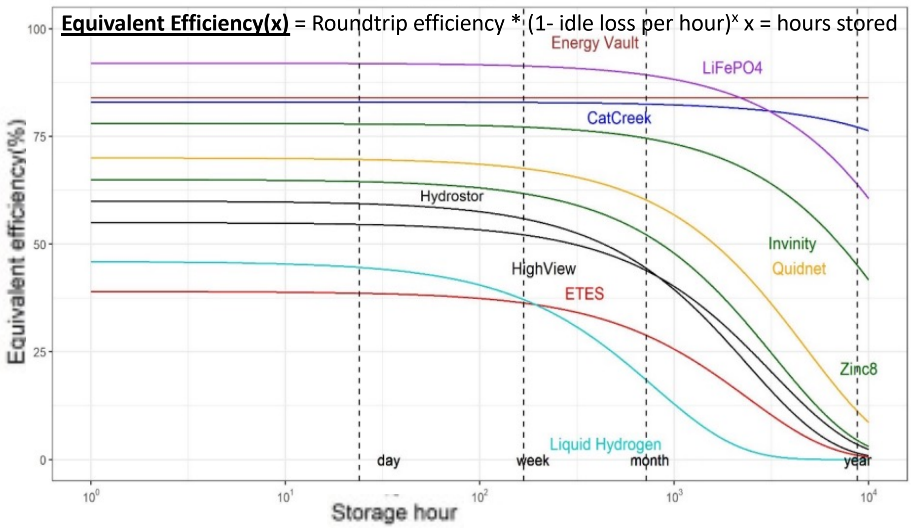
Objective

Give a status report on current energy storage technologies





Background

Reaching California's decarbonization goals requires a great expansion of long duration (>10 hours) energy storage. There are many different technology options, and we need a way to compare between them and judge suitability for different use cases.

Type of storage	Power capacity (MW)	Energy capacity (MWh)	Discharge duration (h)	Self-discharge rate (%/day)	Roundtrip efficiency (%)
Advanced compressed air	200-500+	800-12,000+	4-24	1	60-65
Liquid air	10-200	40-1000	4-24	0.5-1	55-60
Vanadium-based flow battery	0.01-10	0.1-100	4-24	0-1	65-85
Zinc-based battery	0.02-10	0.1-100	4-24	0.5-1	55-75
Flywheels	0.008-25	0.032-100	4	5-10	>86
Gravity using blocks	1-1000	4-10,000	4-24	0	80-85
Pumped storage hydropower	10-3000	100-20,000	10-100	0-0.02	70-85
Geomechanical	100-500	1000-5000	~10	0.5	55-75
Concentrated solar power with thermal storage	10-300	40-2000	4-24	0.5-1	N/A
Thermal	0.5-200	5-50,000	4-24	0.5-1	50-65
Lithium iron phosphate	0.001-300	0.002-2000	0.5-8	0.1-0.3	85-90

Conclusions/Strength Comparisons

Technology	Strengths	Opportunities (technical and market)
Lithium batteries	High efficiency; ease of use	Continued growth – is currently expanding rapidly
Pumped hydropower	High-efficiency; least cost over 100-year lifetime; well established	Can provide long-term benefit to the community including water and jobs once completed. Closed-loop implementation may open many new sites
Gravity	High efficiency and the land footprint can be minimal and/or flexible	Negligible idle loss even over months of time
Flow batteries	Potential to be lower cost than Li batteries for higher energy-to-power ratios	May enter market by providing resilience via microgrids during power outages.
Compressed air	Adiabatic version has higher efficiency and more flexibility in siting	Has potential for large scale, low-cost deployment once it demonstrates performance
Liquid air	Leverages existing supply chain to be scalable; May achieve high efficiency; ready to scale	Is ready to scale deployment for > 4-h systems
Thermal – CSP	Recent cost reductions combined with synergy of CSP + storage	Could combine generation with storage as costs come down
Thermal – without solar	Combined with decarbonization of industrial heating. May use very inexpensive storage media like sand or rocks to increase energy capacity at low cost	Could play primary role of decarbonizing industrial heating, then that success could be leveraged to give inexpensive storage; may be incorporated in existing fossil fuel power plants
Geomechanical	Some versions average oil & gas infrstructure; could scale rapidly to GWs; relatively high efficiency	Leverages oil & gas expertise & workforce. Once de-risked could scale very rapidly
Hydrogen	Can be used as a fuel to replace hydrocarbons	Could provide backbone of decarbonized energy system to drive transportation, heating, and chemical synthesis

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