Liquid Air Energy Storage

Principle

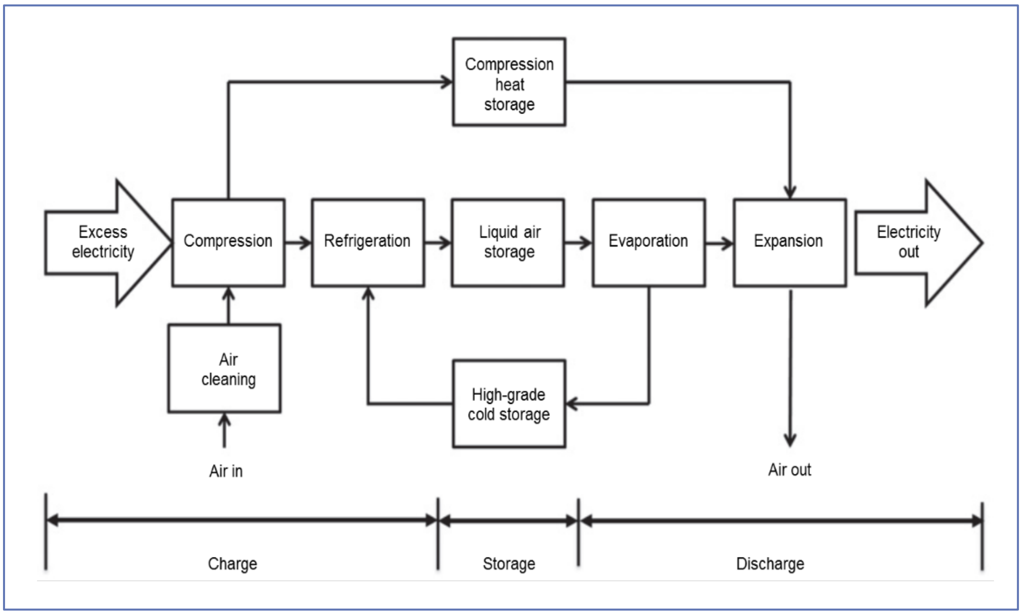

Figure 1. Principle of a Liquid Air Energy Storage system.

Liquid air energy storage (LAES) refers to a technology that uses liquefied air or nitrogen as a storage medium [1]. LAES belongs to the technological category of cryogenic energy storage. The principle of the technology is illustrated schematically in Figure. 1. A typical LAES system operates in three steps. Step 1 is the charging process whereby excess (off-peak and cheap) electrical energy is used to clean, compress, and liquefy air. Step 2 is the storing process through which the liquefied air in Step 1 is stored in an insulated tank at ~ 196°C and approximately ambient pressure. Step 3 is the discharging process that recovers the energy through pumping, reheating, and expanding to regenerate electricity during peak hours when electrical energy is in high demand and expensive. Step 2 also includes the storage of heat from the air compression process in Step 1 and high-grade cold energy during the reheating process in Step 3. The stored heat and cold energy can be used, respectively, in Step 3 and Step 1 to increase the power output and reduce the energy consumption of the liquefaction process.

Characteristics

Main function

Peak-load energy supply.

Balance supply and demand of electricity power.

Peak shaving of electricity grids

Waste heat / cold recovery and efficiency enhancement

LAES is mainly an energy type rather a power type of storage technology and hence suitable for large scale applications.

LAES has an application range that overlaps with compressed air energy storage (CAES) and pumped hydro energy storage (PHES). It is however far energy dense than the two technologies and also has no geographical limitations suffered by CAES and PHES.

The major components used in a LAES system are compressors, turbine, pumps, and heat exchangers, and hence the technology has long life span of 40-60 years.

LAES can effectively use low grade waste heat and cold, which is unique and no other energy storage technologies can do. LAES has a low life time levelised cost as shown in Figure 2.

General performance

Typical Power: ~ 5-650 MW

Cycle efficiency: ~60%

Energy capacity: 10 MWh to 7.8 GWh

Discharge time: >2-24 hours

Response time: ~2.5-10 Minutes

Technical lifetime: 40-60 years

Energy to Power ratio: 2-24

Maturity Level

LAES is at the commercial demonstration stage. As it relies on well proven components that are available off-the-shelf, the scale-up is expected to be comparatively easy, quicker and more effective than many other storage technologies. The Technology Readiness Level (TRL) of LAES is approximately eight, out of nine on TRL scale. A pilot scale plant, 350 kW/2.5MWh, was built in Slough (UK) by a UK company, Highview Power Storage. Such a pilot plant has not only shows the feasibility of the technology, but also its compliance to the UK National Grid STOR standards with a level of reliability of >95%. A commercial demonstration plant, 5 MW / 15 MWh, has been built in Manchester (UK) and under testing.

Maturity Level:

Installed capacity worldwide: 0.005GW

Potential capacity worldwide: 100s of GW

Installation costs: 600 to 3500€/kW

Operations costs (% invests): n/a

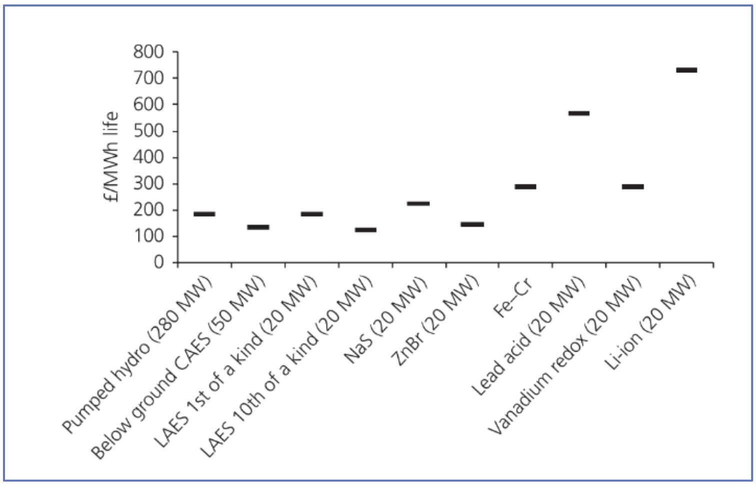

Figure 2. Life time levelised cost of LAES compared with other storage technologies [2].

Potential, barriers and challenges

Figure 3. LAES Pilot plant at University of Birmingham.

Potential

- Well established components;
- No geographical constraints;
- Efficient and effective use of waste heat / cold;
- Easy integration with existing processes;
- Highly competitive capital investment.

Barriers

- No commercial installations yet;
- Lack of standards and regulation;
- Lack of policy supporting the industrial uptake.

Challenges

- Efficient harnessing of waste cold
- Increase roundtrip efficiency
- Increase roundtrip efficiency

Compared with other large scale energy storage technologies, LAES has the advantage of geographically unconstrained. This feature is particularly significant when coupling with existing processes is considered. The availability of cold makes it possible to effectively utilize various waste heat sources. The technology can also effectively use waste process cold from e.g. evaporation of LNG. Main barriers are associated with lack of commercial installations so far and policy related aspects. In the future, efforts should be made to enhance the round trip efficiency.

References

[1] Chen H, Ding Y, Peters T, Berger F. Energy storage and generation. US Patent; 2009.

[2] Morgan R, Nelmes S, Gibson E, et al. An analysis of a large-scale liquid air energy storage system[J]. Proceedings of the Institution of Civil Engineers-Energy, 2015, 168(2): 135-144

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