Long Duration Energy Storage

Beyond Batteries

Today, long duration energy storage (LDES) is attracting intense interest. LDES enables increased capacity of clean yet variable renewable energy by providing longer duration grid-balancing technology. Extreme events continue to demonstrate that yesterday's power grid may not survive tomorrow's weather. LDES can provide both grid flexibility and resiliency to meet these needs.

Compared to available batteries, LDES promises to be lower cost for longer duration by using lower cost and readily available storage materials (salt, sand, iron, zinc, water, air, etc.). In addition, LDES technologies can scale power and energy separately, lowering the cost for the next hour of storage.

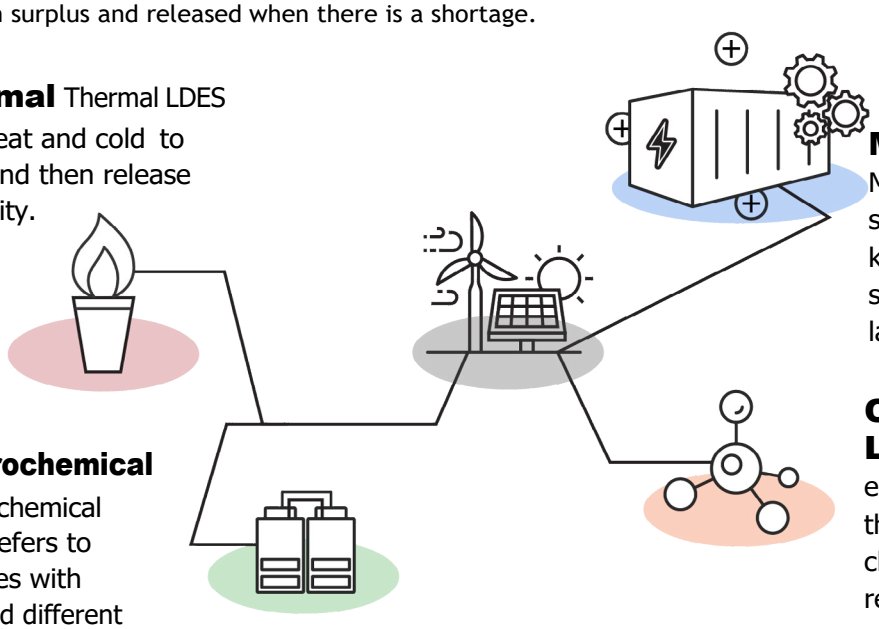
As an example, a well-established LDES technology is "pumped hydro storage" (PHS) where excess electricity is used to pump water uphill to a reservoir; when needed, water flows downhill through a turbine to generate electricity. While there is a large cost to building such a facility, adding additional hours of storage is very low cost: adding additional depth for water in the upper reservoir increases storage duration. One challenge with PHS is that it requires specific geology, so suitable locations are limited. Most of the cost-effective locations have already been developed and are in use.

Recognizing the need for greater amounts of LDES, equipment suppliers are designing a variety of technologies that are modular, scalable, and have incremental low cost for longer duration.

Four Kinds Of Emerging Long Duration Energy Storage

The major technologies for storage are generally classified as thermal, mechanical, chemical and a special type of chemical, electrochemical (batteries). All LDES allows energy to be stored when there is a generation surplus and released when there is a shortage.

Thermal Thermal LDES uses heat and cold to store and then release electricity.



Mechanical Mechanical LDES stores potential or kinetic energy in systems for release later as electricity.

Chemical LDES stores electricity through the creation of chemical bonds, released later as electricity.

Electrochemical Electrochemical LDES refers to batteries with new and different chemistries.

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Emerging Thermal LDES Technology

- **Sensible Storage** (high temperature): A low-cost material, salt, is electrically heated to a high temperature, the heat boils water, making steam, then sends steam through a turbine-generator to produce electricity
- **Latent Storage** (phase change, gas to liquid) – A low-cost material, air, is cryogenically liquified at low temperature and easily stored in tanks, boiled back to a gas at pressure, then sent through a turbine-generator to produce electricity

Emerging Mechanical LDES Technology

- **Kinetic** (rotating mass on bearings): A very large and heavy mass, flywheel, speeds up to charge, slows in speed to discharge energy, turning a motor-generator to produce electricity
- **Gravity** – (mass raised and lowered): An array of concrete blocks, stacked several stories tall, are raised to store energy, then lowered down, turning a motor-generator to produce electricity

Emerging Chemical LDES Technology

- **Electrochemical** (flow battery): The electrodes of a battery are liquid, not solid, flowed through a device and charged, pumped to tanks and stored; then flowed in reverse to discharge. Larger storage tanks increase duration.
- **Low-cost battery cells** (non-lithium): Earth abundant, low-cost materials like iron or zinc or sodium, manufactured as very low-cost battery cells, charging and discharging electricity
- **Hydrogen Fuels:** Hydrogen, produced by electrolysis, steam methane reforming or other processes, can be stored in tanks or underground caverns for future use. The hydrogen can be used in power generation plants or fuel cells to produce electricity. For additional details, please see companion information sheet on Hydrogen.

LDES Opportunities

- LDES can enable greater amounts of clean, carbon-free renewable electricity. While batteries can smooth-out variable renewable generation, LDES can time-shift electricity for future use, and deliver electricity for significantly longer durations.
- LDES can provide electricity, when other forms of generation are unable to, providing grid resiliency
- LDES has low/no capacity reduction over time, leading to longer life spans of up to 30 years

LDES Challenges

- Flow batteries are a proven technology. Developers are working on improvements in design and manufacturing to lower costs.
- Emerging LDES technologies are developmental. They need to be technically proven, ready for manufacturing, and at a very-low marginal cost to be scalable for commercialization.
- The markets for electricity from LDES must value longer duration in a way that yields returns to facility developers. By nature, the last hour of storage will be used infrequently, but when needed by circumstances, must be valued in proportion to the power-grid need that it meets.

LDES Risks

- Most LDES technologies that promise to be low-cost, modular, scalable, and free from significant geographic/geologic constraints are new and developmental. Experience is needed for assured deployment.
- Beyond pumped hydro, none of the emerging LDES technologies have been demonstrated to operate at sufficient scale (50 MW) for grid reliability. Again, experience is needed for assurances.

Successful public/private partnerships among LDES developers, utilities, State and Federal entities, and financial entities needed to mitigate these risks.

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